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OF THE
30th ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1980

October 28, 29, 30, 1980

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Table of Contents

Tuesday, October 28th
Morning Session
Moderators
Frank P. Achorn
James C. Brown

Tuesday, October 28th
Afternoon Session
Moderators
Frank P. Achorn
Thomas L. Howe

Wednesday, October 29th
Morning Session
Moderator William W. Threadgill

Wednesday, October 29th
Afternoon Session
Moderator John L. Medbery

(continued next page)

Continued
Wednesday Afternoon Session
October 29th

Thursday, October 30th
Final Session
Moderators
Paul J. Prosser, Jr.
Harold Green

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(continued next page)

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Our Round Table
With Much Pleasure
Reports These Valuable
Proceedings Covering
Our 30th Annual Meeting

Tuesday, October 28, 1980

Morning Session
Frank P. Achorn, Acting Chairman
James C. Brown, Moderator

Introductory Remarks
Frank P. Achorn

I am sorry to report that because of urgent business our Chairman, Frank T. Nielsson, was unable to attend this morning. I hope to make a suitable substitute for Frank. (Applause).

Discussions for our 3 Day, 5 Session Meeting are: Supply and Demand: Uranium Recovery: New Phosphoric Acid Processes: Reports Concerning a Survey Taken by T.V.A. and The Fertilizer Control Officials: Latest Operating Efficiencies Covering Granulation, Bulk Blends, Fluids: New Developments by European, U.S. and T.V.A. Research Groups: Quality Control: Energy Conservation: Marketing and Agronomic Advantages of Producing and using MAP: Status Pipe Cross Reactor.

We have an Excellent Keynote Speaker, Jim Gillie, of the Phillips Petroleum Corporation. He will enlighten us on various aspects of regulations that have been imposed on Industries thruout the U.S.

I am happy to note that we are starting with an excellent attendance.

James C. Brown, Sales Division—Potash Co. of America, will moderate this morning's Session. Jim please. (Applause)

MODERATOR BROWN: Good Morning. I am happy to be your Moderator. Thanks to our five speakers for agreeing to come back to Our 30th Annual Meeting to give us an "Update Report" on the "Discussions" they gave last year, at Our 29th Annual Meeting. Held in Washington: Subjects— Nitrogen—Potash—Phosphates—Borax and Present Day Fertilizer Situation.

Our first Paper will be given by John Douglas, Assistant to the Manager Agricultural and Chemical Development—T.V.A. John please. (Applause)

Update on Nitrogen Outlook 1980's
John Douglas

Introduction

When Jim Brown asked me to take part again in this Round Table, he asked that I first review my projections of last year and update them or, if necessary, change them. What a job to assign to an economist— to review his errors and perhaps a few of his accomplishments! Well anyway, here goes.

Last year I made one major point on the worldwide nitrogen situation. Then, as now, the best estimates on future world capacity were and are significantly different from the actual capacities which we can expect to be effective for supplying nitorgen fertilizers. Then, and now, major changes in the energy situation are resulting in less than expected production from technologically sound facilities. In Japan and Western Europe the high cost of naphtha and fuel oil has made it almost prohibitive for facilities using these sources of hydrocarbons to produce ammonia. As a result, much of this production capacity is idle or operating at reduced rates. In Indonesia, a shortage of gas at new plants has reduced production well below what it would be if gas were available. In the U.S., the high cost of natural gas combined with low ammonia prices has led to the closing of some three million tons of capacity. Most of this will remain closed until the price of ammonia climbs far above its current level.

Last year we had political turmoil in Iran which reduced availability of ammonia in Iran and in countries supplied by Iranian natural gas. Again this year we have perhaps even more problems in Iran with the current situation between that nation and Iran. Last year both the U.S.S.R. and Mexico were having major problems in operating their large numbers of new plants. I projected, I am afraid, that these operational problems would continue for an intermediate period of time. This was one of the projections which seemingly was not too good. For instance then, both the U.S.S.R. and Mexico have made increasingly large amounts of ammonia available both domestically and on the world market.

Now how do you judge whether my projections last year were good or bad? I projected the world market as being in a tight supply/demand balance for the crop year 1980 with demand increasing about as expected but supply being far below the level which would be indicated based upon numbers of plants. No direct statistics are available to judge the outcome of this projection. As an economist, I would propose that the best answer of such a question is what happened to worldwide prices of major nitrogen products during the year. Prices of ammonia last fall on a worldwide basis averaged about $150 per metric ton f.o.b. Western Europe. Since then, price of ammonia has remained at this level or increased; by the end of June ammonia was about $160-170 per ton. Price of urea last fall f.o.b. Western Europe was $170-180 per ton in bags. By spring 1980 it was well over $200, and by midsummer had increased to $220. Thus, if we can judge the supply/demand situation by prices, it would appear that nitrogen products have remained in tight supply/demand balance; there are no real shortages to lead to extraordinary price increases such as we have seen in the mid-1970's, and certainly no real surpluses of any nitrogen products.

Now some will question what has happened to nitrogen prices in the U.S. during this same period of time. At best, this is a "mixed bag." Prices of urea delivered to the middle corn belt increased over the year—from about $140 to about $175. Prices of ammonia in the same area in the mideast corn belt increased from $120 last fall to $150 or more this fall. Thus, these prices inherently bear out the thesis of a tightly balanced supply/demand situation.

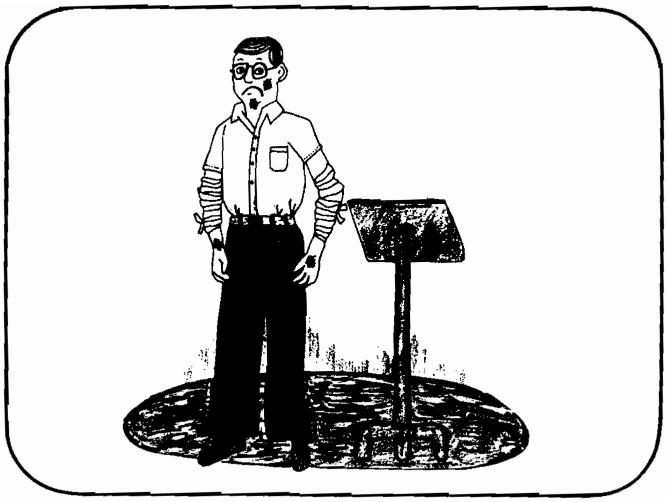
However, ammonia prices on the Gulf Coast of the U.S. have not followed these same patterns. Gulf Coast prices of ammonia were slightly over $100 in early fall 1979. They rapidly increased to $125 and then in early spring increased further to well over $150 per ton, when the flow of ammonia from the U.S.S.R. was temporarily delayed just prior to the crop planting season. With the resumption of the flow of U.S.S.R. ammonia to the Gulf Coast in June and July of this year, the price of ammonia steadily retreated—from its levels as high as $160 to lows around $120. This is a clear indication that the tight supply/demand situation for ammonia on the Gulf Coast does not exist but rather that the tanks are, temporarily at least, running over.

Now for a quick look at a few of the other projections of last year. We expected Japan to have less exports during the year and continuing less as they complete their rationalization of the nitrogen industry. This has been borne out. In Indonesia we expected less exports than had been projected by others. This, too, has been borne out and now we hear that Indonesia is in the market for 200,000 tons of urea to cover prior sales. From Canada we had expected imports to decrease in 1980 from the highs of 1979. They did not. In 1980 Canadian exports of nitrogen fertilizers to the U.S. were about the same as 1979. For the U.S.S.R. we projected ". . . . little improvement in sight at the moment." We were wrong. The U.S.S.R. almost doubled its exports of ammonia to the U.S. in spite of the U.S. partial embargo, which in combination with longshoremen refusing to unload the U.S.S.R. vessels, almost stopped movement for a few months in the spring.

We projected that Western Europe in 1980 would become a net importer of nitrogen for the first time in many years. If we include both the exports of finished fertilizers and the net imports of ammonia into Europe, this projection became a reality in 1980. We expect Europe to become an even larger net importer of nitrogen for the future.

For the U.S. nitrogen picture we projected an all-time high demand for domestic use and exports. The Fertilizer Institute Index reports a seven-percent increase in nitrogen use for domestic purposes for 1980. USDA statistics are not out yet but should be about in this range. Our gross exports for 1980 were up an estimated five percent from 1979, with significant increased in exports of ammonia and nitrogen solutions over-weighing decreases in exports of ammonium sulfate and urea.

On the supply side, we had projected imports higher but questionable—they were. We projected production up by one million tons of nitrogen. It actually increased by 1.3 million tons of nitrogen. Overall, we projected sufficient supply to support five to six percent growth in domestic use. It is clear our Nation did a little better than this.



Slide 1

Situation 1981

In fall 1980 the economic recession continues but there are some signs that we are pulling out more rapidly than expected.

The political embargo by the U.S. continues in a modified form on the grain and fertilizer trades with the U.S.S.R. However, the basic long-term contract for shipment of grain is being completed and the basic long-term contracts for ammonia imports to the U.S. are continuing with expectations that the total amounts of ammonia imported to the U.S. will increase by at least 400,000 tons of ammonia during crop year 1981.

Weather in the summer and fall of 1980 seriously reduced crop production and has had mixed effects upon our agriculture. It has meant that many farmers have been devastated by crop losses. Their total production has probably been cut by 20 percent in the feed grain area. On the other hand, it has had the effect of leading to rapidly escalating prices for the crops and farmers in those areas which have been able to harvest good crops will, in turn, have exceedingly profitable years. The increasing crop prices bode well for increased fertilizer use during 1981.

Accompanying these changes in the agricultural situation have been changes in the agricultural policy in the U.S., all of them favorable to farmers. The USDA official loan, release, and call rates on all crops have been revised upward assuring farmers higher prices for their crops. Adequate amounts of agricultural credit have been pumped into the Farm Credit Administration both to the PCA's and FHA's. Interest rates which climbed above 20 percent in early 1980 decreased for some time but now are inching back up. However, adequate money is available at these higher interest rates whereas in early spring 1980 money was simply not available at any interest rate.

In total, the general situation for fertilizer use during 1981 is still a "mixed bag." However, it appears there are many more factors favoring greater fertilizer use than there are detracting from increased use.

World Nitrogen Supply/Demand Outlook

We can expect demand for nitrogen fertilizers during 1980 to continue its increase at a rate of 2½ to 3 million tons. The continuing pressure on world food supplies is such as to insure that additional nitrogen will be used in order to insure adequate supplies of grain.

On The Supply Side—Again, the bare statistics on numbers of plants coming on-stream would indicate a significant worldwide surplus of materials in 1981 but statistics still can be misleading; feedstock for about 10 percent of the total world's production still costs more than the ammonia produced from the feedstock. As long as this holds true, much of this production capacity will not be truly effective in producing nitrogen.

In addition, a large majority of the total new capacity in ammonia is coming on-stream within one nation—the U.S.S.R. Even if Russia is able to produce the material it is highly improbable that the world's logistics could be improved fast enough to make all this material available to the countries where it is needed. Thus, we do not believe that supply will increase nearly as rapidly as capacity statistics would indicate.

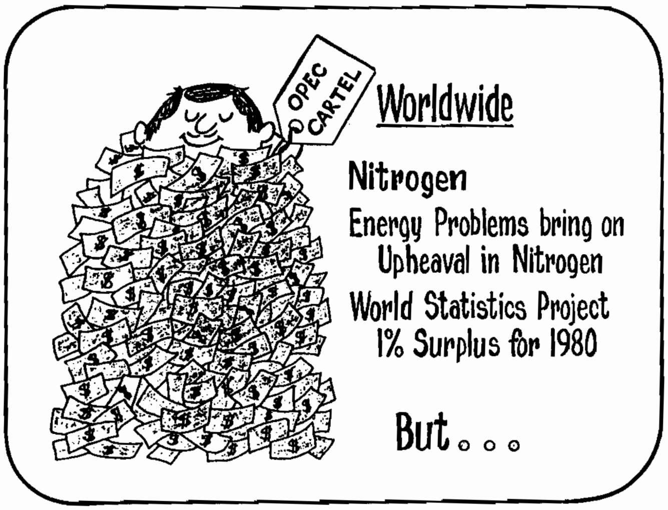
We are projecting a supply/demand balance for 1980 which would remain in tight equilibrium barring unexpected exogenous influences. The equilibrium will be so delicately balanced, however, that almost any significant outside happening could throw the balance into a tight to short supply. On the other hand, any extraordinary rapid rise in price could depress demand and lead to seemingly surpluses.

U.S. Nitrogen Situation

Many factors point to extraordinary increases in *nitrogen demand* for 1981. Foremost among these factors are the evolution of the crop-fertilizer price ratio to the most favorable in more than five years. Crop prices across the board have improved much faster than nitrogen fertilizer prices. As a result, it takes less bushels or pounds of almost any crop to buy a ton of nitrogen fertilizer than at any time in the past five years.

The corn-nitrogen price ratio is a prime example. In the spring of 1980 it took almost 100 bushels to buy a ton of ammonia or urea. With the changing prices on corn and nitrogen, by August this had decreased to less than 70 bushels. Since then the ratio has improved even further. This ratio now is significantly better than at any time since the early 1970's.

The same is true with wheat. By August 1980 advances in wheat prices had improved the ratio 20 percent as compared to the early 1970's. Since then the price of wheat has continued its slow but steady upward trend, and the price of nitrogen certainly has not increased. With cattle and cotton these priced ratios are approaching all-time records.



Worldwide

Nitrogen

Energy Problems bring on Upheaval in Nitrogen

World Statistics Project 1% Surplus for 1980

But . . .

Slide 2

Thus, the U.S. nitrogen industry can well expect an all-time record in nitrogen sales for 1981. In 1980 we surpassed the 11-million-ton market for nitrogen fertilizers for the first time in history. In 1981 we could well surpass 12 million, barring calamitous weather or other unforeseen catastrophic events.

On The Supply Side—In 1980 we produced an unexpectedly large amount of ammonia—18.8 million tons contrasted to only 17.2 million in 1979. This added production came about almost entirely by increasing the operating rate of the plants which were on-stream. Only one or two of the plants which had earlier been closed because of economic problems were restarted. The net result was that those plants which were on-stream operated at as high as a rate of capacity as ever before in history. We really cannot expect as large an increase during 1981 as that during 1980.

One may ask why we do not open up some of the plants which are closed. It takes only a brief glance at the average production costs of ammonia compared with the average sales price to see why very few plants have been reopened. Costs continue to escalate ever more rapidly as the process of deregulation of natural gas continues. It is estimated that average "spigot" production costs of ammonia now exceed $100 per ton. This does not include rate of return on investment or ammortization of the plant investment costs. We cannot expect additional plants to reopen as long as the price of ammonia on the Gulf Coast remains at or near its current level of $120.

Thus, in summary, U.S. production for the year may increase with one or two plants opening and one or two closing. However, we cannot expect to add more than one-half million tons production.

Much has been written about *imports*—especially imports of ammonia—and it is true that U.S. ammonia imports increased by one-half million tons in 1980. Almost all of this came from the U.S.S.R. In 1981 we will see a further increase from the U.S.S.R. At the same time, however, one must look at our exports of nitrogen. In 1980 we exported about the same amount of nitrogen that we imported. We offset the extraordinary large imports of ammonia with nitrogen exports in the form of urea, ammonia, ammonium sulfate, and ammonium phosphates. We imported low-priced nitrogen in the form of ammonia and exported high-priced nitrogen in our upgraded fertilizer materials. For 1981 it seems certain that although we will increase imports of ammonia we will, at the same time, decrease imports of finished nitrogen products. Added to this it seems certain we will increase our exports of urea and nitrogen solutions. The net trade balance then for 1981 should remain as it is in 1980—about a zero balance with no net imports in spite of increasingly high ammonia imports.

Industrial use of ammonia was down in 1980 and we project it will be down further for the full year 1981 by something up to one-half million tons. This material can be released for use in fertilizer.

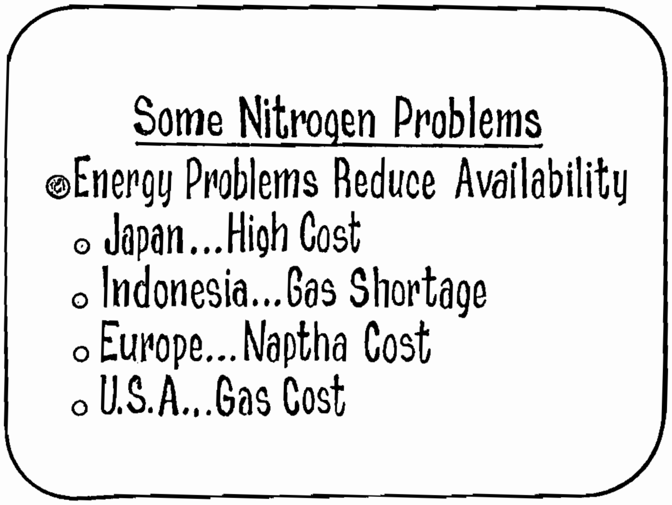
With production up by one-half million tons and no change in the net import picture plus industrial use of ammonia down, the net result will be a total added ammonia supply available for fertilizer operations of about one million tons.

Boiling It Down

Boiling this whole complex down to the very simplest form, we project the nitrogen supply/demand for the U.S. about as follows:

Supplies of nitrogen fertilizers should be ample for the coming year. For the year as a whole there should be no major problems other than normal logistics planning difficulties. We will use all that we make and all that we import. High inventory problems will be ereased during the spring of 1981.

Domestic demand for the year should break all records. However, the fall of 1980 will continue to be



Some Nitrogen Problems

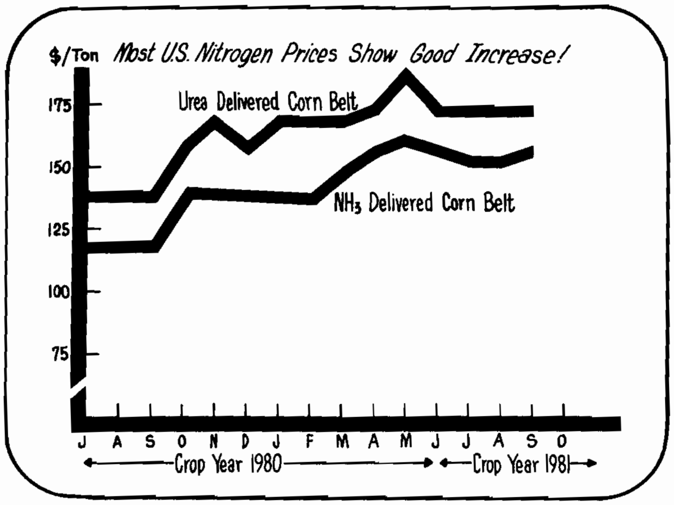
- Energy Problems Reduce Availability
  - Japan...High Cost
  - Indonesia...Gas Shortage
  - Europe...Naptha Cost
  - U.S.A...Gas Cost

Slide 3

slow as bad weather and a general mood of uncertainty prevails across the country. Export demand will increase for urea and nitrogen solutions and will take any surplus off the market.

After a slow fall, the spring season should turn into a "barn burner." Farmers will look at increasing prices of all farm commodities—and at increased fixed production costs which dictate maximum production per acre in order to spread these fixed costs over the least number of bushels—and at the best fertilizer-crop price ratios which they have seen since the early 1970's—and will buy more nitrogen than ever before, by seven to eight percent.

Finally, there will be increasing pressure on all supplies once we get into the spring of 1981 with some probability of spot tightness or even spot shortages of various forms of nitrogen materials as the season progresses.



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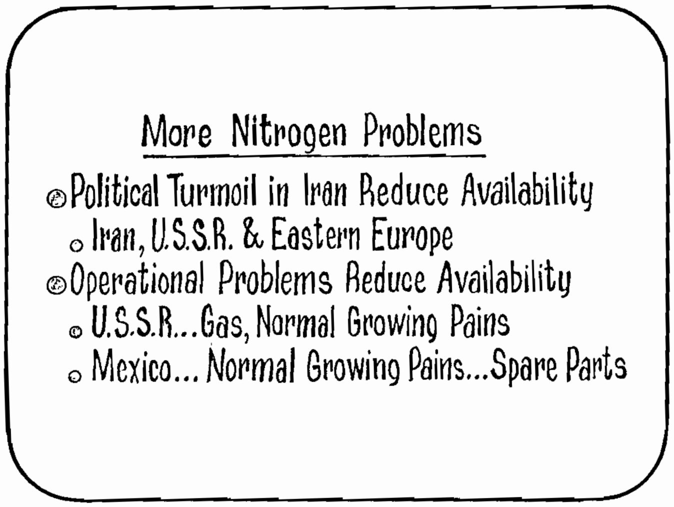
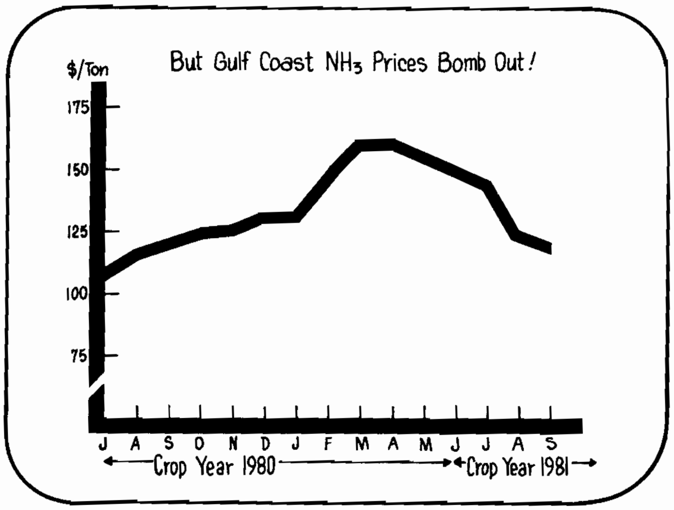


More Nitrogen Problems

- Political Turmoil in Iran Reduce Availability
  - Iran, U.S.S.R. & Eastern Europe
- Operational Problems Reduce Availability
  - U.S.S.R...Gas, Normal Growing Pains
  - Mexico... Normal Growing Pains...Spare Parts

Slide 4



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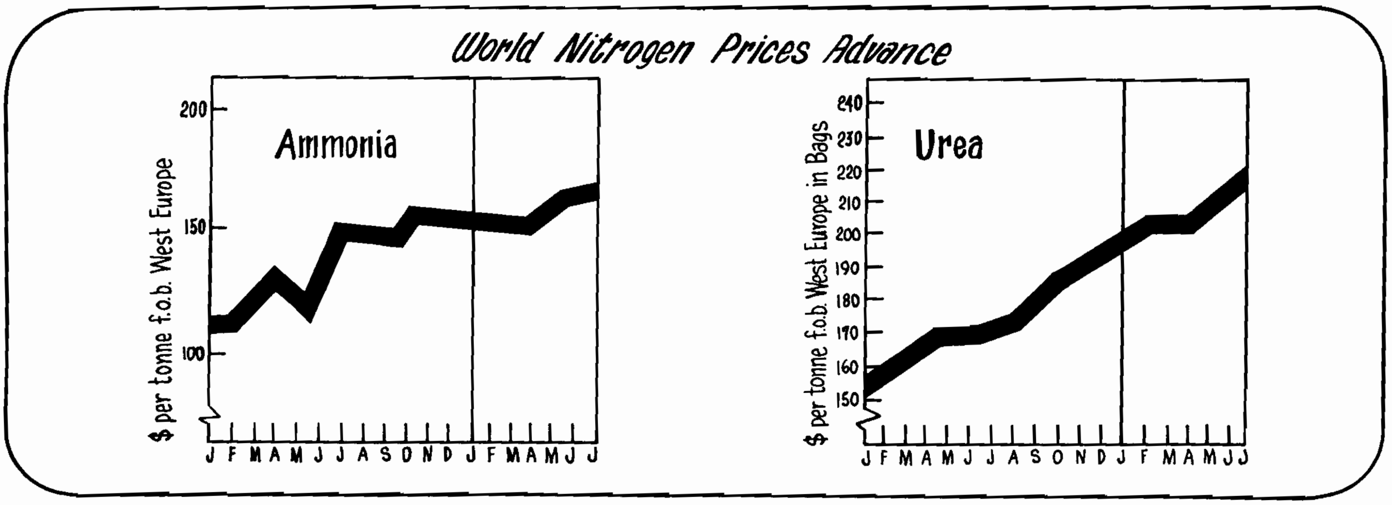

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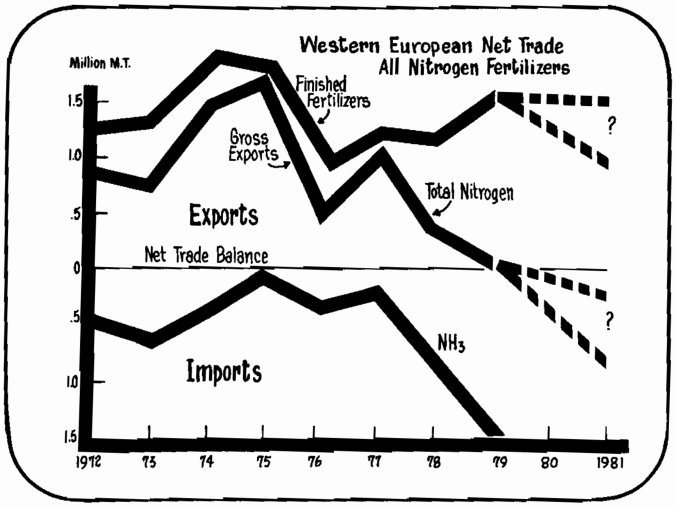

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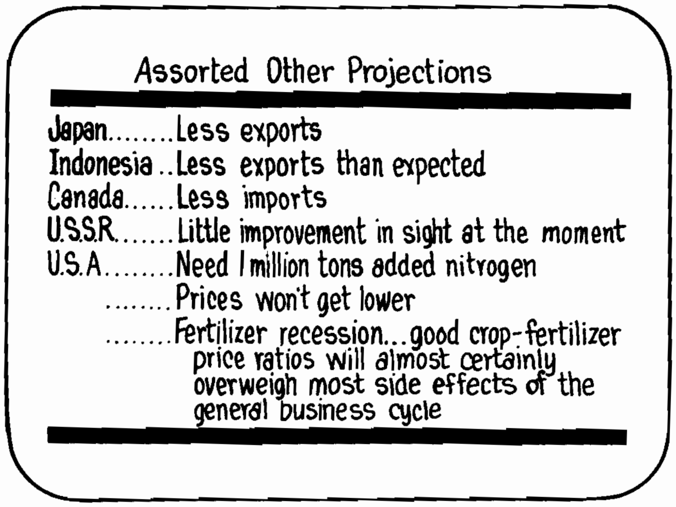
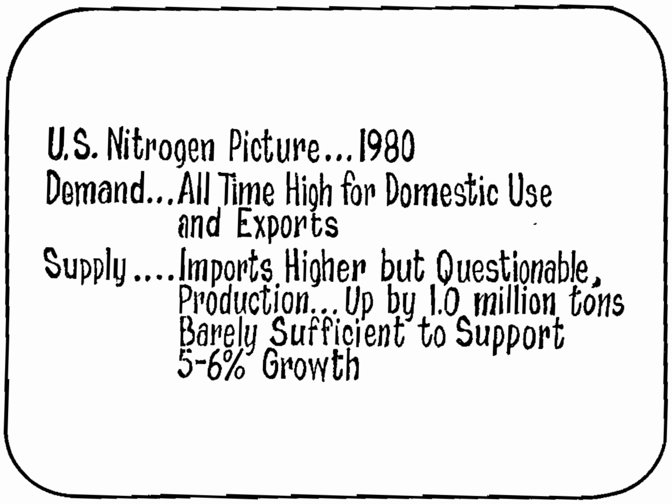


Assorted Other Projections

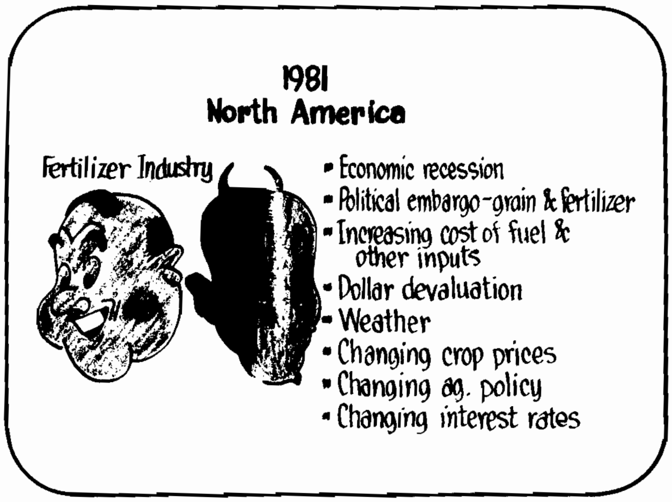
Japan........Less exports
Indonesia..Less exports than expected
Canada......Less imports
U.S.S.R.......Little improvement in sight at the moment
U.S.A........Need 1 million tons added nitrogen
........Prices won't get lower
........Fertilizer recession...good crop-fertilizer price ratios will almost certainly overweigh most side effects of the general business cycle

Slide 9



U.S. Nitrogen Picture...1980
Demand...All Time High for Domestic Use and Exports
Supply....Imports Higher but Questionable,
Production...Up by 1.0 million tons
Barely Sufficient to Support 5-6% Growth

Slide 10



1981
North America

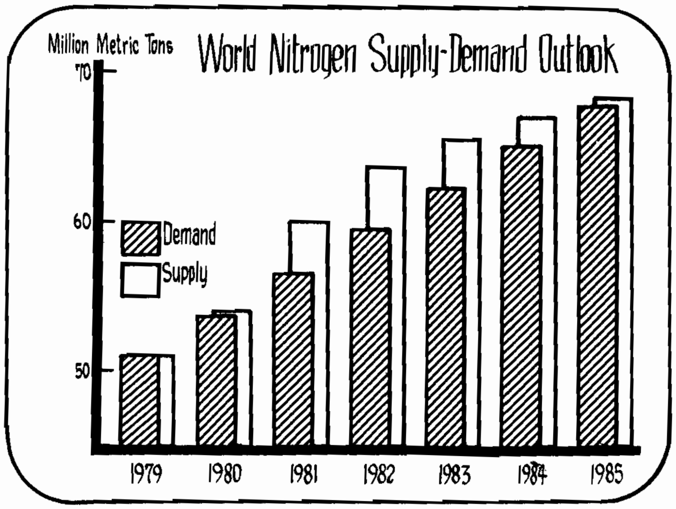
Fertilizer Industry

- Economic recession
- Political embargo-grain & fertilizer
- Increasing cost of fuel & other inputs
- Dollar devaluation
- Weather
- Changing crop prices
- Changing ag. policy
- Changing interest rates

Slide 11

Confused Economist

Slide 12



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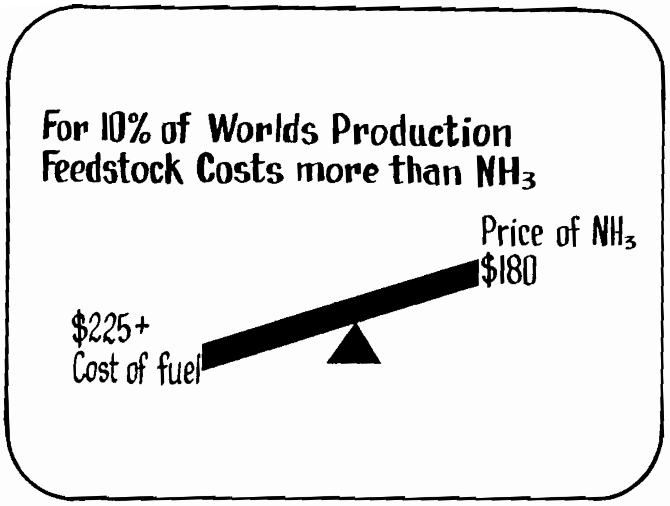
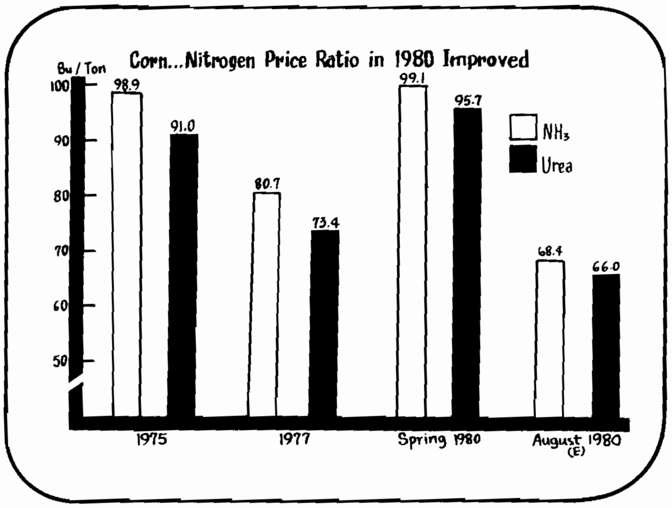

For 10% of Worlds Production Feedstock Costs more than NH_3

Slide 14


Corn...Nitrogen Price Ratio in 1980 Improved

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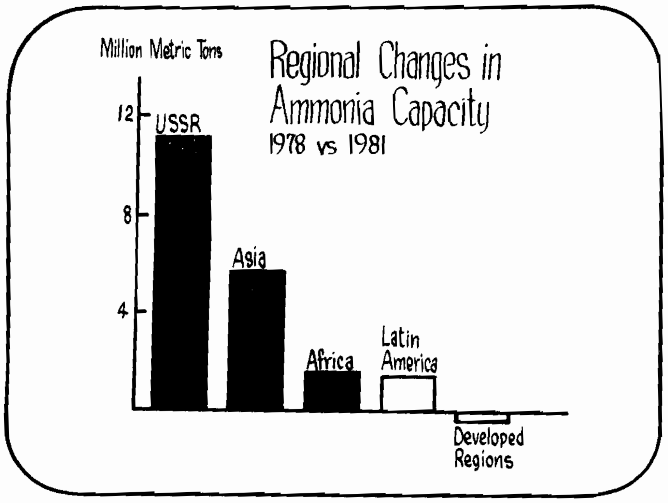
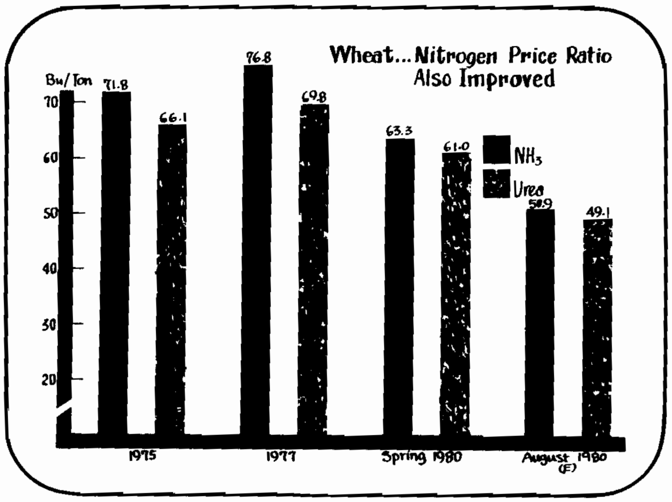
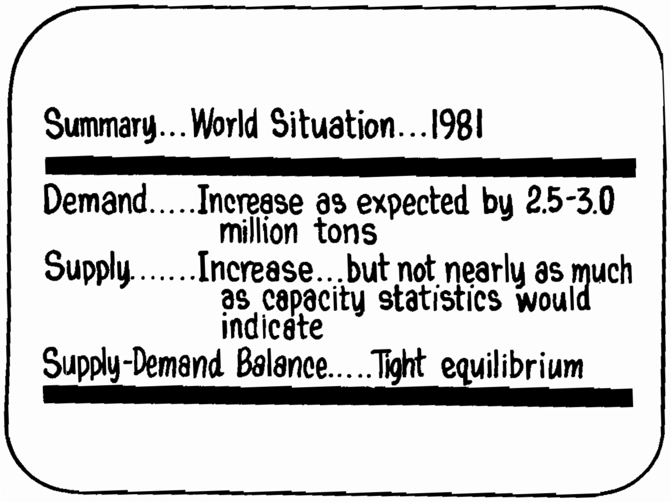

Regional Changes in Ammonia Capacity 1978 vs 1981

Slide 15


Wheat...Nitrogen Price Ratio Also Improved

Slide 18

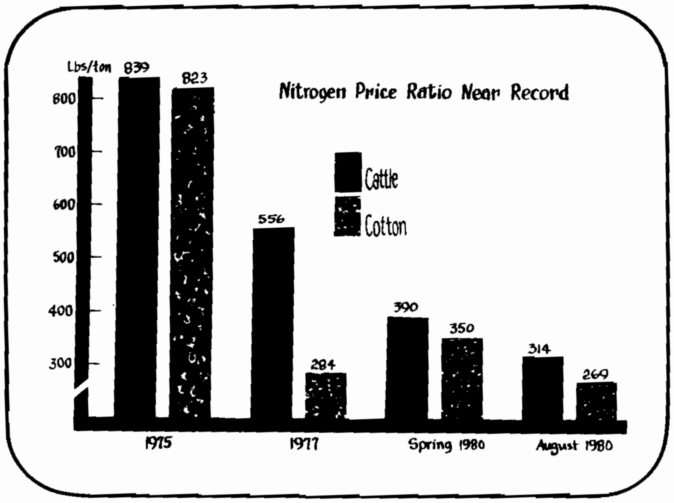

Summary...World Situation...1981

Demand.....Increase as expected by 2.5-3.0 million tons

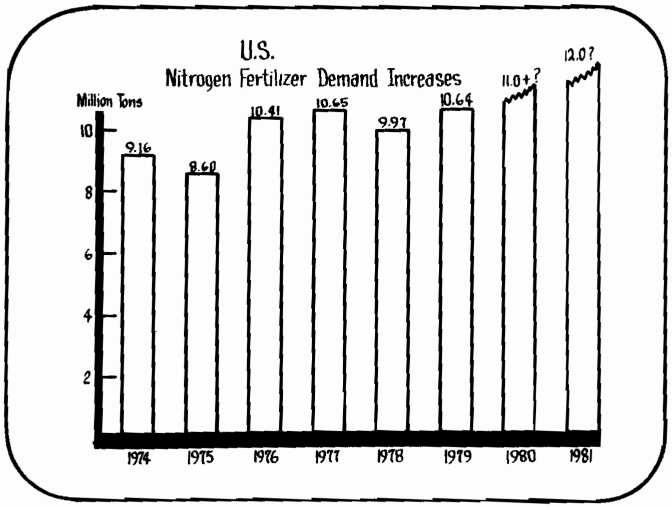
Supply.......Increase...but not nearly as much as capacity statistics would indicate

Supply-Demand Balance.....Tight equilibrium

Slide 16


Nitrogen Price Ratio Near Record

Slide 19



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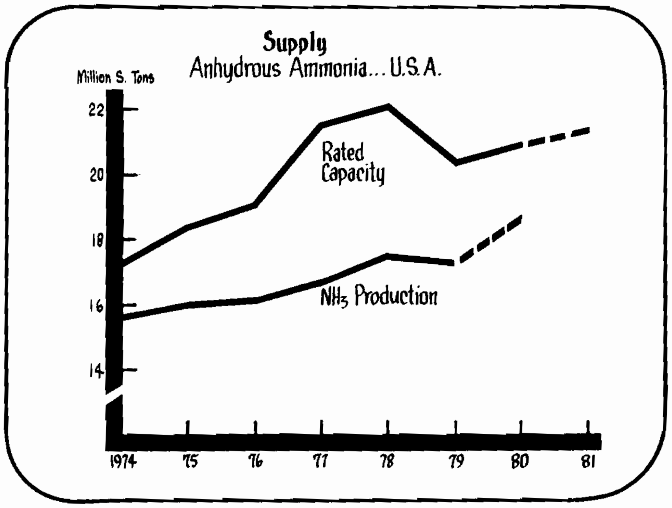

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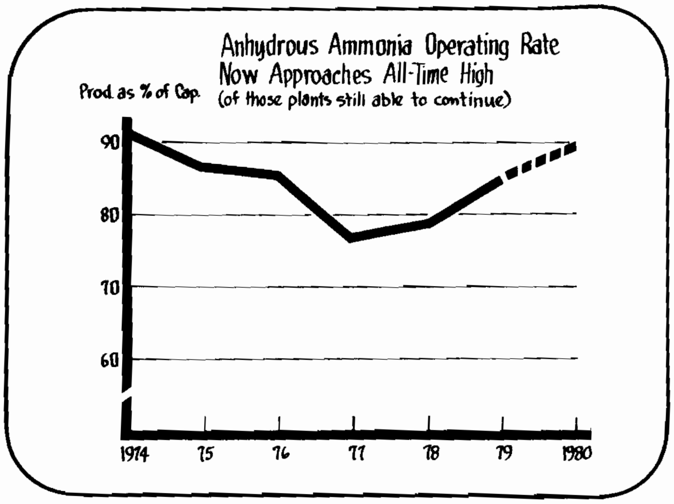

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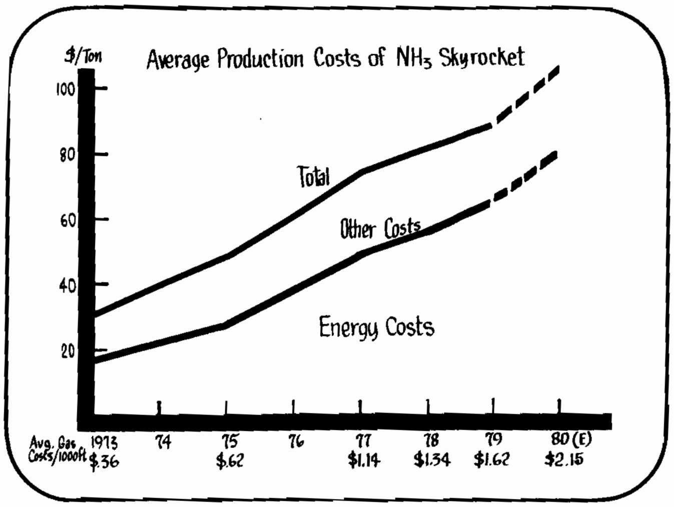

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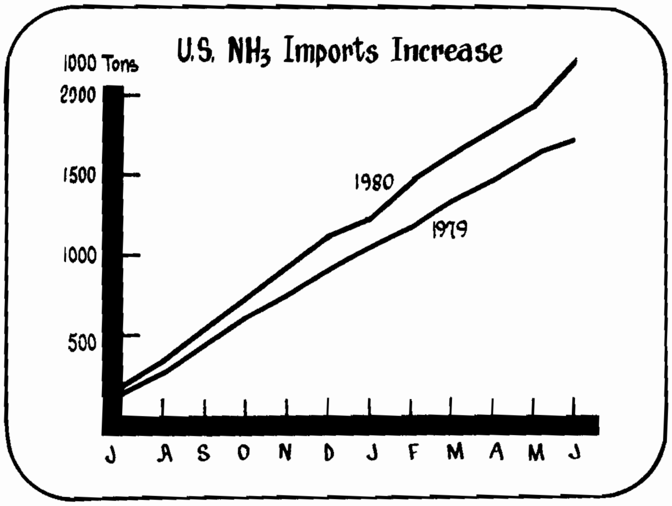

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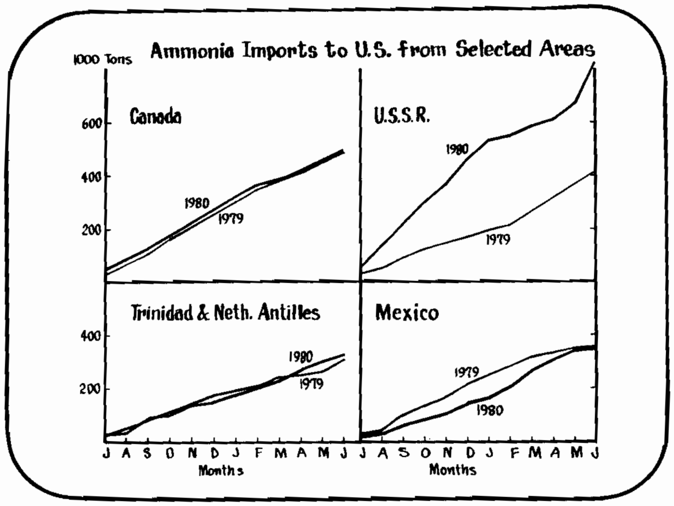

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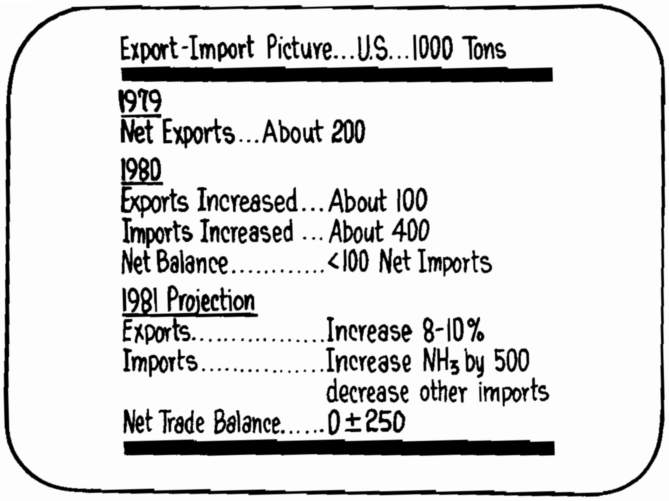


Export-Import Picture...U.S...1000 Tons

1979

Net Exports...About 200

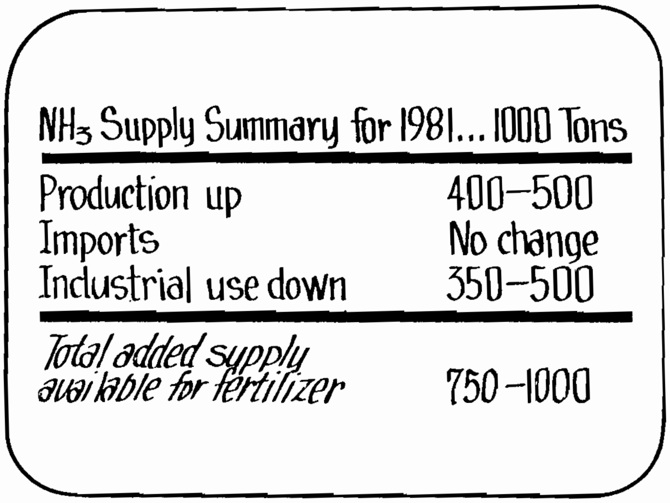
1980

Exports Increased...About 100
Imports Increased ...About 400
Net Balance............<100 Net Imports

1981 Projection

Exports.................Increase 8-10%
Imports................Increase NH_3 by 500
decrease other imports
Net Trade Balance......0 ± 250

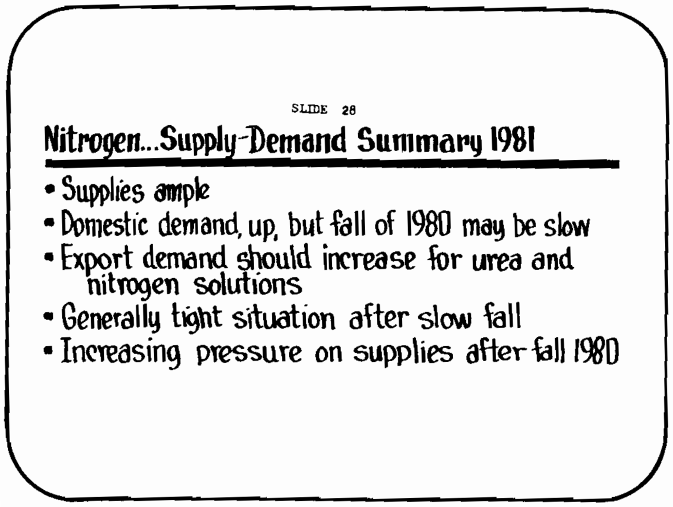
Slide 26



NH₃ Supply Summary for 1981... 1000 Tons

Production up	400–500
Imports	No change
Industrial use down	350–500
Total added supply available for fertilizer	750–1000

Slide 27



SLIDE 28

Nitrogen...Supply-Demand Summary 1981

- Supplies ample
- Domestic demand, up, but fall of 1980 may be slow
- Export demand should increase for urea and nitrogen solutions
- Generally tight situation after slow fall
- Increasing pressure on supplies after fall 1980

Slide 28

Thank you. (Applause)

MODERATOR BROWN: Thank you John Douglas for your latest valuable updated information on the Nitrogen Outlook—1980's.

It is a real pleasure for me to have this opportunity to introduce my "Boss" Dean R. Gidney, President of Potash Company of America, who will give us his latest information on the Present World Potash Market and the outlook for the future. Dean please. (Applause)

The World Potash Market and The Outlook for The Future

Dean R. Gidney

LADIES AND GENTLEMEN: Thank you very much for inviting me back this year to talk to you once again about the current situation in the world potash market and the outlook for the future. (Applause)

Since you gave me the opportunity of addressing you last year, you can readily check out the accuracy of my forecast — at least insofar as one fertilizer year is concerned.

I do have to warn you that when you invite a member of the industry to make this type of presentation, you have to remember that it is difficult for him to be objective. The reason for this is simply that obviously, we would like to get across two points. The first point is that we foresee a pretty tight potash market and the objective of this is to induce you to order your potash early and not to expect price reductions.

On the other hand, we must be careful not to paint too rosy a picture for the future which could be construed as an open invitation to anyone and his brother to decide to enter into potash production.

Since so much of this type of speech is devoted to the nature of the world potash market and some of you have heard so many of these speeches in the past, I will try to deviate a little from the usual format. In endeavoring to do so, I have gone back over internal forecasts which I made for my company since the 1940's and various speeches which I have made to industry and technical organizations for the past 30 years.

It is real interesting to do this and see how on some occasions my ideas turned out to be extremely accurate and on other occasions, they weren't so good. The main theme, however, has always been that the potash market is a world market and that it is world supply and demand which determines the potash balance.

Here are a few comments from some of the old presentations and speeches which may be interesting.

On April 22, 1958, we wrote a paper for internal consumption within our company entitled *"North American World Potash Survey."* This goes back over the history of potash and the pricing of potash and indicates a world productive capacity of approximately 8,100,000 metric tons of K_2O in 1958 which represented a small surplus above effective demand. At that time, we looked ahead for a period of about 12 years to 1970 — at which time, we estimated total world capacity at about 13,500,000 tons and demand some 1,500,000 tons below that. My conclusion was that "we would have a tremendous surplus of productive capacity in 1970 with the greatest part of that surplus existing in the North American market." "The World's greatest deposit of potash lies in Canada. It extends some 300 miles in length and over this length there is a belt some 10 to 20 miles wide at which potentially exploitable potash lies at depths not in excess of 3,500 feet. It is true that capital investment required to develop mine and plant may be on the order of $25,000,000 to $40,000,000 for capacity of about 500,000 short tons of K_2O. However, if reasonable extraction is feasible and cost are favorable, it is hard to believe that no newcomers will appear on the scene in the next decade."

In recommending policies for my company, I suggested the following:

"1. Search for the most economical means of extraction and refining.

2. Intensify promotion at home and abroad. The work of such organizations as the American Potash Institute must be supported wholeheartedly by the entire potash industry. It is their scientific work in the field of agronomy that holds out the greatest hope for increased use of potash in agriculture. North American producers should also intensify education and promotion in export markets and potential export markets as an increase in worldwide consumption is also essential to their welfare."

The first time that I had an opportunity to address the Fertilizer Industry Round Table was in November of 1960, at which time, I apologized for appearing in what was a highly technical discussion. However, I indicated that I felt I had some qualification for the panel on which I was serving because "my service in the potash industry goes back almost to the days when the fertilizer industry was an industry of cow manure and kainite." At that time, we established the standard nomenclatures for the various grades of potash. In 1965, I had the opportunity to speak at the TVA Fertilizer Symposium, at which time, we discussed the current world situation and made projections to 1970 and 1975. Here again, the emphasis was on the worldwide nature of the potash market. Here is the conclusion of that address:

"In consclusion, the domestic or North American potash industry is on the verge of tremendous growth in both production and consumption. Dramatic increases in home market and overseas market consumption will be essential if anticipated new production is to be sold. If all of the potential producers who expect to be in production in Canada by 1970 are successful, we will see a great surplus of productive capacity over demand at that time, and the same may be true if only half of the potential new producers are in operation at that time. Therefore, as previously stated, the problem of the potash industry is now one of marketing and this problem will become more acute and more difficult as additional new producers enter the field, despite the fact that consumption on this continent and in the world should grow at a compounded annual rate of from 5 to 7 percent. Our best educated guesses, based on stated objectives of current and potential producers and on scientific estimates of consumption from agricultural expoerts all over the world, indicate a world production in 1975 of approximately 23,500,000 metric tons of K_2O with a demand of 21,400,000 metric tons of K_2O. A lot of people are going to be making potash. The big fight is going to be in the marketplace — who are going to be the successful sellers?"

At that time, I flashed a picture of the Potash Company of America Sales Department on the screen and said that here was part of the answer. This was certainly presumptuous, but 15 years later, it is still true.

The next address to which I will refer was again a presentation to the TVA Fertilizer Conference in July of 1975. At that time, we discussed the world situation in 1974/75 and presented our projections for 1979/80. The 1974/75 production was very close to that which we had forecast. In our 1965 address, but consumption was somewhat higher— although, there was still a surplus of potash.

Having gone back over all of these addresses, it is sort of hard to approach an analysis of the world potash market in any really different fashion. You will note from the slide which is appearing on the screen that supply and demand in 1979/80 were in very close balance as we predicted at last year's meeting. Eastern Europe remains the principal producing area for potash in the world, with the U.S.S.R. providing about 70 percent of Eastern Europe's production and East Germany providing the remainder. One reason for the close balance in world demand and supply is the relatively poor performance in the Soviet Union during the past fertilizer year. I don't have the actual figures for the fertilizer year, but in calendar year 1979, Russian exports were 17 percent below those of the previous year and production and consumption in the U.S.S.R. was somewhere in the neighborhood of 15 to 18 percent below that of the previous year. In addition to the usual logistic problems, there were some rather serious problems at the mines. Here again, our information is sketchy and we do not want to dwell on something which we really know so little about.

Outlook 1980/81

In looking forward to the current fertilizer year, we don't see any reason to expect very much change in the tight supply/demand balance. As you all know, deliveries of potash in the spring of 1980 in the North American market were very disappointing. One reason for this was the fact that deliveries during the first half of the 1978/79 fertilizer year were far ahead of those of the preceding year and despite the reasonably poor spring season, deliveries for the year in North America were 2 percent ahead of those of the 1978/79 fertilizer year.

With the usual qualifications concerning weather, farm income, farm prices, etc., we foresee a good domestic season in 1980/81. Although, it is possible that fall deliveries will be off, we anticipate that this decline will be offset by increased deliveries in the spring. If this does happen, we will be faced with the usual logistic problems and even despite the fact that there will be an adequate supply of potash, you will once again be faced with the unavailability of some grades at some times and places. This is the stock annual flea to take deliveries of your potash and other materials as early as possible.

In last year's presentation, we projected world supply and demand 5 years ahead and do so again this year. The table which now appears on your screen indicates our estimates for production and consumption of potash in the fertilizer year 1984/85. I want to emphasize, as I have done in the past, that the production figures do not represent rated capacity figures which would be somewhat higher, but the production which we can actually anticipate on the basis of past performance. If these figures are correct or anywhere near correct, we should remain in reasonable balance throughout the next 5 years. Production will probably out-pale demand by a small margin by 1984/85, but if reasonable gains in consumption are made in North America and in the U.S.S.R., it appears that here again, we should have a knife-edge balance.

The major increases in production will come in the U.S.S.R. and in Canada. We remain skeptical that the U.S.S.R. will achieve stated goals, and the production figure which we have indicated is somewhat below those stated goals.

In North America, the increase in production will come from expansions in capacity in Saskatoon and some new mines which are now being developed in the province of New Brunswick. Our own New Brunswick project is going forward and we hope to have some production in 1982, but believe that it will be 1983 before we come close to our rated capacity. The other project in New Brunswick — that of Denison/Potacan — will probably be at least one year behind us. Meanwhile, minor increases in capacity are in process at three of the private industry companies in Saskatoon (i.e.— P.C.A. —Kalium—Comico) and the Potash Corporation of Saskatchewan has announced its intention to make major expansions over the next decade. Shortly after the original draft of this speech and the preparation of the two tables, we received the publicity releases from Potash Corporation of Saskathchewan announcing that the major expansion at the Lanigan Mine of approximately 1 million metric tons of K_2O will be completed by 1983, and further announcing an entirely new mine at Bredenbury which is expected to produce 3,600,000 short tons a year of potassium chloride by 1985. The 3,600,000 tons of potassium chloride translates into approximately 1,950,000 metric tons of K_2O. Obviously, if these projects are completed on schedule, we will have to add additional capacity to that indicated in Table II which represents our forecast for 1984/85. On the assumption that the Lanigan expansion will be completed, but that the Bredenbury new mine probably will not be in full operation, we probably should increase the anticipated production in North America in 1984/85 by at least 1 million metric tons of K_2O. The effect of this would be to indicate a surplus in the neighborhood of 1.6 million rather than 600,000 tons.

Other potential increases in North American capacity exist in the deep deposits in North Dakota and Montana. But, here again, we foresee no production in this area within the next 5 years.

The only major increase in capacity in the European group will come from the Dead Sea works in Israel and it is possible that this expansion can be operative before the end of 1981.

For years we have talked about possible production in Brazil and possible production in Thailand, but have not given sufficient emphasis to the proposed production by Jordan from the Dead Sea. In this Table, you will note that we have included some production from the Brazilian deposits in the state of Sergipe as the Brazilians have enlisted the technical help of the French potash technical people and it is possible that that mine may be in operation by 1984/85. We have also included production by Jordan from the Dead Sea and it is anticipated that this production will be available in 1983.

With reference to consumption, the principal producing areas in the world remain as the largest consumption areas. In the direct order of the amount of production — Eastern Europe is the biggest consumer, followed by North America and Western Europe.

It is clear that in order to dispose of surplus production from these three basic producing areas, other markets must be developed and increased. In Asia, we already have major markets in Japan and India — with good markets in Korea and Taiwan and rapidly developing markets in Southeast Asia. However, the big news concerns the people's republic of China which up to 5 years ago was hardly considered as a potential market. Although, I was interested to note that in my internal memo of 1958 I referred to China as a large potential market some 20 years down the road.

The people's republic has entered into a three year contract with Canpotex for 650,000 tons — with Western Europe for 100,000 tons, and with Potash Company of America for 40,000 tons each for two years and 80,000 tons in the third year, and I believe that they will soon be making a small contract with the Spanish potash producers. This new relatively unanticipated market has taken up any possible slack between production and consumption and estimates are that it will grow dramatically in the next decade. I really believe that my consumption estimates for Asia in 1984/85 are probably too low.

In Latin America, Brazil remains as the principal potash market and continues to grow at a very rapid rate. We recognize the fact that Brazil has serious economic and monetary problems, but agriculture is as important to Brazil as it is to the U.S.A. Export crops are essential to the Brazilian economy and virtually every cash crop in Brazil is a large user of potash. For this reason, we believe that some solution to the payment problems must be worked out and foresee a continuing expansion in the brazilian market. As you know, the alcohol for gasohol is produced principally from sugar cane in Brazil and that alone is a rapidly expanding market. It is clear that in the long run, we must increase the potash consumption in other of the lesser developed countries in the world. But, this is a slow process contingent upon education and financing. It is in the area of education that the potash industry takes its greatest pride. In every presentation that we have made over the last 40 years, we have referred to the work of what is now the Potash/Phosphate Institute and pointed out the great contribution that this organization has made to world agriculture, as well as to the Potash Industry. I don't want to conclude any speech without once again paying tribute to this organization and commenting on the new research program on which they have embarked. Your interest and help in that area will be deeply appreciated and should be in your own best interest.

This has been a rather rambling speech and has not included the usual number of statistics, but I believe that we have furnished sufficient statistical data to show you.

Our conclusions concerning the outlook for the world potash industry during the next 5 years.

1984/85
ESTIMATED WORLD PRODUCTION AND CONSUMPTION OF POTASH
(1,000 M.T. K_2O)

	PRODUCTION	CONSUMPTION	SURPLUS (Deficit)
North America	11,800	7,500	4,300
Western Europe (Inc. Israel)	6,800	6,800	—
Eastern Europe	14,000	12,400	1,600
Latin America (1)	400	2,400	(2,000)
Asia & Oceania	200	3,400	(3,200)
Africa/Mideast (2)	500	600	(100)
TOTALS	33,700	33,100	600

(1) Includes potential production in Brazil.
(2) Includes anticipated production in Jordan.

1979/80
WORLD PRODUCTION AND CONSUMPTION OF POTASH
(1,000 M.T. K_2O)

	PRODUCTION	CONSUMPTION	SURPLUS (Deficit)
North America	9,300	6,520	2,780
Western Europe (Inc. Israel)	6,400	5,900	500
Eastern Europe	10,600	8,800	1,800
Latin America	—	1,700	(1,700)
Asia & Oceania	100	2,600	(2,500)
Africa/Mideast	—	450	(450)
TOTALS	26,400	25,970	430

Thanks again for this opportunity and as usual, I would appreciate the opportunity of trying to answer any of your questions. (Applause)

MODERATOR BROWN: Thank you Dean. Your most interesting report for the Future World Potash Outlook will be helpful to the Fertilizer Industry in its planning for the next 5 years.

We will continue with our Morning Program and when concluded we will have time for questions.

Our next discussion will be given by William R. Rohrer, Senior Vice President— Phosphate Chemicals Export Association. Bill will give us his up-to-date report on "World Outlook for Processed Phosphates 1981". Bill please. (Applause)

World Outlook for Processed Phosphates 1981

William R. Rohrer

PhosChem

Introduction

Once again I am pleased to address this esteemed group to discuss Phoschem's views on the outlook for world trade in processed phosphates in 1981. First though, I would like to digress and briefly critique the paper I presented last year.

1979 Review (Slide #2)

As you may recall, the year 1979 was a somewhat chaotic year for the world phosphate industry with its spot shortages of sulfur and numerous operating pro-

KEY FACTORS IMPACTING P_2O_5 SUPPLIES 1979

I. INADEQUATE SUPPLIES OF SULFUR

II. INSUFFICIENT U.S. PRODUCTION CAPACITY FOR P_2O_5

Slide 2

blems at key mines and plants of several exporting countries. Last year I stated that two of the principal factors that could adversely impact P_2O_5 supplies in the short term were (1) inadequate sulfur supplies and (2) insufficient U.S. production capacity, well, in 1979 world demand for *sulfur* exceeded production by over one million tonnes. Consumption increased by some 5% led by U.S. producers of P_2O_5 whose purchases increased by 7%. The substantial increase in U.S. consumption coupled with the problems in Poland, Canada, and Iran, disrupted traditional sulfur supply patterns and forced both key P_2O_5 exporting countries and countries such as India with substantial domestic P_2O_5 production into the high priced spot market. Even though U.S. stocks of sulfur were drawn down by over one million tonnes, the disruption in supplies did adversely impact P_2O_5 production. In the first half of 1980, sulfur demand continued to exceed production and U.S. sulfur stocks continued to be drawn down. However, Canada is now shipping at record levels and Poland is back on stream and supplying more tonnes to the Western World. In addition, recovered sulfur production in the United States is increasing. Sulfur demand has softened somewhat in the second half of 1980 hence inventories should stabilize for the rest of the year.

However, the current conflict between Iran and Iraq could put further pressure on the spot market in 1981. Combined the two countries export about 900,000 tonnes annually to the world market.

U.S. Production Capacity for Wet-Acid also appeared to be a constraint on P_2O_5 supplies for world trade in the short-term. With both Morocco and Tunisia experiencing various technical difficulties in wet-acid plants and rock mines which reducedP_2O_5 production in 1979, U.S. production was to pick up the slack. Well, the industry performed admirably producing a record amount of fertilizer phosphates (8.8 million tonnes P_2O_5) in 1979 and exporting a record amount, (3.5 million tonnes P_2O_5.

Today the industry continues to operate at extraordinary levels with wet-acid production currently 5% ahead of last year.

The embargo of superacid shipments to the USSR supplemented U.S. Supplies for export by some 500-600,000 tonnes, P_2O_5. In addition, U.S. producers are scheduled to bring 370,000 tonnes, P_2O_5 of wet-acid capacity on stream in 1980 and 1981. Therefore, with the continued high production rates, the new capacity and the continued embargo on superacid shipments to the USSR, the U.S. phosphate industry will be able to cope with the increased requirements of the export and domestic markets in 1981.

Now let's briefly review 1980 and then move on to our forecast for 1981.

1980 Review (Slide 3)

As you well know, calendar 1980 had an inauspicious beginning for the U.S. phosphate fertilizer industry. First the grain embargo on the USSR resulted in a substantial increase in stocks of corn and soybeans which lead to a softening in commodity prices. This coupled with the rapid increase in farm input costs, (fuel, utilities, etc.) and high interest rates resulted in over a 15% drop in P_2O_5 consumption in the spring season.

KEY MARKET DEVELOPMENTS 1980

— GRAIN EMBARGO ON THE USSR

— EMBARGO ON SHIPMENTS OF SUPERACID TO THE USSR

— DRASTIC REDUCTION IN P_2O_5 CONSUMPTION IN DOMESTIC SPRING

— U.S. PRODUCTION OF P_2O_5 MAINTAINED AT RECORD LEVELS

Slide 3

In February, the embargo of superacid shipments to the USSR brought an additional 500-600,000 tonnes of P_2O_5 on the world market. With total world trade in processed phosphates at slightly over 6 million tonnes annually, the addition of the Occidental tonnage had a significant impact on the market. However, even with the embargo and the reduction in domestic P_2O_5 consumption this spring, U.S. producers continued to operate at record levels. Consequently inventories became excessive and international prices softened.

The domestic fall season is soff to a slow start for fertilizer phosphates, with most of the movement coming out of stocks carried over from the spring season. Overall fertilizer phosphates supplies will be ample in 1980 and U.S. producers will be entering 1981 with above average inventories.

World *demand* for P_2O_5 continued at a high level in 1980. Overall world trade in phoschem's four principal products: DAP, MAP, TSP, and merchant phosacid will be up 11% over 1979. Exports of merchant acid will be up almost 20% in 1980 as Brazil, Indonesia, Turkey, and India increase their imports substantially. Consumption of DAP also increased at a high rate with both India and Pakistan purchasing record quantities in 1980. (Slide 4)

The United States will account for roughly 55% of world trade in the four principal products in 1980, followed by Tunisia (10%), Morocco (8%), South Africa (7%) and other exporting countries (20%).

WORLD TRADE IN SELECTED PROCESSED PHOSPHATES 1979—1980

PRODUCT	% INCREASE
DAP	11.5%
MAP	10.0
TSP	(2)
MERCHANT ACID	19

Slide 4

Outlook for 1981 (Slide 5)

Demand. With the favorable price and supply situations, overall world trade in processed phosphates in 1981 will be up an estimated 5% over 1980.

Significant growth in imports is forecast in the *Europe/Africa Region* particularly by such Western European countries as France and West Germany. In *Latin America,* we forecast a 5% increase in imports. However, this is quite speculative given the current unsettled market situation in Brazil. In the *Asia/Pacific Region,* a slight decline in imports of P_2O_5 is anticipated in 1981, as India and Pakistan are expected to reduce imports of ammonium phosphates from the record levels of 1980.

From a *product standpoint,* we forecast that overall demand for ammonium phosphates in world trade, principally DAP will be relatively unchanged in 1981 while exports of TSP are forecast to increase 6% and merchant phosphoric acid, 10%. (Slide 6)

ESTIMATED WORLD TRADE IN SELECTED PROSPHATES BY REGION 1980-1981

(000) METRIC TONS, P_2O_5

	DEMAND		%
REGION	1980	1981	INCREASE
EUROPE/AFRICA	2,741	2,987	9%
ASIA/PACIFIC	1,646	1,592	(3)
LATIN AMERICA	1,375	1,444	5
TOTAL	5,762	6,023	5%

Slide 5

FORECAST FOR WORLD TRADE IN SELECTED PROCESSED PHOSPHATES 1980-1981

(000) METRIC TONS, PRODUCT

PRODUCT	1980	1981	% CHANGE
DAP	5,245	5,066	(3)%
MAP	406	535	32
TSP	2,615	2,763	6
MERCHANT ACID	4,112	4,530	10

Slide 6

Supply. Supplies of processed phosphates from the major exporting countries should be more than adequate to meet estimated demand in 1981. Capacity currently in place and scheduled to come on stream in early 1981 will be sufficient to meet the 5% increase forecast for demand. Supplies from all major exporting countries will be up over 1980.

Supplies of processed phosphates for export from the *United States* will increase in 1981. The additional acid capacity scheduled on stream in late 1980 and 1981 will boost overall U.S. wet-acid capacity to an estimated 9.6 million tonnes, P_2O_5. In 1981 total fertilizer phosphate production is estimated at 9.4 million tonnes P_2O_5 (including 9.2 million from wet-acid and 200,000 tonnes from rock). (Slide 7)

U.S. PHOSPHATE SUPPLY 1981

— ADDITIONAL ACID CAPACITY WILL BOOST TOTAL U.S. WET-ACID CAPACITY TO 9.6 MILLION TONNES, P_2O_5

— U.S. PRODUCTION OF FERTILIZER PHOSPHATES IN 1981 ESTIMATED AT 9.4 MILLION TONNES, P_2O_5 INCLUDING 9.2 MILLION TONNES FROM WET-ACID AND 200,000 TONNES FROM ROCK

— DOMESTIC DEMAND ESTIMATED AT 5.1 MILLION TONNES, P_2O_5 IN 1981

Slide 7

If domestic consumption totals 5.1 million tonnes in 1981, overall export availability will exceed 4 million tonnes. In 1980, total U.S. exports of P_2O_5 will be an estimated 3.6 million tonnes, P_2O_5. Therefore, with the embargo on Russia still in effect, supplies of P_2O_5 for export from the United States will be ample. (Slide 8)

Moricco plans to bring 660,000 tonnes P_2O_5 of wet-acid capacity on stream by the end of the first quarter of 1981. This new capacity will add a minimum of 200,000 tonnes, P_2O_5 to Morocco's exports of wet-acid in 1981. *Tunisia's* new acid and DAP facilities are now operating at near capacity and exports should increase slightly in 1981. (Slide 9)

U.S. PRODUCTION AND EXPORTS OF FERTILIZER PHOSPHATES 1979-1981

MILLION METRIC TONS, P_2O_5

YEAR	P_2O_5 PRODUCTION	EXPORTS	% OF PRODUCTION
1979	8.8	3.5	39.7
1980	9.2	3.6	39.1
1981 -E	9.4	3.6	38.3

E = ESTIMATED

INCLUDES ALL PRODUCTS

Slide 8

REPORTED ADDITIONS TO PHOSPHORIC ACID CAPACITY IN MAJOR EXPORTING COUNTRIES 1980-1981

(000) METRIC TONS, P_2O_5

	1980	1981
UNITED STATES		
AGRICO	—	110
BEKER	—	63
TEXASGULF	90	48
CONSERV (PHILIPP BROS)	45	—
W.R. GRACE	15	—
MOROCCO		
MAROC PHOSPHORE I	165	—
MAROC PHOSPHORE II	—	495
SOUTH AFRICA		
FEDMIS	90	—

Slide 9

In *South Africa,* Fedmis is currently expanding a wet-acid plant in Phalaborwa by 30%. Work is scheduled to be completed by the end of 1980. Overall, South Africa will have over 500,000 tonnes P_2O_5 of exportable acid capacity in 1981. *South Korea's future role in the export market is unclear. Since the country must import such key raw materials as sulfur, naphia, and phosphate rock, the long-term viability of its major producers in the export market is uncertain.*

Summary (Slide 10)

In summary, we expect *demand* for processed phosphates in world trade to continue strong in 1981. Overall demand will increase by 5% with the largest growth forecast in the Europe/Africa and Latin American regions. Demand for ammonium phosphates in world trade will be relatively unchanged while good growth is forecast for TSP and merchant acid.

Supplies of all three products—ammonium phosphates, triple superphosphates, and merchant phosphoric acid—should be available to meet the increase in world demand. Even if the embargo on the USSR is lifted, world supplies of fertilizer phosphates will be adequate.

ESTIMATED SALES OF PROCESSED PHOSPHATES IN WORLD TRADE 1980-1981

THOUSAND TONNES, P_2O_5

REGION	1980	1981	% INCREASE
UNITED STATES	3,296	3,346	2%
NORTH AFRICA	1,144	1,310	15%
WESTERN EUROPE	457	490	7%
SOUTH AFRICA	440	460	5%
SOUTH KOREA	299	276	(8)%
OTHER	387	417	8%
TOTAL	6,023	6,299	5/

INCLUDES ONLY DAP, MAP, TSP AND MERCHAN ACID.

Slide 10

MODERATOR BROWN: Thank you Bill. That was an excellent coverage of the Present Phosphate Situation. (Applause)

Our next discussion will be given by David W. Bixby, Director of Fertilizer Technical Research, The Sulphur Institute. David, please. (Applause)

The Outlook For Sulphur[1]

D. W. Bixby[2]

It is a pleasure to be among friends and discuss the outlook for sulphur. Being friends, you will, of course, not pay too close attention to any possible discrepancies between this years report and that of last year, or between my opinions and those expressed in the several studies made by consulting organizations, trade journals etc. Some of these I have seen, some not. I am sure many of the companies you represent have done independent studies. In the fertilizer business, however, we need all the input we can get to help us keep ahead, or at least abreast, of changing conditions. So I will add my grist to the mill.

At the end of June 1980 the world sulphur market is estimated, roughly to be in balance. Some previous forecasts have indicated that a deficit of 0.5 million tons might occur this year but this seems to have been alleviated by a combination of greater shipments than expected, plus a slight easing in industrial sulphur demand. Some customers may still have problems obtaining material — this is because a moderate surplus is needed for the market to operate smoothly, but most will be able to get what they need. In otherwords, sulphur continues to be in *tight* supply, but, taken as a whole, not in *short* supply.

The 1980 Situation

Lets review what has transpired this year, now well into its last quarter, before getting out the cloudy crystal ball.

On the demand side, use of sulphur in the industrial sector appears to be no more than last year. Indeed, it could be less, depending on the severity of the recession we seem to be in. In June, U.S. chemical production was 7% or more below January levels. Some key industrial users such as caprolactam (used in nylon manufacturing) were off more than 20%. There are also clear signs of a market downturn in Western Europe.

A period of recession can have several effects. Inventories of both fertilizer and industrial users may be reduced. Farmers with reduced income may rely on residual soil nutrients until fertilizer prices decline. Industrial users go down much more rapidly than economic decline itself. Internationally, credit is tighter and developing countries have less funding to work with. On the supply side, oil refineries and metal smelters reduce production.

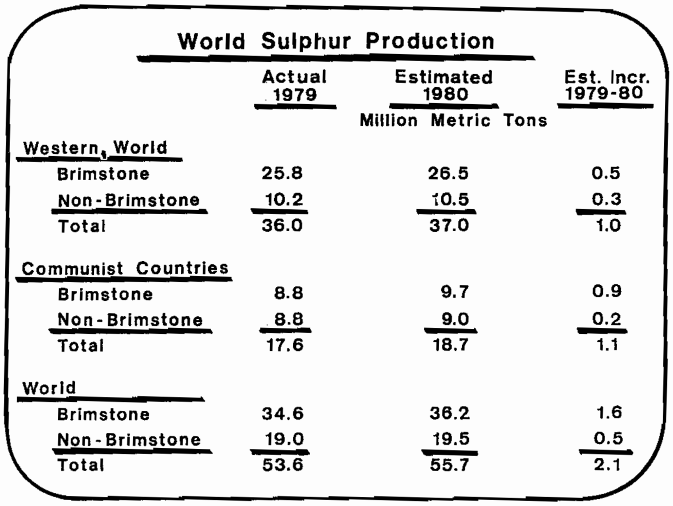
In the fertilizer sector, phosphate fertilizer consumption is the key user of sulphur, accounting for about 50% of Western World consumption. Early in 1980, the outlook in the U.S. for P_2O_5 consumption became more discouraging, because of the tightening of credit, an unfavorable crop — phosphate price ratio, the Russian embargo and bad weather. Since then I understand matters, have improved somewhat for the first two items. The embargo still has its effect on us, although perhaps with a reverse effect on certain other countries which have stepped in.

The bad weather of Spring in some areas became the deadly serious drought of summer in large sections of both the U.S. and Canada. Some areas have benefited from the misfortunes of others. What will be the effect on P_2O_5 sales expectations for the 80/81 season? My guess is that the positive effects of increased crop prices and high grain exports will offset the negative effects of the drought and a decline in the total farm income in 80/81 with a modest growth resuming in 81/82. In any case both the U.S. and Western Europe used less P_2O_5 domestically in the 79/80 fertilizer year. In the U.S. it was 2% less for the whole season but 24% less for the last five months of it, based on the 20 state survey. Corresponding sulphur usage must have decreased by 0.5 to 1 million tons, offset in large measure by the increase in phosphate consumption for the rest of the world, which is part of the reason for the record setting U.S. exports. These exports do depend on local and imported competition, however, and could be curtailed, though probably not in 1981.

In 1979, world usage of sulphur (in all forms) was about 54.7 mm tons. Estimated production was a million tons less, 53.7. Roughly, there was a million ton net withdrawal from stockpiles, mostly U.S. Frasch, to meet the deficit. 1980 world usage is expected to be about the same or slightly less. The expected sulphur supply should be adequate with little if any inventory drawdown. So it seemed when this was written in June.

New Sources — 1980

This year in the Western World, around 1.0 mm tons of new production should become available. However much of this is in the Mid-East, a less than reliable source. As matters stand, the world could be short 250,000 tons in the last quarter of this year. Another 300,000 tons of sulphur as acid can be expected from pyrite and smelting gases. In total, U.S., Canadian and Mexican output should be little different than in 1979, although the make up of the individual subtotal will change somewhat.



World Sulphur Production

	Actual 1979	Estimated 1980	Est. Incr. 1979-80
	Million Metric Tons		
Western World			
Brimstone	25.8	26.5	0.5
Non-Brimstone	10.2	10.5	0.3
Total	36.0	37.0	1.0
Communist Countries			
Brimstone	8.8	9.7	0.9
Non-Brimstone	8.8	9.0	0.2
Total	17.6	18.7	1.1
World			
Brimstone	34.6	36.2	1.6
Non-Brimstone	19.0	19.5	0.5
Total	53.6	55.7	2.1

Slide 1

The communist countries will probably produce about 1.1 million tons more this year of which Poland will contribute about 500,000 tons by bringing production back to the 1979 level. Russia may add 400,000 tons of new sulphur. Also, about 200,000 tons additional sulphur as acid may be expected. Most of this new production will be consumed internally and little if any additional material is likely to be exported over the 2 mm ton level, which was the amount shipped to the West by Poland in 1979.

STOCKPILES

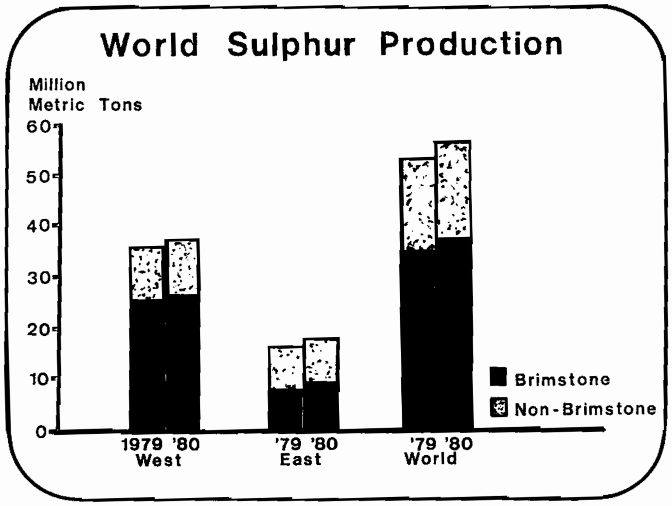
Last year, we noted the shortfall largely due to loss of over 1.0 mm tons production in Poland and Iran. This was made up by removing about 1.3 mm tons from inventory, the bulk of which, 1.1 mm tons, came from U.S. Frasch producers. Canada put back about as much as they took out, and the Middle East producers added some.

We had though that new brimstone production this year should make significant inventory depletion unnecessary. Canada, however, has a remelt capability of roughly 1 mm tons annually and given favorable logistics could provide 7 mm tons to the market. Through July, they have already moved about 800,000 tons more than the same period last year through Vancouver. Net inventory has decreased by 800,000 tons although of course stockpiling continued in remote locations. Mid East stockpiles will increase somewhat. Saudi Arabia, for example, adds about 2,500 tons per day to theirs. The inventory of the U.S., Polish, and Mexican producers early in the year was at a point where further depletions seemed undesirable if adequate working levels were to be maintained. U.S. inventory did in fact drop a further 625,000 tons through August, however, and Mexico was down 300,000 tons through March. These depletions may yet be replaced. This seemed likely when written but much less likely now, with only two months to go.

Summary — 1980 (Slide 2)

1) Supply and demand about in balance.
2) Consumption somewhat less than in 1979 because of recession.
3) Added production compensates for 1979 inventory reduction.
4) Canada remelt capability is available.
5) No large new producers. Half of "new" production to come from existing Polish and Iranian facilities.
6) New communist production used internally.

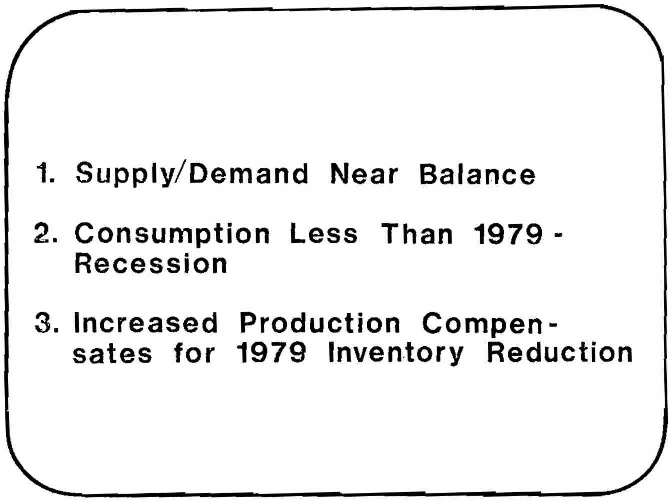
There are a couple of unknowns which could upset the scenario. These are: a) the size of the consumer stockpile and b) the severity of the recession we seem to be in. Either one could change the picture considerably. As we said before, the latter can have several effects, both on the demand and supply picture, but the effect on demand is much more sensitive.



Slide 2

Five Years From Now — 1985

The only thing certain about a five year projection in sulphur supply and demand is that it will be wrong. In the last 20 years there have been several cycles which can be explained but are so regular that one is tempted to make a forecast based upon the pattern. This (Slide 3) is the pattern not including the Canadian stockpiles. If you add them it looks like this (Slide 4). One could have made projections a few years back based on this seeming regularity which would have been good as those of experts using other methods.



1. **Supply/Demand Near Balance**
2. **Consumption Less Than 1979 - Recession**
3. **Increased Production Compensates for 1979 Inventory Reduction**

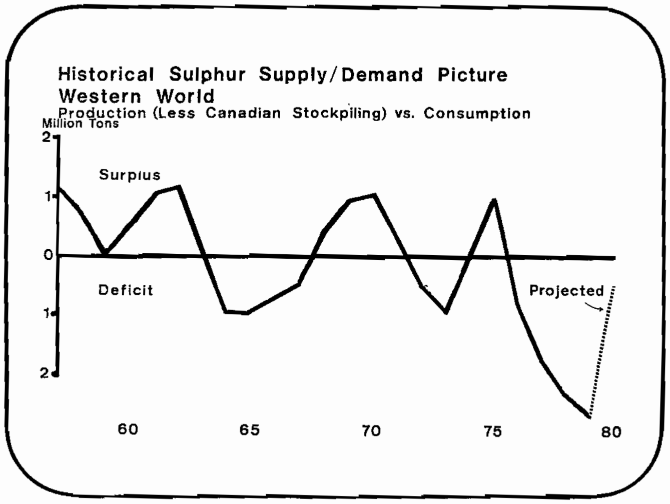
Slide 3

(Slide 5) Sulphur production estimates are shown here for 1980 and 1985. Western World annual increase is on the order of 2.5%. Communist countries 5%. Most of this will happen in 1984-1985, at which time a substantial amount of recovered material could emerge from overthrust belt operations. This source may contribute 600,000 tons by 85 and could be our largest single source by 1980 with perhaps 3 mm tons. In the Communist countries, at least one new Frasch mine in Poland is expected with 1.5 mm tons annual capacity; plus 1.8 mm tons from Russia, from Frasch, native, and recovered sources.

Continued high prices for sulphur and sulphuric acid could encourage pyrite usage. Smelter acid will increase slowly. 80% of oil reserves have a medium to high sulphur content so refinery sulphur output is bound to increase.

4. **Canada Remelt Capability Available**
5. **No Large New Producers. Half of "New" Production from Existing Polish & Iranian Facilities**
6. **New Communist Production Used Internally**

Slide 4



Slide 5

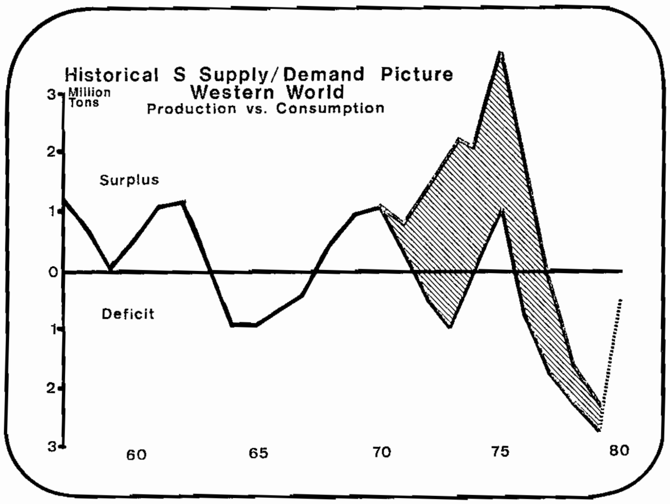
New Sources — 1985

(Slide 6) This Table gives a partial breakdown by source for anticipated brimstone production this year and in 1985.

To save time, lets just look at the last column which shows the changes that are likely to occur. In the Western World, brimstone production increases by 2.8 mm tons. Most of this increase is recovered sulphur with Frasch assumed to be about the same. The U.S. had 1.8 mm tons for 6 mm tons total. Canada decreases 1.9 mm tons, France 0.3 mm tons. The Mid East contributes another 1 mm tons. Presumably, Iran and Iraq will have come to terms and recovered by then. If not, removal of their combined contribution of over 1 mm tons per year could cancel out the material expected from Saudi Arabia. Japan, West Germany and Mexico add 0.2 mm tons each. In the Communist countries, brimstone production increases by 3.3 mm tons. (Slide 7) This slide illustrates the anticipated non-brimstone situation. We see that production in the West is up 2 mm tons, about half from smelter operations, somewhat less from pyrites.

In the Communist countries, non-brimstone increases 1.7 mm tons. As we saw in a previous slide, this gave them a total increase of 5.0 mm tons, slightly in excess of the West. For the World, then, production of sulphur in all forms is up 9.8 mm tons for a total of 65.5 mm tons.

Returning to Canada for a moment, we should remember that they will be able to provide at least 2 mm tons annually from stockpiles in 1985, if given sufficient economic incentive.



Slide 6

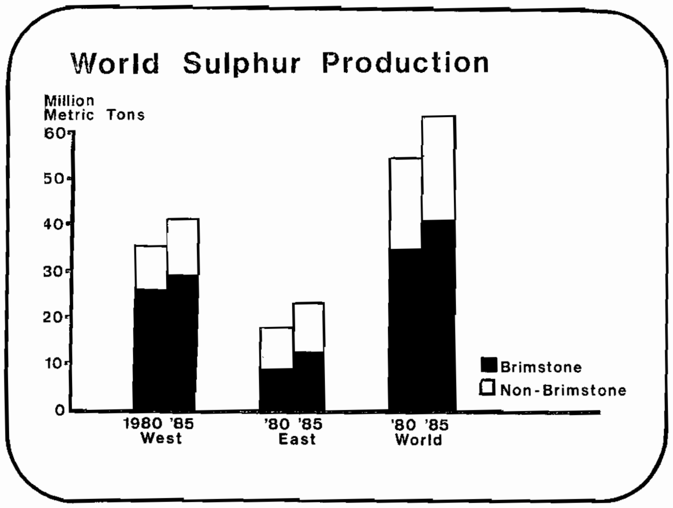
Demand — 1985

(Slide 8) Here is a comparison of production and consumption estimates for this year and 1985. Globally, around 10.5 mm more tons will be consumed, with growth rate for the West of about 3%, for the Communist countries 5%, and for the World as a whole 4%. We have not included new uses for sulphur, such as in highway paving, which we fully expect to be a big user in the future, but not until greater is available beyond this time frame.

As you can see, the rate of estimated consumption increase, is somewhat above that of production. Demand, of course, does not increase on a smooth curve. A large new phos acid plant results in an immediate large increment in demand. If you are planning to build one it would be prudent to have a firm sulphur source for a large portion of its lifetime. World phosphate consumption is expected to be sluggish in 80 and 81, and because it is by far the largest user of sulphur, sulphur usage will also be less than the average growth rate projected for 80 - 85. We expect it to resume its upward growth in a year or so when some of the negative factors have, we trust, been alleviated.

The slight World "surplus" projected for 1985 is not very significant — it could easily disappear into producers or consumers inventories. The "surplus" could turn into a "deficit" if prospects of new production from the overthrust belt are still prospects in 1985 or if a new Polish mine fails to materialize. We may then become dependent on Canada stockpiles and remelt capability. The price of sulphur will be the determining factor in availability from this source.

We conclude that there should be a reasonable supply/demand balance for the 1980-85 period.

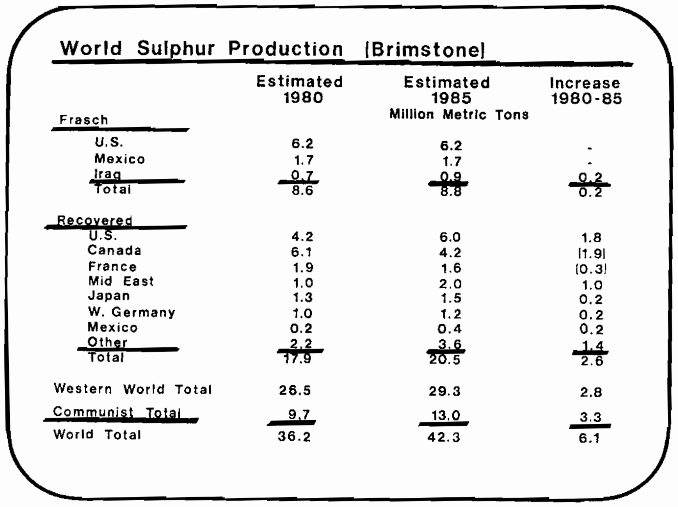


Slide 7

Other Factors Affecting The Sulphur Outlook

We should say a word or two about sulphur pollution abatement. Environmental regulations adopted in the early 70's led most of us to believe that large amounts of low priced sulphur from this source would start to appear by now. It hasn't happened. It *will* happen, but 1990 seems more realistic. Until then, pollution abatement sulphur may do little more than replace declining U.S. and perhaps Mexican Frasch production, barring new discoveries.

During this same time period many producing companies, both voluntary and involuntary, will be using more sulphur products; this trend is, of course, already underway.



World Sulphur Production (Brimstone)

	Estimated 1980	Estimated 1985	Increase 1980-85
		Million Metric Tons	
Frasch			
U.S.	6.2	6.2	-
Mexico	1.7	1.7	-
Iraq	0.7	0.9	0.2
Total	8.6	8.8	0.2
Recovered			
U.S.	4.2	6.0	1.8
Canada	6.1	4.2	(1.9)
France	1.9	1.6	(0.3)
Mid East	1.0	2.0	1.0
Japan	1.3	1.5	0.2
W. Germany	1.0	1.2	0.2
Mexico	0.2	0.4	0.2
Other	2.2	3.6	1.4
Total	17.9	20.5	2.6
Western World Total	26.5	29.3	2.8
Communist Total	9.7	13.0	3.3
World Total	36.2	42.3	6.1

Slide 8

The Long Term Outlook

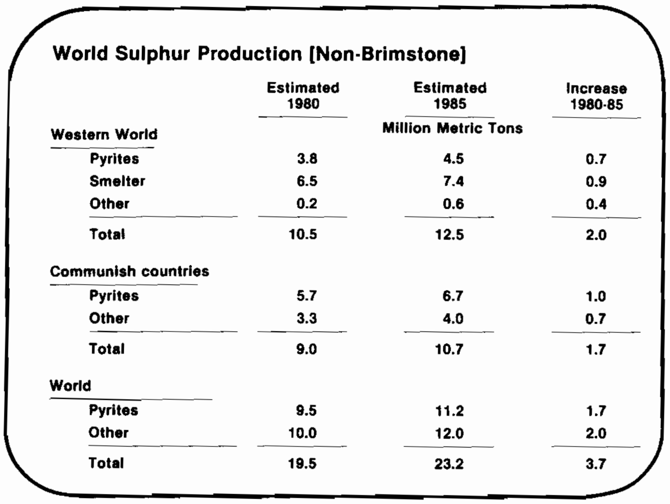
For the period 1986-1990, it is difficult to be optimistic. The Western World is likely to need an additional 15 mm tons/year over 1985 by then, with a resulting Western World shortfall of 5 mm tons. At the moment we cannot be certain where the needed additional material will come from. As we said previously, full scale synfuel plants cannot be expected until after 1990. The hugh new tar sands projects in Canada are bogged down in politics and face an uncertain future

Even though the list goes on, it is possible to conclude on a hopeful note. There is, after all, plenty of sulphur in the world. We really don't have to go to Io and Jupiter for it as suggested last year. 0.6% of the earth's crust doesn't sould like much as a persentage but it represents an immense tonnage. Even now, we emit a great deal more into the air than is being consumed. Sulphur will be obtained from pyrites and other compounds when economics justify it, but that day has not yet come.

The cost of energy is the important part if sulphur cost, as it is of so many things today. Frasch producers use gas to superheat water to melt the sulphur. The cost of gas is such that they can no longer produce and sell profitably at the price of a year or two ago.

Sulphur itself is a valuable source of energy which was easy to ignore with oil at $2 per barrel, but not any more. When brimstone is burned and converted to sulphuric acid, the energy generated is equivalent to about 2 barrels of oil. Now, with some oil at $30/barrel, and sulphur at $120/ton, that sulphur, with an energy value of $60, is equivalent to sulphur at only $64/ton when the $2/barrel oil price was still with us.

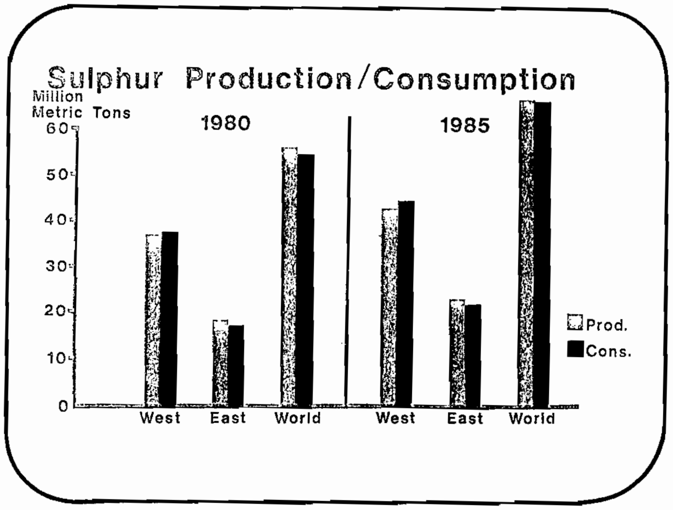
Unfortunately, the more plentiful sources of sulphur in nature require more energy to extract the sulphur than do our present sources — Frasch, sour gas, pyrites and smelter. So, although the long term supply is abundant, the consumer, directly or indirectly, will have to pay the price for developing dependable supplies to meet the needs of the fertilizer and chemical industries. With the true value of sulphur in its three roles — chemical, plant nutrient, and energy source — beginning to be understood, that development seems assured.



World Sulphur Production [Non-Brimstone]

	Estimated 1980	Estimated 1985	Increase 1980-85
		Million Metric Tons	
Western World			
Pyrites	3.8	4.5	0.7
Smelter	6.5	7.4	0.9
Other	0.2	0.6	0.4
Total	10.5	12.5	2.0
Communish countries			
Pyrites	5.7	6.7	1.0
Other	3.3	4.0	0.7
Total	9.0	10.7	1.7
World			
Pyrites	9.5	11.2	1.7
Other	10.0	12.0	2.0
Total	19.5	23.2	3.7

Slide 9



Slide 10

1) Prepared for presentation at the Fertilizer Industry Round Table, Atlanta, Georgia, Oct. 28, 1980.
2) Director of Fertilizer Technology, The Sulphur Institute, Washington, D.C.

MODERATOR BROWN: Thank you Dave for your updated, interesting discussion on Sulphur.

We are doing okay on our time schedule. Our final discussion this morning:"Present Date Fertilizer Situation" will be given by Edwin M. Wheeler, President of The Fertilizer Institute. Edwin, please. (Applause)

Present Date Fertilizer Situation*

Edwin M. Wheeler

In Jim Brown's misdirected letter of invitation to me, he asked that I review briefly with you today what I had talked about last year at this meeting and, then, I guess, Jim, you want me to sum up some of the other papers presented, as well as present my own view, which seems to have a way of creeping in. You will recall last year, I lulled you to sleep after a heavy lunch discussing the changes that were coming in railroad transportation. Of course, they have now reached fruition with with the President of the United States signing a new transportation bill. It will effect everyone in the industry, slowly at first, and then at an ever more accelerated rate. The carriers of the United States are not particularly known for innovation— and have a marketing department that no fertilizer company would keep around more than two to three minutes before they'd hand out the watches and start scraping the names off the doors. Therefore, the rail companies will be very slow in taking advantage of some of the freedoms that the new act has granted them, but as the aggressive carriers do take action, we in this industry are going to be compelled to take a number of new approaches ourselves.

There are some who say we are not too aggressive in that area. Already, we can see the shift in movement of potash coming out of Saskatchewan, down through Thunder Bay and being unloaded on the south side of the Lakes. Because railroad rates are getting so high, our companies are experimenting with ways to cut those costs. Rail rates are, and have been, outrunning any measure of cost of living/consumer price index in the country by more than 10%. That is to say, over the last 36 months, under the aegis of the Peanut Operator, the cost of living in the U.S. has gone up one-third, but the railroad rates have gone up almost 40%. This indicates that a lot of material now will begin to move under contract rates. That means bigger volumes moving at one time, at a lesser rate than single car, but it also means rapid expansion of U.S. warehousing capabilities. One of the critical problems in the phosphate industry today, and one of the reasons we've got this yo-yo effect in Florida, is simply because the plants have expanded far beyond the storage capabilities in Florida. When the material starts backing up, the boys put on their parachute and away go the prices.

We will see our retail operators more and more join hands with the grain industry and truck the grain to the river ports and lake ports and haul back the fertilizer around the season, not just at planting season. We will have, in effect, in due course in the Midwest, 12-month movement of fertilizer, and I think this will be one of the best things that could happen.

We will see, under the new tasks given to the railroads, the rapid disappearance of branch lines, particularly in the Conrail territory. Again, this means we have got to come up with flexibility, and that means a lot of additional trucking. Even though the trucking is going to be expensive, it will not be so expensive if we get two-way hauls, *vis-a-vis* grain and fertilizer. So much for the transportation changes.

The new Staggers Rail Act of 1980 should be called the "Lawyers and Accountants Full Employment Act of 1980" because it's going to take one lawyer per one traffic man. For example, none of the companies will be able to sit down with one another and discuss freight rates any longer. It will be "verboten" because the railroads now go under full anti-trust law, and that ain't bad because I've got two boys who either are, or are going to be, lawyers.

Okay, let's turn now to what you all paid the high price of admission for — the present-day fertilizer situation. I conclude my remarks today by saying it's flaky and I'm going to sit down!

We *do* have a flaky situation, and the "how" and "why" I think we ought to review, because if you are ready to take off for the bar early to get there ahead of the rest of the mob, I happen to think that, when we finish June 30, 1981, we will have had the biggest season that the U.S. industry has every enjoyed.

Now, we have come off the launching pad on a slow start, which I will examine in just a minute. But, as I tried to explain to a number of our foreign guests at the Institute's World Conference in San Francisco in mid-September, one thing is certain for the domestic fertilizer industry in the U.S. We have had only one slippage in annual growth of tonnage in a 25 year span. We have had no slippage since we crossed the domestic consumption mark of 50 million short tons per year. This last year, we moved 53 million tons, and this coming year, we will move 55 million tons. But when people begin to despair of a slow season, they have put out of their mind that we are working on not less than a 50-million-ton base of sales domestically, come hell or high water.

Now, the reason that we, at the Institute, are bullish on fertilizer is simply because we read the daily prices of cash grain and future grain prices. If we can't sell into the current market, friends, there's golden opportunities for the class coming out of 1981 colleges looking for marketing positions.

Let us consider, we are now on the road down in world grain reserves to about the 1972 level. Those of you that remember the panic in the grain market will know what that means for us in the fertilizer market. Grain prices have risen since January 1st between 30 and 50%, and the seers say that corn will continue to rise and should rise above today's closing market by no less than 25% by planting time. To put it another way, this means that, in the Spring of 1981, we are looking at country elevator prices on corn of somewhere between $4.25 and $4.50 a bushel, with wheat at $5.50 to $5.75. Incidentally, this is in face of the biggest wheat crop the United States has ever produced. Soybeans will be somewhere in the vicinity of $9.00 to $10.00 a bushel.

Now, why have we had this sluggish movement then with all this good news pouring in? First of all, as we got ready to plant our wheat, we were extremely dry in the wheat country, and finally the farmers, in desperation, put the wheat in dry soil (or "dusted in", as we call it in Kansas). But, we'll come back in that market very strongly with top dressing, now that moisture is generally spreading through the wheat country, because the farmers out there are desperate for cattle pasture due to the high price of hay. Incidentally, we probably planted the largest acreage of wheat ever planted outside of the wheat belt this fall, with record plantings occurring in Iowa, Illinois, etc., and on east into Ohio.

The fall plowdown demand, contrary to some of the comments made here this morning, is very good and very strong in the area where they have had moisture. In all candor, the land grant schools are urging the farmers to lay off of phosphates and potash in the dry areas, with the argument that, inasmuch as the plants did not remove the heavy plowdown of a year ago, it is not necessary to plowdown this fall. But, as sure as God is watching over this leaky hotel (and I hope he is — it's already starting to go, so I'll speed up), no farmer in his right mind is going to lay off next spring on phosphates and potash, drought or no, with those kind of grain prices. The record clearly shows that they never lay off of fertilizer under any condition if it does what we say it will do. That is, it will make them large sums of money.

We can anticipate there will not be a fence left between Ohio, on the east, and California, on the west, because the farmers this spring will not plant fence-row to fence-row, they will plant border to border. They don't want the damn fence in the way of their planting activities! Therefore, we will overcome this slow fall.

I hope, Bill and Dean, that some of our foreign customers understand that we are in a slight lull, but that's all it is. Demand in the U.S. will upturn in the spring beyond belief.

I think we've got two problems that are causing all of us some concern in this room. It's thoroughly indicative to us now. Our dealers are cleaning out their stocks of phosphates and potash and are going to be most reluctant to restock until at least the turn of the year. The answer, of course, is 14% money. The other reason is, of course, they think fertilizer prices are going down. That is as likely to happen as me having a front seat in heaven! The odds are greatly against that situation for reasons I'll touch upon. But, I am concerned, and from the reports we get from our good retailers and our cooperatives, they are really reluctant to restock simply because they don't want to borrow the dough until after the turn of the year.

Now, in the southeastern part of the country, we have a very difficult situation, particularly in Georgia, South Carolina, Alabama and, to a lesser degree, into the Delta country. Ever since you elected Jimmy Carter President of The United States, apparently, you sent your rain god to Washington—and severe drought two years, back-to-back, has badly affected this market. Of course, the farmers have gone into debt at least beyond bankruptcy. But, as the Good Book says, "Fear not", because I think the rain god will be back on January 20th.

Therefore, we are looking at a situation that, temporarily, has the industry down when, in fact, there is no reason to be downcast. On the contrary, we are going to look at what I prefer to call, "1981—The Year of the Holocaust."

Now, you must consider what is occurring today in the international grain market. I hope I haven't trod upon John Douglas' observation, because on this John and I are in agreement. The United States this last year, in the shipping season finished September 30th, loaded 160 million metric tons of all farm products. 160 million! It produced gross revenues of $46 billion—eight billion up over the previous year, and five billion up over the estimates. In this coming year, the shipping season now underway, we are forecast to load 165 to 170 million metric tons or more of farm products. This will strain the loading capacity of every port in the United States, but the significant thing of it is, as cold weather comes and the riveres freeze up, this heavy movement of grain by barge has to shift to the railroads. What it means, then, is that as our dealers and farmers fully appreciate what's coming, we are going to have a transportation screw-up that boggles the mind.

There are four seats left on the Gidney/Wheeler charter flight that leaves on March 15th, because I don't want to be around when the Congressional investigations begin on why we can't get fertilizer. The testimony is prepared and the answer is very simple. They waited too damn long.

I will now entertain questions from the Chairman, but, mark ye and mark ye well, that with this unprecedented demand for grain—and it may exceed the numbers I have given you based on the severity of the Russian failure and the fact that our friends in other nations are not able to supply them—that we will have a titanic transportation problem. Now, if Reagan is elected, and if he carried out his campaign promise of lifting the embargo to the Soviet Union, you now have to plow back into these grain export figures the extra tonnage the Soviet Union would take. They would take everything they could get through their rag-tag ports and rapidly failing railroad system. But, the whole thing boils down to this—no matter what yardstick you put on the grain outlook or the fertilizer outlook, 1981 will be, beyond a shadow of a doubt in my mind, the best year ever.

Now, there are some "bad news" things that we have to candidly discuss. No farmer, to the best of my knowledge, has ever admired paying more for what he has to buy. Never. But we might as well crossbrace ourselves if this inflationary thing is not arrested in the United States (and the prospects are not good that they will in the the near term), we will once again be going to our farmers this coming year with our production costs rising at the current rate of about 15% per year, being crucified in three major areas and one lesser area.

Energy costs in the U.S. to produce fertilizer are going to continue to rise. Equipment costs are going to continue to rise. The railroads intend to stick it to us because we are, in the main, captive traffic. Lord knows, our labor costs will go up, although, in our industry, we are capital-intensive, not labor-intensive. But, suffice it to say, our farmers will have to roll and ride with us or our production costs will destroy the industry if we are not able to pass them through. Grain prices, fiber prices, are going to have to continue to advance or our farmers are going to be unable to pay us, John Deere and the fuel companies.

Thus, these two things, inflation and costs, are the dark clouds on the sky I see in 1981. I honestly believe that all other factors are so good, however, that those two should not deter us in 1981.

I continue to believe in the gospel of St. John Douglas that we can anticipate a long-term, five-year pull, or a little beyond, of 3% per year compounded growth of nitrogenous materials and that phosphates and potash should come along somewhere at 2.2 to 2.5%. If, however, the Russians would have still another bad crop year, or China would falter, or India would falter, then these figures would rise above that norm for another two years, because of the fact that world grain reserves are down and some of my friends in McLean, Virginia say that the Russian reserves are now gone.

I think, then, that looking ahead over the next five years, agriculture (and that's the only reason we in this room are in this business is to supply our agriculture) has never, ever looked better. I think that one of the classic subjects that we have talked about at these meetings for years is, of course, population growth. A point that Dean has made in previous speeches, as well as have several others, is that there is a rising expectation in the world for a better life and that means a better diet. If you don't think so, you have to go back to what is going on in Poland today. The big ruckus, among other things, is an inadequate diet, and it's causing a drop in productivity. Put another way, the workers simply are not getting a diet high enough in protein to improve or maintain production. This lesson has not been lost on the rest of Eastern Europe and it assures the world that it is not now being lost on the Soviet Union, else you cannot explain why they have sold over $500 million world of gold in the last two months to buy very high-priced, offshore, non-U.S. grain.

You can see that world market growing for American products. Sixty percent of total world food trade is now coming from the United States. This figure will continue to rise. That means demand for the products that we produce.

I think that, if we get this country's act together over the next several years, there is no reason why we should be the least bit concerned about our industry's future or your's in it.

That concludes the extent of my airplane-prepared remarks. I want to add just one thing. Regardless of how you feel about the candidates (and I think you know my favorite story on that—about the two guys in Washington coming down the alley on a dark night. As they approached one another, one of them pulled a gun and said "Okay, baby, Carter or Reagan?" The other guy said, "Oh God, shoot!"), they *are* the candidates. One or the other is going to be the person and pick the people who are going to have a great impact on our nation as a whole and, certainly, on this industry as it relates to questions of grain exports, limitations on phosphate exports, energy supply, energy priority for the fertilizer plants, and so forth. The election is important to us. Always, the country is a damn sight more important than the fertilizer industry.

So, I urge you to vote, not only in the presidential election, but would you kindly reconsider some of the clowns with which you have been providing me to work with in the Congress of the United States!

I hope all of you, your wives, and employees vote, because we still live in the greatest country in the world. Every man and woman in this room wants it to remain so. It's up to us, for our children and our grandchildren, to see that it remains the greatest country in the world.

Thank you. (Applause)

MODERATOR BROWN: Thank you Edwin for your excellent paper.

My special thanks to all of our Morning Speakers.

We had an excellent attendance and we are looking forward to your returning for "Our Session Two" this afternoon at 1:30 P.M. Thank you. (Applause)

Tuesday, October 28, 1980

Afternoon Session
Moderators: Frank P. Achorn—Thomas L. Howe

ACTING CHAIRMAN ACHORN: Good Afternoon. We are indeed very pleased to have Jim Gillie, who is Assistant Manager of the Public Affairs Department for the Phillips Petroleum Corporation, Bartelsville, Oklahoma, as our Keynote Speaker. Jim is well known in the Fertilizer Industry. He has many refreshing and interesting topics to discuss that relate directly to some of the environmental problems experienced by Fertilizer and Chemical Companies. I am sure that you will find Jim's presentation to be interesting and entertaining. Jim please. (Applause)

Keynote Speaker
Jim Gillie

(Note: Jim spoke from rough notes. No printed copy of his talk was available. Please refer to comments by Editing Chairman Spillman who was present during Jim Gallie's talk).

ACTING CHAIRMAN ACHORN: Jim we certainly appreciate and thank you for your fine message. I wish I could remember your first "Humor Story" and before I could you slipped in five others. We appreciate your "Humor Stories" also your remarks in between and your kind Congratulations to Our Round Table for "A terrific job well done in the past and your wishes for our continued success for the future." (Applause)

COMMENTS BY ALBERT SPILLMAN—EDITING CHAIRMAN: I contacted Jim Gillie several times attempting to obtain a copy of his Keynote Address. Jim advised me that he spoke from an "Outline of Notes" not now available, therefore, will not have a copy of his remarks for our printed proceedings. I had the pleasure, with approximately 300 others, listening to Jim's stories; also his in-between "kind remarks" complimenting Our Round Table for keeping the Fertilizer and Chemical Industry informed with "pertinent information on the latest research developments", "updated improvements on buildings and machinery", "latest operating techniques", "quality controls", "supply and demand", "environmental problems" and many other phases of "day-to-day operations". Our audience applauded many times during Jim's talk. I too congratulate Jim for a job well done.

ACTING CHAIRMAN ACHORN: We will continue our afternoon program. With much pleasure I call on our Director Thomas L. Howe, Executive Vice President, Howe, Inc. (applause)

MODERATOR HOWE: Thank you Frank. We have a full afternoon with two excellent Panels and Papers on N.P.K. Fertilizers.

Our first Panel speaking on "Design and Construction of N.P.K. Plants in the 1980's", will be presented in three different parts. There will be:

"Ammoniation and Granulation Plants"
"The Dry Blend Plants"
"The Fluid Plants"

We first saw "The Ammoniated/Granulation Plants" come on stream in the 1950's. Then we saw "The Blend Plants" start springing up in the 1960's. More recently we have seen credible growth of "The Fluid Plants."

The first speaker this afternoon, John R. Everingham, will discuss the section on "Ammoniation/Granulation." John is a Chemical Engineer with a B.S. and M.S. degrees, from the State University of Iowa. He is presently with Chevron Chemical Company. He has been with Standard Oil of California since graduating and started working with The Fertilizer Group in 1960. John has had a number of responsibilities over the years in Research and Development and in Manufacturing Departments. Presently John is Process Research and Engineering Supervisor of The Fertilizer Section. (applause)

N-P-K Ammoniation-Granulation In The 1980's
John R. Everingham

It is a pleasure to be here and to have the opportunity to speak on the subject of N-P-K plants in the 80's. The N-P-K plants we operate are considerably different from any others in the United States. My comments will reflect our ideas and considerations in expanding and upgrading our plants. However, the decisions we make with regard to our plants are in many ways common to all granulation plants. To put things in perspective, I am speaking from both a Research viewpoint and a very close working relationship with Manufacturing.

So you will have a better understanding of our needs, I'll give you a brief description of our products and process.

We produce what some people refer to as nitrophosphates, and to my knowledge we are the only company in the United States producing this type of product. Actually, we produce high analysis products such as 16-16-16, 30-0-0, 27-12-0, 13-34-10, 10-20-20 and many others. Our process uses nitric acid and phosphoric acid to acidulate phosphate rock, and we add supplemental acids including nitric, phosphoric, and sulfuric to achieve the specific grade being produced. The end result is a high analysis product containing both ammonic and nitrate nitrogen. We granulate the slurry produced in the reactor system in a gas fired cocurrent granulator and use conventional equipment for down stream sizing, cooling and coating.

Our plant sites are in Richmond, California; Kennewick, Washington; and Fort Madison, Iowa. The process we use was initially a Potasse et Engrais Chemiques (PEC) reactor system and a C&I/Girdler spherodizer system. Over the years we have significantly modified both parts of the process and have developed a process that produces a high quality N-P-K in a plant that meets all air emission regulations and has zero water discharge. This has been achieved through pilot plant development studies on all parts of the process and in some instances plant scale testing for confirmation.

Now for the 1980's. In the last three years we have replaced the old Kennewick plant with the new design and have essentially tripled its capacity. Early next year we will be bringing on stream a new N-P-K plant at Fort Madison, Iowa which will double its N-P-K production capacity. The Richmond plant was modernized in 1972. We have no plans at this time for a major expansion at Richmond.

I suppose at this point you are wondering why we embarked on expansion of our Fort Madison plant into N-P-K granulation facilities rather than moving into solutions, suspensions, or more typical ammonium phosphate type products. The decision was reached in 1977 by top level management and was based on all factors including our product line, Marketing requirements and economics. At that time fertilizers were not very profitable, but we believed that:

1. The economy would improve.
2. The farmers profit on his products would have to improve for him to survive, and
3. Our high quality N-P-K, with its size and composition uniformity and its demonstrated high yield performance, would command a higher price in the marketplace than our competition.

We still feel this is true and are looking forward to a number of years of increased profitability for the industry.

In the 80's we will be working towards profit improvement, environmental safeguards, and energy conservation. Through the last decade, and I see it continuing through the 80's. we have used approximately half of our manpower and resources in complying with the continually expanding government regulations. This has led throughout our industry to increased plant costs, increased production costs and, as a result, increased end product costs. We hope that our customers recognize that this time and capital investment in addition to the increased raw material and energy costs have played a large part in the end product price increases that have taken place.

Let us consider the various areas I have just mentioned in terms of goals for the 1980's.

From our viewpoint, we are optimistic about our industry's future and are planning on expansion into any profitable area of business that is available. Since we have just expanded our N-P-K production capability, we are faced with profit improvement goals of increasing the profitability of existing plants. This will include work in the following areas:

1. Improvements in equipment reliability and operating factor.
2. Formula modifications to use more economically attractive raw materials.
3. Debottlenecking plants to increase throughput and reduce costs per ton of production, and
4. Reduction in energy requirements is in order to both conserve energy as well as reduce operating costs.

These areas apply to all fertilizer operations, not just N-P-K's.

Environmental Safeguards

This particular area has caused headaches and expense for all of us in the industry, but we are accomplishing what we at one-time thought was impossible. However, I see a silver lining in this crusade. We have reexamined our processes and plants. As a result, we hope we have made well thought out, intelligent changes to comply with regulations and have improved our processes and plant operations. This approach to problem solving will have to continue in the 80's.

The area we are most active in right now is Industrial Hygiene and fugitive dust control. We are working towards elimination of coating agent dusts in our plants, warehouses and distribution locations. Hopefully, we will be modifying all of our plants within a year to bring this problem under control. This will probably require changing from a 2% diatomaceous or clay coating to a combination liquid-clay coating at a combined application rate of less than 0.5%. Our goal is to achieve a reduction in dust levels of at least 80% without jeopardizing our product quality.

At this time, I would like to have a slide put on the screen. From it, I will discuss our process as well as energy and environmental design considerations.

The top half of this slide describes the reactor system with its associated pollution abatement systems. As I said earlier, we started with a string of PEC reactors along with some low energy spray towers for emission control. The scrubber blowdown was discharged to the nearby river.

We now utilize two modified PEC reactors for acidulation, two large tank reactors for neutralization, two PEC reactors for potash mixing and one slurry tank. A Mississippi Chemical Co. (MCC) neutralizer is used to neutralize the supplemental nitric acid that is not required for phosphate rock acidulation.

The problems we faced with the old process were process control and both air and water pollution. The neutralization is now more easily controlled with the tank type system and the MCC neutralizer.

Part of our air pollution problem was caused by nitric acid vapor from the acidulators reacting with ammonia from the neutralizers forming ammonium nitrate aerosols. In the Richmond plant, this problem is controlled with a spray condenser and a high energy scrubber. In Kennewick and Fort Madison, we modified the reactor, fume and scrubber systems to avoid formation of the aerosol.

The water discharge problems have been eliminated by condensation, reevaporation, and recycle back to the process. The MCC neutralizer also plays a large part in the elimination of water from the process.

At the top part of this slide you see a Scrubber #1, an MCC neutralizer, a total condenser, a Scrubber #2 and a recycle water surge tank.

The acidulators are isolated from the neutralizers with a liquid seal. While it doesn't show on the slide, UAN solution in small quantities is fed to the acidulators to suppress NO_x formation. The small air stream that does come off the acidulators is scrubbed in an eductor scrubber. The blowdown goes back to the acidulators.

The MCC neutralizer is efficient and controllable. The vapor emission is a clean steam plume and is an important part of using the heat of reaction to eliminate water from the liquid discharge.

The heat of reaction in the neutralizers produces water vapor containing ammonia and some particulate. This vapor stream is totally condensed. Then, the hot condensate is reevaporated in Scrubber #2, which is an adjustable throat venturi scrubber with about 10" $H_2O\Delta P$. Scrubber #2 is actually an evaporative cooler. Outside air is added to the scrubber to cool the condensate and reevaporate water for clean atmospheric discharge. The cooled scrubber water discharge is recycled back to the spray condenser to act as the condensing medium and a blowdown is taken back to the reactor section to maintain slurry concentration and temperature. This control system provides us with clean air stream and a zero gpm liquid effluent.

Let's move on to the bottom half of the slide which depicts the granulation section or dry side of the process. The basic process is straightforward. We atomize a slurry feed containing about 12-17% water into a co-current hot air stream. The atomized slurry contacts a falling curtain of recycled fines. Product growth takes place and it is simultaneously dried to a product moisture of less than 1%.

Following the granulation-drying step the solids go through screening and solids handling steps. The product size material is cooled in a fluid bed cooler, coated and then sent to the bulk storage warehouse. We call the finished product a UNIPEL because it is uniform in size and each pellet has the same composition.

Now I'd like to discuss what we have done in the granulation section regarding particulate emission control and energy conservation.

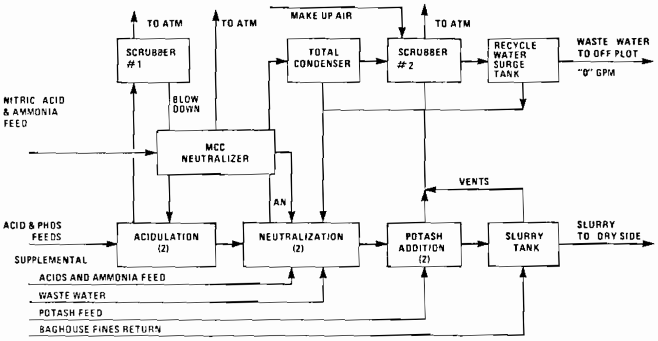
Through pilot plant studies and plant testing, we developed enough confidence to size and install baghouses to control dust emissions. All of our products contain ammonium nitrate. As a result, moisture pickup in the baghouses can be a problem if the humidity of the air streams gets out of hand. The baghouses are excellent capture devices and have replaced cyclones and scrubbers previously used with their associated air and water pollution problems.

There are three areas of energy conservation on this dry side that I'd like to point out. Around the fluid bed cooler we have taken advantage of the heat in the incoming cooling air doing the summer months to vaporize ammonia feed to the reactors by using air chilling coils. This reduces steam comsumption. The discharge air from the cooler is about 130-140°F and it is recycled to the inlet of the gas fired furnace. This has reduced natural gas consumption. An added plus on this recycle system is that it reduces the baghouse and blower sizes by about one third.

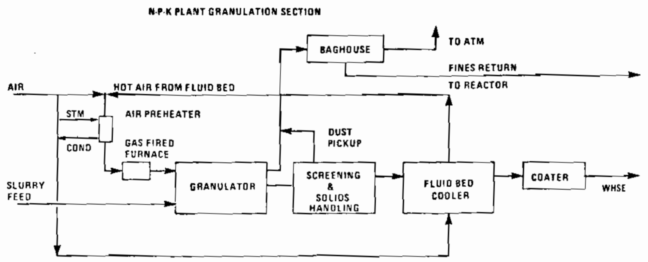
In Kennewick, we had some surplus steam generated from the acid plants and we have utilized this steam to preheat air to the granulator.

This concludes my remarks on what we are attempting to do. In closing, I'd like to say that I had the pleasure of attending the TVA demonstrations a few weeks ago, and seeing their falling curtain urea granulation process and was very impressed with its possibilities. I think you'll find Thursday morning's presentation of this process very interesting.

Thank you for the opportunity of speaking today. (Applause)


CHEVRON CHEMICAL COMPANY
KENNEWICK WASHINGTON

N-P-K PLANT REACTOR SECTION



MODERATOR HOWE: Thank you John. (Applause)

Our next Paper will be given by Clyde Mader. Clyde is Manager of Fertilizer Blend Plants and Machinery Department, Farmland and Industries, Inc., Kansas City, Missouri. Clyde will discuss Dry Bulk Blend Plant Design for the 1980's.

Dry Bulk Blend Plant Design For The 1980's

Clyde Mader

I. The dry belt fertilizer retailers of the 1980's, whether it be the independent dealer, the large corporation outlet, or the local farm cooperative business, have one common goal:

To operate a profit-making business.

The fertilizer retailer is considering an investment of many thousands of dollars for a bulk blend operation.

Aside from the fertilizer, the single largest expenditure will be the bulk blend facility itself.

In his consideration for a dry bulk blend facility, he must shop for as low an initial cost per unit volume of storage area as is practical; a dependable in-load system that meets tonnage capacity requirements; and a blending and/or load-out system that delivers the batch size and daily and seasonal requirements to serve his customers' needs.

A storage plant and a type of in-load and out-load system should be selected that requires minimum maintenance and minimum personnel to operate.

Those involved in the design and construction of bulk blend facilities have a responsibility to the retailer in their capacity as design/build contractors.

To meet these responsibilities, the facility designer must remain constantly aware of fertilizer industry trends, new building materials, new or improved construction methods, material costs fluctuations, and new or improved in-load and out-load equipment systems.

The retailer must be assured the facility package proposal presented him is the most modern and practical available.

II. Farmland Industries has been and is presently involved in the design and construction of dry blend plant construction in 17 Midwestern states.

This involvement has included approximately 500 new plants and plant additions.

Plant locations as far west as Silt, Colorado; east to Ashkum, Illinois; south to Weslaco, Texas; and north to Bottineau, North Dakota have provided valuable experience in low and high humidity and hot and cold climatic conditions.

The new blend plants constructed in these areas have storage capacities ranging from 300 tons to 6,000 tons.

III. In the past ten years the vast majority of dry bulk facilities have been the horizontal flat type facility that utilizes a front-end loader vehicle to transport fertilizer. There is no reason to believe this will change.

For discussion purposes, this type bulk blend facility is broken into three major components:

1. The flat storage plant
2. The in-load machinery system
3. The out-load machinery system

The Flat Storage Plant

All types of design concepts, whether they be wood frame, pole type, or concrete, for flat storage plants in the 300- to 1,500-ton range, are available today. With the many builders experienced in construction of plants of this size, the point may have been reached where additional design is not needed.

With this in mind, this discussion will be directed toward wood frame blend plants in the 2,000- to 6,000-ton range, and some projected blend plant/terminals in the 6,000- to 14,000-ton range, presently on the drawing board.

Two (2) factors are common to all size plants. As the plant capacity becomes larger, the more important these factors become.

The first of the factors is preliminary site planning considerations

A good point to remember is that building sites need not necessarily be altered to fit a plant. It may be most practical to design the plant to fit the available site.

A. Placement of the building on the site should most efficiently use the available rail siding. Consider the rail car flow, the full and empty car placement.

B. Out-load traffic patterns; how well does the additional traffic flow adapt to the present flow?

C. Required excavation or fill and grading should most practically adapt to the surrounding site and drainage. The ideal building site slopes down and away from the completed facility.

The elevation at the front out-load side of the building is ideally below the storage plant floor. This allows the blender or load-out charging hopper to be set low for easy loader access, yet remain above grade for eliminating water problems, and allow for washing out if desired.

D. All site fill and compaction should meet engineering specifications. All footings, both for the storage plant and for equipment, should be designed for local soil conditions. A soil test core is good insurance.

E. Remember, railroad and government agency permits are required by most states. To forget to obtain or to delay obtaining these permits will delay construction start-up. Permits to construct under, over, or near railroad sidings, local building permits and state air control permits are a fact. An application should be initiated as soon as possible to avoid these delays.

The second common factor is the number and size of storage bins

In large plants, this factor becomes extremely important.

There are two schools of thought on bin capacity size: The first is: keep building costs as low as possible by having a minimum number of bins that contain a maximum amount of fertilizer.

The second is: select a number of bins and a bin capacity that allow for systematic turning of fertilizer inventory.

It depends on the storage volume—seasonal movement volume, but the normal recommendations should be No. 2 or a combination of No. 1 and No. 2.

(Figure 1) shows the variable tonnage capacities in the five nominal bin widths offered in our 76' deep wood frame plant, which will be discussed later.

You can see the capacity variations for each size bin with the different weight materials.

Fertilizer with a tendency to set up, such as ammonium nitrate, or 18-46-0, should be stored in several smaller bins so inventory can be turned regularly to prevent inventory losses and extra labor costs.

Fertilizers, which are used in larger quantities or which have minimal storage problems, such as potash, can be stored in larger bins. (Figure 1) shows only one plant size.

TYPE FERTILIZER

NORMAL BIN WIDTH	UREA 47 PCF	NITRATE 55 PCF	**18-46-0 POTASH 60 PCF**	11-52-0 65 PCF	**0-45-0 70 PCF**
12'	275	320	**350**	380	**410**
14'	325	380	**415**	450	**485**
20'	470	550	**600**	650	**700**
24'	570	665	**725**	785	**845**
28'	665	780	**850**	920	**990**

STORAGE CAPACITY IN TONS

Figure 1

In large "A" frame type plants, this material capacity variance becomes even larger, and first consideration should be given to cubic foot or storage volume to determine bin size.

Farmland Industries constructs basically two types of plants in the 2,000- to 6,000-ton range.

Plant profiles are designed around fertilizer, with a nominal average angle of repose of 32 degrees and a material weight of 60 PCF for volume considerations (Figure 2).

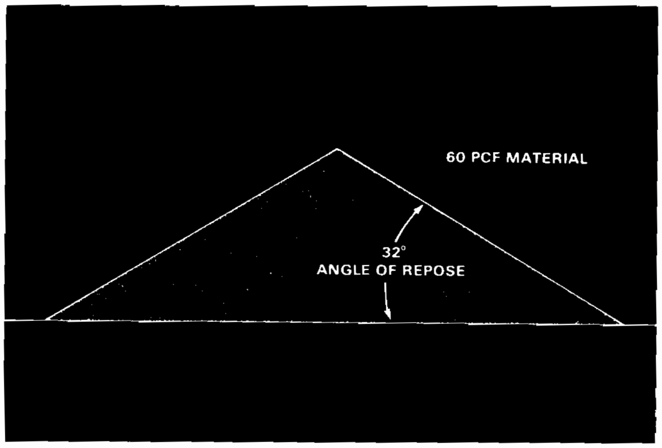


Figure 2

Peak height of full fertilizer fill should be kept below 40' to fall within regulations involving ammonium nitrate storage.

The first (Figure 3) of the wood frame plants is 76" deep overall, with 60'-8" deep bin partitions and a 15'-4" wide work alley.

The back wall height is 12'5".

The front wall height is normally 12'-9", but can be varied to fit equipment requirements.

The peak height is 37'5", with a 12/10 back wall pitch.

For lateral strength, three levels of 1" and 3/4" diameter wall tie-rods are installed horizontally through the plant.

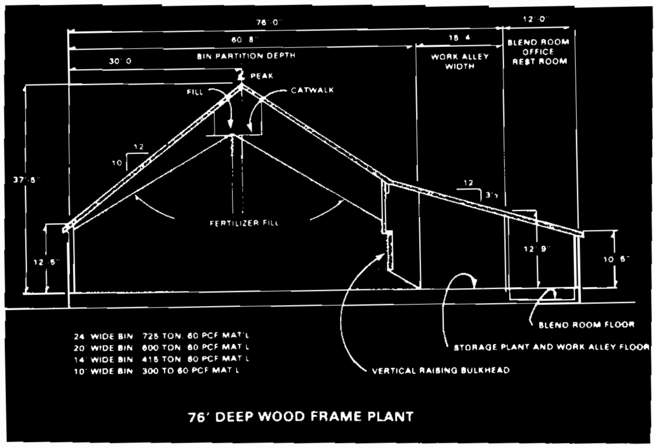


Figure 3

The plant can have either horizontal hinged or vertical raising front bin bulkheads.

Vertical raising bulkheads are preferred on large plants such as this because larger front-end loaders, requiring vertical clearance, are used.

The vertical operating clearance in this plant is approximately 10′.

A catwalk to service overhead machinery runs the length of the plant, over the bins, with adequate head room for plant personnel.

The overall length of a storage plant containg:

Three (3) 28′ wide bins of potash, 2,550 tons
Three (3) 20′ wide bins of nitrate, 1,650 tons
Two (2) 24′ wide bins of phosphate, 1,690 tons

Would be 192′, with a total of 5,890-ton capacity.

The second (Figure 4) of the large wood frame plants is an open front type.

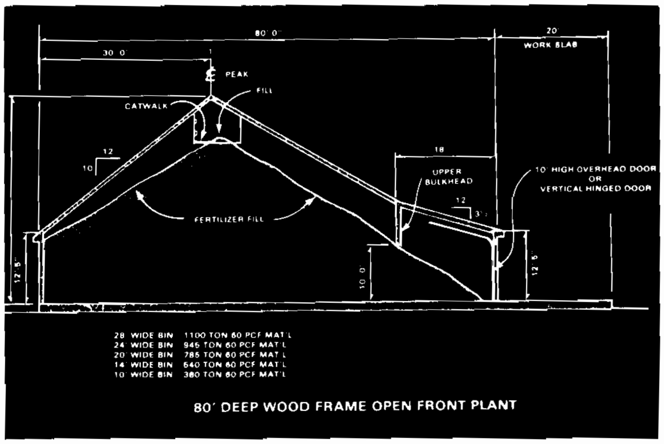


Figure 4

This plant has basically the same profile as the first discussed, except there is no front movable bulkhead or enclosed work alley.

This plant was developed to get as much storage capacity under one roof as possible.

Blending and load-out is outside.

A stationary upper bulkhead is located in each bin as a "safety valve" to prevent overfill from running outside the doors.

The length of a storage plant of this style containing:

Two (2) 28′ wide bins of potash, 2,200 tons
Four (4) 14′ wide bins of nitrate, 1,980 tons
Two (2) 24′ wide bins of phosphate, 2,190 tons
is 170′, with a total of 6,370-ton capacity.

Customer preference determines which style or plant is constructed.

Approximate costs of each of these plants, not including machinery is:

76′ deep x 192′ long plant with a 5,890-ton storage capacity = $42.55 per ton.

80′ deep x 170′ long plant with a 6,370-ton storage capacity = $39.15 per ton.

Blend plants larger than 6,000-ton are seldom considered by our member cooperative associations.

A design and cost study for an "A" frame type prestress concrete structure (Figure 5) was recently completed for a combination receiving terminal and blending operation. The total storage capacity of this facility is 11,500 tons, which includes 2,630-ton for the blending operation and 8,870-ton for the terminal operation.

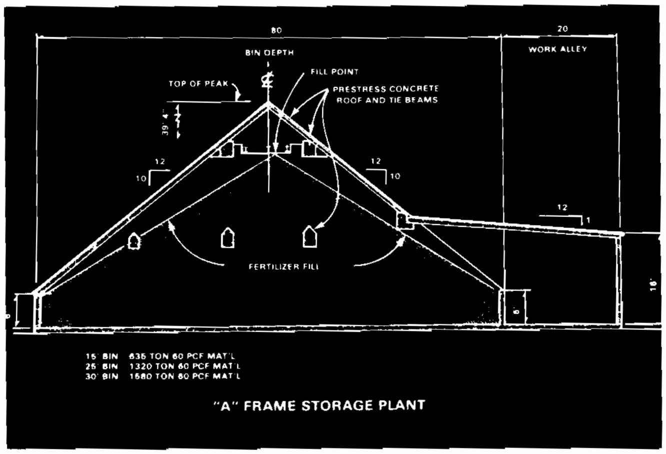


Figure 5

The cost estimate of this plant, excluding all machinery, is $64.80 per ton of storage capacity.

The overall storage plant size is 100′ deep x 256′ long.

Plants of this size and scope become practical as rail lines are closed and uni-trains are utilized for terminal operations.

The second major component of blend plants, the in-load machinery system

Undertrack systems will become almost a must for plants with capacities of 2,000 tons and up.

The light portable undercars are fine for smaller plants, but cannot practically be designed and manufactured to handle the larger capacity operations for any length of time.

An in-load system should meet capacity requirements to handle the large incoming shipments necessary for plant operations.

90 ton per hour capacity is minimum, and around 180 ton per hour may be the most practical for the very large plants.

The number of machinery components should be kept to a minimum.

Many in-load systems that resemble a used equipment lot can be found throughout the industry. Obviously, the more components, the more problems. Maintenance programs, always a necessity, become a full-time job for plant operators.

In-load machinery systems should be designed around the available site room.

A practical system (Figure 6) incorporated into recently completed large plants, consists of a drag conveyor, available from several manufacturers, with either or both rail and truck in-load capabilities.

Installation of this type of system, underrail, must meet railroad requirements and be approved by railroad personnel.

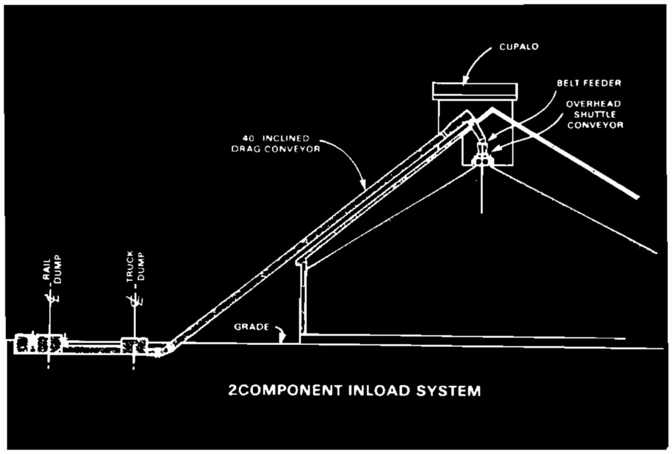


Figure 6

This type of system consists of only two component conveyors, the drag conveyor, which discharges onto a reversing shuttlebelt located over the storage bins for distribution of product.

Facilities with tight site conditions usually require an intermediate bucket elevator for elevating the fertilizer for discharge onto the shuttle (Figure 7).

Both these systems require the rail unloading point be located at the center-rear of the building.

If end of building entry, by the in-load system, is required, an overhead belt with a gravity-tripper is utilized over the bins.

Prewired and interlocked electrical motor control centers, in corrosion-resistant phenolic enclosures, are used in conjunction with the in-load systems.

The third major component of blend plants is the blending and *out-load system.*

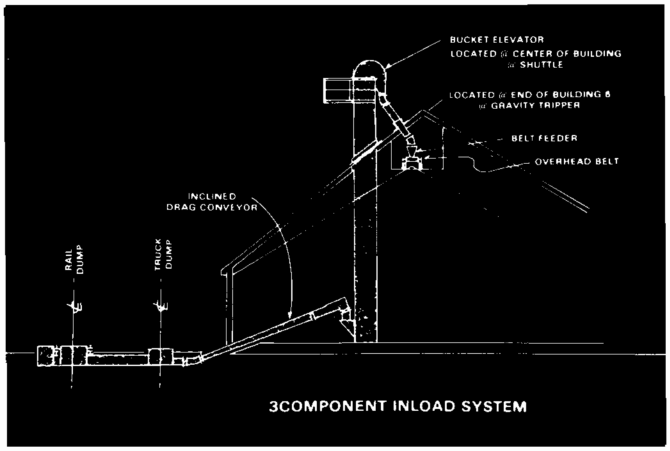


Figure 7

The recent development, by several blender manufacturers, of low-profile, 8-ton rotary blending systems, has provided more plants with lower cost, higher capacity blend systems with a batch size adapting to most spreading equipment.

The lower weight hopper height, generally around 6′, allows an 8-ton blender installation that requires no below-grade pit and is reached easily by most front-end loaders.

Blending towers are predominant in the northern states of our 17-state territory.

Towers usually have holding capacities of 90 tons, with six larger holding bins and three smaller micro bins.

Consideration should be given to blending towers if a plant capacity is around 2,000 tons, and will be turned a minimum of two times immediately and in plants that move a majority of their fertilizer volume in one short season, where time is of the essence.

IV. *Corrosion-Resistant Construction Materials*

Fiberglass flashing, hatches, and louvers should be incorporated into storage plant design where possible; 304 stainless steel, corrosion-resistant carbon steels, or heavy wall sheet metal should be selected for machinery systems. Precision for components should be held to a minimum.

V. *Preventative Maintenance*

Any presentation involving fertilizer facilities is not complete unless discussion of preventative maintenance is included.

This can be called the "what, whys, wheres, and hows" of preventative maintenance!

A. *Prevention of What?*

Costly breakdowns, down time, and delays during the peak fertilizer selling seasons.

Fertilizer handling machinery seldom fails during the off-season, but fails at a time when we need it most, unless a sound preventative maintenance program is practiced.

B. *Why Preventative Maintenance?*

Lost time because of fertilizer handling machinery downturn costs *you* money, not only because of peak season downtown, but also because of excessive shipping charges, lost shipments, costs, etc.

You have an investment of many thousands of dollars in facilities, machinery, and fertilizer.

When you cannot deliver to your customer at a time of his choice, your competitor may be selling him fertilizer *plus* you may not get his business back.

C. *When Do I Perform Preventative Maintenance?*

Your major preventive maintenance program should be scheduled during *each* slack season. This is when you have time and personnel for time-consuming machinery overhaul and major plant repair.

If the major preventative maintenance program is performed correctly, the peak season tool requirements can be reduced to a grease gun and broom.

D. *How Do I Perform Preventative Maintenance?*

First decide what should be included in each slack season's preventative maintenance program.

Provide your personnel with a systematic preventative maintenance checklist.

This list should include every portion of the buand each piece of machinery in detail.

VI. *Conclusion*

If 1980 is any kind of barometer for the next nine years, the 1980s will be an exciting, productive decade for the dry fertilizer industry.

MODERATOR HOWE: Thank you Clyde. Some very excellent ideas. Our next Speaker will be discussing Design and Construction of Fluid Plants for the 1980's. Hovey Tinsman has been a Speaker at the Round Table in the past. He is a graduate of Princeton University, in Chemical Engineering, and also has an M.A. Degree in Business Administration from Northwestern. Hovey and his brother started in business in 1958. His Company, Twin-State Engineering and Chemical Co., manufactures 10-34-0 Solutions, Suspensions, Nitrogen Solutions and is also involved in some Equipment Fabrications. Please welcome Hovey Tinsman, President, Twin-State Engineering and Chemical Co. (Applause)

Design and Construction of N.P.K. Plants 1980's Fluid Fertilizers

R. Hovey Tinsman

In discussing the design for future needs in the fluid industry requires considerable qualification because of the nature of marketing within the fluid segment of the fertilizer industry. Since the birth of fluids in the mid 50s, they have undergone a rapid evolution that has continually resulted in both plant and application equipment being rendered obsolete far sooner than normal depreciation schedules. Product lines have shifted sufficiently fast to cause a strain on capital planning. In addition to rapid evolution, the liquid industry has a further complication in that complete N-P-K liquid programs are, by and large, handled on a regional basis. While it is true some companies have national coverage with complete programs, even their facilities are designed with regional logistics in mind.

For my part, my familiarity with the industry is heavily biased with the corn/soybean acreage in the upper Mississippi valley area near Davenport, Iowa. In this particular area our production and marketing needs encompass a 200 mile radius of the quad cities which stretches from Des Moines East to Chicago and from the Missouri line north into the southern counties of Minnesota and Wisconsin. Within this geography, spendable income from corn and soybean production is both dependable and relatively high compared to most other areas in the country — no small requirement for a viable fluid program. Within this market, approximately 85% of fertilizer production goes toward corn, 10% for soybean, and 5% toward permanent pastures and alfalfa.

Obviously, what limits the marketing area of all N-P-K fluid plants is the transportation of materials and their inherent water content and relatively low analysis. Characteristic of fluid marketing in the upper Mississippi valley is an orientation around dealers servicing farmers in a 10 to 15 mile radius, probably similar to most other locations in the country with the exception of the great plains. The local dealer has two choices for supply. He can buy all base materials from a regional supplier to blend and distribute which has a low capital investment. If the dealer purchases base materials from a regional supplier, the product line normally involves:

28%/32% Nitrogen solution

10-34-0 High Poly Phosphate Solution as a Source of P_2O_5

4-12-35 or 5-15-30 Suspension as a Source of Potash.

He also has the choice of making his own product line from super phosphoric acid, ortho phosphoric acid, or MAP as a source of P_2O_5 and liquid grade potash.

Irregardless of the source but following a marketing program characteristic to liquids, the materials are blended in a mixer with mechanical agitation at the dealer location with the grequent addition of desired herbicides and micronutrients and the resulting mixture custom applied with flotation equipment.

For those unfamiliar with the liquid industry, a point of clarification about liquids and fluids needs to be made. The historic terminology of liquids use to be simple. A product was either liquid and was pumped and sprayed or else dry and stored in a bin. Being dry was easy to identify and easy to label — the villan.

During the mid sixties suspensions came of age — first as concentrated liquids by the removal of approximately half of the water, then ground up dry products such as MAP — all fluidized for custom application through liquid equipment. As a result, the fluid industry today is composed both of the traditional high poly phosphate liquid materials as well as fluidized dry products with a common denominator that they are both applied through liquid equipment.

With this background, we should now turn to the mechanics of the fluid industry. The entire subject area of plant design today divides itself into two distinct catagories which are easily considered separately:

1. Production from super phosphoric acid. Anhydrous ammonia and liquid grade potash.
2. Fluidizing MAP or DAP, correcting the pH to 6.6

with either ammonia or phosphoric acid and the subsequent addition of potash.

While the choice of which production route selected may not be particularly important, it nevertheless depends on many factors such as:

- MARKETING PHILOSOPHY
- AGRONOMIC VALUE
- EXISTING DRY STORAGE FACILITIES
- AVAILABILITY OF RAW MATERIALS
- BOTTOM LINE ECONOMICS FOR BOTH THE FARMER AND THE DEALER AS DETERMINED BY THE DEALER.

This will be looked at later.

A typical poly phosphate system exists at Durant, Iowa where the thrust is manufacturing 10-34-0 from super green phosphoric acid on a year round basis and then blending in the necessary clay and liquid grade potash to develop a full line of high potash materials.

In the design of such a facility or one contemplated in the next few years, five different areas might be investigated from a construction standpoint.

1. *Materials of Construction.* Important to our thinking is that the choice of materials of construction must shift to accomodate the rate of inflation and the ever increasing labor rates for maintenance that are inherent in our economy for the next few years. If, for instance, the rate of inflation is estimated to continue at a level near 10%, construction can accomodate higher original costs in order to achieve substantially reduced maintenance costs as well as significantly longer life from plant design. The only liability of this process is that the evolution of the liquid industry must be taken into consideration in order to avoid the risk of holding obsolete plant and equipment.

Specifically, potash storage can be constructed of wood, metal and cement and we have personally had experience with all three. The use of prestressed concrete is both maintenance free and relatively economical provided care is exercised in the piping of phosphoric acid. The cost of building skin, floor and erection in 1975 was $11.00 per square foot, by 1980 $17.00 per square foot. After five years of service, the prestressed concrete shows no deterioration or maintenance and will be around for a long time. Materials for piping and pumps have moved from carbon steel and PVC to 304L and 316 stainless steel. While steel piping has been successfully used in the past it is subject to rapid deterioration when any heat is applied particularly where poly phosphates are involved. When shifting from 46% poly 10-34-0 to 75%, we found out first hand the additional sequestering power of poly phosphates as steel facilities literally dissolved. All pump selections are conventional heavy industrial chemical pumps constructed of 316 stainless steel with double mechanical seals of tungston-carbide facing. Valve selections correspondingly are industrially accepted pneumatically controlled valves.

The reason for emphasizing the above is that the fluid industry has historically been self experimentation with plant, frequently held together with baling wire because of having made poor choices in materials of construction plant design. This has not been a problem for major producers of nitrogen and phosphate because of your engineering departments and long history in the industry. It's the regionalism and smallness of liquids and a lack of professionalism both in design and procedure that originally caused many problems in the past. For the fluid plants of tomorrow, far greater care will have to be exercised in order to take advantage of the economic equation and to live within accepted OSHA and EPA standards.

Important to the economic equation is control of employee numbers for a highly seasonal business. It is important to avoid coupling high maintenance risk requirements on top of high seasonal operational needs. It is imperative to eliminate the down time risk both from business interruption as well as payroll numbers.

2. *Quality Control Fluid Programs.* Liquid programs have often been strong in marketing and entrepreneur desire but short on quality control and perhaps other aspects of a small business operation. Batch formulations were seldom checked and the total system often lacked quality control and procedures common to larger industrial facilities. Quality control must take the form of assuring the customer that product analysis meets state registration but at the same time avoiding heavy shrinkage losses due to over formulation. While this may be common to basic nitrogen and phosphate procedures, quality control leaves something to be desired in many fluid systems and all bulk blending facilities. Regional processing plants making 10-34-0 and suspension grade materials must have the ability to have on-site analytical work accomplished with sufficient accuracy in order to assure the product being shipped meets desired specifications. It is totally unsatisfactory to forward samples to a distant laboratory because the material will have long been applied before the results are known.

If maximum benefits are to be derived from poly phosphates, then conversion preservation for long periods of storage is mandatory. This means the development of proper cooling and maintaining a tight control on pH. If a suspension grade is to be stored for any length of time, quality control of viscosity must be tight, particle size of potash held to a *consistent* minimum, and cooling controlled to prevent conversion deterioration and the resulting mono ammonium phosphate crystal growth.

3. *Environmental Concerns.* Whether or not the industry agrees or identifies with local, state, and federal environmental concerns as they relate to the fluid industry is totally irrelevant because they are a fact of life. Any dealer or regional processor must identify the projected requirements and concerns of his community and state governments. State governments frown with differing intensities on such areas as nitrate and phosphate spillage, ammonia loss from poorly con-

trolled pipe reactors, health hazards from clay dust, spills of materials that find their way into rivers, streams, streets and roadside ditches. While we may argue over the principle of many of the EPA standards, total containment for the normal dealer and regional processor is relatively cheap. The cost of total confinement control is more than offset by the lower insurance rates and the more successful public relations achieved with the surrounding community. One had to personally experience the emotional problems of poor housekeeping within a community to understand the harm and cost of poor public relations with the non purchasing community.

In a personal experience, we originally were located on the edge of a small community not far from a K-9 grade school with 700 children. As our company's facilities grew, new storage was required for anhydrous ammonia and phosphoric acid storage. Aqua ammonia gave way to jumbo cars with bold print — anhydrous ammonia. The time was when a truck ruptured in downtown Houston and nerve gas was moving from Colorado to the East Coast. In addition, we required steady unloading of potash and the resulting corrosive potash dust. Heavy truck traffic occurred during the spring with night shipping and occasional spills. As a plant facility grows and becomes stifled by an area, extensive time and expense is required to handle the community concerns and complaints. We have experienced the smallest of dealers with their poor housekeeping in communities and their mishandling of atrazine dust, herbicide spillage and occasional fertilizer spillage. The difference between a generally accepted industrial neighbor versus one of arrogance and uncooperation is immense.

At a dealer location, liquid tank storage can be totally enclosed with cement dyking and any tank overrun or leak totally contained and collected. Applicating truck load outs and spillage around mechanical liquid equipment that may contain hazardous pesticides and semi-trailer unloading areas can easily be contained and any containment collected and disposed. At seven retail locations at twin-state we estimate the cost of total containment to be $6,000 to $8,000 per location. This includes a floating slab and cement retaining wall around storage tanks, drainage to collecting tank and its movement to storage or acceptable method of disposal.

At a processing plant such as Durant, Iowa, design thought must be given to such accidents as acid spillage from phosphoric acid tank cars, total clay dust containment from separating the clay from air streams involving pneumatic unloading, field storage tank leakage, truck and rail loading spillage, and the general runoff from the property inherent with watershed characteristics of the land from rainfall. It is not excessively expensive for a liquid facility to install a lagoon system whereby any spills not considered economical to recover can be washed and delivered to a lagoon. As long as lagoon waters contain only N, P and K contaminants, the lagoon level can be controlled by using its liquor as a source of make up water for suspension production. Total confinement will be a fact of life for the fluid industry of tomorrow and the necessary property and provisions must be included in overall plant design. From our experience the dollars involved were rapidly returned through lower leakage insurance costs and other intangible assets.

4. *Evolution of Product Line.* For the fluid industry to successfully operate in the years to come, we see it a requirement that suspensions produced must have the capability to be stored on a year round basis considering adequate and reliable sparging. Dealer and farm storage will not function properly unless heels and partially filled tanks can be retained for the next time of use. A more significant problem in dealing with the independent market is the deterioration of suspension products which have a tendency to cause unnecessary clean out work on the part of the individual dealer or farmer. In short, the product must have a shelf life for a fairly lengthy period of time.

In the poly phosphate product line the industry will have to adapt to passing inpurities on to the field. Inherent in all phosphoric acids are various levels of impurities of aluminum, magnesium, and iron. Historically, a major limitation to the enthusiasm of a phosphate basic supplier has been the concern over cleaning and filtering acid to an acceptable degree for the fluid industry. The process of filtration and the disposal of the resulting sludge is an expensive process that must eventually be passed on to the retail users of a liquid system. Working with the impurities to successfully move them on to the field but in a form not objectionable to a sometimes finicky independent dealer is a challenge to the industry that is currently being met today.

Year round receivability of nitrogen, phosphate, and potash raw materials at the dealer level will eventually be a requirement for maximum economics. A basic supplier transportation system whether it be pipeline or jumbo cars, insulated super acid cars, or expensive covered hopper cars, must be utilized on a year round basis such that the capital investment on a per ton basis is reduced to a minimum. This means moving away from peak seasonal demands. A basic producer's manufacturing facilities function on a year round basis and so must an expensive transportation system. If inventories are to be built for seasonal use it will eventually be more economical that the inventory storage and its cost of equipment and financing of materials be funded in the field.

As energy and railroads are deregulated, more opportunities will be achieved by working with the transportation system to reduce their per unit cost. Eventually that cost savings will be passed on to the field. From an economic standpoint rarely has storage in the field not paid for itself handsomely as a result of price differentials due to the seasonal nature of the business. A further differential is, today, at work in the trucking and barge industries and should be interjected into rail with deregulation.

5. *Market Changes.* Any liquid plant design will *follow* changes in marketing. It will never lead the change in course. The market evolution will be the key to a fluid system design during the eighties. One has only to reflect upon the changes of the past decade. Four row planters and mul-board plows of a decade ago required substantial time on the part of the farm giving custom application equipment a fair degree of breathing room. Today with minimum tillage and dramatically larger equipment, the size of the average farm has escalated while, at the same time, the farmer's work load has decreased. furthermore, the farm is much more concerned on the proper date of planting. The spring season has been dramatically compressed and with the emphasis on timely planting, the time squeeze is now on the dealer.

As the size of the farm continues to increase tomorrow and, by chance, they move toward owning their own storage and application equipment, the whole marketing and service concept of both liquid and dry fertilizer will dramatically change. The cost difference normally associated between dry bulk blend/anhydrous ammonia versus a complete liquid fertilizer program has normally been fairly wide. A good measure of that difference is the cost of a two tier storage system between basic supplier and regional dealer and then the farm. The cost involved with the liquid two tier system are being substantially reduced in some parts of the country. As the farm concentrations continue during the eighties there is reason for enthusiastic acceptance that fluids will indeed be far more competitive for the larger farm — not less competitive.

Another factor that will dramatically affect the fertilizer industry will be the deregulation of natural gas currently scheduled for 1985. This will greatly affect the price of all nitrogen products. In addition, with the further increases in the cost of energy, the phosphate and potash industry will be hot almost equally as hard. The farmer in the upper Mississippi Valley area has traditionally approached continuous crop fertilization in a very unscientific manner. Timing of application was based on his time availability and the market price of products. Analyses applied have depended on what appeared to work best in the county and literally a gut feeling on the part of the farmer and the dealer — not a very scientific approach. Traditionally, there has been little room in farmer planning for three major areas that energy will affect tomorrow:

1. Precision Placement
2. Timing of Application
3. Efficiency of Product

All designed from an agronomic point of view of what achieves the highest yield and profit for the dollar invested. With deregulation of energy, costs of fertilization for crops will encompass a substantially higher percentage of the cost per bushel. There will be a time when the farmer will no longer be able to disregard efficiency. Nitrogen and phosphate in particular will jump to a level where survival will depend on a judicious choice built around maximum efficiency.

The Liquid concept continues to offer the maximum flexibility to react to the advantages of placement, timing, and product efficiency. They can be broadcast and chiselled, knifed and banded. They can be flown or precisely placed in fourteen inch bands at a six inch depth in the soil. As American agriculture looks forward to a larger share of world grain production and as the nation looks forward to a substantially higher level of dollar exports, the liquid industry correspondingly looks forward to a far higher share of the fertilizer market.

MODERATOR HOWE: Thank you Harvey for your most interesting discussion on Liquid Fertilizers. (Applause)

MODERATOR HOWE: We are going to open up our first panel for questions. I have a question here for Clyde Mader. When you design a blend plant, how much rail siding do you need for how many cars? In your talk you discussed Railroad Capacity.

ANSWER: CLYDE MADER: Figuring that each car required about 60 feet of rail siding space, it would depend on the size of the plant that you are talking about.

QUESTION FROM THE AUDIENCE TO HARVEY TINSMAN: You talked about Quality Control in Liquid Plants. How often did the state of Iowa take tests (Samples of your fertilizers)? How close do they watch you.

ANSWER— HARVEY TINSMAN: They came to our plant approximately once a month to take samples. I am not so sure this is as big a concern to us as is the shrinkage from over-formalation or having that month a 10-32.5-0 instead of a 10-34-0. When you have much product out in the field, then you have created a real liability because the Inspectors are not only at Durant, they are at Retail also. You must be awfully sure that you leave that regional processing spot with material that really is on "Specs". It is not that hard to do. Our phosphate supplier allowed one of our employees to go to their facilities to learn how to do the testing of nitrogen-phosphate and potash. We were given the specifications for the testing equipment needed. Not too expensive. We have the right person, properly trained to do our analytical work. We end up with field storage tanks of well mixed 10-34-0, refilling them on a continual basis year-round and we are also drawing out of these tanks on a year-round basis. We take samples radomly about every third day. If our analysis starts to wander than we make the necessary adjustments in the formulation. You asked the question about designing of rail cars within the liquid industry. I really think that one of the big advantages is being able to identify with some sort of multi-car rate. The regional processor that is storing potash, to make suspensions, has a major opportunity, if enough land is available and has accessibility to strong rail to envolve a transportation receiving system to adapt to the advantages of negotiating multi-car-rates. It is not only going to be a factor, it is going to be a big cost factor in the fluid industry. One of the "give and takes" is: Do you build a potash warehouse or do you send the potash to the final user? If it goes to a potash warehouse, lets say Waterloo then has to be reshipped, that is a substantially larger expense than if the regional processor designed a system to also take advantage of the multi-car-rates.

QUESTION—BUD DAVIS, T.V.A.: Clyde talked about dollars; dollars-construction costs; dollars-per ton storage. Harvey Tinsman talked about dollars per square foot. I wonder if Harvey could give us some idea if he is talking about storage and if so, what the dollars per ton storage might be.

ANSWER—HARVEY TINSMAN: Well, Bud, the building we had up there is 40,000 square feet. It cost $11.00 per square foot for the skin. I am talking about: the floor, erection and everything else. Only about one third of that building is devoted to storage of potash, approximately 5,500 tons. I was going thru the same figures when they were mentioning $40 - $50 a ton. If I were to take the $450,000 figure for the building, we have devoted one-third of it to potash storage. We might have $150,000 for 5500 tons of potash. I am not talking about any handling equipment in the building. We felt that the pre-stress building was more expensive than the wood. We actually went to "Cargrill" and talked to them about their experience with it. They told us "for soft storage" one of the real problems they had was fires, electrical fires from storage. That information, coupled with our experience with steel roofing and things like that, took us to pre-stress. For 5 years we have not had a nickle's worth of maintenance on it.

MODERATOR HOWE: Thank you John Everingham, Claude mader, Harvey tinsman and our audience for an excellent discussion covering "ammoniation-granulation", "bulk blend plants" and "fluid fertilizers". (Applause)

MODERATOR HOWE: Our next session on our program is a two-part discussion covering: the advantages of ammoniation-granulation N.P.K mixtures. The first part will deal with Marketing and Agronomic Advantages. The second part will deal with Quality Control Advantages of Ammoniation-granulation. Ben Emkes will discuss the first part. He is General Manager of Seymour Chemical Co., Seymour, Indiana, a graduate of the University of Illinois. He had been with the fertilizer industry since 1949. Thru acquisitions and mergers he has been employed with Bruner Fertilizer Co., Seymour, Indiana, American Agricultural Chemnical Co., Continental Oil Co., Agrico Chemical Co. and at Seymour without even changing a desk. Welcome Ben Emkes. (Applause)

Marketing and Agronomic Ammoniated Fertilizers

Ben Emkes

It is a pleasure for me to be in attendance and participate in this your Fertilizer Round Table Conference. Most of my 30 years of fertilizer industry experiences have been in marketing and administration. Therefore, it is doubly pleasing to be here and share with you a few experiences.

First of all, I want to thank and commend all of those that have been associated with fertilizer production and research for the many fine contributions that they have made towards this industry. The increase in plant food nutrients in each ton and the efficiencies developed in production of these nutrient tons has done much towards the development of American Agriculture. Grain, Feed and Food production in this country far exceeds that of any other country.

Some 30 years ago, when I entered this fertilizer industry, I said to myself, the Fertilizer Industry could only show me opportunities of growth. And indeed it has. In 1953, the State of Indiana consumption reports indicate that the tons sold were 1,140,000. Last year they were 2,971,000 (almost tripled). In 1953, the leading analysis was 3-12-12. Last year it was 6-24-24, (doubled).

On July 15, 1975, it was my opportunity to start a new fertilizer company now known as Seymour Chemical Company, Inc., Seymour, Indiana, a subsidiary of Top Yield Industries, Lexington, Kentucky. With the help of Barney Tucker, Robert Clay and others within our organization, our business in tons has tripled. We have one basic ingredient, and that is Ammoniated fertilizers. Each year we produce and ship approximately 40,000 tons of ammoniated products.

What are granulated ammoniated fertilizers? They have been around since the early 50's, and most people understand what we mean when we mention ammoniated fertilizers. For those that are new—

Ammoniated Fertilizer

Simply stated: "Ammoniated fertilizers are a homogenous mixture with each individual granule containing a percentage of all the specified plant food nutrients".

To acquaint you somewhat with our situation: The roadsign welcomes everybody to the Seymour, Indiana Plant.

The plant itself will store 18,000 tons of product. The tower in the left center of the main building houses the ammoniator. The main plant is all used for the storage of ammoniated fertilizers. One half of the main plant is used for the storage of one analysis— 6-24-24.

The building on the left of the main plant is totally used for material storage — both pulverized or standard products used for manufacturing of ammoniated finished products and granular materials used for direct application and full truckload shipments to blenders. Our blender is used very little — approximately 5,000 tons per annum. The building on the right is used for bagged finished product storage. One half of our ammoniated sales are shipped in bags.

Louisville

The Louisville, Kentucky terminal is used for incoming barge deliveries. We receive both manufacturing materials and products that are shipped for direct application. This terminal stores approximately 14,000 tons.

Kempton

The Kempton, Indiana Terminal located in north central Indiana is used for storing of products that can be delivered to dealers at time of in peak season deliveries. This terminal stores 12,000 tons.

Ammoniated fertilizers are manufactured through a process of combining pulverized products with liquids through a rotating cylinder that does create a chemical reaction so that all products are throughly combined into each pellet or granular piece of goods. It is not difficult to guarantee the minor elements, the ones that we add and the ones that come utomatically through the use of Sulphate of Ammonia, Sulphuric Acid, Normal 19% Superphosphate, etc. In fact, we maintain a guarantee record anywhere from 87 to 95% on all the products we manufacture. Ammoniated fertilizers do not separate. Consequently, the guarantee, even if it be small amounts of minor elements, can be maintained.

Agronomy

Ammoniated fertilizers work well into a solid agronomic program for the farmer. What is agronomy? "Agronomy is that science that secures maximum efficiency of plant food utilization to reach maximum crop yields".

Throughout our years of industry experience, we have noted that we have developed efficient analytical laboratories and the industry has been blessed with well educated and trained agronomists. But in my opinion, we have done a poor job communicating this good information to the spot where it was really needed, and that is the farmer.

We have noted when farmers would come into a dealers location for soil test information, the dealer was not at all prepared to give proper advice, let alone provide him with the tools so that a good soil test could be taken. And yet, part of agronomy is to find the plant food inventory levels and the soil conditions of a given soil, before any sound recommendations can be conveyed to that farmer.

Soil Care Center

Consequently, we have developed Soil Care Centers that are available to fertilizer dealers that they display in their stores. These are self-service information displays that also provide the necessary supplies so that a farmer can take his own soil test, mail it to an independent laboratory, and receive back a sound agronomic recommendation. Approximately 100 of these displays are set up in stores throughout Indiana.

The three (3) simple instructions are printed on the Soil Sample display:

1. Take 1 soil sample bag for each area to be sampled.
2. Take 1 Field History Report and one cloth mailing bag for each 8 soil sample bags.
3. Sign Soil Probe Check Out Sheet when taking a Soil Probe.

Sample Bag (Front)

The Soil Sample Bag is so designed so that it becomes fully identified both for the farmer and the laboratory.

Sample Bag (Back)

Complete instructions as to how a good soil sample should be taken are on the back of the Soil Sample Bag.

Field History Report

The Field History Report is a simple check system that gives the Agronomist some preliminary information about the soil that is to be tested.

Cloth Mailing Bag

The Cloth Mailing Bag is a pre-addressed mailing bag with a plastic liner that will hold eight (8) filled Soil Sample Bags.

Probe Sheet

Probes are expensive, so a Probe Sign-out Sheet is on top of the display.

Fertilizer Recommendation

A Top Field Soil Care Center fertilizer recommendation is returned to the dealer in duplicate, the original going to the farmer and the duplicate to be retained in the dealers files. We also retain a copy in our customers files. For a dealer that is totally in the dry fertilizer business, this happens to be a typical recommendation and one that will bring this farmer good agronomic results. These programs are altered if the dealers have Liquid and Anhydrous Ammonia.

Quality

We do feel that we can continue to give the farmer good agronomic results through the use of ammoniated fertilizers. Small amounts of minor elements can be incorporated into ammoniated goods without segregation.

The strength of marketing any product is directly coordinated with the strength of the marketing personnel. It is difficult to comprehend marketing people lowering the price on a ton of fertilizer the first day that a spreader goes into the field. And yet, some basic producers use this tactic to move their products. Lowering price does not move more fertilizer to the market place.

We will continue to move ammoniated products. The farmer has much invested in his land and equipment. An extra investment in a quality type fertilizer is small compared to his other expenses.

Many of the big farmers tend land that belongs to several landlords. Some of the larger farmers will buy their row starters in bag so that they can easily determine the amouunt of fertilizer they have used at each landlord's farm. The cash renters use the high quality row starters so that they can get maximum profit returns.

We will be marketing ammoniated fertilizers for a number of years. As the fertilizer business becomes more competitive, more companies will be looking to improve the quality of their product. Ammoniation does give us quality.

MODERATOR HOWE: Thank you Ben. (Applause).

Our next speaker, the last of the afternoon, is Larry Stephenson. Larry attended school in Ohio and graduated from Ohio State University in Agricultural Economics. He has been involved in Fertilizer for over twenty years in many different capacities from Sales to Plant Manager. He has been associated with Agrico Chemical, Landmark, Inc. and Frit Industries. He is presently Plant Manager of Plant Life Services, Inc. A manufacturer of ammoniated and blended fertilizers.

Larry Stephenson is here to speak to us on Quality Control Advantages of Granulating N.P.K. Fertilizers. (Applause)

Quality Control Advantages In Granulating N.P.K. Fertilizers

Larry R. Stephenson

My topic is Quality Control Advantage in granulating NPK mixtures. Before I go further, perhaps I should give a little background on our company. Plant Life Services was formed in 1937 as a manufacturer and distributor of farm fertilizers. In 1974, it became a subsidiary of what is now Top Yield Industries. We are located in Marion, Ohio, which is in the central part of Ohio and the eastern edge of the corn belt. We have operated a TVA Type continuous ammoniation system since the late 1950's. We also sell blends and direct application materials. We operate on a wholesale basis and sell through a dealer network, mostly within Ohio. Approximately 50% of our tonnage is ammoniated goods with 20% blends and 30% D.A. materials.

All of us here as manufacturers and distributors of fertilizers have control of three factors that influence fertilizer movement. Those factors are price, service, and quality. I would like to talk to you today about the factor of quality. This is the area where we as granulators of NPK fertilizers have a definite advantage over other forms of dry NPK mixtures.

Through ammoniation-granulation processes, we are able to produce homogenous NPK fertilizer that are more resistant to off spec chemical analysis than that found in dry blend mixtures.

If you review published fertilizer analysis reports from the various states, you will find that ammoniated granular products have considerably less deviation from the guaranteed analysis than dry blend mixtures.

We are quite proud of our record with the State of Ohio during this past calendar year of 1979. The State of Ohio made 81 chemical determinations of ammoniated goods manufactured by our plant. Of those 81, only 3 were found deficient. Our average relative value was 101.2%, Relative value being defined as the total plant food units in the grade. As an example, 6-24-24 has 54 plant food units, 100% would equal 54 units, 101.2% would equal 54.6 plant food units. We do overflormulate slightly, about 1.3% of the relative value of the grade. This corresponds very closely with the results found by the state control officials.

Material flow through the plant is typical of the TVA Type process. Raw material is manually weighed from a 5 hopper cluster bin into a batch hopper, then elevated and passed through 4 mesh R.M. screen, and metered from a surge hopper into a 7 x 10' ammoniator.

We use Phos. acid, sulfuric acid and anhydrous ammonia. We do not use nitrogen solutions. Phos. acid and water are sparged on top of the bed in the ammoniator. Sulfuric acid, anhydrous ammonia and more water are added through submerged bed spargers.

The romantic material (for the uneducated-romatic material is material that is hot, wet and stocky) then drops into our 8'x40' gas fired co-current dryer. The material is then hot screened through a 4'x15' double deck tyler hummer screen equipped with 6 mesh oversize screens and 14 mesh product screens. After screening the material then passes to an 8'x40' counter current cooler after which it is conveyed to storage. Our normal operating rate is 18 T/hr. with a recycle ratio of about 1:1.

As I mentioned earlier, during the calendar year 1979, 81 chemical determinations were made by the State of Ohio control official and only 3 were found deficient. How did we accomplish this? Our people are probably no smarter than anyone else and as you can see from the material flow information I have mentioned, our plant is a typical TVA type granulation unit. We have no especially sophisticated equipment and in fact, we may be slightly below average in this respect.

Well, what did we do? We did it by adhering to principles and operating procedures that I'm sure have been discussed here in the past or published in various manuals or papers by TVA and TFI. Many times we become involved with new processes or new equipment and fail to keep ourselves aware of what is happening to already established procedures. Sometimes these procedures are modified or changed by plant personnel, unbeknownst to us, and thus they become bastardized versions of the procedure and not accomplishing what was originally intended.

I would like to review some of these procedures and practices that are necessary to make a quality homogenous granulated fertilizer.

(1) Use fine raw materials. The use of granular or coarse raw materials results in agglomerated particles rather than a homogenous granules. The use of coarse materials results in little more than an ammoniated blend mixture that is not homogenous and has weak physical and chemical bonds. Because of these weak bonds, the agglomerated particle is much more subject to fracturing which in turn reduces the physical quality of the product. Because of this fracturing and the look of homogeneity in the granule, we have opened the door to one of scourages of the industry, that of segregation.

(2) Be sure of the analysis of inbound raw material. This is especially true when you receive material from a new supplier. First, you need to know you are getting what you are paying for and second, this information is necessary for accurate formulation. If you find that the supplier shipping analysis and your analysis correspond consistantly, then an occasional spot check is all that is necessary.

(3) You must maintain good housekeeping. Over filling bins, bin leaks, payloader dribble, etc. all have an effect on the integrity of any fertilizer grade. Poor housekeeping is certainly detrimental when trying to maintain grade control.

(4) It is important to maintain the desired sizing of finished product. Even though ammoniated fertilizers are relatively homogenous, there are some variations when there is a large disparity in size. Anything less than 98% + 16 mesh, can cause a problem due to segregation. The lower the % on a 16 mesh, the more pronounced the segregation problem.

(5) Checks on metering equipment such as scales, base feeder, and liquid meters should be made regularly. Batcher scales should be checked at least weekly with check weights. The base feeder should be checked and calibrated hourly. Liquid metering accuracy should be checked daily if possible. Beginning and ending measurements of the liquid storage tanks should suffice in this respect, however, if very large volume tanks are used to store liquids, then the installation of a calibrated check tank would be advisable. To maintain desired analysis, you have to have accurate metering.

(6) We should review in plant sampling techniques and procedures. This is one area where many shortcuts are taken by plant personnel. If we want a representative sample, then we must use recognized and standard procedures. A non-representative sample is cometimes worse than no sample at all. At least with no sample analysis there is some doubt and you can deal with that accordingly. But with an analysis from a non-representative sample, you may proceed to work with criteria that is wrong to start with. I could go into a lot of detail concerning correct sampling procedures and techniques, however, if I did those of you who are now on the edge of slumber would pass right on into oblivion! TFI has compiled a manual on Quality Control in Blend Plants. While this manual was initially intended for bulk blend plants, it has a very comprehensive section dealing with sampling procedures that is pertinent to any plant handling dry materials. If you don't have a copy of this manual, I urge you to get one.

(7) Sample results should continually be reviewed. If the sample results aren't what was expected, push for definite reasons why they aren't. This emphasizes the importance of quality control to your supervisory and plant employees and prevents them from having a lackadasical attitude toward quality control. We have to emphasize quality control if we expect our employees to emphasize it.

In summary, if you want to make quality homogenous granulated fertilizer—

You need to use fine material.

You need to analyze raw material inputs.

You need to maintain good housekeeping.

You need to maintain desired finished product size.

You need to check and calibrate metering equipment.

You need to obtain representative samples.

You need to review past analysis.

Because of the homogeneity of properly manufactured ammoniated granular NPK fertilizers, these fertilizers offer a quality that exceeds other forms of dry NPK mixtures. This is especially true when small amounts of minor or trace elements are added to fertilizer mixtures.

Because of this quality, we are able to give the customer what he wants and what he pays for. It also gives us a definite advantage in meeting state labeling requirements. During this past fiscal year, our granulated NPK tonnage increased 22% over the previous year. We feel that the quality we put into our fertilizers had a substantial effect on this, and we plan to continue for the foreseeable future.

MODERATOR HOWE: Thank you Ben Emke and

Larry E. Stephenson for your most interesting discussion. Two parts—

A - Advantages — Ben Emkes
B - Quality Control — Larry Stephenson
Subject: Advantages Ammoniation-Granulation N.P.K. Fertilizers.

To our Audience — Thank you for your kind attention. We conclude our Afternoon Program with thanks to our speakers:

Part One:
John R. Everingham
Clyde Mader
R. Hovery Tinsman
Part Two:
Ben Emkes
Larry B. Stephenson

We had a good meeting. Our meeting tomorrow morning (Session #3) will start promptly at 9 a.m. Have a good evening and thank all of you again. Meeting adjourned. (Applause)

Wednesday, October 29, 1980

Morning Session

William W. Threadgill, Moderator

MODERATOR THREADGILL: Good morning. Our discussions for this Session should be knowledgeable and most interesting. The subjects are Uranium Recovery from Phosphate Rock; Occidental's Hemihydrate; Energy Conservation; Retail Marketing; AAPFCO; Fertilizer Analysis Control and other updated subjects effecting our daily plant operations. Our first Speaker, this morning, is going to talk to you about "Uranium Recovery from Phosphate Rock". I happen to know that this is a hot subject. I come from Lathrop, California and we have been under E.P.A. observation for a little while. Believe me I have an interest in anything radioactive or even anything that professes to be radioactive. Our first Speaker is Edward A. White. Surber is listed on your program, however, John had a conflict on appointments, therefore, could not be here. Ed will present this paper which he also coauthored with John. Ed is a Technical Consultant in I.M.C.'s Fertilizer Group. He received his Bachelor's Degree in Chemical Engineering from The University of Illinois in 1949. Prior to joining I.M.C. Ed worked for Lion Oil Co. and Mead Paper Co. He has held a variety of Technical Assignments with I.M.C. in Research and Development, leading to his present assignment as Technical Consultant for The Fertilizer Group.

Uranium Recovery As A By-Product Of Phosphate Rock Processing

Edward A. White — John Surber

Presented by Edward A. White

It has long been recognized that marine phosphorites throughout the world contain uranium as a minor constituent.

Central Florida (primarily those in Polk and Hillsborough County) reserves show concentrations ranging from a low of 0.003 - 0.030 weight percent of uranium with a typical pebble analysis of 0.015 percent U.

When phosphate rock is processed by the wet process (sulfuric acid digestion) to produce phosphoric acid, most of the uranium is dissolved and can be found in the acid product. Our analyses indicate that as a percentage of uranium, in the rock, the uranium solubilized in the acid may vary from 80, to 95 percent.

Acid as produced at IMC's New Wales, Florida plant typically contains 140 to 180 parts per million of uranium, which is equivalent to 1.0 to 1.2 pounds of U_3O_8 per ton of P_2O_5.

Technology for recovery of this natural uranium has been available for a number of years. IMC[2] operated a uranium extraction process at its Bonnie, Florida complex until 1957 - 1958.

The operation utilized pyrophosphate esters as the extractant of tetravalent uranium from 26 to 30 percent P_2O_5 acid. At that time, process economics compared to Western producers were unfavorable and operations ceased.

Beginning in 1974, uranium market prices began a rapid increase resulting in a six-fold increase by 1976 as seen in the price of yellowcake sold to convertors for upgrading.

With the New Wales Operation on stream in early 1975, consideration of uranium recovery processes began.

Bench scale experiments led to pilot plant operations and during the period November, 1977 to March, 1978, the pilot plant processed over one million gallons of phosphoric acid received from the phosphoric acid plant as primary filtrate. During this time, a large number of rock sources and attack (digestion) conditions were encountered.

The process as devised by IMC includes four distinct phases:

(1) Acid clarification and pre-treatment
(2) Primary solvent extraction and reductive stripping
(3) Re-extraction and alkaline stripping
(4) Precipitation of yellowcake

Two Belgium companies, Societe de Prayon and Metallurgie Hoboken-Overpelt, concurrently developed technology for recovery of uranium from phosphoric acid. A joint venture combining the respective technologies was undertaken, providing suitable modifications for a variety of world phosphates.[3]

The process utilizes the Oak Ridge National laboratory's DEHPA-TOPO process that extracts hexavalent uranium from filter acid.

It had long been recognized that major operating problems due to the organic content of the black acid would be difficult to overcome. If a satisfactory precleaning step could be devised, it was felt that there was enough information available from Oak Ridge[4] and Bureau of Mines[5] literature to scale up the remainder of the process with a minimum of bench scale and pilot plant work.

Our initial bench scale set up confirmed that the organics in the acid contributed to formation of emulsions and subsequent difficulties in phase separation.

The problem is that when separation eventually does occur with clarified or raw acid, the color is extracted by the organic solvent to yield an asphalt type layer at the interface called CRUD. The crud is difficult to remove and causes disposal problems.

Cooling and clarifying the acid removes some of the organics which we call color. Color is determined as absorbance at 408 nm in a spectrophotometer. The 408 nm wavelength was chosen since it yields linear results as the sample is diluted. Treating clarified acid with carbon yielded a green acid. Fresh filter acid has a color in the 2-3 range, while clarification reduces this by 50 percent. Carbon treatment reduces the color further to a level of about 0.4.

Our data indicates that crud formation is a function of acid color. Our acid clean up system is aimed at keeping acid color in the 0.2 to 0.6 range before organic extraction. Pilot plant operations generated a very small amount of crud and demonstrates the effectiveness of feeding organic free, green acid to the solvent extraction circuit.

The basic IMC/Prayon uranium recovery process involves several specific stages. Acid is received as primary or "number one" filtrate from the existing phosphoric acid facility and is stored in surge tanks. The acid is then cooled, utilizing spiral heat exchangers, pretreated, clarified, then passed through activated carbon columns. This entire system is referred to as the "Acid Clean-Up" Operation. It is in this step that solids and humic materials are removed from the acid to produce a clean, green phosphoric acid.

There are four trains sof carbon columns, each train handling up to 400 GPM or 30 percent clarified acid.

To date, the carbon column system has worked well and it is felt that it provides an effective means of pretreating the acid prior to solvent extraction. Logic controllers used in regeneration of the carbon columns are located behind the operators' console where computer graphics are available on the CRT screen for each unit operation.

Under normal conditions, two columns are operated in series and a freshly regenerated column used to replace the lead column when exhausted. Columns are resequenced when the carbon column product reaches a color of 0.6 or 40 hours, whichever comes first. Sequencing is accomplished by diversion of acid flows. The complicated valving during resequencing is handled by programmable logic controllers.

The cleaned acid is then transferred to the solvent extraction area. For DEHPA-TOPO to be an effective extractant, the uranium must exist in the U^{+6} valence state. Due to the iron-uranium redox couple, it is essential that all iron present in the phosphoric acid, at this point, be in the Fe^{+3} state.

Many techniques are available to accomplish oxidation. Air, oxygen, hydrogen peroxide and other chemical oxidants were considered. At New Wales, hydrogen peroxide is being used since it does not contaminate the phosphoric acid products. Common chemical oxidants such as chlorates and nitrates are not acceptable alternates due to corrosion considerations. However, a continuing program is underway to develop alternate techniques.

The amount of oxidizer required can vary substantially from day to day depending on the rock source and the operating conditions of the phosphoric acid attack circuit. The Fe^{+2} level in the product acid is monitored continually to optimize oxidizer usage.

The oxidized acid is transferred to the primary extraction system.

Oxidized phosphoric acid is contacted with a mixture of DEHPA-TOPO, dissolved in a diluent, utilizing a counter-current solvent extraction technique. At New Wales, four stages of extraction are employed. More or less stages can be used depending on specific process requirements.

The DEHPA-TOPO concentration is normally 0.5 molar DEHPA and 0.125 molar TOPO. The overall system, as indicated previously, is based on work conducted at Oak Ridge National Laboratories.[4]

Forty-two inch diameter settlers were used in the pilot plant phase of the development. The commercial plant uses settlers varying from forty-two feet to fifty-five feet in diameter. In these, acid flows downhill by gravity, while the organic is pumped counter-currently to the next stage. The control room for the primary extraction area utilizes CRT screens and computer graphics for ease in monitoring individual instrument loops.

There is a single train of mixer settlers, circular in diameter to be ultra conservative because of the large flows involved (1200 to 1400 GPM).

Raffinate phosphoric acid, leaving the Primary Extraction Circuit, is then treated to remove any entrained organic and returned to the phosphoric acid plant. Treatment consists of an aqueous settling step, followed by air flotation. Organic entrainment in the raffinate is typically 20-30 PPM as analyzed using infrared spectroscopy.

The raffinate acid is evaporated to concentrate the P_2O_5 for use in other end products.

It is significant that other than removal of humic material and uranium from the acid, both in rather minute quantities, no other chemical constituents are removed. Although the acid, prior to evaporation, is green and may remain green when concentrated to 54 percent strength if the entire acid stream is processed and if evaporation temperatures are not too high, all of the problems normally accompanying wet process acid use remain.

Ammoniation will precipitate iron, aluminum, magnesium and other metals as various phosphate compounds.

Post precipitation of iron and aluminum phosphates will occur as merchant acid is aged due to solubility relationships.

Of interest is that no problems have been encountered in production of DAP or Triple Superphosphate using green feedstock.

There is some indication that evaporator scaling may be less than with brown acid. Another benefit is that defluorination is more easily carried out with green acid if production of feed phosphates is undertaken.

Pregnant organic is stripped with a small stream of reduced phosphoric acid. The strip acid is about 1.5 percent of the main acid stream on a volume basis. Reduction is effected by adding iron metal to provide the proper amount of Fe^{+2} in the system.

Since DEHPA-TOPO has little affinity for U^{+4}, the presence of Fe^{+2} in the strip acid reverses the extraction reaction. The stripping of the organic is efficient and produces a substantial increase in uranium concentration. Usually, a 55-65 fold increase in U concentration is observed in the strip acid, compared to the main phosphoric acid stream. Therefore, the loaded strip acid will contain about 10-12 G/L of U_3O_8.

The loaded strip acid is oxidized and treated in a Secondary Extraction Circuit with DEHPA-TOPO. The operation is the same as in the primary circuit. However, the volumes involved are considerably smaller because of the higher concentration of uranium in the strip acid. The lean strip, minus most of its uranium content as it exits the Secondary Extraction Circuit, is returned to the feed end of the Primary Circuit.

In the secondary strip circuit, the pregnant organic is mixed with a dilute ammonium carbonate solution to remove the uranium from the organic, while the DEHPA is converted to an ammonium salt. A weak ammonium carbonate solution is used in order to avoid uranium precipitation in this circuit.

Barren organic is regenerated and returned to the secondary extraction circuit. Regeneration is accomplished using a mineral acid which supplies H^+ ions to the DEHPA, thus reconverting it to the acid form.

Loaded alkaline strip solution is next treated in a proprietary processing step in order to reduce the pH, remove CO_2 and prepare the solution for uranium precipitation. This step is extremely critical to the operation.

A continuous precipitation circuit is utilized in this proprietary system. Hydrogen peroxide is added to the preparedx strip solution, the pH is adjusted and uranyl peroxide, $UO_4 \cdot 2H_2O_2$ is precipitated.

The uranium slurry is clarified, washed, centrifuged, then dried. This technique results in a uranyl peroxide product of exceptional purity, since the peroxide route is quite selective for uranium under the conditions employed. The uranyl peroxide remains a bright yellow through the wash stage and the dried concentrate may be yellow, orange, red or brown depending on the product temperatures attained during drying.

As a general rule, the concentration of various contaminants in the final product is significantly below allowable limits established by the UF converters. X-ray fluorescences is one of the methods utilized to maintain quality control.

The outside of the refinery illustrates the care taken in the design stages. Structural steel is externally placed to provide smooth interior surfaces to facilitate washdown. Dried concentrates are loaded into steel drums through an automated filling system which can be operated from a separate control room.

With respect to radioactivity, most of the hazardous radionuclides, radium and its daughters, are removed from the process in the acid plant with the gypsum. The only problem in the uranium recovery plant is from dusting in the drying and packaging operations. Sophisticated methods to prevent the inhalation of dust by the workers and dust collectors to prevent its spread to outlying areas have been installed. Health monitoring procedures have been set up more stringent than the conditions and limitations specified by the State of Florida.

Uranium has been known for hundreds of years as a substance to impart color to glass and ceramics but it is only in this century (1939) that it was discovered to have the ability to release a fantastic amount of energy. Complete fission of U-235 produces 2.5 million times more heat when completely fissioned than the combustion of an equal weight of carbon in wood, coal, oil or natural gas.

The yellowcake as recovered from phosphoric acid is natural uranium containing 99.3 percent U-238 and 0.7 percent U-235. It must be further upgraded to produce fuel for nuclear reactors.

The complete New Wales facility has the capacity to process 2,000,000 pounds of U_3O_8 annuallya by receiving feed from two modules at nearby CF locatins as well as the acid produced on site. This can potentially furnish enough energy for the city of Chicago with some left over. It is a proven method to reduce dependency on imported oil and supplement energy supplies.

REFERENCES

(1) Cathcart, J. B., Uranium in Phosphate Rock, U.S. Geological Survey Open-File Report 75-321, Reston, Virginia (1975).

(2) Nielsson, F. T., Surber, J. H., IMC's Re-Entry into

the Field of Recovering Uranium from Wet-Process Phosphoric Acid, ACS, Las Vegas, Nevada (1980).

(3) Berry, W. W., Dubreuco, A., The IMC/Prayon Uranium Recovery from Phosphoric Acid Process, ISEC, Leige, Belgium (1980).

(4) Hurst; F. J., Crouse, D. J., Brown, K. B., Solvent Extraction of Uranium from Wet Process Phos Acid, ORNL Pub., ORNL-TM-2522, 1969.

(5) Shabbie, M., Tame, K. E., Hydrogen Peroxide Precipitation of Uranium, U.S. Bureau of Mines, Report of Investigations, RI 7931, 1974.

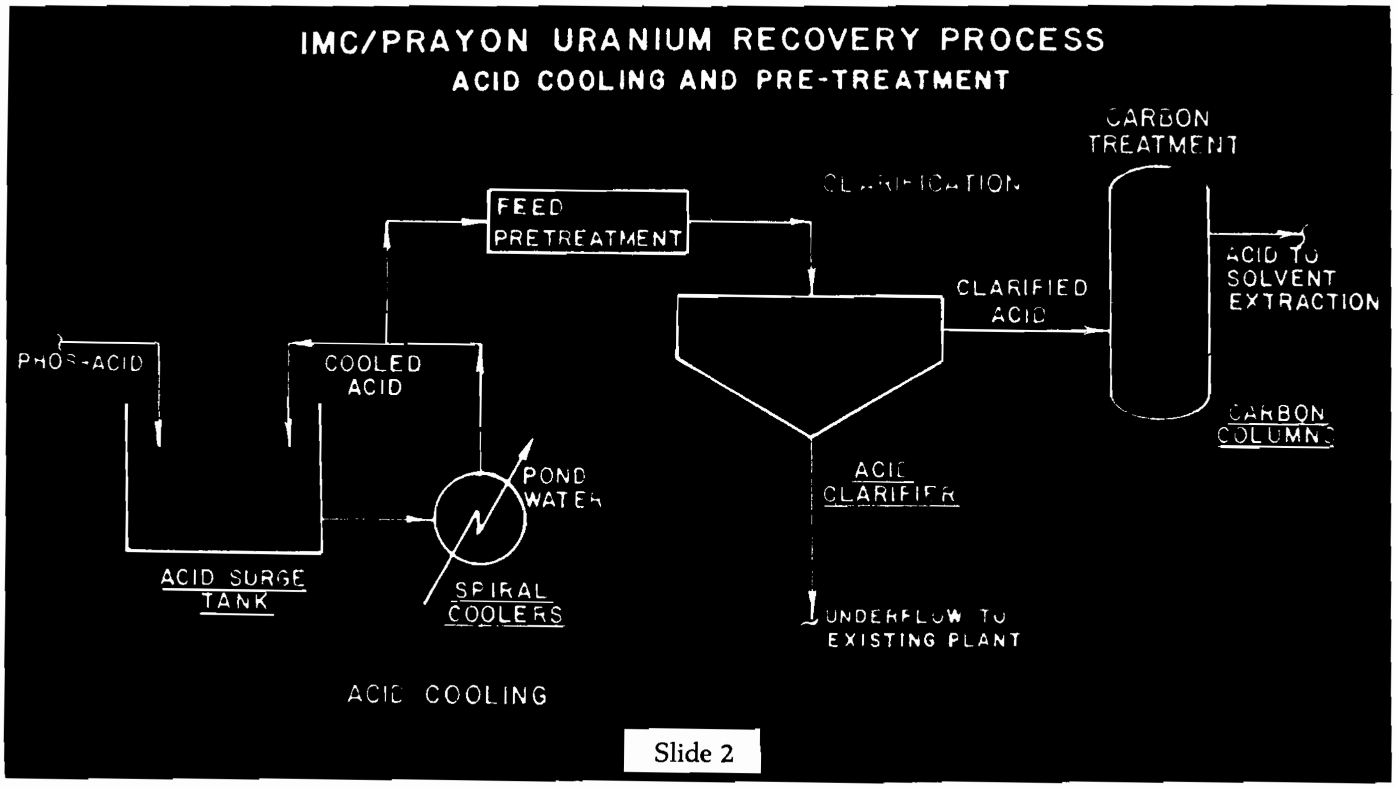
MARINE PHOSPHORITES RESERVES AND URANIUM CONTENT

LOCATION	RESERVES(1)	URANIUN AVERAGE		(CATHCART 1975) RANGE(2)
Central Florida	2.1 x 10^9	Concentrate	0.011	(0.003-0.030)
		Pebble	0.015	
North Florida — South Georgia	0.3 x 10^9		0.006	(0.004-0.011)
North Carolina	2.0 x 10^9		0.006	(0.004-0.011)
Idaho, Montana, Utah, Wyoming (Phosphoria)	6.0 x 10^9		0.009	(0.002-0.021)

(1) Tonnes recoverable product containing at least 24 percent P_2O_5

(2) Uranium in percent of phosphate product

Slide 1

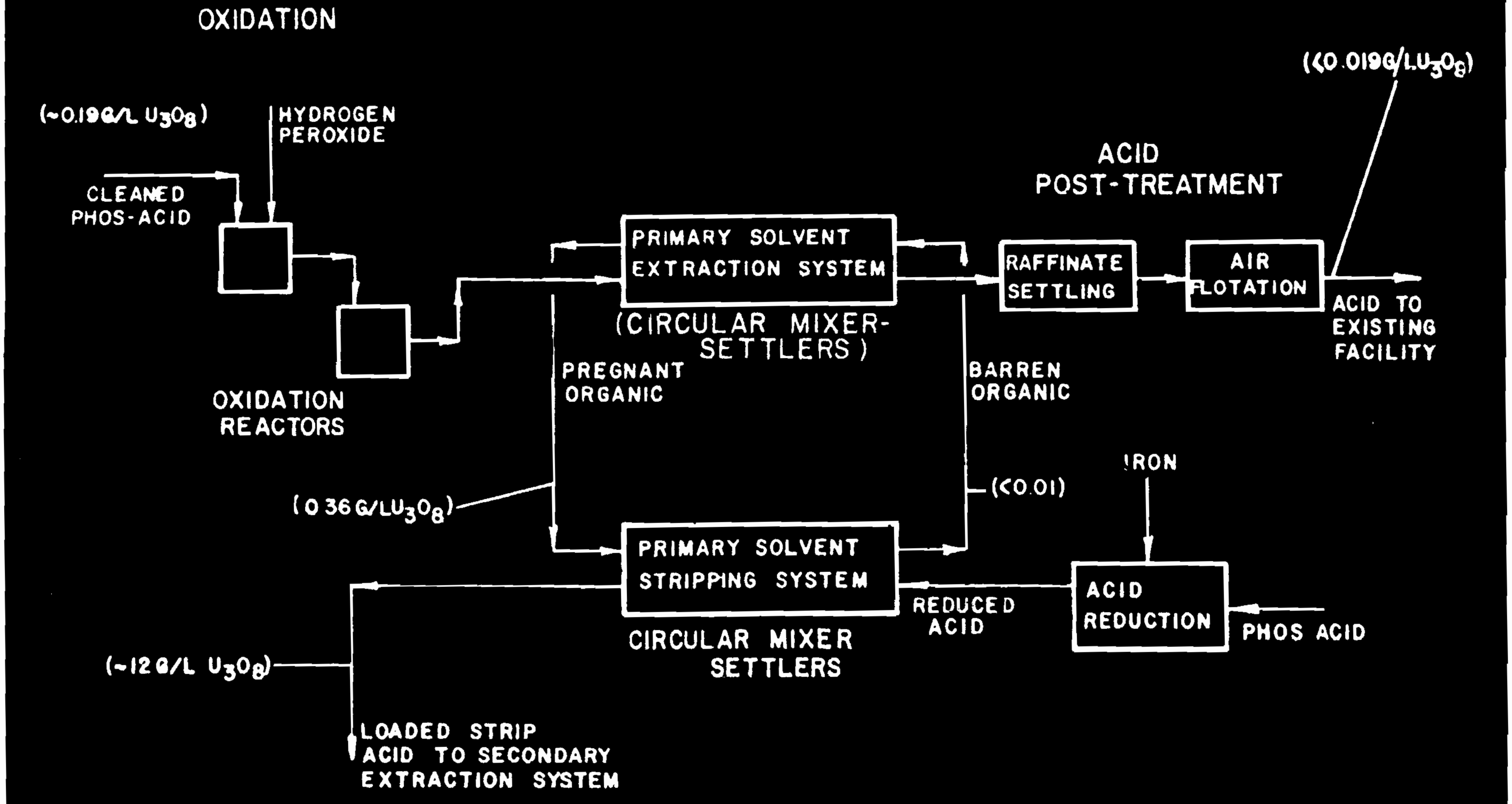


IMC/PRAYON URANIUM RECOVERY PROCESS

ACID COOLING AND PRE-TREATMENT

Slide 2

IMC/PRAYON URANIUM RECOVERY PROCESS
ACID OXIDATION, PRIMARY SOLVENT EXTRACTION/ STRIP AND ACID POST TREATMENT



OXIDATION

(~0.19G/L U_3O_8)

HYDROGEN PEROXIDE

CLEANED PHOS-ACID

OXIDATION REACTORS

(0 36G/LU_3O_8)

PRIMARY SOLVENT EXTRACTION SYSTEM

(CIRCULAR MIXER-SETTLERS)

PREGNANT ORGANIC

BARREN ORGANIC

(<0.01)

PRIMARY SOLVENT STRIPPING SYSTEM

CIRCULAR MIXER SETTLERS

(~12G/L U_3O_8)

LOADED STRIP ACID TO SECONDARY EXTRACTION SYSTEM

REDUCED ACID

IRON

ACID REDUCTION

PHOS ACID

ACID POST-TREATMENT

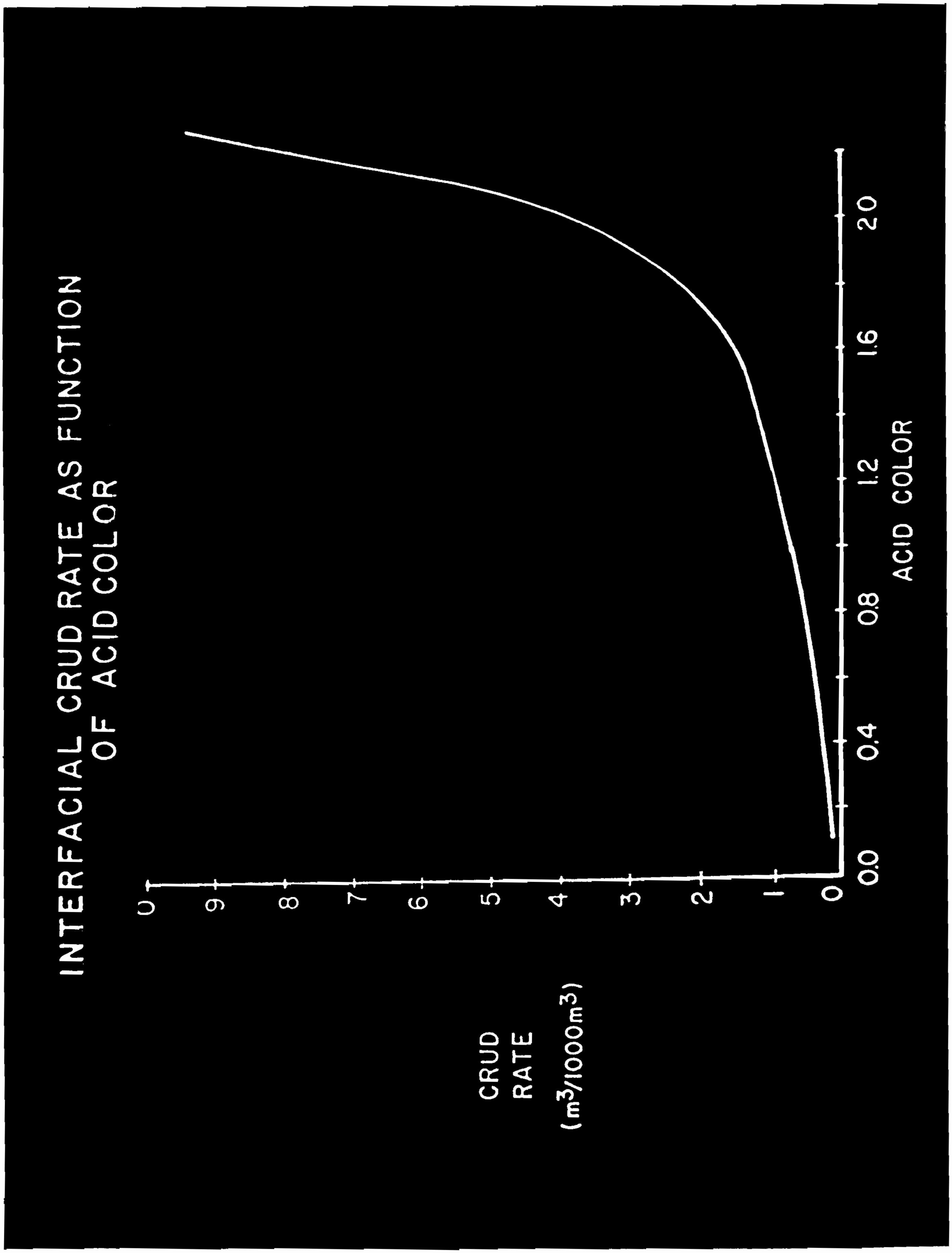
RAFFINATE SETTLING

AIR FLOTATION

(<0.019G/LU_3O_8)

ACID TO EXISTING FACILITY

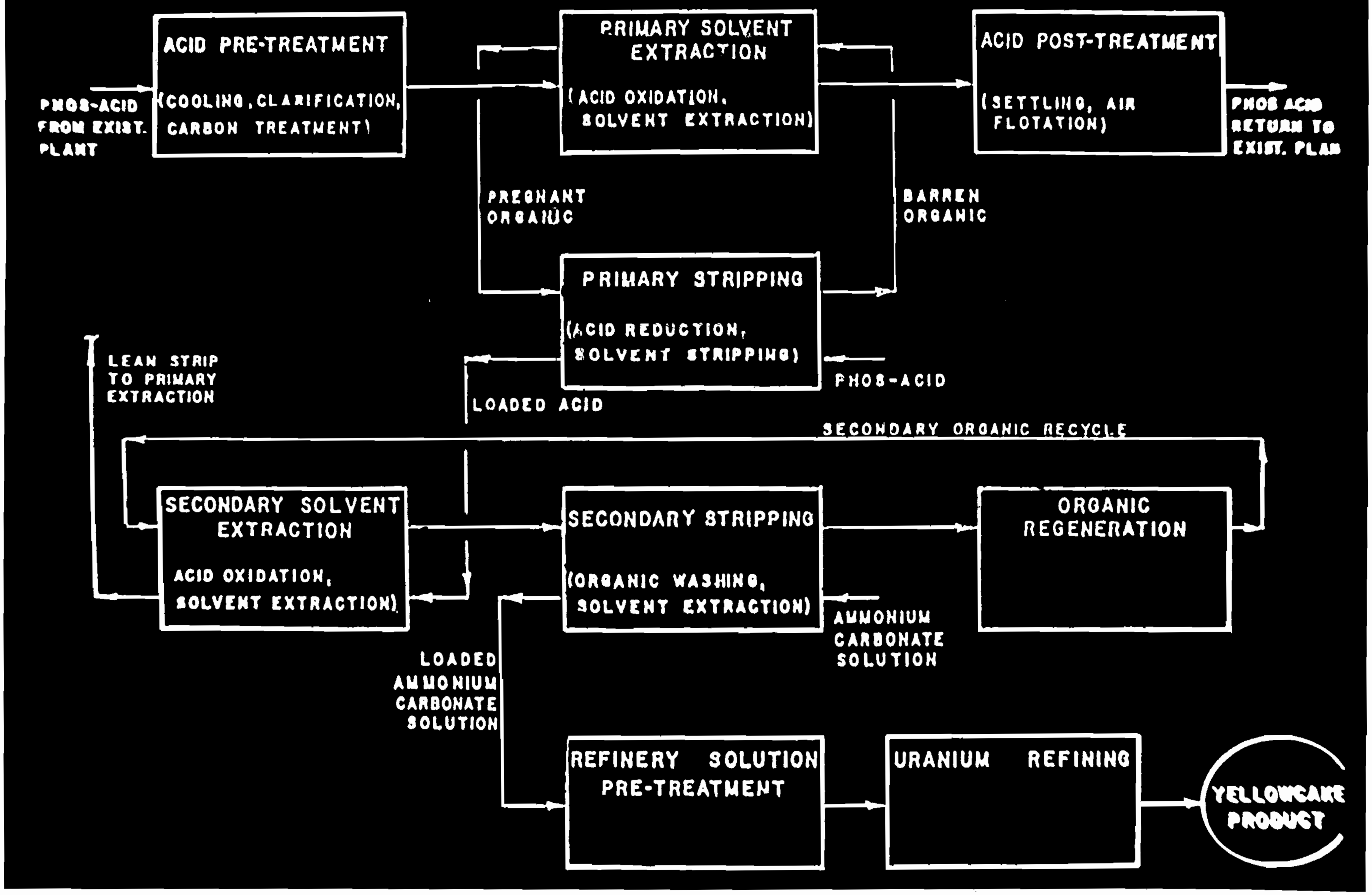
Slide 3


INTERFACIAL CRUD RATE AS FUNCTION OF ACID COLOR

Slide 4

IMC/PRAYON URANIUM RECOVERY PROCESS

OVERALL BLOCK DIAGRAM



PHOS-ACID FROM EXIST. PLANT

ACID PRE-TREATMENT (COOLING, CLARIFICATION, CARBON TREATMENT)

PRIMARY SOLVENT EXTRACTION (ACID OXIDATION, SOLVENT EXTRACTION)

ACID POST-TREATMENT (SETTLING, AIR FLOTATION)

PHOS ACID RETURN TO EXIST. PLAN

PREGNANT ORGANIC

BARREN ORGANIC

PRIMARY STRIPPING (ACID REDUCTION, SOLVENT STRIPPING)

PHOS-ACID

LOADED ACID

LEAN STRIP TO PRIMARY EXTRACTION

SECONDARY ORGANIC RECYCLE

SECONDARY SOLVENT EXTRACTION ACID OXIDATION, SOLVENT EXTRACTION)

SECONDARY STRIPPING (ORGANIC WASHING, SOLVENT EXTRACTION)

ORGANIC REGENERATION

AMMONIUM CARBONATE SOLUTION

LOADED AMMONIUM CARBONATE SOLUTION

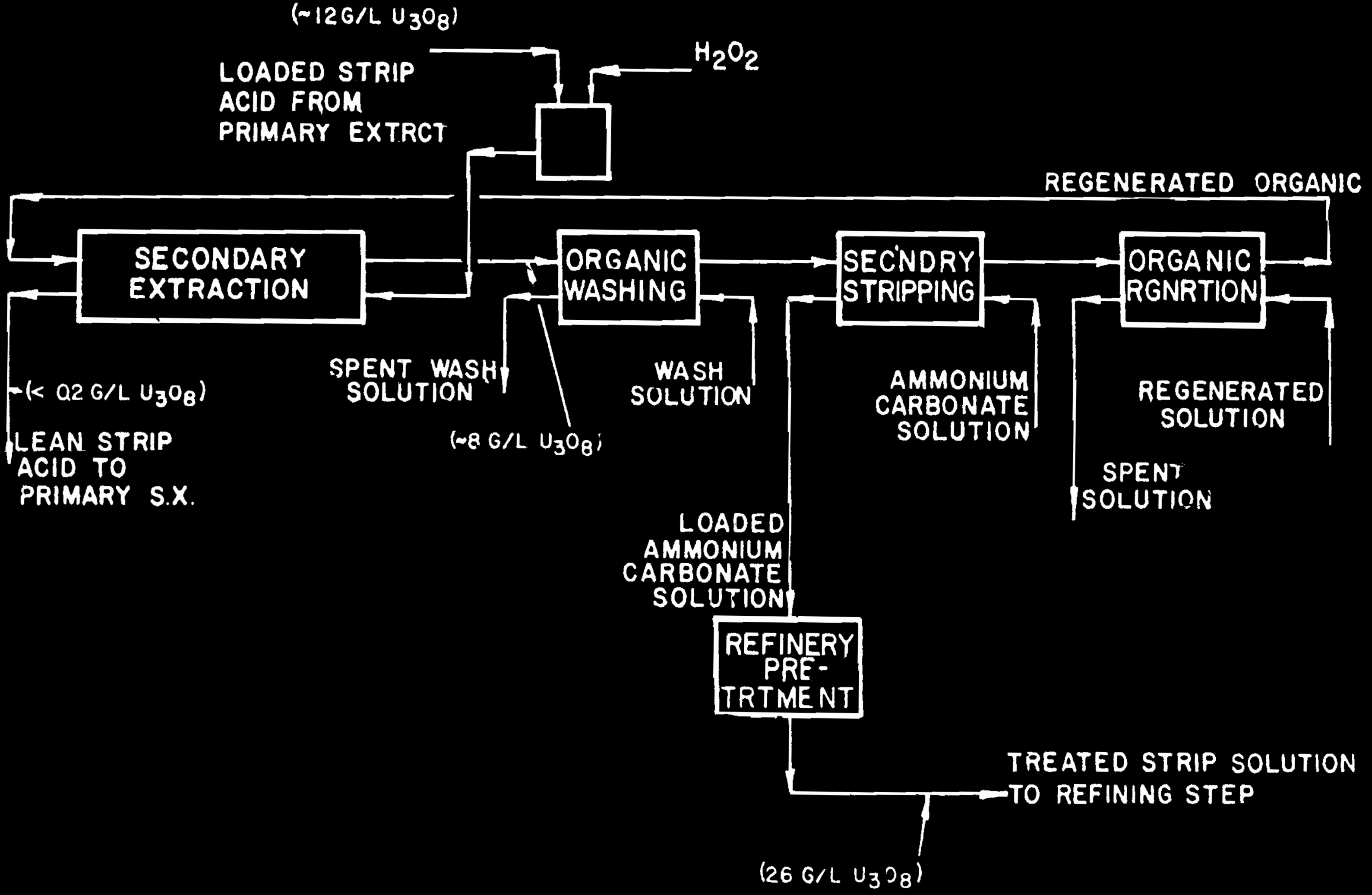
REFINERY SOLUTION PRE-TREATMENT

URANIUM REFINING

YELLOWCAKE PRODUCT

Slide 5

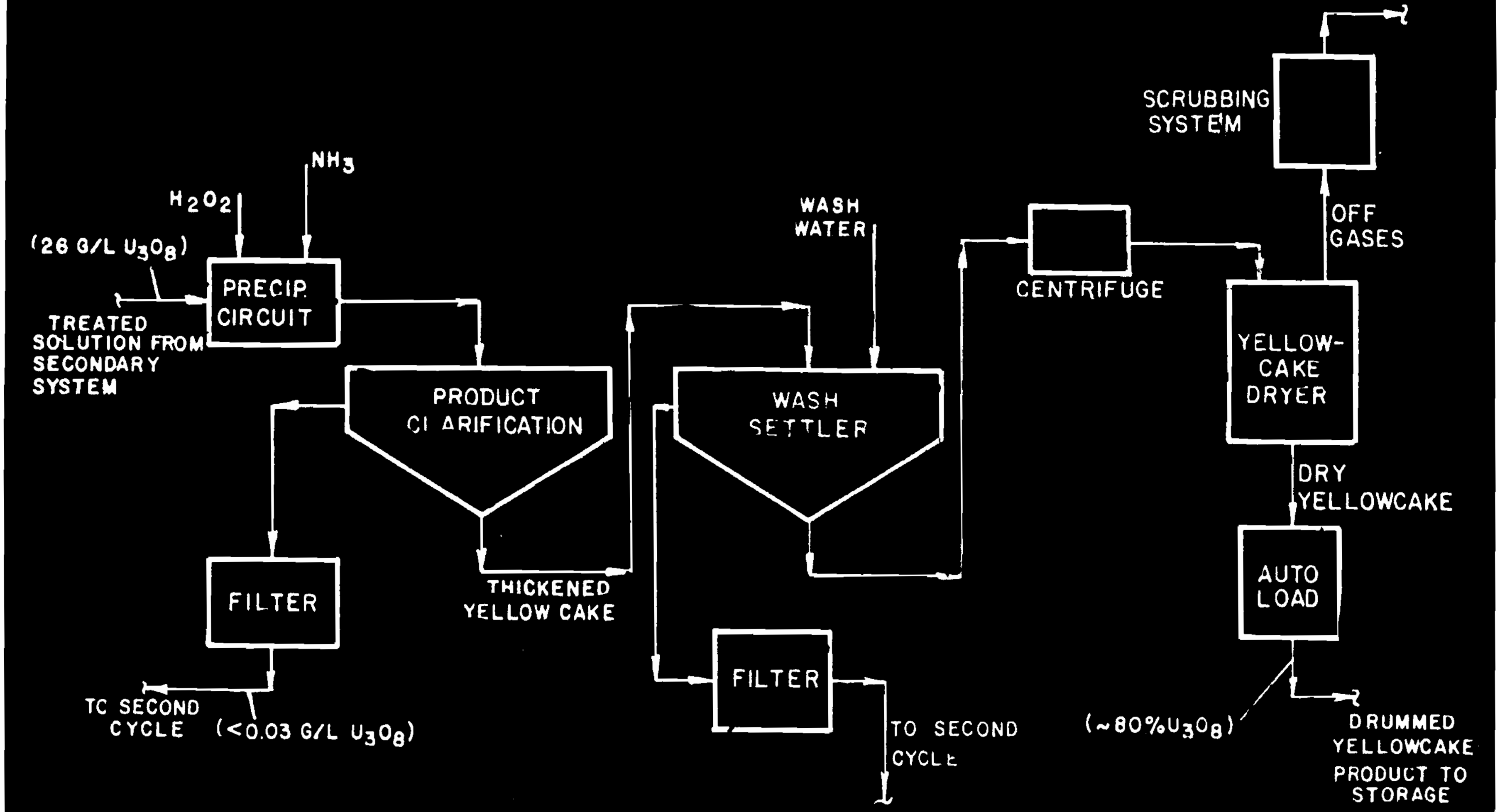
IMC/PRAYON URANIUM RECOVERY PROCESS
SECONDARY EXTRACTION/STRIP SYSTEM



Slide 6

IMC/PRAYON URANIUM RECOVERY PROCESS

URANIUM PRECIPITATION AND DRYING



Slide 7

MODERATOR THREADGILL: Thank you Ed White. (Applause)

We will entertain any questions that you may have.

QUESTION FROM THE AUDIENCE: You use carbon in the acid cleanup. Could you tell me what you do with the spent carbon? I understand it is regenerated and eventually will be discarded. What do you do with this material and how much is there?

ANSWER—ED WHITE: We have had some unpleasant and pleasant surprises. We use surprisingly little carbon. To answer your question "How do we dispose the spent carbon?" So far we just put this discarted material in a bunker and keep it. In the back of our minds we think we will grind the spent carbon up and add it here and there because powdered carbon is handy stuff. The quantity used so far is quite small. The balance just pile it up or burn it.

QUESTION FROM THE AUDIENCE: What is the magnitude of your solid losses and what do you think is the optimum recovery of uranium?

ED WHITE—ANSWER: I do not wish to comment on the first question. Answering your second question, a little over 90%. The primary solvent extraction is where, in a sense, most of your losses occur. More properly you just do not take it out of the acid. The rest of the ystem runs very tightly. Down the road, as we accumulate experience and a data base, we may well take it up or down a little.

QUESTION FROM JIMMY RABINOWITZ: "Negev Phophates: What level of organic solvent remains in the acid that you pump back into the plant? Is there any method of keeping the proper level in order so there will not be any effect on the rubber lining or on the concentrators?

ED WHITE—ANSWER: The organic level is typically about 20 to 30 parts per million. We reduce it by letting the acid settle, then the organic floats to the top. At this point most of it comes off. In the second stage we use floatation. Here we have a typical float cell which generates small bubbles of air. These bubbles rise through the acid and the organic attaches itselfd to it. The Preon People, Metallurgy Hobokon, also use activated carbon contact to remove organic. So far we have not encountered problems with this step. We have monitored quite carefully because we are concerned about attack on the rubber in the plant.

MODERATOR THREADGILL: Any other questions for Ed? Thank you. (Applause)

Out next Speaker will be discussing Occidental's Florida Hemihydrate operating experience. Lawrence E. Mercando is Vice President of Technology for the Agricultural Products Group at Hooker Chemical Co. He directs agricultural research and development activities and is responsible for the coordination of product and process technologies relevant to the manufacturing, distribution, application and agronomic effect of agricultural products. He is a graduate of Polytechnic Institute, of Brooklyn, with a B.S. in Chemical Engineering. His involvement with the Hemihydrate Process. Larry was responsible for technical and economic evaluations of process. Prior to the 1979 expansion he reviewed the process design during engineering of the commercial plant and is responsible for licensing of Occidental's Fertilizer Technology. Lawrence please. (Applause)

Occidental's Florida Hemihydrate Operating Experience

Lawrence E. Mercando

Contents

Background

Occidental developed a new hemihydrate phosphoric acid process in the early 1970's. The process was thoroughly investigated during a carefully planned development program which included bench scale testing, pilot plant development and demonstrations in a 350TPD[1] prototype plant. The development established the process requirements for a commercial operation and verified the following major advantages for the OXY hemihydrate process:

1. High strength acid and hence lower energy requirements to evaporate to final shipping concentration.
2. Lower capital costs.
3. Low agitation energy requirements in the reaction vessels.
4. Low impurities and low solids content in product acid.
5. Reduced consumption of sulfuric acid.
6. Proven ability to operate on Occidental's wet unground rock.
7. Good filtration rates.

Note 1: All tons are short tons (2,000 pounds per ton) unless otherwise stated.

Based on the success of the development program and consideration of the advantages listed above, the OXY hemihydrate process was included in Occidental's expansion program between 1975 and 1980 as indicated in the following tables.

P_2O_5

Year	TPY P_2O_5	Process
1966	220,000	Dihydrate
1975	440,000	Dihydrate
	110,000	OXY Hemihydrate
1979	550,000	Dihydrate
	110,000	OXY Hemihydrate
1980	550,000	Dihydrate
	510,000	OXY Hemihydrate

This paper will cover the pilot plant development program, process description, design and operation of both the 350STPD P_2O_5 and 1430TPD P_2O_5 OXY hemihydrate plants and the economic advantages of the process.

Pilot Plant Development

Development of the OXY hemihydrate process was started in the early 1970's when Occidental was evaluating various phosphoric acid processes for their expansion plans. The objective was to increase phosphoric acid production from 220,000 TPY P_2O_5 to over one million tons of P_2O_5 per year by 1980 using the best available technology.

The technical study, which included several existing phosphoric acid processes, concluded that the hemihydrate process was the most advanced technology available, particularly with respect to lower energy requirements. The available commercial processes, however, were not acceptable to Occidental because they suffered from disadvantages previously associated with hemihydrate technology, such as low filtration rates, scaling problems and corrosion problems. Occodental, through the Occidental Research Corporation, therefore, initiated a research and development program to develop a hemihydrate process which would eliminate these disadvantages.

The process was developed around fundamental crystallization theory taking into account such variables as crystal habit, size distribution, weight of crystals formed for each set of conditions, the number of crystals formed and rates of crystal formation and growth. It was soon discovered that highly filterable slurry could be produced with the correct liquid phase parameters, vessel volume ratios and with crystal habit and population control.

Most of the early work on the process was done in a one-tenth TPD pilot plant. This size is a convenient step up from bench scale operations without being so large as to require heavy equipment. Occidental has two pilot plants of similar size, which are used for testing various rocks and generating information for plant design. Data from the pilot plant showed that scale-up could be based on kinetic data without constraints imposed by the need for geometric and dynamic similarity. This leaves the designer with very wide scope in the choice of vessels, agitators and other equipment and a clear path to design for economic balance between capital and operating costs. This also means that existing phosphoric acid plants can be converted to the hemihydrate process and much of the existing equipment retained.

Process Description

The Occidental hemihydrate plants make 38-44% acid directly from wet, unground rock. A simple flow diagram of the reaction system is illustrated in Figure 1.

The wet unground rock is weighed and fed in the slurry tank where it is mixed with recycle acid from the filter. Strong agitation and sufficient retention time allow much of the carbon dioxide in the rock to be removed at this state. Defoamer is added as necessary.

The still reacting monocalcium phosphate slurry from the slurry tank flows by gravity into the dissolver. Rock dissolution is largely completed in this vessel. The dissolver is a single agitator draft tube reactor.

Slurry is pumped from the dissolver into the crystallizer, also a single agitator draft tube reactor, which is kept under vacuum. Sulfuric acid is added to this reactor to complete the formation of the calcium sulfate hemihydrate crystals ($CaSO_4 \cdot \frac{1}{2}H_2O$). A proprietary crystal modifier is added, as necessary, at this stage. Process heat is extracted from the crystallizer by vacuum evaporation. Slurry is circulated between the two reactors at a rate which controls two distinct sulfate levels.

From the crystallizer, the hemihydrate slurry goes into a filter feed tank, which acts as a process surge tank as well as a holding tank during start-ups and shutdowns. Slurry filtration is conventional, with rates equal or exceeding hemihydrate. Three counter-current washes are used. In Occidental's plants pond water is used to start these washes. The hemihydrate cake is sluiced with water and pumped to the pond where it provides a suitable diking material. Dewatering rates are better than observed with dihydrate cakes.

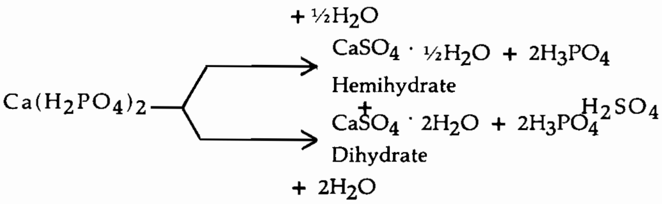
The process can be equipped to recover fluosilicic acid from the crystallizer vapors using conventional recovery equipment. This is possible because vapor velocities in the crystallizer are much lower than those in dihydrate process flash coolers and entrainment is correspondingly lower.

The basic reactions of both the hemihydrate and the dihydrate routes are essentially the same. Both go through a rock dissolution step followed by a crystallization step.

In the dissolution step the phosphate rock (apatite) is reacted with phosphoric acid to form monocalcium phosphate:

$$Ca_{10}F_2(PO_4)_6 + 14H_3PO_4 \longrightarrow 10Ca(H_2PO_4)_2 + 2HF$$

In the crystallization step the monocalcium phosphate reacts with the sulfuric acid to form either the hemihydrate crystals or the dihydrate crystals:



$$Ca(H_2PO_4)_2 \xrightarrow{+\frac{1}{2}H_2O} CaSO_4 \cdot \tfrac{1}{2}H_2O + 2H_3PO_4 \text{ (Hemihydrate)}$$

$$Ca(H_2PO_4)_2 \xrightarrow{+2H_2O} CaSO_4 \cdot 2H_2O + 2H_3PO_4 \text{ (Dihydrate)}$$

$$+\ H_2SO_4$$

Which of the hydrates will form depends on the temperature and the concentration of the phosphoric acid. Higher acid concentration (38-52% P_2O_5) and elevated temperature favor the formation of the hemihydrate. This is precisely why the hemihydrate route produces the desirable high strength acid.

Until successfully resolved by Occidental, the hemihydrate crystallization step often resulted in:

- Poor crystal size distribution and shape, which in turn resulted in poor filtration rates and the need for oversized, expensive filters.
- Unstable crystals, which caused filter cake conversion and high scaling rates, which required frequent shutdowns for cleaning.

These limitations were overcome by the application of modern crystallization theories. The relations between process variables and the crystallization parameters that affect plant performance, such as crystal size distribution, crystal shape and stability were determined both on the laboratory and the pilot plant. Advanced crystallization kinetics techniques, such as population balance, were used extensively to determine crystal nucleation and growth rates on which crystal size distribution critically depends.

Occidental's ultimate success is due to establishing methods for achieving optimum crystallization conditions by controlling process variables. It was determined that the best control can be achieved by conducting the basic dissolution and crystallization steps in separate vessels. Proper design of these vessels is important. Additional control of the crystallization is obtained by the use of a proprietary crystal modifier.

The control parameter established for the process permit the reaction and formation of highly filterable crystals to occur under conditions where less sulfuric acid is required than experienced with dihydrate processes. The lower sulfuric acid requirements, which have been repeatedly demonstrated in the laboratory, pilor plant and both commercial plants, is principally due to the following contributions:

- 2% free sulfate in 42% hemihydrate acid compared to 2.5% normally contained in 28% dihydrate acid (equivalent to 3.25% in 42% acid).
- Higher P_2O_5 losses experienced in the hemihydrate process due to unreacted rock and lattice bound P_2O_5 results in correspondingly lower sulfuric acid consumption. P_2O_5 losses are, therefore, partially compensated for by the equivalent savings in sulfuric acid usage.
- Lower solubilization of rock impurities, particularly aluminum, thereby reducing sulfuric acid consumption.

The net result is that the sulfuric acid requirements of the OXY hemihydrate process are less than 100% stoichiometric to the calcium in the rock feed.

Four U.S. patents and many foreign patents have been issued on the process and special equipment designed for the process; many other patent applications are pending. The patented entrainment separator, used in vacuum service on the crystallizer and the table filter, has proven effective and reliable.

350STPD P_2O_5 Plant

Plant Design

The first expansion in 1975 was planned to increase the capacity at the original Suwannee River Chemical Complex from 220,000TPY to 550,000TPY P_2O_5. This expansion included building a 350TPD prototype plant. However, since the OXY hemihydrate process had not been commercially proven, a large conventional dihydrate plant was installed at the same time in order to provide the major portion of the required additional production.

The prototype production plant was designed for 350TPD P_2O_5. i.e. approximately 3,500:1 scale-up from the pilot plant. It was designed to run on unground calcined rock. However, well into the engineering of the plant calcination was abandoned, mainly because of rapidly rising fuel cost. Over the next two years, major improvements were made, primarily involving pumping and agitation equipment.

The first main engineering revision was to rework the pump and piping system that move slurry between reactor vessels. One pump was eliminated entirely by raising the slurry tank above the dissolver. A major problem was selection of a pump that would handle the gaseous crystallizer feed slurry, since gas quantities were not accurately known. Occidental has since developed new methods and mathematics for calculating pressures in aerated slurries, which enabled close specifying of operating conditions for the pumps in the Swift Creek plant. The large size of these pumps, which had never previously been used in aerated slurry duty, made it difficult to predict actual performance. However, the performance of these pumps has been entirely satisfactory in both production size plants.

Selection of materials of construction posed new problems in wet process manufacturing because of the higher temperatures which exceed 200°F. Different conditions in each vessel are taken into account when specifying materials, and in some cases special fabrication techniques are required. Welding of high grade alloys is one example.

The plant was built with an oversize filter to accommodate possible process improvements and throughput increases. In 1978, the original tilting pan filter was reassigned to the adjacent dihydrate plant and a new smaller table filter was added. The table filter was sized after an intensive investigation of filtration rates during a comprehjensive two month plant test in 1977.

Operations

The 350TPD OXY hemihydrate plant was initially started up in 1975. After incorporation of modifications previously discussed, it was conclusively demonstrated in a special two month test in 1977. Details of this test were published in a paper delivered by Dr. Fernando Ore to the British Sulfur Institute in November 1979. The test consisted of a 44 day run, followed by a 10 day production run. Provisions were made to assure uninterrupted supply of raw materials, and additional tankage and samples were used for more accurate determination of plant performance. The plant was started in the hemihydrate mode using a new startup procedure at 105-s, tons p.d. P_2O_5 rate. The filter was lined out within two hours of startup and within 48 hours the design rate of 350 s. tons p.d. was achieved without any problems. A summary of the plant performance for the 44 day and 10 day operations is presented in the following table.

HEMIHYDRATE PLANT TEST

	44 Day Test	10 Day Test
Rock fed, s. tons	40,346	11,485
P_2O_5 fed, s. tons	12,956	3,708
P_2O_5 in acid produced, s. tons	11,790	3,447
H_2SO_4 used, s. tons	32,042	8,839
Sulphuric acid usage, tons/ton P_2O_5	2.72	2.60
Rock usage, tons/ton P_2O_5	3.42	3.43
P_2O_5 recovered, % (based on 42% acid inventory)*	91.00	93.00
Operating factor, %	83.50	99.00
Downtime, external	1.90	0.31
Downtime, process	6.60	——
Downtime, mechanical	8.00	0.65

*This recovery at 42% P_2O_5 acid concentration is comparable to that of the dihydrate process when the losses incurred in the necessary additional steps of evaporation and clarification, that are required to bring the 28% acid to the 42% level, are taken into account.

Following the test, there were some mechanical problems still unresolved and intensive work in the first few months on 1978 led to modifications that overcame these difficulties. 1979 was the first year of dedicated production for this plant and it achieved 95% of its production goal. During 1979, the maximum instantaneous rate was increased to 525TPD. Most of the production from this plant goes into granular products, without any further treatment other than passing through a raked surge tank. Hemihydrate acid is highly desirable in the granular plants because of its lower impurities, enabling better grade control and longer operation between clean-outs.

The following table summarizes the production achievements of the plant in 1979:

350STPD P_2O_5 PLANT OPERATIONS

Start of Full Commercial Operation	December 1978
Maximum Design Rate	350STPD P_2O_5
Planned Rate	350STPD P_2O_5
1979 Budget Production	110,000 STons P_2O_5
1979 Actual Production	105,000 STons $P_2{}^{\circ}{}_5$ (95%)
Average Rate	425STPD P_2O_5
Maximum Rate achieved	525STPD P_2O_5
Acid Quality	Highly desirable

1430STPD P_2O_5 PLANT

Plant Design

In 1979 a "grass roots" expansion at Swift Creek was made to increase the overall production capacity from 660,000TPY P_2O_5 to more than 1,000,000TPY P_2O_5, with the new production capacity providing the bulk of the SPA required for the Russian Project. The importance of this project and the criticality of the phosphoric acid operation to the project required that Occidental produce a high quality acid at minimum cost. The eventual success of the Occidental 350TPD hemihydrate plant at Suwannee River led to selection of the OXY hemihydrate process for the 1,430TPD plant, which came on stream— in November 1979.

When the Swift Creek plant was conceived, the limiting factor for a single train unit was the size of a draft tube agitated vessel, in this case the dissolver. So the design proceeded with two dissolvers with one crystallizer. This concept was checked in the pilot plant and, as expected, gave a higher recovery than the single dissolver concept. But, engineering studies showed that the use of two crystallizers with two dissolvers improved the plant layout. This situation became more visible on a scale model built as engineering proceeded. At this stage, with some equipment problems still unresolved, and several months into the engineering, the decision was made to change from the single train concept to a single split train reaction system feeding a single filter.

Each side of the split train is approximately twice the size of the 350TPD plant. Dissolvers are 35 ft. in diameter, crystallizers 26 ft. The free surface to volume ratios were optimized; in the case of the crystallizers, this gives vapors velocities much lower than those in dihydrate process flash coolers and entrainment is correspondingly lower. This increases the attractiveness of fluosilicic acid recovery from the crystallizer vapors. The Swift Creek Ucego filter was purchased before the smaller model at Suwannee River was brought on line, and as it turned out, before the nameplate capacity was finally established. Since the installation of the Size 7 Ucego at Suwannee River, the standard operating rate has gone up to 500TPD being maintained for long periods without the filter limiting throughput. By comparison, the 1430TPD Swift Creek plant is expected to be capable of at least 1,800TPD on the Size 12 filter, and has operated at rates in excess of 1700TPD.

Operation

The 1430TPD plant was started up in November 1979. The first month of operation, using only one reactor, had its share of normal start up problems, but the operation was very smooth. Plant rates of up to 900TPD, more than 25% over design, were achieved. The second reactor was brought on line in December. As familiarity with the system was achieved, rates were gradually increased, exceeding 1700TPD. Production in 1980 is indicated in Figure 2, 1980 Production Schedule for Swift Creek Hemihydrate Plant.

Occidental's new Swift Creek Complex is unique in that it was designed to produce SPA as the only phosphate product. Since the U.S. Government's embargo on phosphate sales to Russia, Swift Creek has produced merchant grade acid, bypassing the SPA process. There is no requirement for supplemental steam and the complex generates much of its own electricity, largely made possible by the high strength of hemihydrate acid. The product acid is pumped to one of two agitated storage tanks. Clarification equipment was installed for use prior to evaporation, but is often bypassed because of high clarity of the hemihydrate acid.

Cost savings are realized by the use of wet, ungroun phosphate rock from the adjacent beneficiation plant. Control of the process, due to moisure variations, has not been a significant problem to date. Hemihydrate gypsum stacking characteristics, which were unknown prior to the Swift Creek plant, have been favorable in that the solids dewater much more rapidly than conventional gypsum and provide suitable diking material.

Operation of the Occidental hemihydrate plants is basically continuous except for a scheduled shutdown one day per week for approximately 12 hours. Such weekly shutdowns are practiced by Occidental in all their phosphoric acid units and are essential to maintaining the plants in good operating condition for continuous production throughout the entire year. During this time, the system is washed with water from the cooling pond and routine maintenance is forformed. Normal maintenance includes replacement of older filter cloths, inspection and cleaning (if required) of the filrate and gypsum disposal systems, and performing preventive maintenance.

Scaling of equipment and pipelines has been extremely low. About every six weeks, a slight scale buildup is removed from the filtrate pipes, and a small growth of scale on the filter table is removed about every four months. The low scaling is due to the nature of the process, and the use of a sufficient supply of flush water to keep solids washed into the gypsum system.

Piping and equipment in the reaction section remain virtually free of scale. The only line which has an installed spare for washing while the plant is in operation is the filter feed line. Most of the reactor circulation piping continues circulating slurry when the plant is shut down, and remains unwashed between major reactor cleanings.

The reactors are scheduled for a routine shutdown every four months. During this time the vessels are inspected and cleaned if necessary. Agitators and circulating pumps receive preventive maintenance and pipelines are cleaned as needed. The normal shutdown time for a reactor is five days, including draining and filling.

Most of the rotating equipment, such as pumps and agitators, operate at very low speeds, so there is almost no wear due to solids abrasion. Mechanical seals for centrifugal pumps are used to the maximum extent possible to minimize slurry dilution from seal water.

Operation of the pilot plant and two commercial plants has demonstrated that the process is simple, reliable and easy to control. This is attributed to the fact that the operation ranges on key variables (e.g. specific gravities, temperature, SO_4) are wider than for gypsum processes, and the process responds much faster because there is complete control of slurry flows, slurry composition and sulfate and temperature gradients in each reaction vessel.

Economics

Basis for Process Selection

The recommendation and decision to select the OXY hemihydrate process in preference to some of the best known dihydrate processes for Occidental's expansion at the Swift Creek site in White Springs, Florida, was not made until an extensive economic evaluation was made.

In the first quarter of 1978 a detailed comparison of the potential production costs of the OXY hemihydrate process was made with other dihydrate processes. It was recognized that determination of production costs based on claims made for the various processes could be misleading since such claims are usually made for operation under controlled conditions, with selected raw materials and with maximum supervision. In addition, Occidental planned to process wet, unground rock and utilize techniques for establishing P_2O_5 recoveries which, although considered realistic, usually indicate P_2O_5 recoveries which are lower than those indicated by more conventional methods. In order to prevent the comparison of misleading data, primary consideration was given to the comparison of production costs established on the basis of actual results from Occidental's operating plants at Suwannee River. Production of phosphoric acid in this chemical complex was achieved in two dihydrate plants and the 350TPD OXY hemihydrate plant.

The actual differences in commercial plant operating data from one of the dihydrate plants and the OXY hemihydrate plant, under similar operating conditions and using similar unground phosphate rock feed, is presented in Table 1. Based on this data the projected differences in production costs were projected for the new larger phosphoric acid plant proposed for the 1979 Swift Creek expansion using local U.S. market prices for raw materials.

The comparison shown in Table 1 indicated that Occidental could produce 42% P_2O_5 acid from an OXY hemihydrate plant at a cost of $9.36 per ton P_2O_5 less than the cost of producing 42% acid from a dihydrate plant including the necessary evaporation step. This is equivalent to a cost reduction of $4,150,000 per year when producing 443,300TPY P_2O_5.

With respect to the raw material requirements, the results indicated that the cost reductions from lower sulfuric acid consumption more than offset the higher consumption of phosphate rock and defoamer. The main cost advantages of the OXY hemihydrate process are evident when comparing utility requirements and the credit for power which can be generated from the additional steam made available by producing 42% P_2O_5 acid rather than 28% P_2O_5 acid.

It should be noted that the Swift Creek expansion plans included the production of sulfuric acid and, therefore, generation of steam in a fuel fired boiler was not required with either a dihydrate plant or a hemihydrate plant. The complex design included a power generation plant which would generate electrical power from all excess steam produced in the sulfuric acid plant and not used in the fertilizer complex. Therefore, the lower steam requirements for the OXY hemihydrate plant result in making more steam available for the power generation plant. The credit of $4.80 per ton of P_2O_5 indicated represents the extra power which can be generated from this additional steam.

Current Production Cost Evaluation

Occidental has gained much operating experience with its two commercial hemihydrate plants since the extensive technical and economic evaluation was made in 1978. Since the evaluation was made, the 350TPD hemihydrate plant has been in operation for an additional two (2) years and the new 1430TPD plant has been in operation since November 1979.

It is interesting to compare the results of the 1978 projected production cost differences between Occidental's dihydrate and hemihydrate plants with the current operation. The production cost comparison, based on current operating data, is shown in Table 2. The comparison indicates that, based on present operating results and updated raw material costs, Occidental is capable of producing 42% P_2O_5 acid from the OXY hemihydrate plant at a cost of $11.89 per ton P_2O_5 less than it would have cost from producing 42% acid from a dihydrate plant including evaporation from 28% P_2O_5 to 42% P_2O_5. The yearly savings at a production of 443,300 TPY P_2O_5 would be $5,270,000.

The larger savings of $11.89 per ton P_2O_5, compared to the $9.36 per ton P_2O_5 projected in 1978, is primarily due to relative changes in the cost of raw materials and utilities. Operating performance of the plants with respect to raw material and utility requirements were very close to what was projected in 1978.

The rock cost advantage shown for the dihydrates process is a result of higher P_2O_5 recoveries experienced in commercial operations. Based on Occidental's experience and the present status of the hemihydrate operation, it appears that the difference in P_2O_5 recoveries is approximately 2.5%. We are confident that with further experience in the operation of the commercial plants and incorporation of planned technological improvements the recovery of the existing OXY hemihydrate plants will be improved to within 1% of the best dihydrate processes.

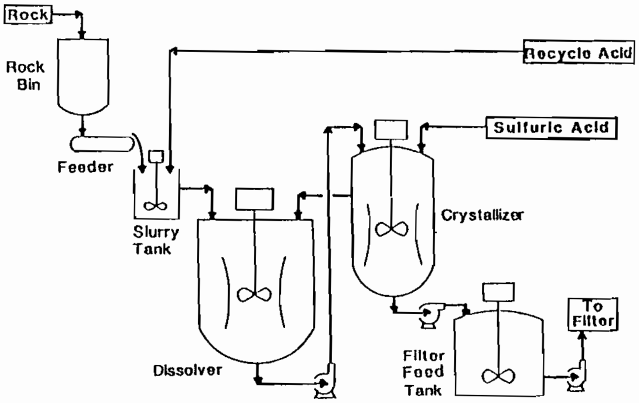
The comparison in costs indicates that the lower sulfuric acid requirements of the hemihydrate process more than offset the effect of lower P_2O_5 recoveries. An evaluation of escalating costs for sulfuric acid and rock, as shown in Figure 3, reveals that changes in the sulfuric acid cost will have a greater effect than corresponding changes to the rock costs. For example, if the rock cost increases by 20%, it would favor the dihydrate production costs by an additional $0.53 per ton P_2O_5. A corresponding increase of 20% in sulfuric acid cost, however, improves the cost advantage of hemihydrate by $1.18 per ton P_2O_5. In reality the price of sulfuric acid has increased at a greater raste than rock during the past several years.

The rapid rise in electric power costs and fuel costs during the past two years and expected continued increase in energy reinforce the justification for selecting a low energy process such as the OXY hemihydrate process. For example, the cost of electric power has increased by more than 30% from 3.4 cents per KWH to 4.5 cents per KWH. The resulting savings from electric power which can be made from additional steam made available from the hemihydrate process is thus increased from \$4.80 per ton P_2O_5 to \$6.35 per ton P_2O_5. The sensitivity of this cost saving to electric power cost is shown in Figure 4.

It is were necessary to continuously produce makeup steam in a boiler, the credit for additinal steam made available from the OXY hemihydrate plant would be substantially more. At the current price of fuel the cost of generating 100PSIG steam in an oil fired boiler is approximately \$6.00 per thousand pounds of steam. Based on this value, the difference in production cost established by Occidental for its dihydrate and hemihydrate plants would be increased from \$11.89 per ton P_2O_5 to \$19.45 per ton P_2O_5.

The effect of oil prices on the potential savings from the lower stream requirements of the hemihydrate process for producers who must operate boilers to meet their steam requirements is indicated in Figure 5. The savings at an oil price of \$25 per barrel is approximately \$11.60 per ton P_2O_5 compared to a savings of \$16.25 per ton P_2O_5 at a price of \$35 per barrel.

Occidental is proud of the success of its two commercial hemihydrate plants and feels the development and selection of this process provide maximum protection against continuing rapid rises in sulfur and energy costs. Occidental's 350TPD plant, the largest hemihydrate unit of its time, was a daring innovation in the mid seventies. Its 1430TPD plant is the forerunner of wet process technology for the eighties. The installation of these plants assures Occidental of a strong marketing position for many years in an industry to be highly competitive.



Occidental Hemihydrate Process - Reaction Section

Figure 1

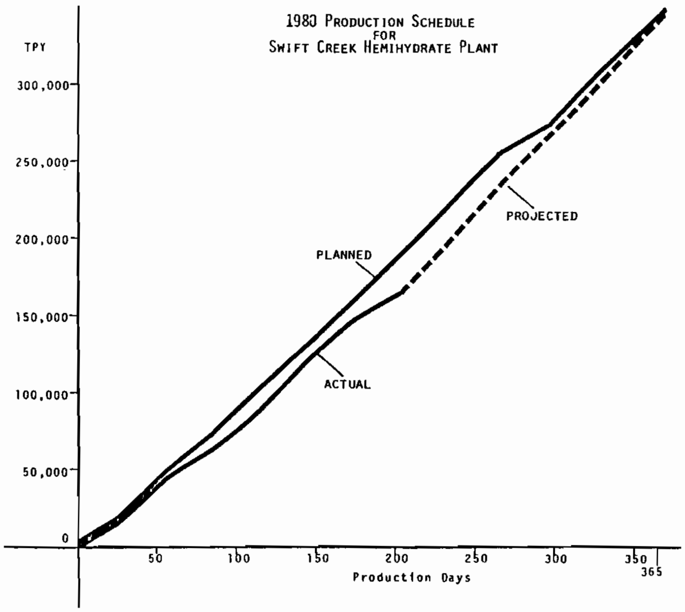


Figure 2

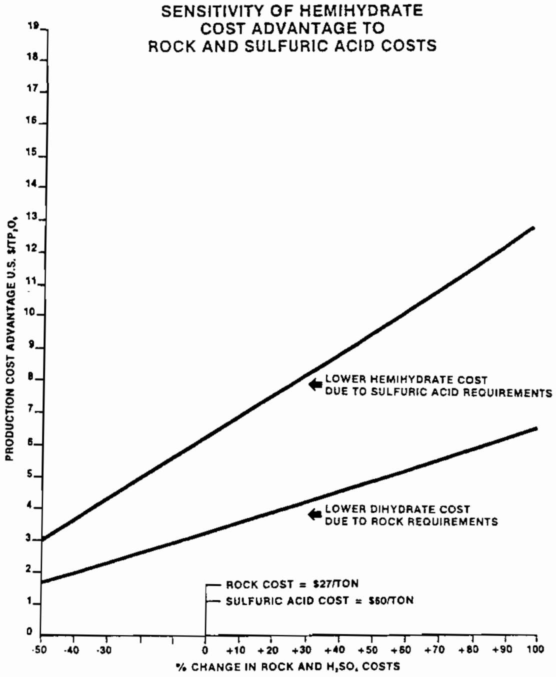


Figure 3

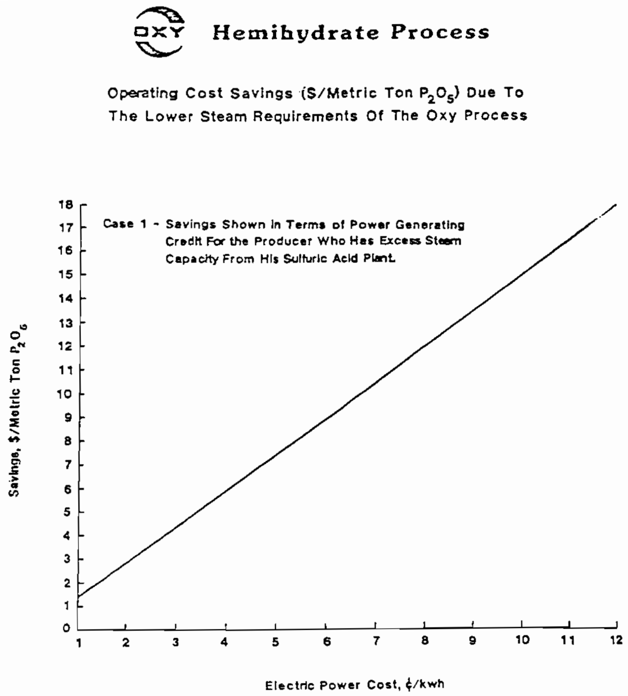


Figure 4

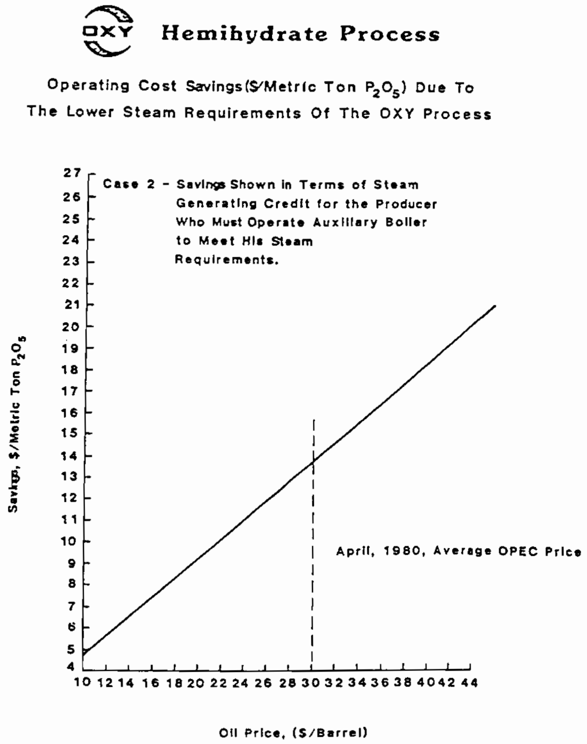


Figure 5

Projection in 1978

PRODUCTION COST FOR 1430STPD P_2O_5

HEMIHYDRATE (42%) vs. DIHYDRATE (CONC. TO 42%)

	Difference in Requirements		Cost Savings Projected for Hemi $/T P_2O_5
	Hemi Advantage	Di Advantage	
Phosphate Rock T/T P_2O_5 ($20.00/T)	---	0.127	(2.54)
Sulfuric Acid T/T P_2O_5 ($40/T)	0.169	---	6.76
Defoamer & Modifier #/T P_2O_5	---	8.500	(2.01)
Power KWH/T P_2O_5	19.500	---	0.66
Process Water Gal/T P_2O_5	2,500	---	0.26
Depreciation, Taxes, Insurance	---	---	1.43
Credit for Power Generated from Additional Steam (#/HR)	138,000	---	4.80
Projected Savings for Hemihydrate			$9.36/T P_2O_5
Projected Yearly Savings at 443,300 TPY P_2O_5			$4,150,000

Table 1

Experience in 1980

PRODUCTION COST FOR 1430STPD

HEMIHYDRATE (42%) vs. DIHYDRATE (CONC. TO 42%)

	Difference in Requirements		Cost Savings Due to
	Hemi Advantage	Di Advantage	Hemi - \$/T P_2O_5
Phosphate Rock T/T P_2O_5 (\$27/ton)	---	0.098	(2.65)
Sulfuric Acid T/T P_2O_5 (\$60/ton)	0.098	---	5.88
Defoamer & Modifier #/T P_2O_5	---	8.500	(1.29)
Power KWH/T P_2O_5	35.060	---	1.58
Process Water Gal/T P_2O_5	4,000	---	0.59
Depreciation, Taxes, Insurance	---	---	1.43
Credit for Power from Additional Steam (#/HR)	138,000	---	6.35
Savings for Hemihydrate			\$11.89/T P_2O_5
Yearly Savings at 443,300TPY P_2O_5			\$5,270,000/Year

Table 2

MODERATOR THREADGILL: Thank you Lawrence. (Applause)

MODERATOR THREADGILL: As you know, our industry is an Energy Sensitive Industry. I am sure that you ave questions dealing with this. I have had a lot of comments in regard to this paper so I will entertain any questions at this time.

QUESTION FROM ROGER RIBAS—BROWN AND ROOT: When you say that you have grown a crystal, and the picture shows an agglomerate, could you specify a little bit more. Are we actually also growing the individual crystals that form the agglomerate, or the ability consists of making an agglomerate itself?

ANSWER—LAWRENCE E. MERCANDO: Really, we do not consider it to be an agglomerate. We consider it to be a raspberry like crystal. We consider them to be individual crystals. We purposely get a distribution of sizes to allow us to grow different size crystals and to help our filtration.

QUESTION FROM—ROBERT L. SOMMERVILLE: You certainly are to be congratulated on developing, perhaps, the first of the American Phosphoric Acid Processes. I must say that your report is what I really expected you to tell us based on experience and information I had on hemihydrate. I would like to ask one question. Your equipment configuration is a little bit different than other single stage hemihydrate plants, however, the process looks basically very much the same as the Windmill plant in Holland and some of the others. Is there a real process difference between your plant and, say, Windmill, for example?

ANSWER—LAWRENCE E. MERCANDO: We are referring to the fact that both are single stage hemihydrate processes. Really, when you look at a phosphoric acid process, if you describe a process, it is hard to know which process you are describing. There are phosphoric acid processes to produce phosphoric acid from reacting sulphuric acid with rock. The development of process is really subtle improvements, one over the other. When you just look at the surface (and I did not get into details) its difficult to see the differences. When you talk about the Fisons Process, filtration rates are about double. That gets back to our crystal rates. So, obviously, we are doing something different. In answer to your question: Yes, there are some very definite differences in the way we operate, the way we circulate our rates, the way we control our sulfites. There are some very, very definite differences that allow us to grow these crystals.

QUESTIONS FROM ED WHITE—IMC. CORP.: What has been your maintenance experience in a comparison between the conventional and the hemihydrate plants?

ANSWER—LAWRENCE E. MERCANDO: The maintenance experience we can relate to both plants. The new plant—it is hard to tell. It is a new plant and the maintenance has been very, very low. I think when you are comparing a new plant to an older one (Our dihydrate plants, one plant, went in, in 1966 and the other in 1975), it is not a fair comparison. The two plants, running side by side, we project equal maintenance costs for both of them. When you take into account that you have one less evaporator you reduce the maintenance on that evaporation. Still, when you take the overall case, with the evaporator, we consider them to be about equal in maintenance costs.

QUESTION FROM CHARLES CHURCHMAN—BADGER AMERICA: Do you see any difference, or do you think there might be a difference, in your recoveries if you were using ground rock versus unground rock? How does the recovery drop off or is it affected by the size distribution on the ground rock?

ANSWER—LAWRENCE E. MERCANDO: When I talk about a difference in recoveries of 2½%, I am specifically referring to our own "OXY Rock." The difference in recoveries are really lattice bound P_2O_5. Our unground rock, or undigested rock, is about the same. The difference is in the lattice bound. Now, if you go to a purer rock, a Tobo Rock or a Moroccan rock, the difference in recoveries will be less with ground rock. We also have a better recovery than we have now. As I say, we are running with unground rock, minus 20% mesh. In some degrees, it's partially ground, but we do not grind it. I would say that, if we went to ground rock we would have higher recoveries. If we were using a purer rock, we also would have a recovery that was close to the dihydrate conditions. We also are doing some further development work. We feel that we can reduce our lattice bound losses to a point that we can set within 1% of a dihydrate process. We also have developed a recrystallization step for a case where you do have high cost rock, or you are looking for gypsum, or if you really need the high P_2O_5 recoveries. We have now developed a recrystallization add-on to the process that would allow us to make 50% acid and recoveries of 96-98½%, depending on the purity of the acid that we want to end up with.

QUESTION FROM GENE LANDGRAF—THE HAYWARD-ROBINSON CO., INC.: We are also interested in hemihydrate Processes, and I want to congratulate the author on an excellent paper. I have a couple of questions. What was the recovery? You really did not mention that. This may involve proprietary information, but we are intrigued by the crystal habit and by the apparent small sizes of the reaction vessels. I wonder if you could shed any light on processing conditions? Is it solely due to chemical control of sulfate concentration and P_2O_5 concentration which enables you to grow these raspberries, or do you have to add some secret ingredient? Also, the normal dihydrate processes uses about eight hours retention time in the digesters. Your vessels look smaller than that. Are they in fact?

ANSWER—LAWRENCE E. MERCANDO: Let me refer to the first question on recoveries. We purposely try to make a comparison because, when you talk about recoveries, it depends on what conditions you are talking about. Is it a pilot plant run? Is it from a laboratory? Is it under control conditions? When I look at the recoveries, it is under actural operating conditions. If you are a producer, you know that, when you are really running to produce a maximum production, your recoveries are not going to be as high as when you are running a test run. Now, in reality, we would expect from our pilot plant work that our recoveries would be (say the dihydrate conditions we could be talking about 95% recovery) 93, 92½%. These numbers are actually based on our dihydrate operation, under the conditions of pushing the plant, for 93% recovery at 42% level. The recoveries of the hemihydrate process was about 90½% to 91%. Again, that is under actual operating conditions and pushing the plant. We would expect, under control conditions, they would be closer to what we projected in the pilot plant.

The second question on the ability to grow the crystals. It is not just one thing. It is, obviously, a configuration of the reaction vessels, the way we circulate and the way we control sulfates. We do have an additive that we add in there which helps to stabilize the crystals and also to prevent some nuclearation of crystals. So, it is a combination of a lot of things that enables us to grow the crystals. The reaction vessels are somewhat smaller. Depending on the rock, the reaction retention time is in the range of four to five hours.

QUESTION FROM BUD DAVIS, T.V.A.: I wonder if you have done any pilot plant tests with rock from Central Florida? If so, and particularily if you used unground rock, could you comment?

ANSWER—LAWRENCE E. MERCANDO: We have tested other rocks. We have not tested Central Florida Rock. We have tested Moroccan Rock. We have tested Western Rock calcined and uncalcined. We do, in the next few months, have a major program to test as many rocks around the world as possible, including Central Florida Rock. Generally, we have found that, in the tests of other rocks, the correlation seems to be consistant with what you would expect with the dihydrate process. Moroccan Rock—our filtration rates were about 80% to 85% of what they are with Northern Florida Rock. So, we fully anticipate that with Central Florida Rock, it is going to be quite similar to our OXY Rock.

QUESTION FROM BILL SHELDRICK—WORLD BANK: I was fairly intimately concerned with the development of the hemihydrate process some years ago. It seems to me, that the principles involved are very similar, which is basically the growing of an agglomerate of the stable half of hemihydrate. The observation I would like to make, is, some of these other hemihydrates make 50% acid directly. I think that it is rather unfair to compare filteration rates for the 42% acid with 50% acid which is very much more viscous, which in fact, does offer the opportunity of cutting out all evaporation stages. I think it also offers the advantage of further sulfuric acid savings, although this is set against the high lattice loss because of the higher P_2O_5 in the reaction system. What I would like to ask the Speaker is, did Occidental weigh up the merits of 50% acid directly and did they sort of optimize on the 42% taking into account all of these factors?

ANSWER LAWRENCE E. MERCANDO: I mentionto the fact, before that, we have developed a recrystallization step to our process. In that recrystallization process we are making 50% acid. The filtration rate has got to be lower because it is viscons. We are designing it so that we can use the same size filter by less washing. The filtration rate is going to be somewhat slower and you will have more P_2O_5 loss. For a one-step operation we found that the loss of filtration rate and the loss of P_2O_5 did not justify going into the 50% level. Now, when we had looked at the hemihydrate in 1973-74, we were looking at these processes when making the 42% level. When I refer to the filtration rates being half of what we have come up with, I am talking about filtering at 42% level, because we were very serious about it. We wanted to move. We were not anxious to embark on a research program. We all know what research costs. It costs a lot of money to do this, and it ties up your people doing it. So, we were not anxious to go and develop a new process. We were very hopefull that one of the processes that were available, at the time, could be used.

QUESTION FROM JORGE POLO—I.F.D.C.: You said that the three bad points that you had to contend with the normal hemihydrate processes were corrosion, scaling and low filtration. Now, the first two, corrosion and scaling, do you feel that your process had an advantage over the other hemihydrate processes?

ANSWER LAWRENCE E. MERCADO: I mentioned that hemihydrate processes did have disadvantages with the higher temperatures, and there also was corrosion. Part of the solution was in better materials being available. We are developing better alloys. I think all of the hemihydrate processes benefit by the availability of better alloys. I think our advantage may be because of our concentrated research efforts across the board. This is for all of Occidental Petroleum. We do have a lot of know-how and have done a lot of work in selecting the right materials of construction for different conditions. When you go through our plant, you will note that we use various alloys, and we change at certain points. It is not obvious why you are changing. So, in answer to your question, one, yes all of the hemihydrate processes have benefited by better alloys. I think we have the advantage because we are able to select the right materials for the right conditions. With respect to scale, part of the secret of growing the crystals that we do is, not only does it give us good filtration rate, it also minimizes the amount of scale that goes together. If we form nucle, that precipitate out or attach to the equipment and scale out, we are going to reduce the scaling.

MODERATOR THREADGILL: Lawrence thank you. Larry will be around the rest of the day. If some of you want to visit with him he is certainly available. (Applause)

Our next speaker is going to continue to deal with energy savings. Jim Kelly, with Davy McKee Corporation, is going to talk to us about design options for energy conservation in fertilizer complexes. Jim is currently Senior Process Engineer with Davy-McKee Corporation, Lakeland, Florida. He is responsible for process design on projects concerning phosphoric acid, Norsk Hydro N.P.K. sulphuric acid, methonol, substitute natural gas, ammonium and formaldehyde. He has assisted in startups for phosphoric acid and Norsk Hydro NPK. Jim received his B.S. in chemical engineering from Tufts University in 1943. Jim please. (Applause)

Design Options for Energy Conservation In A Fertilizer Complex

V. E. Leon, J.C. Kelley
and H. P. Porch
Presented by J. C. Kelley

Introduction

The steadily rising cost of crude oil, with all of its economic and political implications, has prompted U.S. production and engineering companies to search for ways of reducing the amount of energy spent in the manufacture of fertilizer. This paper will examine different design options aimed at achieving this goal in: sulfuric acid plants, phosphate rock grinding plants, dihydrate phosphoric acid plants, dihydrate phosphoric acid plants, and granular diammonium phosphate plants. Ways of minimizing steam, fuel oil and electrical energy consumption in new and existing phosphate complexes will be discussed. Some of the options discussed not only save energy but in some cases reduce the capital required for the construction of new plants. The paper is divided in three parts. Part 1 will deal with a sulfuric acid plant, Part 2 with rock grinding and phosphoric acid production, and Part 3 with the production of granular diammonium phosphate.

Sulphuric Acid Plant

In the late 60's and early 70's environmental pressures forced changes in sulfuric acid plant designs. During the close of the last decade energy costs began to reshape the sulphuric acid plant design for the 80's.

This paper discusses a sulphuric acid plant current used in a fertilizer complex and designed to meet environmental regulations. This type of plant is still being offered today.

In a sulphur burning plant, heat is derived from five sources and removed by three methods. The first *source* of heat is the heat of compression of atmospheric air by the main blower, followed by combustion of sulphur in the sulphur furnace, reaction heat from the oxidation of SO_2 to form SO_3, condensation of water vapor atmospheric air and SO_3 from the oxidation reaction, and dilution of the acid. Heat is *removed* from the gas to steam, acid to water, and losses to atmosphere in the stack gas and radiated heat from the acid plant vessels and ducts.

A review of the basic flowsheet, represented by Figure 1, allows the analysis of energy into and out of the system and provides an understanding of the total energy distribution. A fertilizer complex manufacturing 100 STPH DAP and 1100 STPD P_2O_5 requires a sulphuric acid capacity of 3300 STPD 100% H_2SO_4. The sulphuric acid is produced by two trains of 1650 STPD 100% H_2SO_4 each. Table 1 summarizes the heat inputs and outputs afor a single 1650 STPD sulphuric acid train.

84,400 scfm of "wet" atmospheric air is drawn into the system through the air inlet filter-silencer by the main blower, which then compresses the air to 170" W.C. while raising the air temperature from 90°F to 170°F. During this operation, the blower consumes approximately 3020 HP and adds 8.0 MM Btu/h to the air. As stated earlier, this is the first input of energy into the system.

To prevent corrosion of the plant equipment, it is necessary to dry the incoming atmospheric air in the drying tower where the wet air contacts a circulating stream of 98.5% H_2SO_4. The air is dried and the acid is heated by the sensible heat transfer of 0.3 MM Bcu/h from the gas to the acid, water condensation and dilution of the acid add a further 6.6 MM Btu/h. Thus, up to the point of dry air leaving the tower, 8.0 MM Btu/h has been transferred to the gas by the blower and 6.9 MM Btu/h has been transferred to the acid.

All the dried air passes to the sulphur furnace where it is used to burn molten sulphur to maintain a 10% SO_2 gas strength. The design production rate and overall conversion of SO_2 to SO_3 of 99.7% requires the combustion of 45 M lb/h of sulphur which adds 179.7 MM Btu/h to the gas. This combustion of sulphur is the largest supplier of energy to the plant, but most of the heat, 113.7 MM Btu/h, is recovered in the No. 1 waste heat boiler as steam while cooling the gas to the first catalyst mass inlet temperature.

Across the first catalyst mass, about 62% of the SO_2 is converted to SO_3. The heat of reaction raises the temperature of the gas by the addition of 36.8 MM Btu/h of reaction heat, about 85% or 31.2 MM Btu/h of this heat is recovered in the converter waste heat boiler where the gas is cooled to the second catalyst mass inlet temperature. Across the second mass, the conversion of SO_2 to SO_3 increases to 87% which contributes 14.9 MM Btu/h to the gas.

After the second catalyst mass, the hot gas is cooled, reheating the gas returning to the third catalyst mass from the interstage absorption tower.

SO_3 is absorbed in a circulating stream of 98.5% sulphuric acid in the interstage absorption tower. The acid is heated by the addition of 26.8 MM Btu/h by the sensible heat from cooling the gas and 69.4 MM Btu/h from the condensation of sulphur trioxide. The drying tower and interstage absorption tower acids mix in the pump tank with sufficient water to control the acid at 98.5% H_2SO_4.

The reheated gas from the interstage absorption tower, containing 1.5 vol. % SO_2, enters the third catalyst mass where the overall conversion of SO_2 to SO_3 reaches 99%. The heat of oxidation of SO_2 to SO_3 adds 7.1 MM Btu/h to the gas stream. leaving the third catalyst mass, the gas cooled in a steam superheater to the fourth mass inlet temperature. Across the fourth catalyst mass, SO_2 conversion reaches 99.7% overall. The conversion of SO_2 to SO_3 across the fourth mass adds 0.4 MM Btu/h of heat to the gas. From the fourth mass, the gas passes through an economizer/superheater where 31.6 MM Btu/h of heat are removed before the gas enters the final absorption tower. In the final absorption tower, the SO_3 formed in the last two catalyst masses is absorbed in a countercurrent flow of 98.5% H_2SO_4. The acid leaving the tower is heated by 21.3 MM Btu/h due to cooling the gas and 10.2 MM Btu/h from the condensation of sulphur trioxide. Acid from the final absorption tower mixes with the acid produced in the drying-interstage absorber system and water in the final absorption tower pump tank. Hot acid from the final absorber pump tank is pumped through an acid cooler before returning to the final absorption tower. To provide the necessary 93% H_2SO_4 for the phosphoric acid plant, a stream of 98.5% H_2SO_4 is withdrawn from the final absorption tower acid system and diluted in a circulating stream of 93% H_2SO_4 and water.

TABLE 1

Summary of Heat Inputs and Outputs
(Base Case — Double Absorption)

IN	MM Btu/h
Compression of air	8.0
Combustion of sulphur	179.7
Oxidation reaction	59.2
Condensation of water	6.6
Condensation of SO_3	79.6
	333.1

OUT	MM Btu/h
Heat to steam system	186.3
Heat to acid system	134.6
Heat losses	12.2
	333.1

The resultant mixture is cooled in an acid cooler to the final 93.2% H_2SO_4 product temperature by the removal of 8.7 MM Btu/h of heat.

Of the total 333.1 MM Btu/h of heat energy entering the acid plant, about 56% or 186.3 MM Btu/h is recovered by the steam system, about 40% goes to the acid system, and the remainder is lost to the atmosphere. In the flowscheme of Figure 1, all the heat given to the acid system is rejected via a water cooling tower as warm air and water vapor.

Table 2 tabulates the steam produced by the two sulphuric acid trains and the demands of steam users. Steam demands afor the phosphoric acid and DAP plants are based upon the new generation of energy efficient phosphoric acid and DAP plants.

TABLE 2

STEAM SYSTEM

(2 Sulphuric Acid Trains)

	Column 1 lb/h	Column 2 lb/h
Total steam produced (600 psig 700°F)	328,540	328,540
Steam to blower and boiler feedwater pump tubbines (600 psig 700°F)	160,000	160,000
Sulphur and boiler feedwater heating (50 psig)	68,000	68,000
Phosphoric acid plant (50 psig)	103,400	103,400
DAP plant (50 psig)	0	23,500
Total 50 psig required	171,400	194,900
50 psig available	160,000	160,000
Total 600 psig to letdown to 50 psig	11,400	34,900

The main blower and boiler feedwater pump turbines exhaust at 50 psig to provide most of the low pressure steam for sulphur and boiler feedwater heating, phosphoric acid, and DAP plants. Total 600 psig 700°F steam exported in column 1 amounts to 157 140 lb/h and if this were put through a condensing turbogenerator set would generate about 14.7 MW of electric power. If the 600 psig 700°F steam exported in column 2 is passed through a condensing turbogenerator it would generate about 13.7 MW of electricity.

For the acid plant in Figure 1, the power demand is as follows:

a) Inside battery limits	450 HP
b) Offsites-cooling tower fans, pumps, sulphur pumps, etc.	850 HP
	1300 HP

Without power factor corrections, this represents a power demand of approximately 0.97 MW.

The difference between columns 1 and 2 represents the DAP plant steam requirement.

From the previous discussion, it can be seen that there are areas for improvement to enhance energy recovery. Some of the areas for improvement are:

Main Air Blower — relocating the main air blower after the drying tower, the dry air is heated by the acid by the transfer of 7.7 MM Btu/h to the air and reducing the acid cooling duty by 8.5 MM Btu/h. Because of the higher suction temperature and pressure, the blower horsepower requirements are increased by 13% and the increased blower discharge temperature transfers an additional 8.7 MM Btu/h to the air which is recovered in the No. 1 waste heat boiler.

Abbsorption Tower Inlet Gas Temperature — past plant designs cooled the gas entering the absorption tower to a temperature of 420-450°F, however, some recent plants have been designed for absorption tower gas inlet temperatures of 350-400°F. A small change such as going from 420°F to 400°F results in an increase of 5.2 MM Btu/h to the steam system. Before a lower gas temperature is used, an evaluation must be made comparing the increased furface area and capital cost versus the heat energy recovered. Another method to recover additional energy is to discard the intermediate absorption tower system and incorporate an emission control system such as ammonia scrubbing, on the plant tail gas. This has the advantage of a lower capital cost of about $2.7 MM and an energy recovery in the form of steam of about 32 MM Btu/h.

Acid System — the heat lost to the acid system represents about 40% of the total heat input to the plant. Removal of some of the heat by preheating boiler feedwater, process water heating, Rankine-cycle electric power generation, or steam generation, using vapor recompression will improve the plant economics. If the heat from the drying tower acid cooling system were recovered by preheating the boiler feedwater, an amount of heat equal to 33.8 MM Btu/h would be added to the steam system. This would have a great effect on reducing the quantity of low pressure steam needed for boiler feedwater deaerating.

Boiler Feedwater — heat losses to boiler blowdown and heat required for deaeration of the make-up water can be reduced by a considerable amount by returning the condensate from the phosphoric acid plant.

Power Generation — past practice has been to use the high pressure steam produced in the acid plant to drive steam turbines on the main air blower and boiler feedwater pump with the excess high pressure steam being let down across a pressure reducing valve. However, as current and future energy costs increase, and plants are designed to use steam energy more efficiently, cogeneration of electric power can be an attraction alternate. The turbogenerator set would be designed for a combination of extraction condensing conditions to maximize power generation. The steam condensate being returned as boiler feedwater.

Ammonia Scrubbing — discarding the intermediate absorption tower system in favor of an ammonia scrubber on the tail gas results in a lower capital investment, increases the quantity of steam by about 16% and reduces total plant pressure drop by about 40" W.C.

For the fertilizer complex of an 1100 STPD P_2O_5 phosphoric acid plant, 100 STPH DAP plants, and two 1650 STPD 100% H_4SO_4 sulphuric acid plants, the flowscheme as represented by Figure 2 would include the energy savings outlined previously.

In summary, the plant design basis would be:

1. Mono acid system
2. 10% SO_2 gas strength
3. Blower after drying tower
4. 650 psig steam system
5. 400°F gas temperature to absorption tower
6. Ammonia scrubbing
7. Demineralized boiler feed water
8. Boiler feed water heating using the acid cooler
9. 100" W.C. clean boiler discharge pressure
10. All running equipment on motor drives
11. All steam to turbo-generator condensing at 4" Hg absolute with an extraction stage at 50 psig to satisfy the phosphoric acid plant steam demand

If ammonium sulphate cannot be tolerated in the plant operation, a double absorption process can be offered incorporating energy savings similar to the single absorption with ammonia scrubbing process.

Table 3 has been compiled on the basis of single absorption with ammonia scrubbing outlined in the above summary.

TABLE 3

Power Generation

(2 Sulphuric Acid Trains)

	Column 1 lb/h	Column 2 lb/h
Total steam produced (600 psig 700°F)	383,480 lb/h	383,480 lb/h
Steam required by P_2O_5 plant & DAP plant	103,400 lb/h	126,900 lb/h
Sulphur system steam demand	10,000 lb/h	10,000 lb/h
Total extraction at 50 psig	113,400 lb/h	136,900 lb/h

Column 1

Total power generated is about 28.7 MW. Power requirements of each sulphuric acid plant amounts to about 4610 HP or roughly 3.5 MW leaving 21.7 MW of electric power available for the phosphoric acid and DAP plants.

Column 2

Total power generated is about 27.3 MW. The difference between columns 1 and 2 represents the steam requirement at the DAP plant. The resultant export power available for other uses is reduced to 20.3 MW.

Figure 3 represents the generation and distribution of steam for an acid plant flowscheme shown in Figure 1. The turbogenerator set is used at a pressure reducing station to make-up the difference between the 50 psig available from the turbines and that required by the fertilizer operation.

Figure 4 diagrams the generation and distribution of steam for the single absorption with ammonia scrubbing plant shown in Figure 2.

Assume $0.03/KwH for electric power the turbogenerator set in Figure 4 would realize a total credit of approximately $5.11 MM annually based on an electric export of 20.3 MW. This compares to about $3.45 MM annually for the scheme shown in Figure 3.

Phosphoric Acid Plant

Basis of Typical Plant

To match a 100 STPH Davy McKee DAP plant, a Prayon phosphoric acid plant producing 1100 STPD of P_2O_5 is chosen. This is a middle range plant. Recent plants have been larger and many of the previous plants smaller. Equipment for this size plant is readily available from vendors and all has been proven by recent installations.

The basis of design are briefly:

1. 66% BPL phosphate rock is used as a feed stock.
2. 93% P_2O_5 is the weak acid concentration.
3. 28% P_2O_5 is the weak acid concentration.
4. Based on filter losses, yield runs 95.5% at design conditions.
5. Water is pumped from the cooling pond at 90°F.
6. Half of the weak acid is concentrated to 54% P_2O_5 and half of the 28% P_2O_5 is used directly from storage.
7. Acid clarification is assumed to be no problem.

The plant is a typical turn key design. One of the conditions is soaring energy cost. We can no longer use steam, condensate, electricity, and other utilities as if they are in unlimited supply. Heats of reaction must be used even though they are at a low level.

Design Options

Because of the energy crunch, the choice of design options have narrowed. We no longer have cheap electricity. We no longer have surplus steam. We can not afford to throw away our condensate. We must increase our efforts on better water management.

The design options referred here will be the following:

1. Wet grinding vs. dry grinding.
2. The new low level flash cooler
3. The triple usage of pond water.
4. Minimize the use of steam in the phosphoric acid plant so that electricity can be maximized in a turbogenerator.
5. Reduce energy required for pumping and agitation.

Wet Rock Grinding

Wet or dry grinding used to be a big argument. Several recent papers (1,3) and a patent issued in 1977 (2), have convered the pro's and con's of the process. The rising cost of crude oil has assured us that the decision to go "wet" was correct and justly timed. A flowsheet, Figure 5, shows how simple the process is.

If drying can be avoided, energy cost can be saved. The big advantage of the wet rock system is the saving of 11 gallons of fuel per ton of P_2O_5 feed. At today's prices of fuel, this amounts to about $7.70 per ton of P_2O_5 produced. Thus, wet grinding is favored because of low energy consumption.

Low Level Flash Cooler

During the previous round of expansion, several unexpected problems popped up in the attack and flash cooler system that need improvement. The system needed the following:

1. Lower delta T to prevent scaling.
2. More circulation in the attack tank to prevent solids buildup.
3. Lower pumping head to save horsepower.
4. Better usage of horsepower to improve mixing.
5. Better attack tank configuration.

A simplified flowsheet, Figure 6, shows these improved systems.

The circulation through the flash cooler has been increased about three times to lower the delta T to 3.5°F. The circulation through the flash cooler has also become the means of circulating slurry around the attack tank and thus, the circulator pumps are eliminated. The flash cooler is situated at a lower elevation which reduces the head on the inline pump. The regulated vacuum inside the flash cooler draws the slurry level up into the vessel and the axial flow pump returns the cooled slurry back to the attack tank.

The redesigned system composed of the attack tank, flash cooler vessels, slurry pumps, and compartment agitators has reduced horsepower significantly. Yearly power savings on this size plant amount to about $80,000 based on $0.03/KWH.

As an Additional benefit the downtime for cleaning the attack tank and the flash cooler system should be less so there should be a gain in operating factor above the 317 days projected.

Triple Usage of Pond Water

In the more recently designed plants, the pond water is reused several times, thus reducing the pond water demand and pumping costs. Flowsheets, such as Figure 7, have gradually changed from single to double to triple usage in the last ten years. Briefly, cold water from the cooling pond (90°F) is pumped to the evaporator condensers for initial duty. This warm water from the hot well (110°F) is then pumped to the flash cooler condenser for the secondary duty. Finally, the hot water from the barometric seal tank (140°F) on the flash cooler condensers is pumped up to wash and slurry the filter cake. If this system is operated judiciously, about 40% reduction in pond water demand is achieved. Other plants have gone one step further and are considering the recycle of water from the third stage evaporator barometric condenser to the first stage evaporator barometric condenser. This water system shows a savings of 10% lower horsepower base on a reduction of pump heads and flows.

There is also another advantage to the system in that the gypsum pond is used to dissipate considerable heat by using hot water as the carrier.

Minimize Steam Usage

Up until a few years ago, steam at all pressure levels were in excess supply. There was sufficient medium pressure steam for ejectors, plenty of low pressure steam for evaporation. As the price of energy goes up, it is more economical to install a turbogenerator and make electricity. Thus, the cost of steam has changed in the last five years. Now it is cheaper to install vacuum pumps and use the high pressure steam for generating electricity.

Extra care should be taken during operation to prevent dilution of the weak acid (28%). If the operation is sloppy and careless and 27% P_2O_5 acid is made instead of 28%, the evaporation load increases 7 to 8%. The penalty will be the cost of extra capacity, more steam and more cooling water.

The return of hot condensate to the deaerator in the sulfuric acid plant is another energy related subject. If this hypothetical plant returns its condensate, 11 MM Btu/Hr is saved. This is steam that can be made into more electricity. Just the yearly energy value alone is worth over $337,000 (using steam at $4.1000 lbs).

Reduce Energy for Pumping and Agitation

This is a subject that delves into the detail design and equipment selection. All we can do here is mention some broad generalities. Every energy user should be specified and purchased with care. Here are some general ideas that may reduce the energy demand of pumps and agitators.

1. Locate ball mill near the attack tank.
2. Lower filter height.
3. Lower evaporator height.
4. Reduce recycle of acid from clarification to attack tank.
5. Lower flash cooler (see Section).
6. Use high efficiency electric motors.

All these ideas above are being worked on to reduce energy consumption in new plants. In the older plants built 10 or 15 years ago, the above mentioned parameters are fixed. Most phosphoric acid producers are making changes to improve energy consumption. They usually do it along with a production increase.

Conclusion

Most of the above ideas are incorporated into latest Davy-Prayon design. Some have been used in the design we have done in the last ten years; others are being incorporated into revamps.

The whole process is not as simple as portrayed here. The design is complicated by other factors which are:

1. Declining rock quality.
2. Sludge acid streams from clarification.
3. Tougher emission regulations.
4. Pond water management.
5. Uranium recovery.
6. Local conditions and climate.

Diammonium Phosphate Plant

The end result of all the operations in a phosphate complex is usually the manufacture of a granular phosphate grade. This last section of our paper will examine different options that should be considered in the design and operation of DAP granulation plants with particular attention to energy conservation. The options considered deal mainly with the conventional preneutralizer (reactor) type plant. Some of these are presently being used in granulation plants throughout the North American continent. Others are options which are applicable to granulation plants and that warrant further investigation and discussion among groups such as yours.

The basic reactions involved in the process is the neutralization of the wet process phosphoric acid with ammonia as shown by the following main reactions:

$$1.\quad \underset{\text{ammonia}}{NH_{3(g)}} + \underset{\text{phosphoric acid}}{H_3PO_{4(1)}} \longrightarrow \underset{\text{monoammonium phosphate}}{NH_4H_2PO_{4(s)}} + \text{Heat}$$

$$2.\quad NH_4H_2PO_{4(s)} + NH_{3(g)} \longrightarrow \underset{\text{diammonium phosphate}}{(NH_4)_2HPO_{4(s)}} + \text{Heat}$$

The third main reaction which mainly affects the % P_2O_5 in the product is the formation in situ or the addition of prereacted ammonium sulfate as shown by the following reaction:

$$3.\quad 2NH_{3(g)} + \underset{\text{sulfuric acid}}{H_2SO_4} \longrightarrow \underset{\text{ammonium sulfate}}{(NH_4)_2SO_4} + \text{Heat}$$

The sulfuric acid or ammonium sulfate added to the process acts as a diluent and its feed rate is controlled to reduce the % P_2O_5 (giveaway P_2O_5) in the product. Usually a DAP plant will be located in a complex that has a phosphoric acid plant and both 28% P_2O_5 phosphoric acid and 54% P_2O_5 phosphoric acid are used as feed. The 28% phosphoric acid is metered into the scrubber seal tank where it is recirculated thru primary, (Usually venturi type) scrubbers to recover the ammonia and dust present in the gas streams. The 54% P_2O_5 phosphoric acid is normally metered directly to the reactor.

Plant Description

The flowsheet for a conventional DAP plant is shown in Figure 8. A combination of liquid and/or gaseous ammonia is fed to the plant. If liquid ammonia is used a cooler is usually required to subcool the incoming ammonia and ensure that the meters are not exposed to two phase flow and thus subject to errors. Many plants use a steam heated shell and tube ammonia vaporizer where either all or part of the ammonia is vaporized before being fed to the process. When a vaporizer is used, the gaseous ammonia streams can be measured accurately and there is no need for an ammonia cooler.

Some of us have heard different arguments of the effect on granulation caused by the use of either liquid or vapor ammonia. I have personally been involved in the startup or operation of eight ammonium phosphate granulation plants and a firm believer that, other factors being equal, either liquid or vapor ammonia will provide as good a granulation characteristic as the other. The only real difference is the heat content of the ammonia supplied to the process and its effect on the process due to the water evaporation rates throughout the different sections of the plant.

In the reaction or slurry preparation step approximately 60% of the total ammonia feed is reacted in an atmospheric pressure reactor with 54% P_2O_5 acid and the 28% P_2O_5 phosphoric acid liquor from the primary scrubbers. This exothermic reaction evaporates water from the acid and produces a thick slurry containing a mixture of monoammonium and diammonium phosphate. The addition of ammonia is usually regulated to maintain an NH_3:H_3PO_4 mole ratio of 1.40 to 1.50 which is the maximum solubility point for this slurry. The addition of the 28% acid with the scrubber liquor is adjusted to minimize the % water in the slurry while maintaining a suitable fluidity for pumping to the granulator.

In the granulation step the slurry from the reactor, containing between 15% to 20% free water, is metered into the granulator and distributed over a cascading bed of recycle material. This recycle material is made up of recycled product, fines and ground oversize from the screens, and dust from the equipment vent cyclones. The slurry wets the fine particles which are rotated and tumbled in the granulator to produce particles which are around 50% product size material. The remaining 40% of the ammonia is metered into the granulator under the rolling bed of material to complete the reaction of the slurry to an NH_3:H_3PO_4 mole ratio of 1.9 to 2.0.

Material discharges from the granulator with 3%-4% moisture and falls by gravity into a direct fired concurrent rotary dryer. The dryer supplies the heat required to dry the material to less than 1.5% moisture. The material from the dryer discharges thru a lump breaker into a screen feed elevator.

In large capacity plants, (i.e., 100 STPH or greater) the height of a slow speed, continuous, bucket elevator is limited by the chain strength and it is not possible to feed the required number of double deck screens by gravity. It then becomes necessary to use a dragflight conveyor to feed a bank of screens. Other alternates would be the use of a centrifugal elevator which has a greater chain wear rate, or the use of parallel or series smaller capacity continuous elevators to feed the screens.

In the screens the product size material is separated from the fines and oversize material. The latter is ground by cage or chain mills and returned by a dragflight conveyor along with the screened fines to a recycle elevator. The recycle elevator returns the material back to the granulator. Product size material from the screens falls into a product surge bin and is removed from the bin by a vibrating pan, gate, or variable speed belt at the required production rate of the unit. Excess product material overflows from this bin and is returned to the granulator to maintain a constant recycle ratio. Normal design practice has been to specify a recycle ratio of 5:1. After some operating experience is gained, the plants can usually be operated at a ratio of 3.5:1. The product stream normally discharges into a rotary cooler and is usually cooled to about 120°F. A new plant should be designed with a product cooler. I say this not only because of possible pile setting problems, but also because the cooler keeps the product heat in the plant and this helps to maximize 28% phosphoric acid consumption. A small amount of drying also occurs in the cooler which serves as a back up for future increases in plant capacity.

The gases from the reactor and granulator go directly to a venturi scrubber. The gases from the cooler and equipment vents are first passed thru cyclones and then routed to the same or to a separate venturi scrubber. The dryer exhaust gases pass thru a cycline prior to entering a separate venturi scrubber. The dust trapped by the dryer, cooler and equipment vent cyclones discharges by gravity into the recycle conveying equipment. In newer plants the gases from the venturi scrubbers are passed thru a tail gas scrubber for fluorine removal prior to atomspheric discharge.

Energy Considerations

In order to examine the heat requirements of conventional DAP plants three different cases will be reviewed from a material and energy requirment standpoint. These are:

Case 1 Liquid Ammonia
Case 2 Vaporized Ammonia
Case 3 Vaporized Ammonia with Cooler Air Recycle

For all three cases the following conditions were set:

1. The 54% P_2O_5 and 28% P_2O_5 acid streams were set to provide a combined 63% P_2O_5 dry basis content.
2. Reactor slurry free moisture = 20%
3. Product moisture 1.5%.
4. Recycle material to product ratio = 5:1.
5. Fuel oil No. 6 (HHV = 18,367 Bru/lb).
6. NH_3 recovery 98%.
7. P_2O_5 recovery 99%.

Since a plant using liquid anhydrous ammonia imports only fuel as its main external heat source, it was felt that this would be a good base case for comparing the energy requirements of DAP plants. Table 1 shows a material energy balance for such a plant using liquid 99.5% enhydrous ammonia.

As shown, the amount of water required, above that supplied by the 28% and 54% phosphoric acids, is 264 lbs/ton of DAP. If the impurities present in the 28% phosphoric acid do not present a problem in achieving DAP grade, this water could be added with more 28% acid. The combined acid strength could be lowered from 38% to 34.3% P_2O_5, and this would reduce the amount of steam required at the phosphoric acid plant evaporators by 317 lbs per ton of DAP produced. For a 100 STPH DAP plant this would represent 31,700 lbs per hour of steam which could be used for other purposes such as electricity generation in a condensing turbine. Increasing the amount of 28% phosphoric acid to satisfy the water demand would also lower the scrubber mole ratio from approximately 0.70 to 0.54 thereby reducing ammonia losses. The external heat aupplied to the process as fuel for the dryer amounts to 417 M Btu per short ton of DAP which is equivalent to 2.8 gals of No. 6 fuel per ton of DAP product.

By comparison Table 2 shows a balance based on feeding vaporized ammonia to the DAP plant. In this case, the amount of additional water required by the plant increases by 46% to 387 lbs per short ton of DAP. Assuming, as in Case 1, that the 28% P_2O_5 acid quality is not a problem, the combined 54% and 28% acid concentration could be lowered to 32.8% P_2O_5 and the phosphoric acid evaporators steam requirement could be lowered by about 46,400 lbs per hour of steam for 100 STPH of DAP produced. Therefore assuming that the quality of 28% acid is adequate the phosphoric acid plant evaporator duty can be reduced by an equivalent of 14,700 lbs/hr of steam with the installation of an ammonia vaporizer. The fuel required at the dryer decreases by 20% to an equivalent of 2.2 gals of No. 6 fuel oil per ton of DAP.

Thus the increase in heat supplied by the vapor ammonia evaporates more water from the reactor and the plant requires more water to maintain the same reactor slurry conditions. By the same token, the vapor ammonia supplied to the granulator provides an increase in heat and evaporates more water in the granulation step. This lowers the water fed to the dryer and causes a reduction in fuel oil demand. Thus, depending on the installed evaporator capacity at the phosphoric acid plant and the overall phosphoric acid quality, the installation of a steam heated ammonia vaporizer can be a viable alternate for increasing the overall capacity of a fertilizer complex. Present plant practice is to use a steam heated shell and tube heat exchanger to vaporize the ammonia. At the conditions listed in Table 1 this ammonia vaporizer would require about 235 lbs steam per ton of DAP or 23,500 lbs/hr for a 100 STPH DAP plant.

As shown by Tables 1 and 2 most DAP plants have one thing in common, the heat lost by the gases leaving the venturi scrubbers is enormous. This is due mainly to the large quantity of water vapor present in these gases. In older plants this heat is wasted in the stack gases. Newer plants require a tail gas scrubber to achieve lower fluorine emissions. These plants use either recirculated fresh water or once thru pond water as the scrubbing medium in the tail gas scrubber. The plants using recirculated water usually operate with a stack temperature of 150°F and most of the heat from the venturi scrubber gases is lost to the stack. The plants using once thru pond water usually operate with a stack gas temperature of 105-115°F. In this case most of the heat from the venturi gases is absorbed by the pond water. Depending on the actual stack gas temperature, a DAP plant can increase the heat load to the cooling pond by as much as 1,300 M Btu/ton of DAP produced. The heat required to evaporate the ammonia is only about 200 M Btu/ton DAP. Thus the heat presently wasted in most DAP plants is over 6 times the heat required to evaporate the ammonia. We will discuss this in more detail later in the paper.

Table 3 shows the heat and material balance for a third DAP plant. This balance is also based upon using vapor ammonia, and using the same acidsand reactor slurry composition. However, for this case, the gases leaving the cooler are recycled, after dust removal, into the dryer combustion chamber and the dryer shell has been insulated to minimize heat losses. As shown, the savings in fuel requirements are about 133 M Btu/ton of DAP when compared with the balance for base case using liquid ammonia (Table 1) and 48 M Btu/ton of DAP when compared to the plant using vapor ammonia without recycle of the cooler air (Table 2). 80§ of this latter energy saving is attributed to the recycle of the cooler air and 20% to the insulation of the dryer shell. The dryer shell losses where calculated based on the average skin temperature of 181°F which was measured on a 12′ O by 70′ long DAP dryer and a surrounding air temperature of 90°F. It should be noted that the actual skin temperature of a dryer will be affected by the dryer gas inlet temperature. The pay out period for the cost of materials and labor to insulate this dryer was calculated at 1.7 years. This pay out period would be decreased in cooler climates such as Canada. In warmer climates such as in Florida the pay out period may be slightly longer but has the added advantage of dropping the temperature inside the building making it more comfortable especially in the summertime.

Assuming that No. 6 fuel oil is used at the dryer combustion chamber, the consumption per ton of DAP product would be 2.78, 2.21 and 1.89 gallons respectively for the three cases.

Another major advantage of the recycle of the cooler gases into the dryer is that the amount of air which must be vented from the plant is reduced by 32%. This is not only favorable from fan size and horsepower requirements but can also help to reduce the fluorine and particulate emissions from a DAP plant. Using the cooler air recycle scheme the gases from the reactor, granulator and equipment vent (RGV) tail gas scrubber for a 100 STPH plant decrease from 176,300 to 91,200 acfm. Due to the lower gas flow this tail gas scrubber would be reduced in size from 23′-0″ to 16′-6″ in diameter and the fan BHP requirements would decrease from 1151 BHP to 757 BHP. At $.03 per KWH and using an 85% plant operating factor, this amounts to a savings of U.S. $66,000 per year. Since the venting requirements for the dryer and RGV systems are now almost identical, the design and equipment fabrication cost would also be minimized by the cooler air recycle scheme. The dryer and RGE fans can also be identical thereby reducing spare part inventory requirements.

Another alternate that also warrants serious consideration particularly in the design of new plants is the use of hot (145°F) water from the tail gas scrubber to vaporize the ammonia. This would free 23,500 lbs per hour of steam which could then be used to generate about 1.4 MWH per hour of steam which could then be used to generate about 1.4 MWH at the sulfuric acid plant. Since about 68% of the heat loss in the venturi acrubbers occurs in the RGV venturi this scrubber would provide the hottest tail gas water available and would be the place to install a hot water ammonia vaporizer.

A quote was recently obtained by Davy for this type of unit for a nominal 93 STPH plant.

A comparison of this hot water shell and tube exchanger vs that of a steam heated unit is shown below. A plant operating factor of 85%, a plant life of 20 years and an interest rate of 15% were used to calculate the annual capital costs.

The water pumping cost were based on pumping 2385 gpm thru a pressure drop of 13 psi at 50% pump efficiency. The 13 psi drop is more than adequate to cover the pressure drop thru the tubes and an automatic temperature control water valve. The water would flow into the vaporizer at 145°F and leave at 128°F.

This heat exchanger would typically be a kettle type heat exchanger with straight tubes and removable heads to facilitate cleaning of the tubes during scheduled down days. This type of unit could also be used on tail gas scrubbers which use recirculated fresh water as a scrubbing medium. I should add that some of these recirculating scrubbers have a tough time meeting Florida regulations on fluroine emissions due to the high temperature (150°F) of the wet stack gases.

	Steam Vaporizer	Hot Water Vaporizer
Tube area	896 ft^2	3722 ft^2
Tube material	304 SS	316 SS
Equipment cost	$43,000	$100,000
Steam requirements (lbs/hr)	22,031	0
Annual steam cost ($4/1000 lbs)	$656,171	0
Water requirements (gpm)	0	2385
Annual pumping cost ($.03/KWH)	0	$6,023
Annual capital cost	$6,870	$15,976
Annual operating cost	$663,041	$21,999
Difference in capital cost		$57,000
Difference in operating cost		$641,042
Payout for hot water unit (yr)		0.09 (1 month)

A comparison of the cost to operate a plant with an ammonia vaporizer and without cooler air recycle (Case 2) and that of a plant that uses cooler air recycle and a hot water ammonia vaporizer (Case 3) is shown below. A cost of $0.70/gal was used for No. 6 fuel oil.

	Fuel Cost	Fan Motor Elec. Cost	Vaporizer Cost	Total Cost
Case 2	$1.55	$0.26	$ .96	$2.77/ton
Case 3	$1.32	$0.17	$0.03	$1.52/ton

At a yearly production rate of 744,600 tons of DAP, the savings achieved by Case 3 would be equivalent to $931,000 per year.

Material Handling System

As well as the important concept of energy conservation, we are continually looking at other means of improving plant design.

Up to now design practice has been to screen all of the material discharging from the dryer and to return the excess product back to the granulator. Normal practice has also been to use double deck screens to remove the fines and oversize material. Since the separation of fines is more difficult than that of oversize the number of double deck screens required to achieve a given duty is usually dictated by the surface area of the bottom deck. In the case of a 100 STPH plant a minimum of six double deck screens would be required to achieve a product having a particle size around 95%-6+14 Tyler mesh. The height required to feed these screens by gravity would exceed the height limitation placed by the strength of continuous bucket elevator chains. Therefore the design of the solids handling system would then be limited to the use of a dragflight conveyor or two continuous bucket elevators to feed the screens.

A screening concept now being offered by Davy eliminates the need of a second conveyor (dragflight or bucket elevator) in large capacity plants. The proposed system is shown in Figure 9. This system utilizes single deck screens for better screening efficiency and screens only the amount of product required so that the production rate of the plant can be met under changing granulator conditions. Material from the dryer is discharged by gravity to a set of three scalping screens. Oversize material is ground by chain mills and discharged to a short dragflight conveyor. Fines and product size material amounting to 50% of the dryer discharge is elevated to a second set of two single deck screens where the fines are separated from the product size material. The maintenance and cleaning effort required to keep up with 5 screen panels installed in single deck screens should be far less than that required for keeping up with 12 screen panels 6 of which are located in the bottom deck of double deck screens.

I should also be noted that in this plant the dryer discharge grizzly has been designed to eliminate the need of a lump breaker and its associated maintenance problems.

The alternates described in this section are options offered by Davy McKee in the design of granulation plants. To summarize these options are:

1. Recycle of cooler air to minimize fuel consumption.
2. Insulation of the dryer shell.
3. Use of single deck screens on large capacity plants.
4. Use of hot water from the tail gas scrubbers in lieu of steam for the ammonia vaporizer.
5. 32% reduction in the total air flow requirements.
6. Elimination of lump breaker.

The energy saved by the above are as follows for a 100 STPH DAP plant:

Fuel oil = 4.8 x MM Btu/hr
50 psig steam = 23,500 lbs/hr
Electrical energy = 294 KW

Obviously, any given fertilizer complex will have its own priorities and inherent requirements with respect to achieving the best combination of energy savings. Each individual site must be examined with regard to geographic location, installed equipment and method of operation. It is sincerely hoped that some of the ideas presented in this paper can either be incorporated into existing operations or serve as a basis for some that can.

TABLE 1

CASE 1 - LIQUID NH_3

OVERALL PLANT BALANCE

		Lbs per ton of DAP Product						M Btu per Ton of DAP
Stream	Temp. °F	Dry Material	P_2O_5	NH_3	Free H_2O	Dry Air	Total	*Heat
Input								
Air	90				232	9276	9508	274
54% phos. acid	175	796	513		155		951	35
28% phos. acid	150	698	426		823		1521	75
$NH_{3(g)}$	109	451		451	2		453	17
H_2SO_4 93%	110	49			4		53	1
Water	90				264		264	3
Fuel Heat					20		20	416
Reaction Heat								989
TOTAL		1994	939	451	1500	9276	12770	1810
Output								
(1) Gases	154	24	9	9	1470	9276	10770	1770
Product	120	1970	930	442	30		2000	30
Dryer shell loss								10
TOTAL		1994	939	451	1500	9276	12770	1810

*Reference temperature = 77°F

(1) Gases leaving venturi scrubbers

TABLE 2

CASE 2 - VAPOR NH_3

OVERALL PLANT BALANCE

		Lbs per ton of DAP Product						M Btu per Ton of DAP
Stream	Temp. °F	Dry Material	P_2O_5	NH_3	Free H_2O	Dry Air	Total	*Heat
Input								
Air	90				232	9276	9508	274
54% phos. acid	175	796	513		155		951	35
28% phos. acid	150	698	426		823		1521	75
$NH_{3(g)}$	109	451		451	2		453	230
H_2SO_4 93%	110	49			4		53	1
Water	90				387		387	5
Fuel Heat					16		16	331
Reaction Heat								989
TOTAL		1994	939	451	1619	9276	12889	1940
Output								
(1) Gases	156	24	9	9	1589	9276	10,889	1900
Product	120	1970	930	442	30		2000	30
Dryer shell loss								10
TOTAL		1994	939	451	1619	9276	12889	1940

*Reference temperature = 77°F

(1) Gases leaving venturi scrubbers

TABLE 3

OVERALL PLANT BALANCE

CASE 3 - VAPOR NH_3 COOLER AIR RECYCLE AND INSULATED DRYER

Input		Lbs per ton of DAP Product						M Btu per Ton of DAP
Stream	Temp. °F	Dry Material	P_2O_5	NH_3	Free H_2O	Dry Air	Total	*Heat
Air	90				157	6276	6433	185
54% phos. acid	175	796	513		155		951	35
28% phos. acid	150	698	426		823		1521	75
$NH_{3(g)}$	109	451		451	2		453	230
H_2SO_4 93%	110	49			4		53	1
Water	90				377		377	5
Fuel Heat					14		14	283
Reaction Heat								989
TOTAL		1994	939	451	1532	6276	9802	1803
Output								
(1) Gases	165	24	9	9	1502	6276	7802	1769
Product	120	1970	930	442	30		2000	30
(2) Dryer loss								4
TOTAL		1994	939	451	1532	6276	9802	1803

*Reference temperature = 77°F

(1) Gases leaving venturi scrubbers

(2) Insulated Dryer

Complex Overview

Designing the overall complex will help to reduce energy and utility requirements. The sulfuric acid plant will not only be an efficient chemical unit but also the main power plant. Steam and electric power production will be maximized in this area.

Water usage will be designed used on a complex-wide scale. Reuse of water several times as illustrated in the paper is becoming the rule. Total recycle of water within the complex is being forced by EPA regulations. Condensate, cooling tower purge and cooling water reuse must be designed into the complex.

Steam users in the phosphoric acid unit and DAP unit will be curtailed as much as possible since steam makes a more valuable product as electric power. Even the heat in hot water and condensate will be carefully considered and used.

The design selection of process equipment in all areas will become more critical. Plot arrangement will become more demanding to take advantage of gravity flows or reduce the heads on pumps.

Thus, you can see that designing an energy efficient fertilizer complex is a complicated business. So we must take a close look at all the factors and schemes that save energy and evaluate before we leap in and do it.

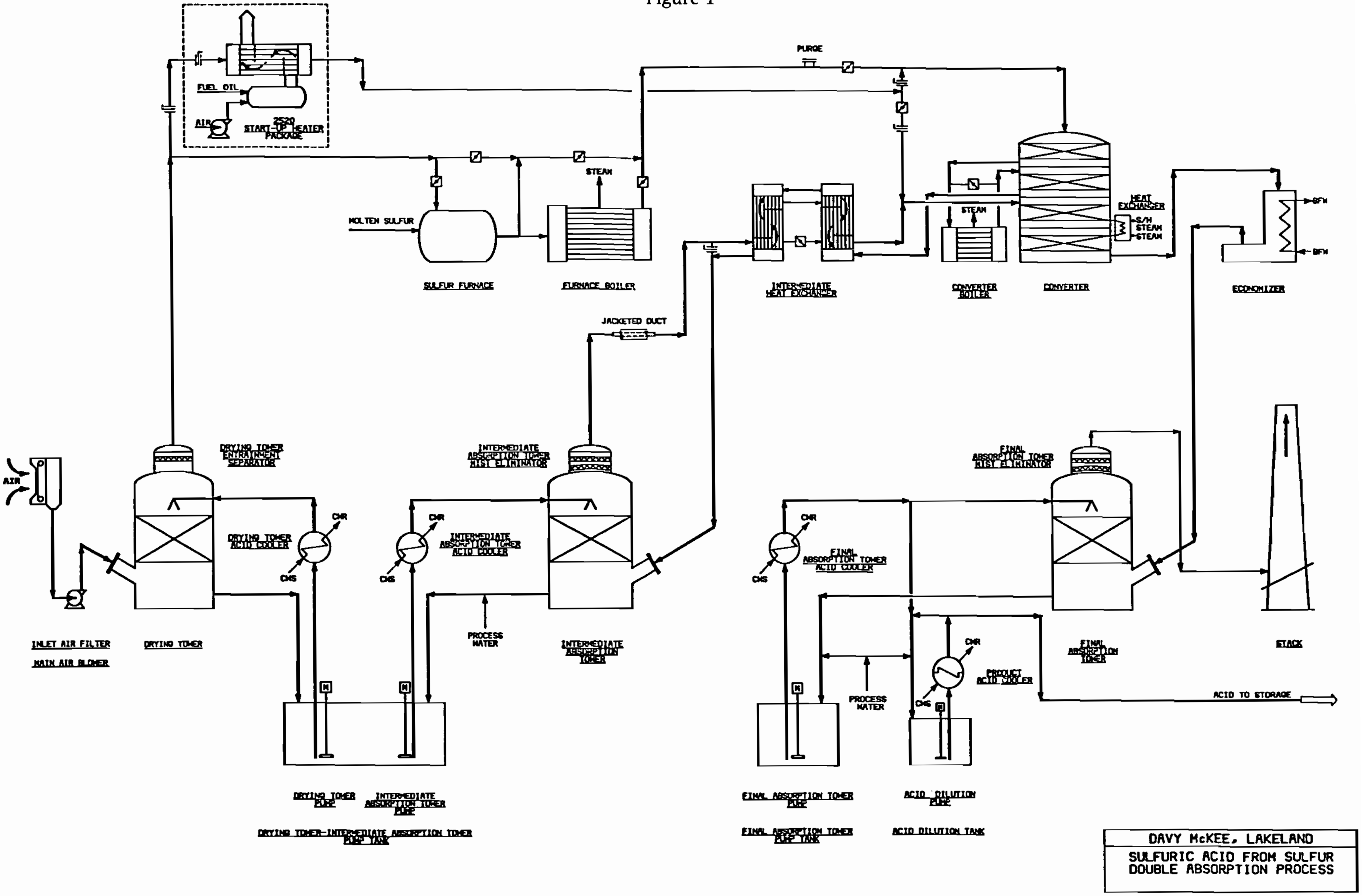
Acknowledgment

In behalf of the coauthors and of Davy McKee, I would like to express our sincere appreciation for giving us the opportunity of presenting this paper.

BIBLIOGRAPHY

1. Kelley, J. C. & Houghtaling, S. V., "Wet Rock Grinding Helps to Improve Older Phosphoric Acid Plants".
2. Houghtaling, S. V., U.S. Patent No. 4,044,107 (August 23, 1977).
3. Houghtaling, S. V., "Wet Grinding of Phosphate Rock Holds Down Dollars, Dust, and Fuel". *Engineering and Mining Journal (1975).*

Figure 1



PURGE
FUEL OIL
AIR
2520
START-UP HEATER
PACKAGE
MOLTEN SULFUR
STEAM
SULFUR FURNACE
FURNACE BOILER
INTERMEDIATE
HEAT EXCHANGER
STEAM
CONVERTER
BOILER
CONVERTER
HEAT EXCHANGER
S/H STEAM
STEAM
BFW
BFW
ECONOMIZER
JACKETED DUCT
AIR
DRYING TOWER
ENTRAINMENT
SEPARATOR
INTERMEDIATE
ABSORPTION TOWER
MIST ELIMINATOR
FINAL
ABSORPTION TOWER
MIST ELIMINATOR
CHR
CHS
DRYING TOWER
ACID COOLER
CHR
CHS
INTERMEDIATE
ABSORPTION TOWER
ACID COOLER
CHR
CHS
FINAL
ABSORPTION TOWER
ACID COOLER
CHR
CHS
PRODUCT
ACID COOLER
PROCESS
WATER
PROCESS
WATER
INLET AIR FILTER
MAIN AIR BLOWER
DRYING TOWER
INTERMEDIATE
ABSORPTION
TOWER
FINAL
ABSORPTION
TOWER
STACK
ACID TO STORAGE
DRYING TOWER
PUMP
INTERMEDIATE
ABSORPTION TOWER
PUMP
DRYING TOWER-INTERMEDIATE ABSORPTION TOWER
PUMP TANK
FINAL ABSORPTION TOWER
PUMP
ACID DILUTION
PUMP
FINAL ABSORPTION TOWER
PUMP TANK
ACID DILUTION TANK
DAVY McKEE, LAKELAND
SULFURIC ACID FROM SULFUR
DOUBLE ABSORPTION PROCESS

Figure 2

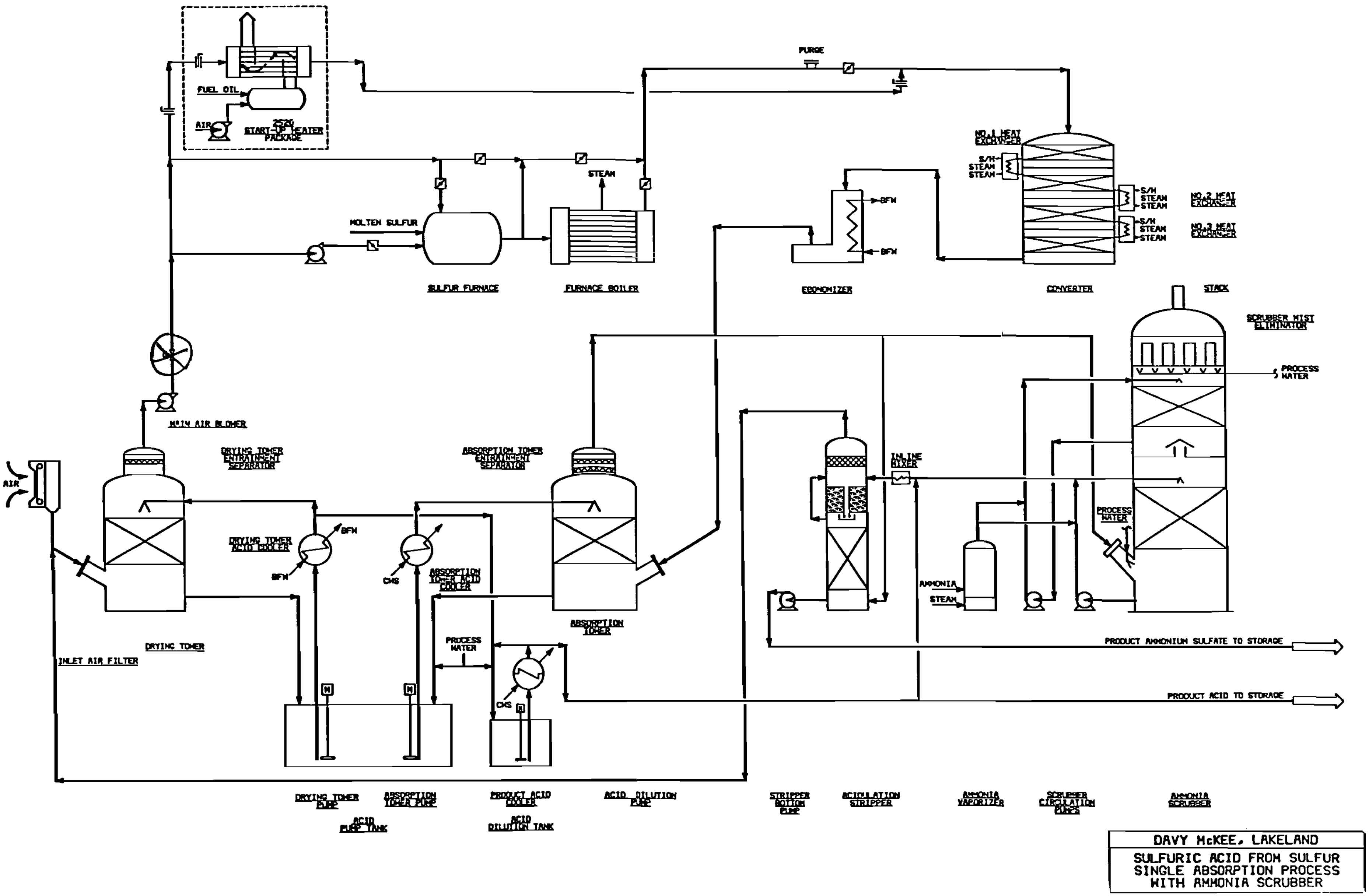
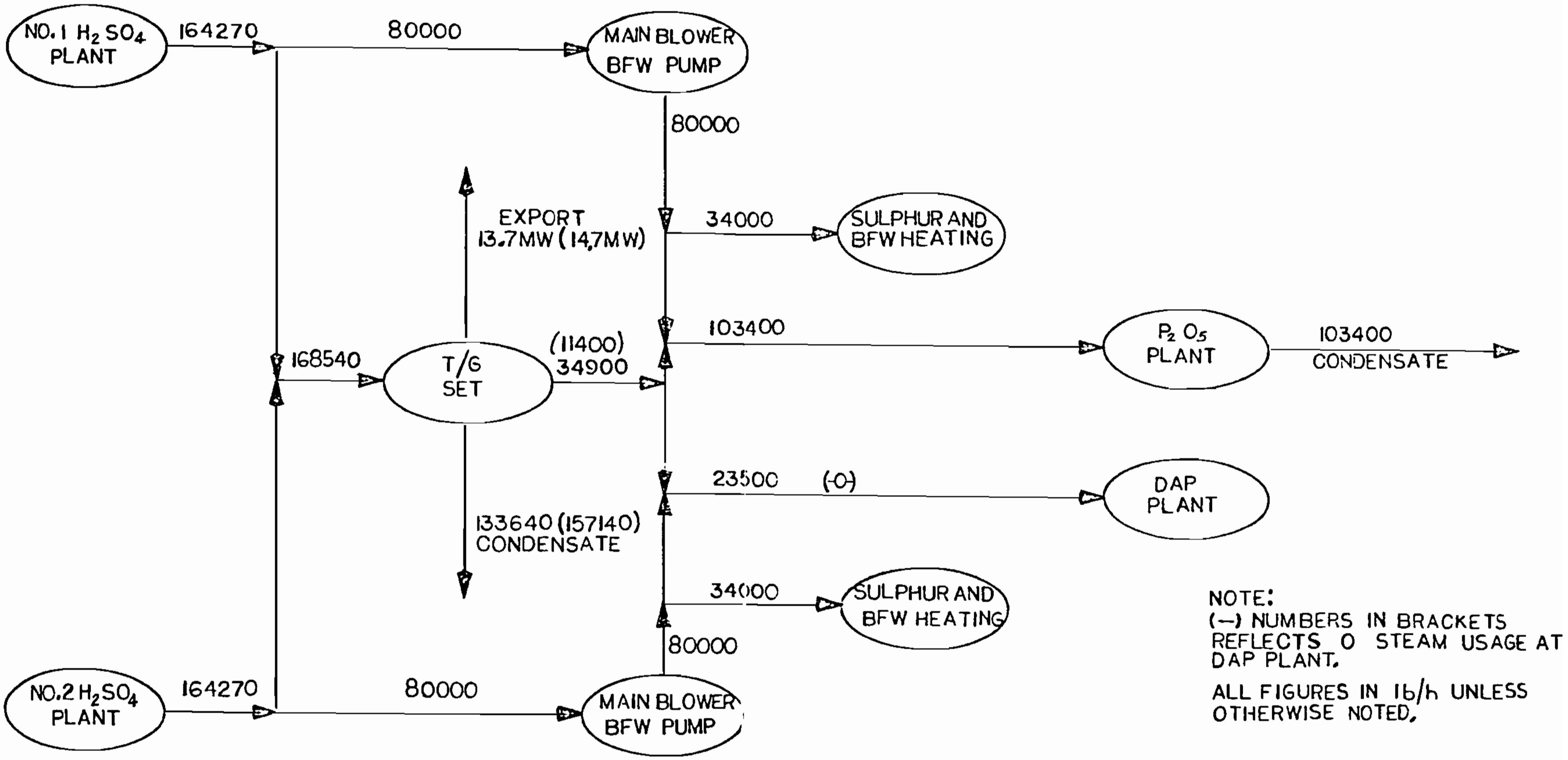

2520
START-UP HEATER PACKAGE
FUEL OIL
AIR
PURGE
MOLTEN SULFUR
STEAM
SULFUR FURNACE
FURNACE BOILER
BFW
BFW
ECONOMIZER
NO.1 HEAT EXCHANGER
S/H
STEAM
STEAM
S/H
STEAM
STEAM
NO.2 HEAT EXCHANGER
S/H
STEAM
STEAM
NO.3 HEAT EXCHANGER
CONVERTER
STACK
SCRUBBER MIST ELIMINATOR
PROCESS WATER
MAIN AIR BLOWER
AIR
DRYING TOWER ENTRAINMENT SEPARATOR
ABSORPTION TOWER ENTRAINMENT SEPARATOR
DRYING TOWER ACID COOLER
BFW
BFW
CWS
ABSORPTION TOWER ACID COOLER
ABSORPTION TOWER
PROCESS WATER
CWS
DRYING TOWER
INLET AIR FILTER
INLINE MIXER
PROCESS WATER
AMMONIA
STEAM
PRODUCT AMMONIUM SULFATE TO STORAGE
PRODUCT ACID TO STORAGE
DRYING TOWER PUMP
ABSORPTION TOWER PUMP
ACID PUMP TANK
PRODUCT ACID COOLER
ACID DILUTION TANK
ACID DILUTION PUMP
STRIPPER BOTTOM PUMP
ACIDULATION STRIPPER
AMMONIA VAPORIZER
SCRUBBER CIRCULATION PUMPS
AMMONIA SCRUBBER
DAVY McKEE, LAKELAND
SULFURIC ACID FROM SULFUR SINGLE ABSORPTION PROCESS WITH AMMONIA SCRUBBER

Figure 3

(BASECASE — DOUBLE ABSORPTION)

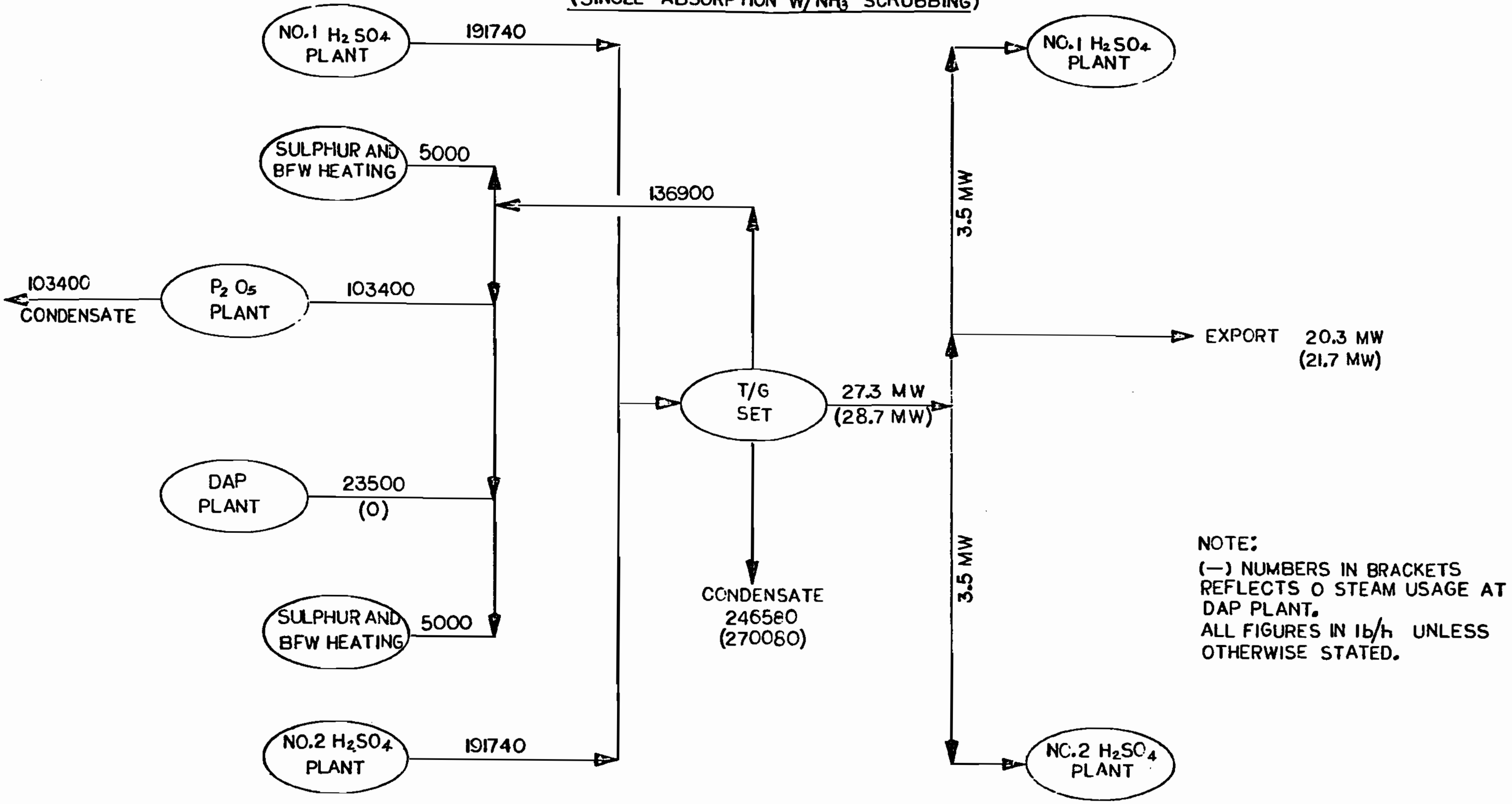


NOTE:
(—) NUMBERS IN BRACKETS REFLECTS 0 STEAM USAGE AT DAP PLANT.

ALL FIGURES IN lb/h UNLESS OTHERWISE NOTED.

Figure 4

(SINGLE ABSORPTION W/NH_3 SCRUBBING)



NOTE:
(—) NUMBERS IN BRACKETS REFLECTS O STEAM USAGE AT DAP PLANT.
ALL FIGURES IN lb/h UNLESS OTHERWISE STATED.

Figure 5

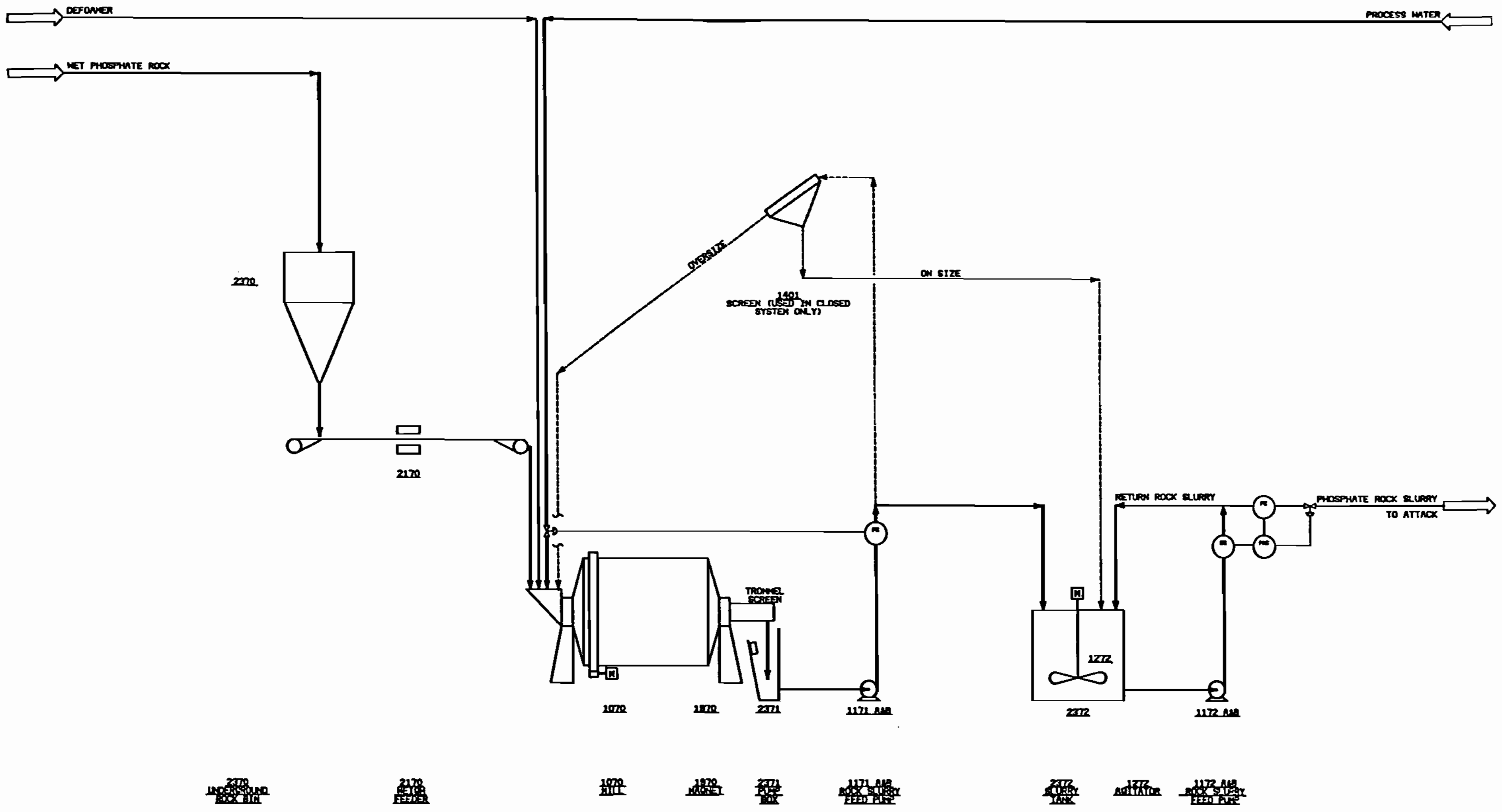


FIGURE 5
DAVY McKEE, LAKELAND
WET ROCK GRINDING
PROCESS FLOW DIAGRAM

Figure 6

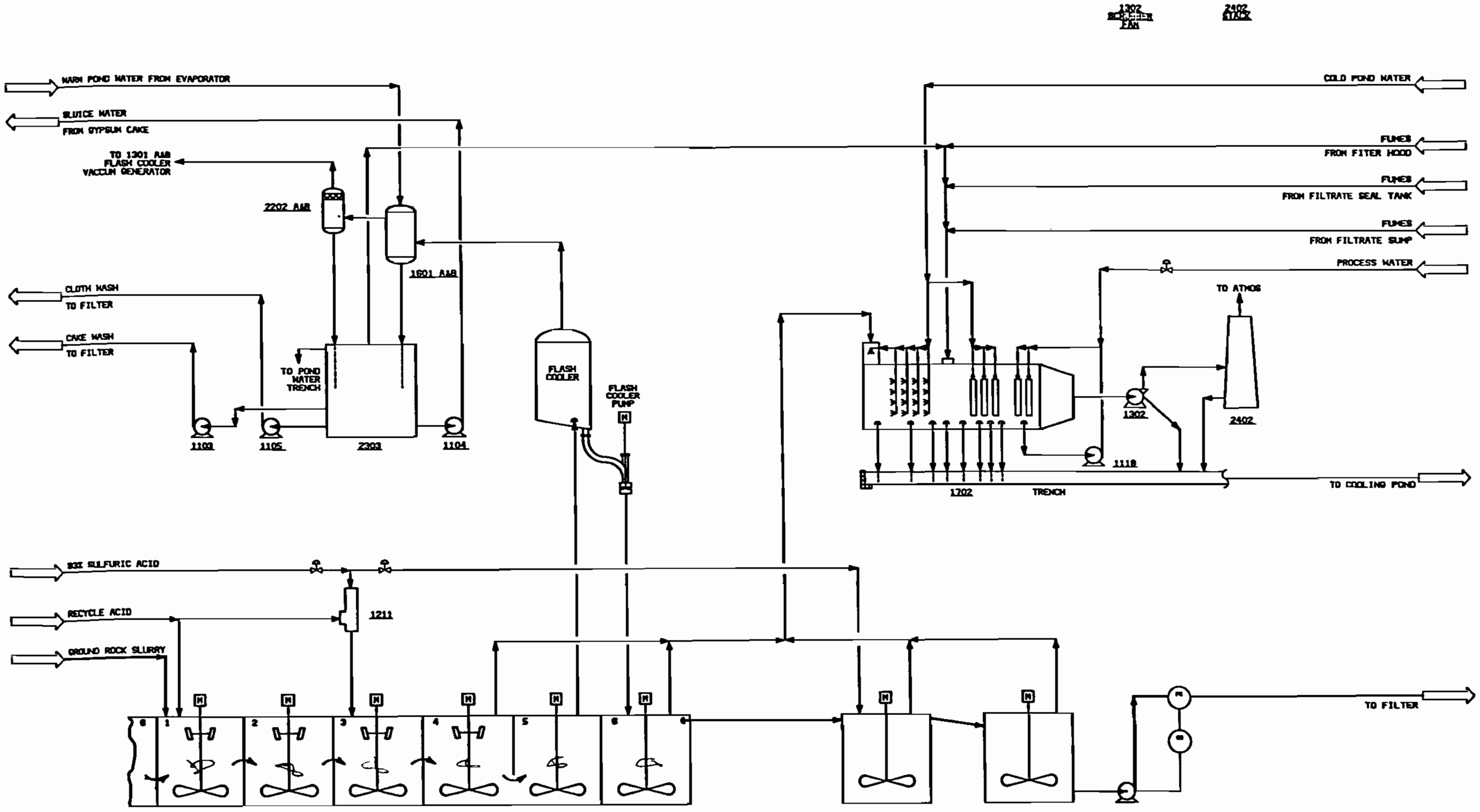


FIGURE 6

DAVY McKEE, LAKELAND

DIHYDRATE PHOSPHORIC ACID PROCESS
PRAYON ATTACK SYSTEM
PROCESS FLOW DIAGRAM

Figure 7

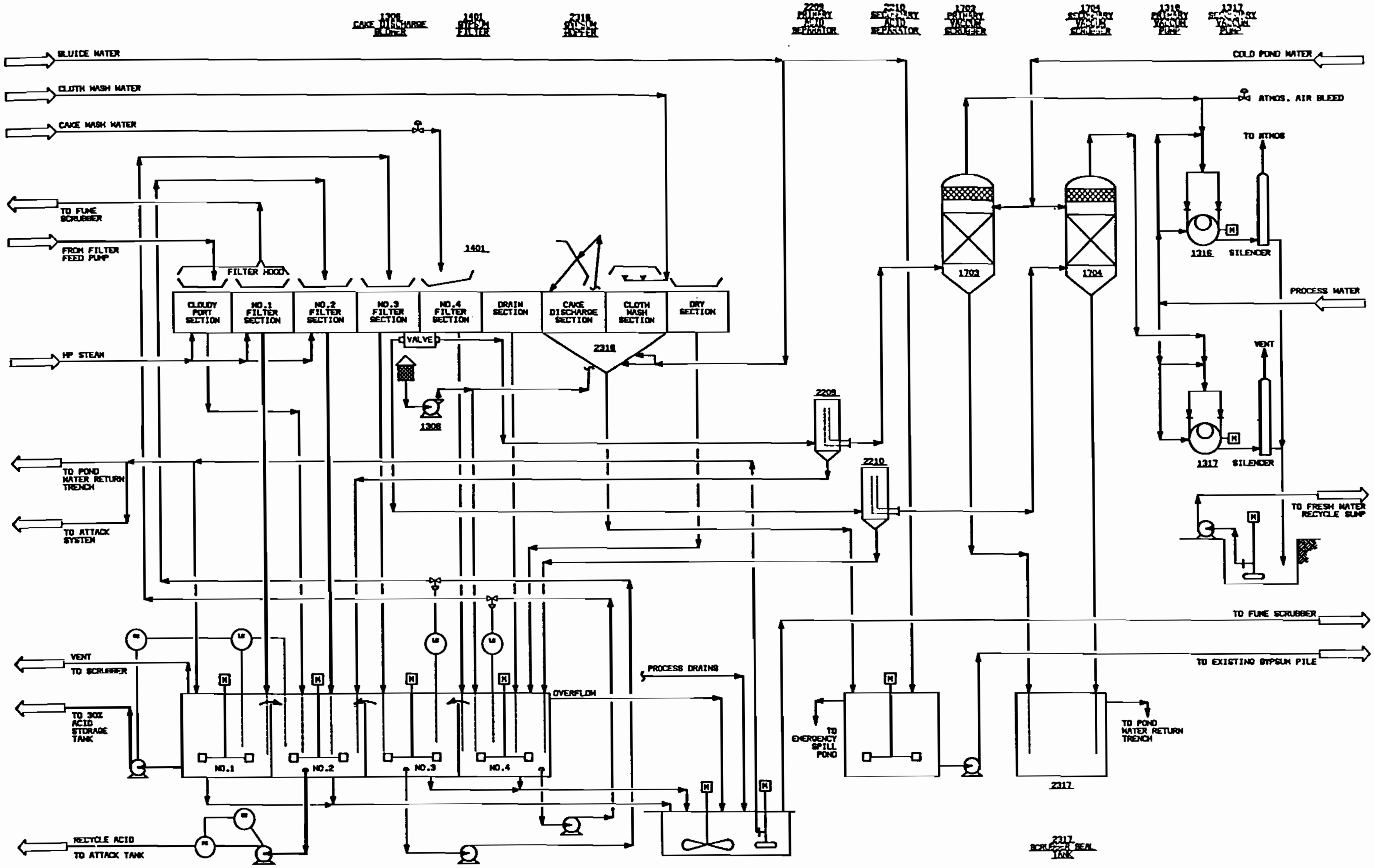


FIGURE 7

DAVY McKEE, LAKELAND

DIHYDRATE PHOSPORIC ACID PROCESS
PRAYON FILTRATION SYSTEM
PROCESS FLOW DIAGRAM

Figure 8

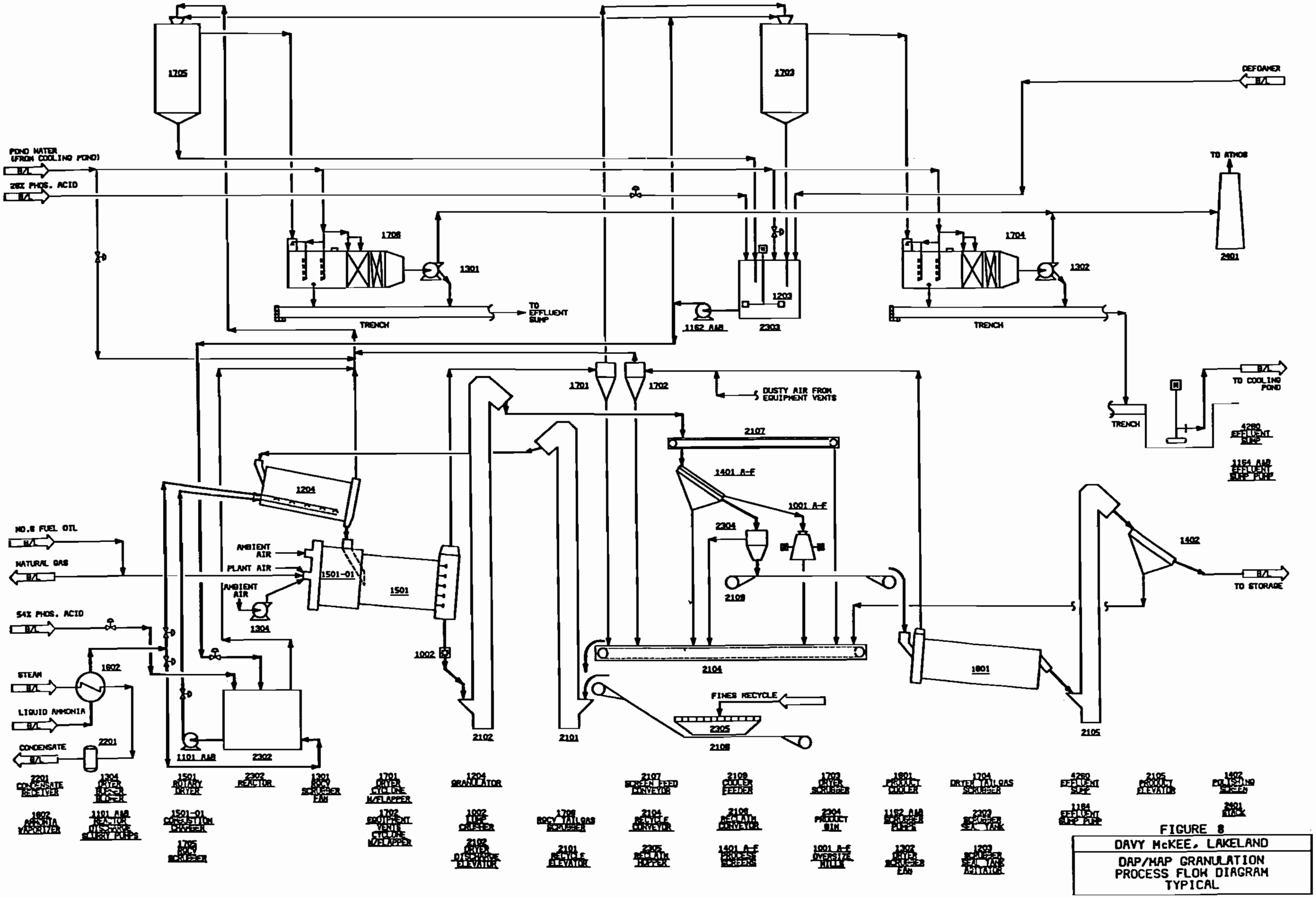
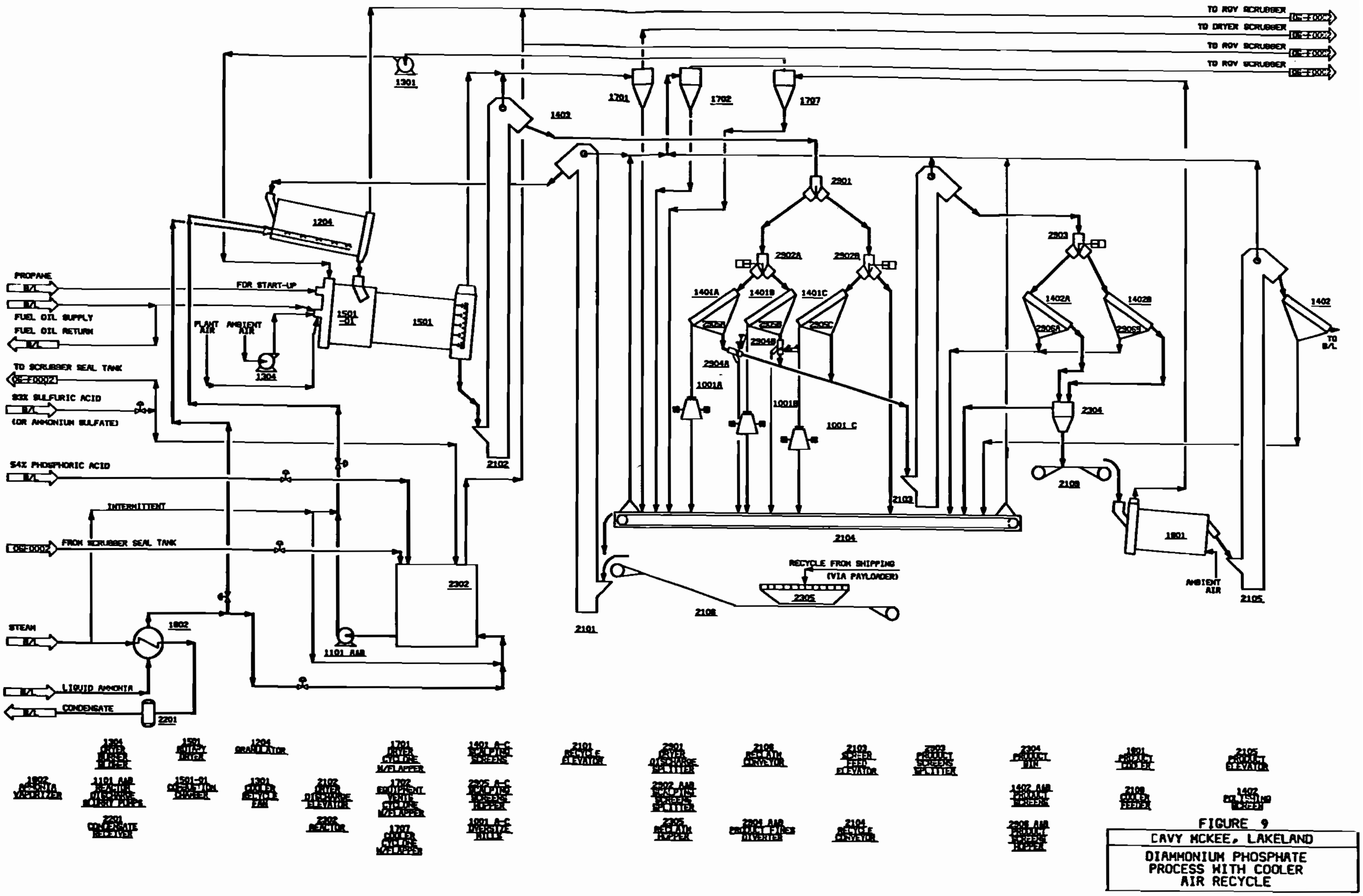

1705
1703
DEFOAMER
B/L
POND WATER (FROM COOLING POND)
B/L
26% PHOS. ACID
B/L
TO ATMOS
2401
1706
1301
1203
1704
1302
TRENCH
TO EFFLUENT SUMP
1162 A&B
2303
TRENCH
1701
1702
DUSTY AIR FROM EQUIPMENT VENTS
B/L
TO COOLING POND
TRENCH
4280 EFFLUENT SUMP
1164 A&B EFFLUENT SUMP PUMP
2107
1204
1401 A-F
1001 A-F
2304
1402
NO.6 FUEL OIL
B/L
NATURAL GAS
B/L
AMBIENT AIR
PLANT AIR
AMBIENT AIR
1501-01
1501
1304
2109
B/L
TO STORAGE
54% PHOS. ACID
B/L
1002
2104
1601
STEAM
B/L
1602
LIQUID AMMONIA
B/L
CONDENSATE
B/L
2201
1101 A&B
2302
2102
2101
FINES RECYCLE
2305
2106
2105
2201 CONDENSATE RECEIVER
1602 AMMONIA VAPORIZER
1304 DRYER BURNER BLOWER
1101 A&B REACTOR DISCHARGE SLURRY PUMPS
1501 ROTARY DRYER
1501-01 COMBUSTION CHAMBER
1705 RDCV SCRUBBER
2302 REACTOR
1301 RDCV SCRUBBER FAN
1701 DRYER CYCLONE W/FLAPPER
1702 EQUIPMENT VENTS CYCLONE W/FLAPPER
1204 GRANULATOR
1002 LUMP CRUSHER
2102 DRYER DISCHARGE ELEVATOR
1706 RDCV TAILGAS SCRUBBER
2101 RECYCLE ELEVATOR
2107 SCREEN FEED CONVEYOR
2104 RECYCLE CONVEYOR
2305 RECLAIM HOPPER
2109 COOLER FEEDER
2106 RECLAIM CONVEYOR
1401 A-F PROCESS SCREENS
1703 DRYER SCRUBBER
2304 PRODUCT BIN
1001 A-F OVERSIZE MILLS
1601 PRODUCT COOLER
1162 A&B SCRUBBER PUMPS
1302 DRYER SCRUBBER FAN
1704 DRYER TAILGAS SCRUBBER
2303 SCRUBBER SEAL TANK
1203 SCRUBBER SEAL TANK AGITATOR
4280 EFFLUENT SUMP
1164 EFFLUENT SUMP PUMP
2105 PRODUCT ELEVATOR
1402 POLISHING SCREEN
2401 STACK
FIGURE 8
DAVY McKEE, LAKELAND
DAP/MAP GRANULATION PROCESS FLOW DIAGRAM TYPICAL

Figure 9


TO ROV SCRUBBER
OE-F002
TO DRYER SCRUBBER
OE-F002
TO ROV SCRUBBER
OE-F002
TO ROV SCRUBBER
OE-F002
1301
1701
1702
1707
1403
2901
1204
2902A
2902B
2903
1401A
1401B
1401C
1402A
1402B
1402
TO B/L
2905A
2905B
2905C
2906A
2906B
2904A
2904B
1001A
1001B
1001 C
2304
2109
2103
2102
2104
2101
2108
1801
AMBIENT AIR
2105
RECYCLE FROM SHIPPING (VIA PAYLOADER)
2305
PROPANE
B/L
B/L
FOR START-UP
FUEL OIL SUPPLY
FUEL OIL RETURN
B/L
1501 -01
1501
PLANT AIR
AMBIENT AIR
1304
TO SCRUBBER SEAL TANK
OE-F002
93% SULFURIC ACID
B/L
(OR AMMONIUM SULFATE)
54% PHOSPHORIC ACID
B/L
INTERMITTENT
OE-F002
FROM SCRUBBER SEAL TANK
2302
STEAM
B/L
1802
1101 A&B
LIQUID AMMONIA
B/L
CONDENSATE
B/L
2201
1304 DRYER BURNER BLOWER
1501 ROTARY DRYER
1204 GRANULATOR
1701 DRYER CYCLONE W/FLAPPER
1401 A-C SCALPING SCREENS
2101 RECYCLE ELEVATOR
2901 DRYER DISCHARGE SPLITTER
2108 RECLAIM CONVEYOR
2103 SCREEN FEED ELEVATOR
2903 PRODUCT SCREENS SPLITTER
2304 PRODUCT BIN
1801 PRODUCT COOLER
2105 PRODUCT ELEVATOR
1802 AMMONIA VAPORIZER
1101 A&B REACTOR DISCHARGE SLURRY PUMPS
1501-01 COMBUSTION CHAMBER
1301 COOLER RECYCLE FAN
2102 DRYER DISCHARGE ELEVATOR
1702 EQUIPMENT VENTS CYCLONE W/FLAPPER
2905 A-C SCALPING SCREENS HOPPER
2902 A&B SCALPING SCREENS SPLITTER
1402 A&B PRODUCT SCREENS
2109 COOLER FEEDER
1402 POLISHING SCREEN
2201 CONDENSATE RECEIVER
2302 REACTOR
1707 COOLER CYCLONE W/FLAPPER
1001 A-C OVERSIZE MILLS
2305 RECLAIM HOPPER
2904 A&B PRODUCT FINES DIVERTER
2104 RECYCLE CONVEYOR
2906 A&B PRODUCT SCREENS HOPPER
FIGURE 9
CAVY MCKEE, LAKELAND
DIAMMONIUM PHOSPHATE
PROCESS WITH COOLER
AIR RECYCLE

MODERATOR THREADGILL: Thank you Jim Kelley for your most interesting discussion on Energy Conservation covering a Fertilizer Complex. (Applause)

I will now entertain questions.

QUESTION—CHARLES G. CHURCHMAN, BADGER AMERICA, INC.: What do you think you can get the steam pressure down to running to the heater and evaporators? What do you think the limit is on the low pressure side for getting that energy out?

JIM KELLEY: Are you talking about the energy in the evaporators?

CHARLES CHURCHMAN: No, the steam pressure of the steam going to the evaporator heater. What do you think you can get it down to as a minimum pressure level and still operate an evaporator effectively and yet recover as much energy as possible?

ANSWER—JIM KELLEY: I think you can get it down to 10 lbs. (10 psig). I think you need that 10 lbs. to get through the evaporator, heater and the condensate system.

QUESTION FROM RUDY TIMON, BREWSTER PHOSPHATES: In regard to your D.A.P. Plants do you think the dust has to be removed from the cooler prior to being directed to the dryer?

ANSWER—JIM KELLEY: Yes. It goes thru a cyclone and then into a scrubber. The dust has to be removed.

QUESTION H. SAEHADHO, BILLDUNE FERTILIZER: This is about the condensate return system. How do you monitor the ph coming off the acid plant?

ANSWER—JIM KELLEY: The pH, or the conductivity usually goes thru three conductivity cells. There is one at the evaporator, one at the surge tank in the phos. acid area and there is one over in the sulphuric acid plant. Believe it or not, every once in a while, a bad condensate gets thru all three. This is human error. In the case I am referring to, I will not mention any names, the operators had turned off two of the three conductivity circuits. They split a tube in the evaporator and the one in the sulphuric acid plant was not working, so they got acid condensate into the boiler which is not good.

QUESTION FROM ROBERT M. SOMERVILLE, LANDSKRONA INTERNATIONAL, INC.: Do you have any comments on the relative merits of a turbo generator set in the sulfuric acid plant as compared with putting in a lot of turbin drives around the plant?

ANSWER—JIM KELLEY: Yes, I prefer the turbo generator set. With all of the steam generators around the plant you have to run in steam lines and run out condensate lines. It becomes quite a piping nightmare. It is better to centralize your electricity in a turbo generator set and then make your main blower electrical and your boiler feed water pumps electrical too. Then you have an all electrical system in the plant with a turbo generator in a central location. At least that is the way it looks best to the engineers at Davy.

MODERATOR THREADGILL: Any other questions? Thank you Jim. (Applause) Our next speaker will be talking to us on a very important subject: "Retail Marketing of Fertilizers in the U.S." This paper was prepared by Norman L. Hargett, Fertilizer Distribution Analyst T.V.A. and Ralph Pay, Division of Feeds, Fertilizer and Pesticides, State Plant Board of Little Rock, Ark. Mr. Hargett will present the discussion. (Applause)

Retail Marketing Of Fertilizers In the U.S.[1]

by

Norman L. Hargett[2]

and

Ralph Pay[3]

Presented by Norman L. Hargett

Introduction

Each year the U.S. fertilizer industry sells more than 50 million tons of fertilizers worth 6.5 billion dollars to 2.3 million American farmers. This vital link between producer and farmer consists of about 12,000 bulk blenders, fluid mixers, ammoniation-granulation plants and retial stores. These retail fertilizer outlets receive fertilizer materials from basic producers of ammonia, phosphoric acid, diammonium phosphate, triple superphosphate, and potash. Then they mix, blend, suspend, granulate, and add micronutrients and pesticides and sell the products to farmers. A diagram of the U.S. fertilizer production and distribution flow is shown in Figure 1.

Twenty-five years ago the fertilizer marketing pattern involved basic producers who supplied products to large regional mixing plants. These regional plants were owned and operated by wholesale distribution mixers who combined basic materials into a few fertilizer mixtures for distribution to retail outlets and sale to farmers.

Today, the principal marketing pattern consists of basic producers who provide basic materials to large-scale ammoniation-granulation plants, dry bulk blenders, and liquid and suspension mix plants. These materials are then combined into hundreds of fertilizer mixtures for sale to farmers.

Periodically, TVA, in cooperation with the Association of American Plant Food Control Officials, conducts a survey of the retail segment of the U.S. fertilizer market. The survey provides current information for the compilation and publication of the *Directory of Fertilizer Manufacturers in the U.S.* and a profile of the retail market.

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1. Presented at the Fertilizer Industry Roundtable, Atlanta, Georgia, October 28-30, 1980.

2. Fertilizer Distribution Analyst, Tennessee Valley Authority, Muscle Shoals, Alabama 35660.

3. Director, Division of Feeds, Fertilizer & Pesticides, State Plant Board of Little Rock, Arkansas 72205.

Survey of the Fertilizer Industry

In 1973-74, the Association of American Plant Food Control Officials (AAPFCO) and the National Fertilizer Development Center (NFDC) conducted the first survey of U.S. fertilizer distributors. Results were presented at The Fertilizer Industry Roundtable annual meeting in 1975. A second survey was made in 1976-77 and again presented at the Roundtable meeting in 1977. The latest survey was made in 1979-80 and we are pleased that the Roundtable Committee has asked us to present these new results.

The 1979-80 survey is based on a return of 5,985 questionnaires. Bulk blenders, fluid mixers, granulation plants, and a few basic producers are included in the analysis. Based on reported fertilizer distribution in 44 states participating in the survey, the 3,817 plants reporting total annual distribution account for 60 percent of the total fertilizer consumed in the U.S.

Five states—California, Minnesota, Missouri, Nebraska, and New York—did not respond to the survey and are not included in the following analysis. These states furnished listings of fertilizer registrants which are included in the *Directory of Fertilizer Plants in the U.S.*

Of the 5,985 questionnaires returned, 4,616 plants indicate they are fertilizer manufacturers with bulk blend, liquid mix, and/or granulation facilities. A regional breakdown by type of fertilizer plant is shown in Table 1. Summaries of the survey data for each region are shown in appendix Tables A, B, and C. Sixty-three percent of the fertilizer plants responding are in the East North Central and West North Central states. According to USDA, these states account for 46 percent of all fertilizer materials distributed in Fiscal year 1979 ending June 30.

Distribution by class indicates that 41.5 percent of all fertilizers were dry bulk or bagged blends. Fluid fertilizers (including mixtures, anhydrous ammonia, nitrogen solutions and other direct application materials) account for 31.9 percent; granulation materials account for 16.2 percent; with the remaining 10.4 percent consisting of dry direct application materials, such as ammonium nitrate (33.5-0-0), and diammonium phosphate (18-46-0). Percentages of materials distributed by all plants are shown in Table 2. Applying these percentages to the 51 million tons of materials distributed in fiscal year 1979 indicates that 21.2 million tons of dry blends (both bulk and bagged), 8.3 million tons of granular NPK mixtures, and 5.2 million tons of fluid mixtures were used. Previous AAPFCO surveys indicated similar distribution patterns.

Granulation Plants

Granular homogeneous complete mixtures continue to be a major marketing channel for N, P, and K. However, conventional ammoniation-granulation plants have changed. These plants now use large quantities of phosphoric and sulfuric acid, anhydrous ammonia, and other fluids to produce granular NPK fertilizers, while their use of run-of-pile triple superphosphate, normal superphosphate and ammoniating solutions is decreasing. Diammonium phosphate (18-46-0) is also a popular source of both nitrogen and phosphate for granulating complete mixtures. Many have installed new pipe-cross reactors and, as a result, production levels have generally increased. Granulation plants also provide an excellent way for incorporating micronutrients in mixed grades and for using byproduct materials.

There are relatively few ammoniation-granulation plants in the U.S. The 1974 AAPFCO survey listed 118 plants, the latest only 82. Supplementary data, updated in August 1980, indicates that 107 ammoniation-granulation plants are operating (Figure 2). Total tonnage of NPK mixtures from these plants is estimated to be 8.5 million tons—including both large plants, primarily producing for the farm market, and smaller plants, producing for the non-farm market. Leading grades produced by these granulation plants are 10-10-10, 5-10-15, 3-9-18, 5-10-10, 6-24-24, 10-20-20, 3-9-9, 13-13-13, 12-12-12, and 6-12-18. Average analysis of all grades produced by granulation plants is 35.1 percent.

Of the 82 plants included in the AAPFCO survey 44 are exclusively ammoniation-granulation plants. Thirty-five of these 44 plants produced 4.6 million tons of fertilizer for an average annual through-put of 132,980 tons. Of this, 33 percent was sold to blenders or retailers for use in their plants or for resale. Raw material and finished product storage amounted to 27.4 percent of the total annual distribution (Table 3).

Granulation plants including units with bulk blend and/or fluid facilities, indicate a slightly higher storage capacity of 32.5 percent of annual distribution. Only 9 percent of the 35 plants add pesticides to mixtures, 82 percent add micronutrients, and 22 percent of the total tonnage of the granulation plants is custom applied. Forty-nine percent of these plants are in the Atlantic Coast states and thirty percent in the Midwest.

Bulk Blend Plants

Bulk blending became prominent in the middle 1950's with the introduction of granular diammonium phosphate. Because manufacturing and distribution was simpler and more economical than traditional methods, bulk blending grew rapidly. Today it is the largest system of manufacturing and distributing fertilizer mixtures. Bulk blenders buy materials from basic producers or granulation plants and mix these materials to grade or as specified by the farmer. A primary reason for this rapid growth is the ability of dealers to provide the farmer with needed services such as custom mixing and spreading at attractive prices.

Bulk blending works best with well-granulated, closely-sized, dry materials that do not deteriorate in storage. Bulk blending and granulation have been complementary developments as needs of blenders have motivated manufacturers of granular materials to provide an increasing supply of materials with improved physical properties. Materials most commonly used for bulk blending are ammonium nitrate, urea, ammonium sulfate, diammonium phosphate, granular triple superphosphate, and potassium chloride. More plants report the use of urea as a nitrogen source than any other material. Ammonium nitrate is second in importance. diammonium phosphate and triple superphosphate are the main sources of P_2O_5 (Table 4). Other materials used include normal superphosphate; ammonium phosphate grades, such as 16-20-0, 27-14-0, and 11-48-0; and complete mixtures, such as 6-24-24.

Of the 4,616 plants included in the AAPFCO survey 2,428 were reported to be exclusively bulk blend facilities. The typical bulk blend plant has a total annual throughput of 5,410 tons of all materials. Of this total, 3,167 tons are dry bulk blend mixtures with 9-23-30, 6-24-24, 10-10-10, 19-19-19, 17-17-17, 8-32-16, 10-20-20, 0-26-26, 6-15-40, and 10-26-26 being the leading grades. Average analysis for these 10 grades is 53.5 percent, and is considerably higher than grades produced in other types of fertilizer mix plants. The average bulk blend plant also distributes 1,513 tons of dry direct application materials, such as ammonium nitrate and diammonium phosphate. The typical plant distributes 792 tons of anhydrous ammonia and 691 tons of nitrogen solutions. Average tonnages are only for plants handling these products and therefore are not additive (Table 5).

Through the 5,410-ton average annual distribution may appear high, a frequency distribution of these 2,428 bulk blend plants (Figure 3) indicates the greater number of plants are in the 1,000-3,000-ton range. The mode—2,079 tons—is the value occuring with greatest frequency and the median—3,167 tons—represents the middle value of all bulk blend plants included in the survey. The survey shows 55 percent of the respondents with distribution between 1,000 and 4,000 tons.

Storage capacity for raw materials and finished products averages 44.3 percent of the total annual distribution for the 2,428 plants (appendix Table A). A comparison with the previous survey shows that bulk blend plants have not increased their storage capacity relative to total distribution. Storage is an important function of the retailer because it allows basic producers to maintain monthly production levels despite a highly seasonal market. Bulk blenders indicate that 68 percent of their storage was filled as of December 31, 1978, and 30 percent as of June 30, 1979.

The survey reveals that bulk blenders have increased farmer services. In 1979 a total of 44.1 percent of the fertilizer was custom applied by blenders and 31.5 percent was spread by the farmer with rental equipment (Table 6). By contrast, in 1974, and 1976, 30 percent and 25 percent respectively of the fertilizer distributed by blenders was custom applied. The West South Central region had the greatest percentage of fertilizer custom applied followed by the Mountain and New England regions. Data on custom application indicate that more material is being applied by farmers than is being custom applied by blenders. However, dealers often provide rental application equipment to farmers.

Other services offered by blenders, such as adding pesticides and micronutrients to fertilizer mixtures, are shown in Table 6. Almost 67 percent of all bulk blend plants add micronutrients, 43 percent add herbicides, 29 percent add insecticides, 44 percent add seed to their dry bulk blend, and 19 percent have bagging facilities. These data indicate that complementary services continue to be a vital part of the bulk blenders' fertilizer marketing program.

Eighty-six percent of all blend plants have no other manufacturing facilities. However, 346 plants have both bulk and liquid facilities, 57 have bulk and suspension, and 121 have all three.

Data relating to the form or type of business reveals that 7.0 percent of these bulk blend plants are sole proprietorships, 3.7 percent partnerships, 46.1 percent corporations, and 43.2 percent cooperatives (Table 7).

Fluid Fertilizer Plants

The number of fluid-fertilizer-mix plants has also grown at a remarkable rate during the past 15 years. However,, production of liquid and suspension fertilizers has been hampered at times by limited supplies of suitable phosphate materials. As with dry bulk blending, little investment is required for establishing a fluid mix fertilizer unit. With suspensions, higher analysis grades can be produced at a lower unit cost than with liquids. Today, fluids continue to expand in the fertilizer market.

Both bulk blend and fluid mix fertilizer distribution systems provide an economical way of combining intermediate fertilizer materials produced at widely dispersed production points. They also serve as storage facilities in the market area and are the major point of contact between dealers and farmers.

Fluid fertilizers including liquids and suspensions are considered in this analysis. In the 1950's, more elemental phosphorus and furnace phosphoric acid was available than needed for the industrial market. This surplus was used in liquid fertilizer by neutralizing it with low-cost ammonia to produce 11-17-0 or 10-34-0. Production of high-nitrogen, nonpressure urea-ammonium nitrate solutions further promoted liquid fertilizers, as these solutions can be used in the manufacture of fluid fertilizers or as a direct application material. Advantages of fluid fertilizers include ease of mixing, ease of incorporating additives and securing homogeneity of the mixture, convenience of mechanical handling, and high reliability of fluid application systems.

Suspension fertilizers are defined as liquids in which salts are suspended by the incorporation of a suspending agent. Complete solubility of phosphate is not required in suspensions. This allows a wider range of phosphate materials to be used. Mono-ammonium phosphates (MAP) have recently become a primary source of P_2O_5 for suspension manufacture (Table 4). Suspensions also permit production of higher analysis grades than is possible with conventional liquids. Consumption of all fluid mixtures (liquids and suspensions) as reported by USDA for fiscal year 1979 was 4.4 million tons. In 1979, five states—Georgia, Illinois, Indiana, Iowa, and Texas—accounted for half of all fluid mixtures used. Based on the AAPFCO survey it is estimated that suspensions now comprise 40 percent of all fluid mixtures, up from 25 percent in 1974 and 33 percent in 1976.

The AAPFCO survey shows an average annual throughput of 3,840 tons for the 446 plants listing only liquid mix facilities. A typical plant distributes 2,091 tons of liquid mixtures, 793 tons of anhydrous ammonia, 1,293 tons of nitrogen solutions, and 718 tons of liquid direct application materials, such as 10-34-0 and 8-24-0 (Table 5). The ten leading liquid grades reported are: 20-10-0, 4-10-10, 7-21-7, 2-6-12, 7-22-5, 5-10-10, 6-18-6, 4-8-12, 10-34-0, and 16-20-0. Analysis for these grades averages 30.2 percent. These plants also distribute significant tonnages of bulk and bagged dry mixtures and materials, such as ammonium nitrate and diammonium phosphate.

Comparable data for the suspension fertilizer plants show an average annual throughput of 3,604 tons including 1,991 tons of suspension mixtures, 487 tons of anhydrous ammonia, 670 tons of nitrogen solutions, and 775 tons of dry and liquid direct application materials (Table 5). The ten leading suspension grades produced by these suspension plants are: 3-10-30, 4-12-24, 3-9-27, 6-18-18, 13-13-13, 3-9-18, 10-30-0, 5-10-15, 20-5-10, and 5-15-30. Average analysis for these grades is 39.3 percent compared to 30.2 percent for liquids. Similar to the liquid plants, these suspension plants also distribute significant tonnages of dry complete mixtures. A frequency distribution of all fluid plants (both liquids and suspensions) indicates the greatest number of plants in the 1,000- to 3,000-ton range (figure 4). Compared to bulk blend plants, fluid facilities tend to be smaller. The mode for fluids is 1,245 tons compared to 2,079 tons for bulk blending. The median for fluids is 2,064 tons while for bulk blends it is 3,167 tons.

Storage capacity for liquid fertilizer plants surveyed amounts to 45.7 percent of the total annual distribution. Suspension plants have a storage capacity of 11.3 percent of the total annual distribution. Both liquid and suspnesion plants show increases in their storage capacities in the past several years. In December 1978, 62 percent of the storage facilities for liquids was filled with 30 percent filled as of June 30, 1979. Suspension plants report 61 and 26 percent for the same periods. Storage capacity by region and type of fertilizers is shown in Table 3.

A total of 40 percent of the liquid fertilizers tonnage is custom applied (appendix Table 8) with 35 percent of the tonnage applied by the dealer and 5 percent by application contractors. The farmer applies 28 percent using his own equipment and 30 percent using rental equipment. Similar to the bulk blenders, farmer application of liquid fertilizers is far greater then custom application by the dealers, although dealers provide the rental equipment for farmers to apply 30 percent of the fertilizer.

The percentage of custom applied suspension fertilizers is higher than that for both bulk blends and liquids. Almost 79 percent of suspension mixes is custom applied, and unlide bulk blend and liquid plants, suspension dealers custom apply 75 percent of the fertilizer. The higher percentage is because suspensions generally require more sophisticated application equipment, (Table 6).

Ownership data relating to all fluid fertilizer plants show that 13.0 percent of these plants are sole proprietorships, 7.3 percent partnerships, 63.6 percent corporations, and 16.1 percent cooperatives (Table 7).

National Market Patterns

Other services—The survey also provides a composite description of the U.S. fertilizer market system. Of the 5,985 respondents, 4,616 have manufacturing facilities such as bulk blending, liquid and suspension mixing, and granulation or basic production units. Almost 41 percent offer anhydrous ammonia, 75.8 percent provide custom application services, 32.2 percent add insecticides, 46.6 add herbicides to their fertilizer mixtures, and 64.3 percent add micronutrients. Consultation service is offered by 64.9 percent of the manufacturing plants.

Non-farm use—The survey shows that 3.0 percent of total tonnage for all respondents is for nonfarm use. Granulators sell 8.8 percent of their annual tonnage for non-farm use; bulk blenders, 2.5 percent; and fluid mixers, 1.1 percent. As also shown to the previous survey, more nonfarm or small-packaged fertilizers are provided by basic producers and/or granulators than by small blenders and fluid mixers.

Types of plants—About 74 percent of all manufacturing plants have bulk blend facilities and 35.2 percent have fluid mix facilities. Twenty-four percent of the fluid mixers have both liquid and suspension facilities.

Ownership patterns—Nine percent of all manufacturing plants indicate their form of business as sole proprietorships; 5.0 percent as partnerships; 51.6 percent as corporations; and 34.4 percent as cooperatives (Table 7).

Directory of Fertilizer Manufacturers

A 1980 edition of the DIRECTORY OF FERTILIZER PLANTS IN THE U.S., based on respondents to the AAPFCO survey, is available through the National Fertilizer Development Center. The directory lists plant location, plant type (bulk blend, fluid mix, or granulation), plant owner's or manager's name, telephone number, storage capacity, and related services offered by each plant. Requests, including prepayment of $5 per copy, should be directed to the National Fertilizer Development Center, Room F222, Fertilizer Economics and Marketing Research Staff, Marketing and Distribution Economics Section, Muscle Shoals, Alabama 35660. (See Note Attached)

TABLE 1

SUMMARY OF DIRECTORY LISTINGS--1980[a]

REGION	TOTAL LISTINGS[b]	BULK BLEND ALL	BULK BLEND BB ONLY	FLUID ALL	FLUID LIQ	FLUID LIQ ONLY	FLUID SUS	FLUID SUS ONLY	FLUID LS ONLY
New England	86	33	27	10	3	–	9	4	1
Middle Atlantic	390	142	124	31	26	11	14	4	4
South Atlantic	856	301	259	198	148	72	111	41	44
East North Central	2,935	960	800	346	30	47	203	31	98
West North Central	4,502	1,623	1,427	778	73	447	193	25	92
East South Central	517	247	233	75	35	14	60	33	16
West South Central	1,665	434	378	341	318	243	58	14	26
Mountain	519	197	150	86	82	27	22	3	9
Pacific	661	66	47	54	53	26	11	1	4
Total	12,131	4,003	3,445	1,919	1,704	887	681	156	294

REGION	GRANULATION ALL	GRANULATION GRAN ONLY	ALL PLANTS[c]	TOTAL QUESTIONNAIRES[c]	QUESTIONNAIRES AS % OF TOTAL[d]
New England	2	1	42	43	50.0
Middle Atlantic	10	3	167	207	64.8
South Atlantic	31	19	493	576	67.3
East North Central	13	5	1,209	1,285	43.8
West North Central	4	4	2,370	1,420	57.5
East South Central	12	7	324	359	69.4
West South Central	7	3	739	1,593	95.7
Mountain	–	–	241	347	66.9
Pacific	3	2	104	155	66.5
Total	82	44	5,689	5,985	62.4

[a] Types of plants determined by AAPFCO survey

[b] Includes questionnaires and list of registrants

[c] Includes data on type of plant supplied by both lists of registrants and the AAPFCO questionnaires. (4616 from survey, 1369 from lists)

[d] Adjusted for states that did not participate in the AAPFCO survey

TABLE 2
DISTRIBUTION OF FERTILIZER MATERIALS IN THE U.S. BY CLASS--1980

CLASS	Percent of Total Fertilizer[a] 1974	1976	1979	Total Material 1974	1976	1979
	--------%	--------	--------	------Million Tons	------	------
Dry Bulk Blends	33.3	33.7	35.8	15.7	16.5	18.3
Dry Bagged Blends	9.2	6.4	5.7	4.3	3.1	2.9
Bulk Granulation	4.9	9.9	9.9	2.3	4.9	5.1
Bagged Granulation	6.2	9.0	6.3	2.9	4.4	3.2
Fluid Mixtures (Liq & Sus)	9.7	9.6	10.1	4.6	4.7	5.2
Anhydrous Ammonia	7.2	9.5	9.2	3.4	4.7	4.7
Nitrogen Solutions	7.1	9.4	10.8	3.3	4.6	5.5
Dry Direct Application Mat.	19.7	9.5	10.4	9.3	4.7	5.3
Liq. Direct Application Mat.	2.7	3.0	1.8	.7	1.5	.9
Total	100.0	100.0	100.0	47.1	49.1	51.1

[a] AAPFCO-TVA Fertilizer Plant Surveys

TABLE 3
STORAGE CAPACITY OF BULK BLEND, FLUID, AND GRANULATION PLANTS[a]

REGION	Bulk Blend	Liquid	Suspension	All Fluid	Granulation	All Plants
	(% of Total Fertilizer Distribution)					
New England	69.8	-	37.2	21.5	66.8	54.4
Middle Atlantic	66.4	16.6	31.6	28.7	49.7	55.2
South Atlantic	30.4	28.6	23.4	31.5	31.3	29.7
East North Central	44.8	48.8	32.6	47.6	31.2	43.4
West North Central	53.3	57.4	57.4	69.1	43.5	55.7
East South Central	53.7	31.6	37.4	41.8	23.4	29.8
West South Central	36.9	54.6	22.0	42.2	37.6	35.6
Mountain	40.4	37.6	14.6	30.5	-	35.7
Pacific	31.8	12.5	33.3	26.2	50.5	35.4
AVERAGE	44.3	45.7	31.3	44.6	32.5	39.3
No. Plants Reporting	3,213	446	134	1,432	69	3,781

[a] AAPFCO Fertilizer Plant Survey--1980

TABLE 4
TYPES OF MATERIALS USED IN BULK BLEND, FLUID, AND GRANULATION PLANTS[a]

MATERIALS	Bulk Blend	Liquid	Suspension	Granulation	Pipe Reactors
			(% of Plants)		
Ammonium Nitrate	41.4	-	-	-	-
Ammonium Sulfate	21.7	2.8	4.3	75.0	8.0
Urea	66.1	5.7	2.2	20.0	12.0
Urea (soluble)	-	7.4	14.4	-	30.0
DAP (18-46-0)	94.5	1.5	5.8	85.0	6.0
MAP (11-52-0, etc)	10.7	2.3	31.7	45.0	18.0
Normal Superphosphate	4.1	-	-	60.0	-
Triple Superphosphate	78.4	-	-	82.5	-
Nitrogen Solutions	-	83.9	73.3	-	82.0
Anhydrous Ammonia	-	9.3	37.4	85.0	66.0
10-34-0	-	86.0	69.1	-	86.0
Phosphoric Acid	-	8.9	7.2	75.0	40.0
Superphosphoric Acid	-	3.8	1.4	-	56.0
Ammoniating Solutions	-	-	-	70.0	-
Sulfuric Acid	-	-	-	90.0	-
Dry Clay	-	3.6	53.1	-	46.0
Fluid Clay	-	1.9	18.7	-	18.0
Potassium Chloride (STD)	93.9	12.5	18.0	92.5	24.0
Potassium Chloride (SOL)	-	38.8	59.7	-	78.0
By-Products	-	4.9	2.2	-	-
Other	16.9	-	21.6	22.5	8.0
Number of Plants Reporting	2,727	472	139	40	50

[a] AAPFCO Fertilizer Plant Survey--1980

TABLE 5
AVERAGE THROUGHPUT FOR BULK BLEND, LIQUID MIX, AND SUSPENSION FERTILIZER PLANTS 1980[a]

	Bulk Blend Only		Liquid Only		Suspension Only	
CLASS	PLANTS	TONS	PLANTS	TONS	PLANTS	TONS
Dry Bulk Blend Mixtures	2,340	3,167	57	578	15	426
Dry Bagged Blend Mixtures	954	1,420	37	402	10	185
Granulation Bulk Mixtures	362	989	52	1,187	28	2,426
Granulation Bagged Mixtures	669	553	46	388	27	365
Liquid Mixtures	268	403	378	2,091	13	477
Suspension Mixtures	20	994	25	898	125	1,991
Anhydrous Ammonia	1,182	792	168	793	56	487
Nitrogen Solutions	1,171	691	330	1,293	114	670
Direct Application, Dry	1,046	1,513	64	821	15	464
Direct Application, Liq.	195	334	211	718	44	311
Total Plants	2,428		446		134	
Average Throughput		5,410		3,840		3,604

[a] AAPFCO Fertilizer Plant Survey--1980

TABLE 6
OTHER SERVICES OFFERED[a]

SERVICE	BULK BLEND	LIQ	SUS	ALL FLUID	GRAN.	ALL PLANTS
			(% of plants)			
Adding Herbicides to Mixtures	42.6	49.3	91.0	71.3	8.5	46.6
Adding Insecticides to Mixtures	29.4	30.2	52.2	48.4	5.7	32.2
Adding Micronutrients to Mixtures	66.5	63.2	86.5	79.9	82.8	64.3
Adding Seeds to Mixtures	44.0	8.5	18.6	27.5	-	33.6
Bagging Equipment	18.6	-	-	-	62.8	14.2
Soil Testing	85.0	70.6	90.2	83.2	62.8	74.9
Consultation Service	73.0	68.1	58.9	73.2	57.1	64.9
Custom Application	44.1	40.2	78.9	56.6	9.0	75.8
Number of Plants	2,428	446	134	1,299	35	3,914

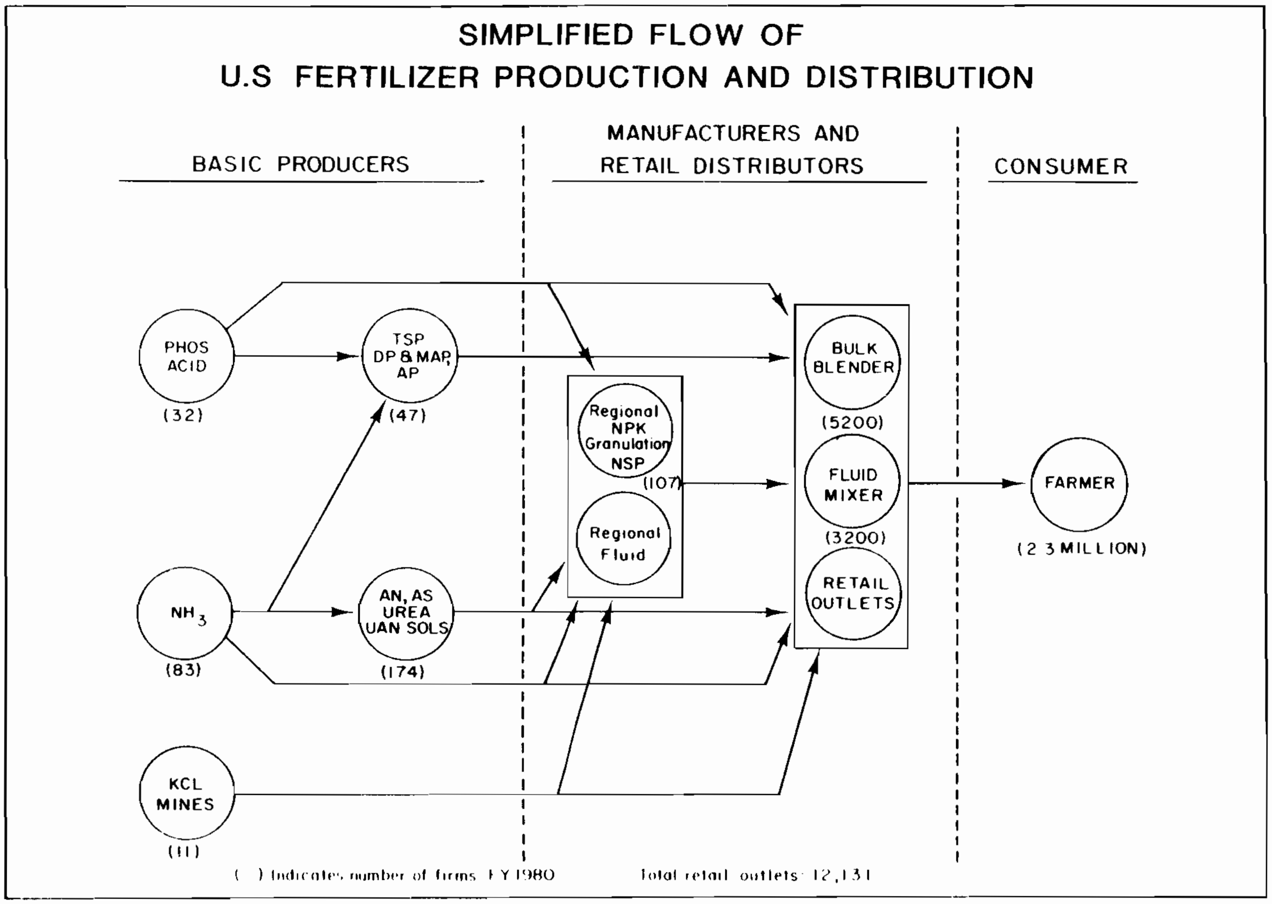
[a] AAPFCO Fertilizer Plant Survey--1980

TABLE 7
FORM OF BUSINESS[a]

FORM	BULK BLEND	LIQUID	SUSPENSION	ALL FLUID	GRANULATION	RETAIL OUTLETS	ALL PLANTS
			(% of plants)				
Sole Proprietor	7.0	13.0	12.0	13.0	1.3	29.6	9.0
Partnership	3.7	7.3	6.7	7.2	-	8.2	5.0
Corporation	46.1	63.1	71.6	63.8	81.0	45.6	51.6
Cooperative	43.2	16.6	9.7	16.0	17.7	16.6	34.4
Number Reporting	3,228	1,259	654	1,466	79	1,529	4,306

[a] AAPFCO Fertilizer Plant Survey--1980

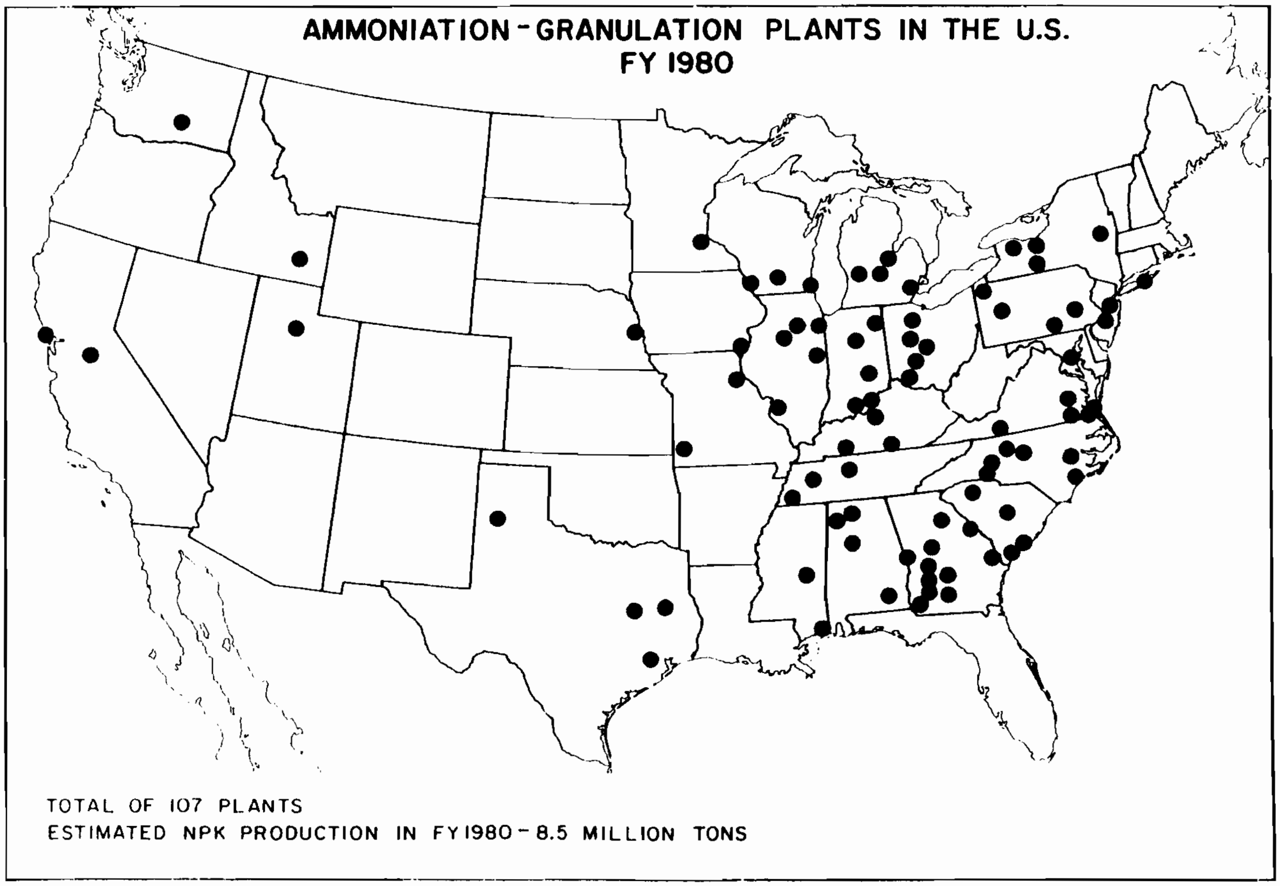
Figure 1



SIMPLIFIED FLOW OF U.S FERTILIZER PRODUCTION AND DISTRIBUTION

( ) Indicates number of firms FY 1980 Total retail outlets: 12,131

Figure 2

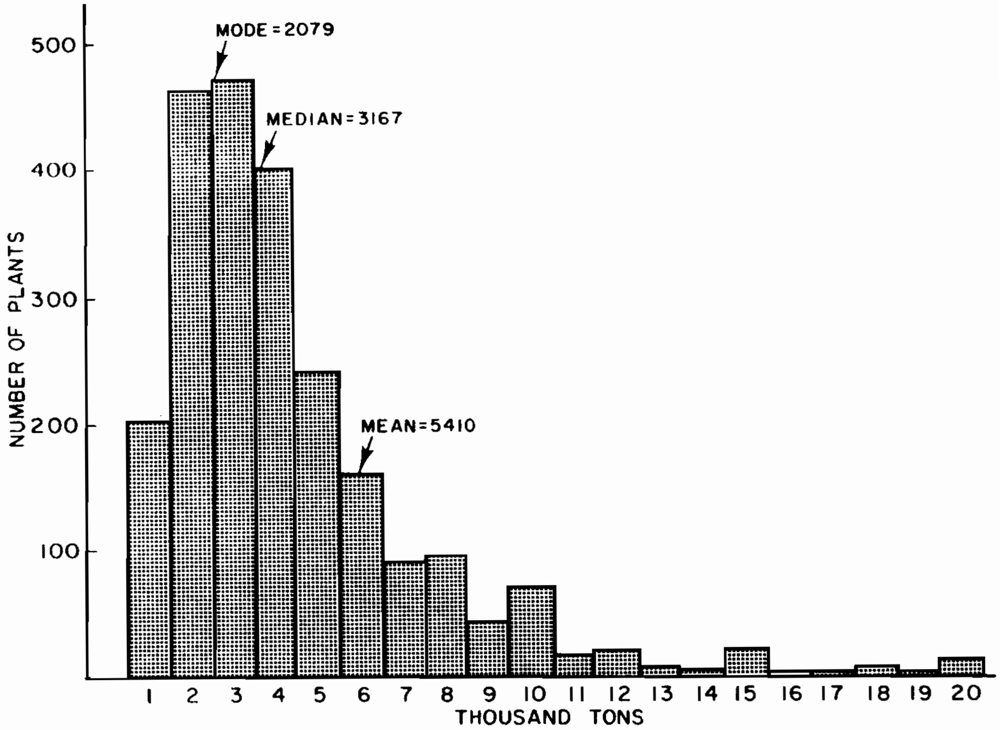


AMMONIATION-GRANULATION PLANTS IN THE U.S. FY 1980

TOTAL OF 107 PLANTS
ESTIMATED NPK PRODUCTION IN FY1980 - 8.5 MILLION TONS

Figure 3

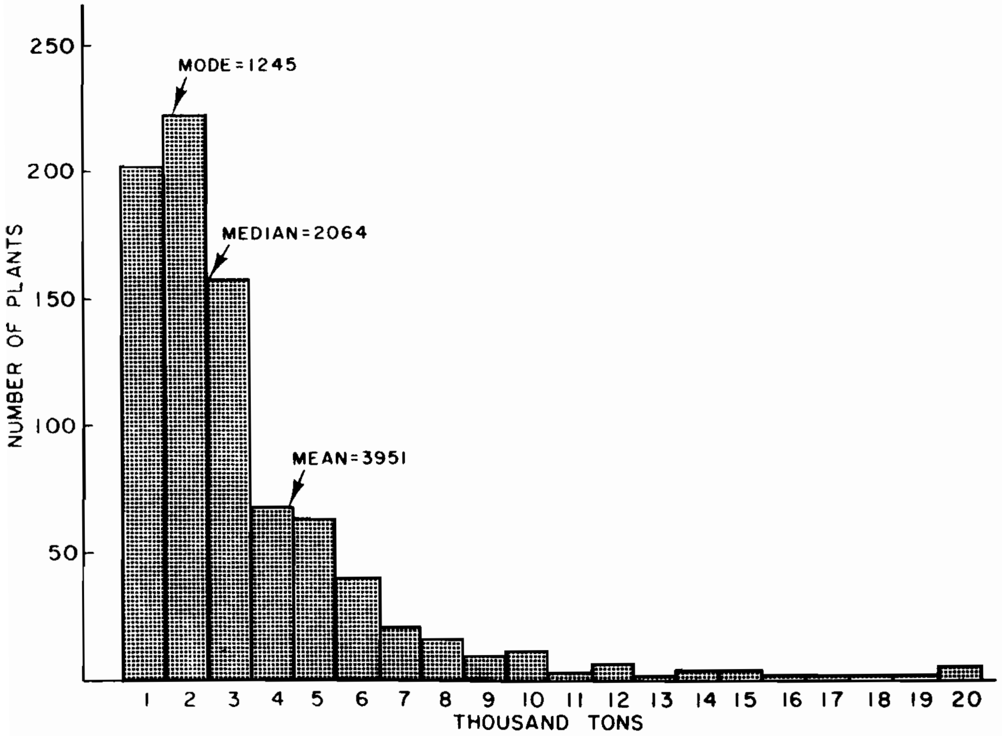
FREQUENCY DISTRIBUTION FOR U.S. BULK BLEND FERTILIZER PLANTS



AAPFCO Fertilizer Plant Survey - 1980. Based on 2428 bulk blend plants.

Figure 4

FREQUENCY DISTRIBUTION FOR U.S. FLUID ONLY FERTILIZER PLANTS



AAPFCO Fertilizer Plant Survey - 1980 Based on 847 fluid mix plants.

APPENDIX TABLE A

REGIONAL SUMMARY OF BULK BLEND PLANTS--AAPFCO FERTILIZER PLANT SURVEY
1980

	REGION									
	New England	Middle Atlantic	South Atlantic	East N. Central	West N. Central	East S. Central	West S. Central	Mountain	Pacific	Total
Bulk Blend Plants Only [a]										
Number	18	107	240	752	706	201	226	138	40	2,428
Avg. size plant, tons	4,061	4,841	9,699	5,454	3,490	5,925	7,837	3,290	5,892	5,410
Storage cap., distri., %	69.8	66.4	30.9	44.8	53.3	53.7	36.9	40.4	31.8	44.3
Fert., custom applied, %	47.6	38.8	44.8	41.0	42.3	43.2	60.0	51.8	39.8	44.1
By dealer	31.1	29.4	22.0	38.1	38.5	33.7	45.8	46.9	32.8	35.3
By others	16.5	9.4	22.8	2.9	3.7	9.4	14.2	4.9	7.0	8.8
By farmer (own equip)	46.2	24.7	44.0	14.4	15.5	20.8	10.4	21.1	40.0	21.7
By farmer (rental)	5.6	33.3	6.6	42.5	40.8	32.6	28.1	21.9	17.1	31.5
Plants offering: %										
Addition herb.	22.2	42.9	32.5	60.1	34.9	60.1	25.2	13.0	32.5	42.6
Addition insect.	11.1	34.5	27.0	42.5	21.6	47.2	8.4	8.6	27.5	29.4
Addition micro.	50.0	70.0	88.3	73.8	55.5	76.6	56.6	43.4	77.5	66.5
Addition seeds	5.5	42.9	54.1	51.4	25.0	81.5	50.8	28.9	25.0	44.0
Soil test	27.7	79.4	86.2	89.6	89.2	79.6	70.3	79.7	85.0	85.0
Consultation SVC	33.3	68.2	70.0	79.9	74.3	66.1	62.3	68.1	82.5	73.0
Plants w/bagging equip., %	22.2	22.4	30.8	21.2	11.7	16.4	16.3	14.4	47.5	18.6
All Bulk Blend Plants										
Number	33	142	301	960	1,623	247	434	197	66	4,003
Avg. size plant, [b] tons	6,269	7,310	11,257	6,626	3,785	6,683	9,251	4,369	6,756	6,380
Storage cap., disti., [c] %	50.9	56.3	35.6	44.4	61.0	54.3	35.6	36.2	33.5	45.4
Fert., custom applied, %	54.1	30.8	47.6	44.9	45.0	44.8	56.0	55.1	42.5	46.2
By dealer	22.3	21.8	25.2	39.8	41.5	34.3	43.0	50.0	33.9	36.8
By others	31.8	9.0	22.4	5.0	3.5	10.5	12.9	5.2	8.6	9.4
By farmer (own equip)	39.6	30.6	39.7	14.0	14.3	19.5	11.4	14.8	38.5	20.5
By farmer (rental)	4.6	21.8	6.8	39.0	39.3	30.6	31.0	26.2	16.5	29.7
Plants offering: %										
Addition herb.	30.4	43.0	36.5	63.7	42.4	60.0	27.8	26.5	40.0	47.2
Addition insect.	21.7	34.1	28.2	46.1	27.2	46.9	9.1	19.8	36.3	32.9
Addition micro.	52.1	72.3	88.7	76.1	60.4	76.9	61.1	54.6	81.8	69.8
Addition seeds	13.0	39.0	52.5	52.8	26.9	80.7	49.4	36.4	25.4	44.5
Soil test	39.1	78.0	85.1	89.8	90.2	79.8	72.8	81.7	85.4	85.6
Consultation SVC	43.4	68.2	69.2	79.6	76.0	66.1	66.3	70.1	78.1	73.9
Plants w/bagging equip., %	30.4	27.6	34.4	21.3	11.2	18.3	17.9	15.4	43.6	19.5
Non-farm tonnages, % of distribution	1.7	16.8	3.5	.8	.4	4.8	1.6	2.1	2.5	2.5
Form of business:										
Sole proprietor, %	9.7	5.0	5.3	7.2	4.5	9.0	13.6	5.1	5.0	7.0
Partnership, %	-	2.1	3.6	4.6	3.3	4.5	5.2	2.6	-	3.9
Corporation, %	48.4	45.4	61.7	45.7	34.8	51.2	50.6	52.0	68.3	46.0
Cooperative, %	41.9	47.5	29.4	42.5	57.4	35.2	30.6	40.3	26.7	43.1
Plants offering limestone, %	42.4	68.3	75.7	31.1	10.8	33.6	23.3	1.5	21.2	25.3
Distribution of fert. by class, %										
Dry bulk blends	31.7	37.4	54.1	42.3	54.5	47.1	46.8	41.2	45.5	47.1
Dry bagged blends	28.6	12.6	15.4	6.9	2.9	20.5	4.9	2.9	8.8	8.8
Bulk granulation	18.9	10.7	8.8	4.5	2.1	6.7	5.6	6.8	2.5	5.6
Bagged granulation	6.5	24.5	8.2	5.0	1.8	9.4	2.4	0.5	2.5	5.7
Liquid mixtures	1.1	2.0	1.2	4.4	2.5	0.1	3.4	1.8	4.4	2.8
Suspension mixtures	7.2	0.2	1.3	1.2	1.7	2.5	0.9	0.5	0.1	1.3
Anhydrous ammonia	-	0.6	0.5	8.6	16.3	2.2	3.1	7.8	2.3	6.7
Nitrogen solutions	2.2	7.1	6.7	10.9	7.1	2.9	2.5	16.4	7.6	7.7
Dry DA materials	2.4	4.4	3.6	13.6	8.9	7.6	20.1	18.6	23.5	11.4
Liquid DA materials	0.1	0.3	0.3	1.9	0.9	0.2	0.9	2.2	2.8	1.1

[a] All data for bulk blend plants only based on returns of 2428 plants

[b] Based on 2875 plants

[c] Based on 3213 plants

APPENDIX TABLE B

REGIONAL SUMMARY OF FLUID PLANTS--AAPFCO FERTILIZER PLANT SURVEY
1980

	REGION									
	New England	Middle Atlantic	South Atlantic	East N. Central	West N. Central	East S. Central	West S. Central	Mountain	Pacific	Total
Liquid Mix Plants Only [a]										
Number	-	7	63	27	93	11	201	23	21	446
Avg. size plant, tons	-	7,239	5,179	2,466	3,555	2,269	3,822	2,256	4,446	3,840
Storage cap., distri., %	-	16.6	28.6	48.8	57.4	31.6	54.6	37.6	12.5	45.7
Fert. custom applied, %	-	87.0	41.1	63.2	44.7	86.0	31.0	49.1	20.6	40.2
By dealer	-	67.6	37.4	56.5	37.8	71.7	28.4	45.5	14.6	35.4
By others	-	19.4	3.7	6.7	6.9	14.3	2.6	3.5	6.0	4.8
By farmer (own equip)	-	8.2	45.2	20.8	45.7	4.9	15.5	14.7	8.6	27.6
By farmer (rental)	-	2.7	8.5	7.7	7.5	8.9	52.9	22.1	69.5	29.5
Plants offering:										
Addition herb, %	-	85.7	63.4	74.0	70.9	72.7	28.8	47.8	52.3	49.3
Addition insect, %	-	85.7	36.5	55.5	46.2	54.5	12.4	30.4	47.6	30.2
Addition micro, %	-	71.4	76.1	62.9	69.8	100.0	56.2	65.2	38.0	63.2
Addition seeds, %	-	28.5	11.1	33.3	8.6	9.0	2.4	17.3	9.5	8.5
Soil test, %	-	85.7	63.4	74.0	80.6	72.7	65.1	78.2	80.9	70.6
Consulation SVC, %	-	71.4	46.0	44.4	69.8	63.6	75.6	78.2	76.1	68.1
Suspension Mix Plants Only [b]										
Number	4	3	37	27	22	26	12	2	-	134
Avg. size plant, tons	725	2,133	5,519	2,248	2,413	3,930	3,863	2,821	-	3,604
Storage cap., distri., %	37.2	31.6	23.4	32.6	57.4	37.4	22.0	14.6	-	31.3
Fert., custom applied, %	95.0	81.2	76.8	82.7	76.8	85.8	78.0	16.8	-	78.9
By dealer	94.0	66.2	73.0	82.4	75.6	77.0	75.7	16.8	-	74.9
By others	1.0	15.0	3.9	0.3	1.2	8.8	2.2	0.0	-	4.0
By farmer (own equip)	0.0	18.8	9.9	6.6	14.3	5.4	13.5	0.9	-	9.2
By farmer (rental)	0.0	0.0	7.1	10.7	8.9	8.0	8.5	0.0	-	7.8
Plants offering:										
Addition herb, %	100.0	100.0	91.8	96.2	95.4	92.3	75.0	-	-	91.0
Addition insect, %	100.0	100.0	37.8	62.9	72.7	42.3	33.3	-	-	52.2
Addition micro, %	100.0	100.0	94.5	85.1	95.4	76.9	75.0	-	-	86.5
Addition seeds, %	-	33.3	21.6	33.3	18.1	7.6	-	-	-	18.6
Soil test, %	100.0	100.0	89.1	96.2	100.0	80.7	91.6	-	-	90.2
Consultation SVC%	100.0	33.3	54.0	51.8	54.5	65.3	83.3	-	-	58.9
All Fluid Mix Plants										
Number	10	31	198	346	778	75	341	86	54	1,919
Avg. size plant, [c] tons	6,333	6,211	8,252	6,873	3,982	4,619	6,012	6,086	6,089	5,919
Storage cap., distrib., [d] %	21.5	28.7	31.5	47.6	69.1	41.8	42.2	30.5	26.2	44.6
Fert., custom applied, %	37.0	66.3	54.4	64.7	58.7	78.2	38.9	61.7	43.6	56.6
By dealer	33.0	52.5	45.4	56.4	55.5	65.3	34.8	55.1	32.7	49.5
By others	4.0	13.7	9.0	8.4	3.2	12.9	4.1	6.6	10.9	7.0
By farmer (own equip)	49.3	25.2	28.5	11.0	18.1	8.3	14.7	9.2	24.6	17.6
By farmer (rental)	9.0	6.7	7.2	22.2	20.8	12.3	45.6	25.0	30.5	22.1
Plants offering:										
Addition herb., %	88.8	82.6	75.7	89.1	83.6	86.8	34.5	64.9	60.9	71.3
Addition insect., %	88.8	73.9	42.9	70.8	56.4	52.4	14.0	49.3	56.0	48.4
Addition micro., %	77.7	91.3	85.3	88.0	84.2	85.2	63.0	81.8	65.8	79.9
Addition seeds, %	33.3	30.4	22.0	51.5	26.3	16.3	8.4	38.9	19.5	27.5
Soil test	100.0	91.3	73.4	91.9	91.2	80.3	69.7	84.4	85.3	83.2
Consultation SVC	100.0	73.9	55.9	74.0	77.7	65.5	77.4	76.6	73.1	73.2
Non-farm tonnage, % of distribution	4.7	1.8	1.3	1.1	0.9	1.1	0.4	1.8	1.2	1.1
Form of business:										
Sole proprietor, %	11.1	22.6	7.6	9.5	10.4	19.7	22.6	10.2	2.2	13.0
Partnership, %	-	9.7	6.6	5.4	6.2	14.1	10.6	6.8	-	7.3
Corporation, %	44.4	58.1	81.3	70.0	57.2	52.1	57.1	61.4	71.1	63.6
Cooperative, %	44.4	9.7	4.5	15.1	26.2	14.1	9.7	21.6	26.7	16.1
Plants offering limestone, %	60.0	54.8	65.7	28.6	12.6	41.3	5.0	-	14.8	21.2
Distribution of fert. By class, %										
Dry Bulk blends	18.7	23.0	10.8	18.5	21.5	8.7	8.1	21.4	23.4	15.3
Dry bagged blends	32.2	7.6	6.5	1.9	0.9	2.4	0.8	1.9	5.3	2.8
Bulk granulation	-	3.6	14.2	3.5	3.1	11.4	2.0	6.6	1.9	5.5
Bagged granulation	-	2.8	7.0	6.1	1.2	6.2	0.2	0.1	0.8	3.5
Liquid mixtures	2.8	42.5	24.7	15.5	14.4	7.9	27.8	11.5	15.6	19.7
Suspension mixtures	25.3	7.3	16.4	12.4	11.7	46.8	5.9	3.0	2.8	12.0
Anhydrous ammonia	-	0.7	1.1	8.7	10.9	2.1	10.5	6.3	8.2	7.4
Nitrogen solutions	2.8	9.4	15.5	18.5	24.4	10.4	17.8	32.4	13.8	18.9
Dry DA materials	0.6	1.0	1.3	4.7	5.6	3.4	8.7	10.1	13.7	5.6
Liquid DA materials	17.6	2.1	1.2	4.8	4.7	1.0	6.2	5.7	14.7	4.7

[a] All data based on 446 plants

[b] All data based on 134 plants

[c] Based on 1229 plants

[d] Based on 1432 plants

APPENDIX TABLE C

REGIONAL SUMMARY OF GRANULATION PLANTS--AAPFCO FERTILIZER PLANT SURVEY
1980

	REGION									
	New England	Middle Atlantic	South Atlantic	East N. Central	West N. Central	East S. Central	West S. Central	Mountain	Pacific	Total
Granulation Plants Only [a]										
Number	1	2	18	4	1	7	1	-	1	35
Avg. size plant, tons	-	33,000	141,516	45,000	-	194,285	-	-	-	132,980
Storage cap., distri., %	-	76.2	25.3	45.3	-	18.0	-	-	-	27.4
Fert., custom applied, %	-	-	30.2	-	-	0.7	-	-	-	9.0
By dealer	-	-	9.1	-	-	0.3	-	-	-	2.8
By others	-	-	21.1	-	-	0.4	-	-	-	6.2
By farmer (own equip)	-	-	55.8	-	-	73.6	-	-	-	20.6
By farmer (rental)	-	-	3.3	-	-	0.4	-	-	-	1.2
Plants offering: %										
Addition herb.	-	-	-	50.0	-	14.2	-	-	-	8.5
Addition insect.		-	-	25.0	-	14.2	-	-	-	5.7
Addition micro.	-	100.0	83.3	100.0	-	100.0	-	-	-	62.8
Addition seeds	-	-	-	25.0	-	14.2	-	-	-	5.7
Soil test	-	100.0	72.2	75.0	-	42.8	-	-	-	62.8
Consultation SVC	-	100.0	50.0	50.0	-	57.1	-	-	-	57.1
Plants W/Bagging Equip., %	-	100.0	50.0	100.0	-	85.7	-	-	-	62.8
All Granulation Plants										
Number	2	10	31	13	4	12	7	-	3	82
Avg. size plant, [b] tons	31,500	41,555	110,832	90,275	235,000	127,166	168,195	-	210,000	106,453
Storage cap., distri., %	66.8	49.7	31.3	31.2	43.5	23.4	37.6	-	50.5	32.5
Fert., custom applied, %	45.7	6.4	40.6	65.2	-	4.0	30.0	-	-	21.6
By dealer	-	0.5	6.6	17.9	-	2.2	30.0	-	-	4.7
By others	45.7	5.9	34.0	47.3	-	1.8	-	-	-	16.9
By farmer (own equip)	54.3	47.5	43.1	13.2	-	1.1	5.0	-	-	21.1
By farmer (rental)	-	-	2.6	17.9	-	1.2	55.0	-	-	3.2
Plants offering: [b] %										
Addition herb.	-	11.1	3.5	27.2	-	16.6	-	-	-	10.1
Addition insect.	-	11.1	-	18.1	-	16.6	-	-	-	7.2
Addition micro.	50.0	77.7	82.1	90.9	-	91.6	100.0	-	-	82.6
Addition seeds	-	-	-	9.0	-	25.0	20.0	-	-	7.2
Soil test	50.0	55.5	60.7	72.7	-	50.0	80.0	-	-	59.4
Consultation SVC	50.0	55.5	46.4	45.4	100.0	50.0	100.0	-	-	52.1
Plants w/bagging equip., %	50.0	88.8	60.7	81.8	-	91.6	80.0	-	-	72.4
Non-farm tonnages, % of distribution	-	46.2	7.6	3.6	-	2.7	10.0	-	-	8.8
Form of business:										
Sole proprietor, %	-	10.0	-	-	-	-	-	-	-	1.3
Partnership, %	-	-	-	-	-	-	-	-	-	-
Corporation, %	50.0	50.0	90.3	84.6	100.0	75.0	100.0	-	66.7	81.0
Cooperative, %	50.0	40.0	9.7	15.4	-	25.0	-	-	33.3	17.7
Plants offering limestone, %	-	10.0	51.6	7.7	-	16.7	14.3	-	-	25.6
Distribution of fert. by class, %										
Dry bulk blends	3.0	1.6	0.5	3.2	-	0.7	8.3	-	-	1.8
Dry bagged blends	-	3.9	0.2	0.7	-	1.8	1.4	-	-	0.9
Bulk granulation	78.3	29.1	66.6	24.8	68.0	59.0	8.3	-	21.0	49.6
Bagged granulation	17.1	63.3	19.9	30.0	-	26.2	4.5	-	7.0	22.0
Liquid mixtures	-	-	4.3	1.7	-	-	0.5	-	-	2.1
Suspension mixtures	-	-	0.1	0.1	-	0.7	0.5	-	-	0.3
Anhydrous ammonia	-	-	0.7	6.2	15.0	0.3	9.1	-	3.0	2.8
Nitrogen solutions	-	-	3.6	9.5	-	0.6	31.2	-	59.0	8.2
Dry DA materials	1.5	2.0	3.7	20.0	17.0	5.5	11.2	-	10.0	7.6
Liquid DA materials	-	-	0.3	3.7	-	5.2	1.3	-	-	1.9

[a] All data for granulation plants only based on 35 plants

[b] Data based on 69 plants

MODERATOR THREADGILL: Do we have any questions for Norman. You did a good job — you answered them all. Thank you very much. (Applause)

MODERATOR THREADGILL: Our next Speaker will give you an explanation of the basis of AAPFCO's investigation allowances. Hilton V. Rogers, from Spartanburg County, South Carolina, received his B.S. in Agronomy from Clemson in 1948 and his Masters at The University of Wisconsin in 1959. He has worked as an Assistant County Agent, as a County Agent in the Cooperative Extension Service in South Carolina and also as an Agronomist in Soil Fertility and later in Extension Agronomy Work at Clemson University. He has been serving in his present position as Head of the Fertilizer Inspection and Analysis Department, at Clemson University, since 1970. He is currently on the Board of Directors of the American Association of Plant Food Control Officials and is Past President and Director of the Southern Association of Feed, Fertilizer and Pesticide Control Officials. Hilton, you are on. (Applause)

Explanation of the Basic of AAPFCO's Investigational Allowances Fertilizer Inspection and Analysis Dept. Clemson University

Hilton V. Rogers

The title of this discussion is "Explanation of the Basis of AAPFCO's Investigational Allowances". At the twenty-eighth annual meeting of Association of American Plant Food Control Officials at Atlantic City, New Jersey in August 1974, Robert C. Rund presented a paper entitled "The Background and Rationale of AAPFCO Recommended Investigational Allowances". I shall refer to his paper many times in my discussion.

There have been two other papers in recent years dealing with AAPFCO investigational allowances. These are "A Review of AAPFCO's Investigational Allowance" by H. Grey Verner, Occidental Chemical Company and "Review of AAPFCO Investigational Allowance" by Robert C. Rund, Office of Indiana State Chemist, Purdue University. Both of these papers are in Official Publication No. 33 Association of American Plant Food Control Officials. These reviews were from two different individuals from two different points of view. One was of a representative of the fertilizer industry and the other of a control official.

The basis of AAPFCO's investigational allowance is a proposal of the AAFCO Committee on Guarantees and Tolerances in 1966. The recommendation of the committee was officially adopted in 1968 by AAPFCO and is now recorded in the rules and regulations under the Uniform State Fertilizer Bill.

In his 1974 paper, Rund comments: *"The proposal was based on the summation of all variations inherent in an official inspection which could possible be influenced by processes under control of the regulatory office. Such variations are recognized to be the result of: (1) the effect due to the random variation of the means of 10 core samples (the taking of the sample), (2) the effect due to the reduction of the gross sample, (3) the day to day variation of analyses within a laboratory and, (4) the laboratory bias due to methods and/or analysts. The committee developed these effects from published work of Miles and Quackenbush (7) and from the report of Quackenbush, Rund and Miles (13) in 1966. The recommendation was adopted in 1968 and is now an official rule of the Association of American Plant Food Control Officials under the Uniform State Fertilizer Bill. By referral to Tables 1, 2, and 3 we may visualize the "buildup" of "Investigational Allowances" currently in use."*

The report of Quackenbush, Rund and Miles to which Rund refers is a report on an elaborate piece of research conducted by Dr. F. W. Quackenbush and Professor S. R. Miles. This research involved four different grades of dry products prepared by the U.S. Department of Agriculture laboratories at Beltsville, Maryland. One liquid grade was also used. The experiment was designed to fully utilize statistics so that the data would be as useful as possible. The dry grades used were 4-16-32, 8-32-16, 16-8-8 and 32-4-4 and contained two or more of the following materials: granular diammonium phosphate, run-of-pile normal and triple superphosphate, crystalline ammonium sulfate, standard muriate of potash, prilled ammonium nitrate and prilled urea.

Samples were sent to the supervisors of 12 regulatory laboratories and 12 industry laboratories. Great care was given so that only the supervisor would know the identity and origin of the sample. Weighings were replicated 48 times for each of the four grades so that each laboratory would receive two samples of each grade. To prevent bias, the first samples were submitted to the chemists in a normal operating manner without the chemists being aware of the nature of the study. At a later date, another sample of the same grade was submitted in the same manner.

In his 1974 paper, Rund states: *Twenty-three laboratories of the original twenty-four completed the assignment and reported results. The total experimental findings and evaluations are reported in the Journal of the AOAC (13). Through this study we have gained very reliable estimates of the variations due to sample reduction and laboratory analyses of any laboratory chosen at random. These variances are correlated with nitrogen, available phosphoric acid and potash concentrations of 4 to 32/ each.*

The results of the research along with the results of a sampling study by Miles and Quackenbush (2) reported in 1955 contributed to the buildup of components of variance.

This buildup was so designed that statistically the variances due to (1) sampling, (2) reduction and intralab differences and (3) interlab differences could be calculated into a standard error. The standard error was used in the calculation for the investigational allowance of 5, 10, 15, 20, 25 and 30 percent nitrogen guarantees. The same procedure was used in calculating the investigational allowance for phosphate guarantees and potash guarantees. Values found greater than this magnitude below guarantee are due to causes beyond those for which variances are given. The chance of making a wrong decision here is no greater than 1 in 100.

For acceptable use of these investigational allowances, the rules and regulations of the AAPFCO Uniform State Fertilizer Bill specifies: *For those investigational allowances to be applicable, the recommended AOAC procedures for obtaining samples, sample preparation and analysis must be used. These are described in Official Methods of Analysis of the Association of Official Analytical Chemists, 11th edition, 1970, and in succeeding issues of the Journal of the Association of Official Analytical Chemists. In evaluating replicate data, Table 19, page 935, Journal of the Association of Official Analytical Chemists, Volume 49, No. 5, October, 1966 should be followed.*

Averaging at least two values must be adhered to. If more than two values are obtained, all significant values must be averaged. Values carried to two decimals are needed in applying averages to this table. Values may be "rounded" to one place where preferred in reporting.

This is briefly an explanation of the basis of AAPFCO's investigational allowances. These allowances are based on the assumption that the plant nutrients in the lot sampled are exactly the amounts guaranteed and that the material or mixture of materials in a given area is distributed uniformly enough so that the lot can be sampled reasonably accurately.

These allowances are not designed and were never intended to reduce deficiencies caused by errors in formulations, scale and other equipment malfunctions, contamination or extremely mismatched materials.

There are some registrants who consistantly have reasonably low deficiency records. There are others who have problems. All registrants are operating under the same rules, therefore, some must have more control than others.

As R. C. Rund so aptly stated " . . . . Finally, it should be noted that nothing remains stable forever and, admittedly, the components of variance upon which the current AAPFCO Investigational Allowances are based grow older and are subject to obsolescence just as any other criteria. Whenever they can be improved, updated or corrected I am sure the control official of today will be alert, cooperative and receptive to such changes."

I would concur with this statement but would hasten to add that if and when changes are made, let us base these changes on carefully designed studies and not select figures without reasonable justification.

REFERENCES

(1) Rund, Robert C., *AAPFCO Official Publication*, No. 28 (1975).
(2) Miles, S. R. and Quackenbush, F. W., - *J.A.O.A.C.*, *38*, 108-130 (1955).

MODERATOR THREADGILL: Thank you Hilton. Do we have any questions? Thank you. (Applause)

Our last speaker of the morning, and I am looking forward to his talk, is Cecil R. Spooner, from Donaldsonville, Georgia. He attended high school here and graduated from the University of Georgia in 1953 with a B.S.A. degree. At that time he was President of the Senior Class and belonged to numerous organizations. In 1953 he spent six months as an exchange student in Syria and Lebanon. This was sponsored by the national 4-H Club Foundation. He worked as a county agricultural agent in Telfair County for five years and also was associated with Coker Pedigree Seed Co., in Hartsville, S.C. and Dekalb Agricultural Association in Dekalb, Illinois. This was before going with the Department of Agriculture in 1964. He was appointed to the position as Division Director, Plant Food, Feed and Grain, in 1967. He is Past President of the Southern Feed, Fertilizer and Pesticide Association and is presently Director of AAPFCO. Cecil please. (Applause)

Do We Actually Have A Trend To Increasing Fertilizer Deficiencies?

Cecil R. Spooner

During the past months, I have done much mind and soul searching regarding the topic of this presentation. Reviewing all of the statistics available have given me a broader knowledge of other problems that are related. The other areas I feel carry a more important effect than just a few fertilizer deficiencies that are related to a few dollar penalties that are being paid by the industry to the consumer.

The No. 1 problem is the effect or losses when consumers are confronted with drastic losses in production and income when large errors are made in formulation and spreading of their fertilizer. A correct fertilizer is the life blood to any farmer, without this life blood other ideal conditions will fail to do any good. You, the fertilizer industry should never take lightly your responsibility, in determining much of the success to a farmer and the happiness of a well fed nation.

At this time I wish to pay tribute to you for the many problems you have overcome with hard work and dedication that has been a direct benefit to the farmer.

The fertilizer consumer considers you a necessary and needed friend and adviser. I know you cherish this unique working relationship you have built over the years. Without the farmer we cannot exist. Without the fertilizer industry the farmer cannot survive.

In thinking about the fertilizer deficiencies we should review as to where they develop and what ingredients are involved in the order of their importance. First, in number of deficiencies is dry blend with liquid mix next, and ammoniated following in third position. Incredient deficiencies are first found in the secondary and micronutrients followed by phosphate then potash and nitrogen.

Records indicate that approximately one hundred thousand samples are taken and analyzed by control officials in the United States. These records indicate that thirty percent of the samples taken are done so in only four states. Also, it is noted that thirty percent of the total fertilizer deficiencies are reported in only four states. The value assessed by regulatory officials for fertilizer deficiencies and penalties has risen to just above two million dollars. Statistics show that fifty-three percent of the dollar deficiencies are paid in just four states.

Based on the facts that I have just given, it shows a clear indication that we have failed in developing a favorable trend over our nation on uniform volume sampling and deficiency assessments. Let me make it clear that I am not trying to develop set figures that would be adequate for uniform regulation of the industry. Records show that we are a long way from being equal represented in all areas in sampling. This is evident as we review the volume sales in the different areas of the country and look at the statistics as to the regulatory actions.

Figures show that the total fertilizer deficiencies and penalty payments over the nation has more than doubled in the last 5 to 6 years. This fact I agree, but when you take into consideration of price increase along with the difference of the number of states reporting over this period, I question as to whether this indicates an increase. I fail to see that the trend is increasing on a dollar basis when you consider the difference in the dollar transactions in the industry.

I was very disturbed to reviewa the report regarding the differences on lot sizes. A range from 3 to 408 tons per sample was disturbing. All the information seems to indicate that the trends of deficiencies is leveling off. The number of samples taken, percentage of dediciencies and dollar value of deficiencies based on increased price of fertilizer are showing the leveling-off trend.

I do feel that records show that the blending of fertilizer constitutes a larger volume of your sales. From this view point since the major problem came from blending and we are seeing a leveling offf on deficiencies and penalties, then this is a clear indication that you the industry is doing a better job. I believe in an active regulatory program for the fertilizer industry and I feel that most of you agree with me. My experience in the regulatory field does not lead me to believe that deficiency payments directly improve fertilizer quality. Quality has come about as a result of an informed and consciencious fertilizer industry.

MODERATOR THREADGILL: Thank you Cecil. Do you in the audience have any questions. I think we in the fertilizer business need the kind of talk that we just heard because I think our's is setting high standards of excellence. Cecil has really emphasized that point. I think we need to be forever aware of that. I also appreciate his remarks in regard to the farmer. I have always looked at this industry as a country boy's expression: "A three legged stool," One of them being the farmer. Without him, we are nothing. Whether you are a scientist, a manufacturing man or a salesman, he is so important to our total. Then you have the dealer whatever form he may take. And then you have the basic manufacturers. All of us need to strive for that high standard of excellence. Thank you so much Cecil. (Applause)

That is really the end of our morning session. If there are no messages or announcements we stand adjourned until 1:30 P.M. Thank you for your kind attention. (Applause)

Wednesday, October 29, 1980

Afternoon Session
John L. Medbery, Moderator

MODERATOR MEDBERY: Before we begin I would like to recognize our visitors from foreign nations, that is, nations other than the United States. We have a good many with us. (Applause) We are honored to have as our first speaker, Andre F. Kayaert of the Europene Company, "Nederlandse Stikstof Maatschappij N.V. (NSM)" for short. Andre was born in 1943. He holds a degree in Chemical Engineering from the University of Brussels, granted in 1966. Between 1968 and 1970 he worked in road building materials research and then moved into Nitrogen Production. He is presently the Manager of Production for the urea units at the Sluiskil factory in the Nederlands. Please make welcome Andre Kayaert. (Applause)

N.S.M. Fluidized-Bed Urea Granulation Process

Andre F. Kayaert

Introduction

Nederlandse Stikstof Maatschappij N.V. (NSM) has been for more than 20 years an active urea producer, with a yearly capacity of about 700 000 MT and was one of the first to ship big quantities of urea prills in bulk to the USA, China, India and other overseas markets. *(Slide: aerial view of Sluiskil factory)*

Until recently NSM solid urea was made only by the traditional prilling technique, whereby a near water-free melt is crystallized from droplets during free fall in a 50 to 60 meters high tower (so-called prilling tower). *(Slide: prilling tower of urea plant n°6).*

Experience with the urea markets soon learned the versatility but also the limits of prilled urea, both as a product (size, mechanical strength) and as a process (space, investment, dedusting).

These facts activated research which eventually led to the fluidized-bed granulation process. Although the first aim of this technology was to obtain a product having bigger size than prills to satisfy the market for bulk blending, the pilot plant development confirmed that the large unit capacity of prilling towers and the high-quality advantages of other well-known granulation processes could be combined at lower cost by fluidized-bed granulation.

The result was a competitive process, making a new product with a new technology, realized in an industrial single stream production unit of 800 MTD.

Product Description

(Slide: combined view of microprills, prills, granules, forest grade granules).

This slide illustrates how the granular urea fits into the NSM product package.

The bulk blending ability of these granules can be illustrated by the TVA segregation test. (Slide: segregation test with prills). (Slide: segregation test with granules).

Other physical characteristics favorably compete with present commercial urea solids.

Table I

Typical characteristics of the NSM granulated urea:

Moisture content			:	0.2%
Biuret content			:	increase of approx. 0.03%
Crushing strength (*)			:	3 kg
Bulk density loose			:	720 - 740 g/l
Bulk density tamped			:	740 - 760 g/l
Average diameter			:	2.2 mm 2.8 mm
Screen analysis			:	% %
	<	1.25 mm	:	1.0 0
1.25	—	1.60 mm	:	4.1 0.4
1.60	—	2.00 mm	:	28.4 3.2
2.00	—	2.50 mm	:	34.5 28.1
2.50	—	3.15 mm	:	24.4 40.8
3.15	—	4.00 mm	:	7.6 26.2
	>	4.00 mm	:	0 1.3

(*) on granules of 2.5 mm diameter.

(Slide: typical characteristics of NSM urea granules)

1) *Moisture content:* 0.2%.
   Although solution with unusually low concentration is atomized, the final product has a very low moisture content, obtained through the slow buildup by accretion where thousands of tiny droplets crystallize while simultaneously evaporating the solution water. The crystallization heat is thus used "on the spot" and not lost to the cooling air flow like in prilling or drum granulation.

2) *Biuret content:* negligible increase.
The low biuret results from the use of less concentrated feed solutions at lower temperatur and from the small recycle of scrubber solution.
3) *Crushing strength:* 3 kg on 2.5 mm granules.
High strength is due to the buildup of imbricated crystals to form granules able to withstand the highly turbulent erosion in the fluidized bed.
4) *Bulk density:* nearly similar to prilled product.
The buildup under evaporative conditions leaves only marginal internal porisity.
5) *Size range:* from prill size to forest grade.
6) *Dustfree and free flowing* characteristics in bulk handling, without need for any coating.
(Slides: dumping in store, reclaiming and ship loading).

Process Description

(Slide: fluidization pattern) The granulator builds a 1 meter high fluidized bed of granules supported on a perforated plate through which the fluidization air flows up, with submerged pneumatic nozzles spraying upwards from just above the perforated support plate.

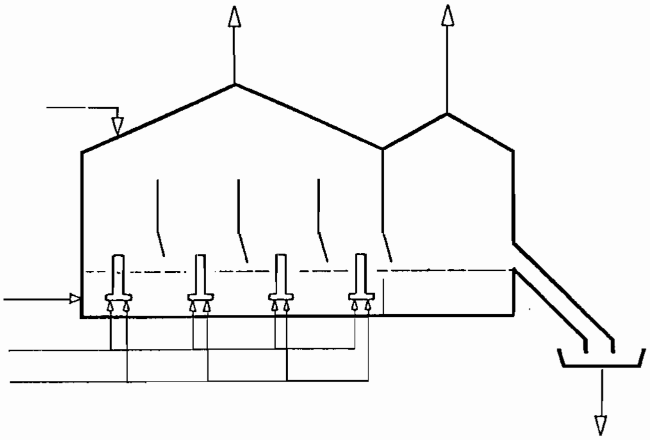


Figure 1
(From U.S. Patent 4219589)

The fluidized bed is divided in several chambers. Suspended solids move from one chamber to the following one, underflowing through slots between the perforated plate and the partitioning walls.

The granules leave the granulator also by bottom bleeding, and not by overflow above a gate, as it is standard practice in fluidization, to avoid stagnation of agglomerates.

Recycle of sieved-off fines and crushed new nuclei is done in the first chamber above bed level.

The air space above the bed is kept under slight vacuum to avoid dust in the surrounding area. This underpressure however is so small that no rotary valve or other troublesome lock device is required on the recycle stream.

The atomization spraying uses low pressure air with a diffusion pattern such as to guarantee that spray cone does not break through the fluidized-bed layer. This granulator fits in the flow diagram shown, with its several process lines:

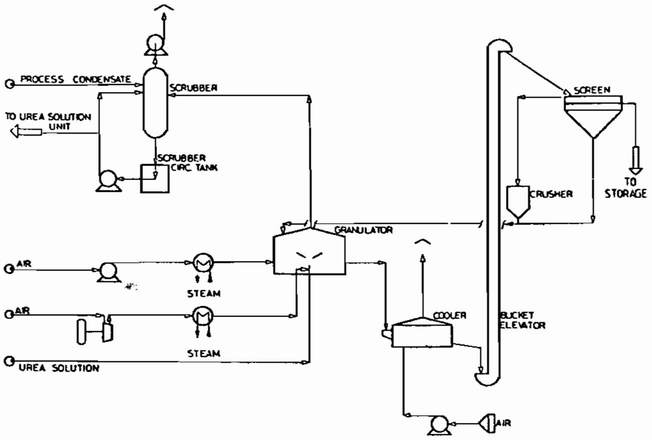


Figure 2
NSM urea granulation flow diagram

— urea solution from a concentration plant to about 95%;
(Slide: flow diagram with urea solution feed).
— fluidization air with start-up heater, heated low pressure atomization air mixing with fluidization air; exhaust air extracted by a fan after scrubbing; (Slide: flow diagram with air lines).
— scrubber liquid at 45% concentration recycled to the urea synthesis section. (Slide: flow diagram with scrubbing lines).

The main process features can be analyzed according to the following typical data:

Table II

Process features of NSM granulation process:	**Typical**
Urea solution concentration	95-96%
Solids recycle ratio	0.5/1
of which :	0.4.1 fines
	0.1/1 coarse
Urea dust recovery rate, as 45% solution	4%

(Slide: process features of NSM granulation process).

a) *Low concentration.*
The evaporation capacity of the fluidized bed allows the use of an urea solution having a concen-

tration as low as 95-96%. The crystallization heat of urea, which is much higher than other common salts, is partly used to evaporate the solution water from the fluidized bed instead of being lost to the cooling air, like in prilling or drum granulation. Heating of the fluidization air is minimized and used only for fine temperature control of the fluidized bed. Air chilling is never required.

b) *Low recycle ratio of solids.*

The recycle ratio of fines is only 0.4/1, thanks to the staged buildup in the granulator.

Recycle ratio of crushed product is about 0.1/1 and it is completely dependent on the crusher performance, where seed balance has to be realized.

Recycle of solids has negligible influence on the thermal balance of the granulation process in contrast with drum granulation.

c) *Low dust formation/low scrubber solution recycle.*

Overall dust quantity is only 4% of final product. It consists mainly of coarse particles from the crushing of oversize material and thus it is easy to catch by means of standard scrubbing equipment.

Assuming 99.8% for the scrubbing efficiency, an overall product efficiency of 99.99% is easily obtained.

d) *Low air flow.*

As a direct consequence of the impact of evaporation heat on the thermal balance, the required flow of fluidization air is also lowered. It is about half the flow compared to drum granulation and less than one fourth compared to prilling.

Economy

Detailed economic data are beyond the scope of this presentation. One of the key variables is the exhaust dust load tolerated locally.

Local climate and storage specifications are also to be considered.

Apart from the advantages resulting directly from the fluidized-bed granulation, indirect savings from:

- final concentration,
- solution recycle,
- cooling.condensing/hydrolysis of process water,

have to be included.

As a guesstimate, an investment bonus of 1 300 000 $ could be expected for a 1 000 MTD single stream unit compared with a prilling plant with dedusting and final cooling. (Slide: layout of granulation plant).

Operating Experience

1. Operating conditions of the NSM fluidized-bed granulator are identical at all feed rates. The only variables are inlet temperature of the fluidization air and/or concentration of the urea solution.
2. Capacity variation is obtained by manual addition of nozzle lines with a fine automatic control of the nozzle pressure.

   Turndown to about 10% of nominal load is possible, while full load can be regained in less than 2 hours, without upsetting size balance.
3. Run length is indefinite. The granulator is self-cleaning with spontaneous removal and scalping of any formed agglomerates. Besides the well-known childhood troubles, no evidence of critical fouling has been experienced in any inspection during more than one year of operation.
4. Dust formation is well under control with only moderate influence of the air flow. Owing to the stable dust load, the urea concentration in the scrubbing solution can be controlled at 45% without risk of crystallization.
5. The fluidized bed has low sensitivity to variations in air flow of the two main fans, each remote control of inlet vanes. Underpressure on top of the fluidized bed can be automatically controlled.
6. Product size is determined by sieve choice and crusher fineness, from prill size to forest grade. If sieve is doubled, size variations can be realized on stream, at reduced capacity.
7. Size stability is very high, thanks to the low recycle ratio and the buildup process, which occurs purely by accretion on the crushed nuclei, without any interference by agglomeration of individual particles. Crusher performance is of paramount importance and is one of the key know-how components.
   Buildup from crushed seed to final product size is illustrated in the next slide. (Slide: comparison seed material/final product).
8. Smooth scrubber operation has been obtained by the choice of a well-proven type, with only minor modifications to improve level control and avoid dust buildup in the inlet duct. Continuous process water spraying on the mesh demister pad guarantees high scrubbing efficiency.
9. The plant is equipped with a fully automatic trip system providing safe shutdown ability.
   The unit can be restarted without cleaning after a total power failure by using the air buffer in the atomization air feed line.

This concludes the presentation of the NSM granulation process, which concentrated on the practical operation topics of this technology, in order to cover the main fields of interest of this audience.

I will be glad to answer any question concerning this or other process topics.

NSM intends to present other topics to the fertilizeı industry in future papers. (Slide: aerial view of sluiskil factory).

Sorry: Slides were not available.

MODERATOR MEDBERY: Thank you very much Andre Kayaert. (Applause) Now we have an opportunity to ask Andre Kayaert some questions.

QUESTION—BUD DAVIS, TVA: Have you tried to granulate any other fertilizer salts beside urea?

ANSWER—ANDRE KAYAERT: We are now operating our Pilot Plant (it is more than 100 tons a day) in ammonium nitrate. We are making a test market product which is already shipped in Europe. Maybe there will be an opening in this direction also. Urea is certainly the most attractive product for this technique because it is difficult to granulate by other techniques and it has the characteristics of having a very high crystallization heat say 60 kilograms.

QUESTION—JORGE PALO, I.F.D.C.: You showed that any size up to forestry grade urea could be made in that type of process, your process. There seems to be an interest in some parts of the world to produce what has been called super granular urea up to one gram. Do you have any experience trying to make these large granules?

ANSWER—ANDRE KAYAERT: I told you up to forestry grade. In my opinion, forestry grade is, say six to eitht millimeters. In fact, when I left the unit last week, we were just starting up with the forestry grade material, which is done with the same equipment. We use a little more airflow and we try to rearrange the solids system mainly to avoid an over quantity of nuclei since this is only a process working by accretion, not agglomeration. So, if you crush product and you send it back as such ungranulated, you will end up with much too much nuclei. So, what we do for foresting grade is: We first send the crushed product through the sieve and we dissolve a fine fraction of all the material coming out of the granulator. Also, any erosiion appearing in the granulator can be taken care of by that first sieving, so this is industrialy proven up to six to eight millimeters. In our laboratory, we have also done tests to higher sizes. It also works but only on the laboratory size. We have never tried it industrially. I think we will have to invent a new type of safety shoe with these products because you are slipping over these everywhere.

QUESTION—TRAVIS HIGNETT, I.F.D.C.: You mentioned granulating ammonium nitrate. Perhaps this was pure ammonium nitrate or was it calcium ammonium nitrate? If it was pure have you tried calcium ammonium nitrate?

ANSWER—ANDRE KAYAERT: We started with pure ammonium nitrate which is stabilized with magnesium nitrate, giving specific advantages in these granulation processes. As I heard, the last months, they also added some dolomite powder to go in the direction of calcium ammonium nitrate. It is 33.5% nitrogen, which in Europe has an easier storage specification but also with the aim of going as low as 26% Nitrogen.

MODERATOR MEDBERY: Any other questions for Andre? Do you have build-up in the fluid bed granulator? How do you control that?

ANSWER—ANDRE KAYAERT: The main feature of the system is that all agglomerates are removed from the bottom line. The flow from one chamber to another is not by overflow, but on the perforated plate. You will see it in the briefing. I have a slide of that. Our perforated plate has holes which are not vertically upward but are getting preperential direction so that bad fluidizing agglomerates of 1 centimeter can be removed. The control in the Industrial Plant is so good that we never have agglomerates bigger than one centimeter. I have seen odder results in the pilot plant, where you would get agglomerates as big as a fist out of the granulator spontaneously. It is, of course, mixed fluidization patterns since you have fluidization there but you also have atomization which is much more turbulent.

QUESTION FROM FRANK ACHORN: What was your production rate and the size of the unit?

ANSWER—ANDRE KAYAERT: The production rate is 800 metric tons per day. We had a problem in the beginning when the plan was first born on paper, it was 500 tons. Some of the equipment was already purchased at that moment. We had sieves which were good up to 500 tons. We had to upgrade them to 800 tons which is rather difficult because, when you are losing sieve efficiency, that means that all of the fines are not taken to stores, then you have trouble in maintaining the sieve balance. Since last week we have installed new sieves to carry an 800 ton capacity.

MODERATOR MEDBERY: Thank you once again, Andre, for a very interesting paper. (Applause)

MODERATOR MEDBERY: Our next speaker does not require an introduction. If anybody has earned the title "Mr. Fertilizer", it is he. He did, however, furnish me with some personal data, and I will pass this information on to you. He graduated from Duke University in 1929. His first job was with the U.S. Department of Agriculture in Washington, D.C. at the Fertilizer Investigations Laboratory. This was in 1929. He joined the fledgling TVA in 1938, and worked his way up to become Director of the TVA Division of Chemical Development, holding this position from 1960 to 1973. He retired from TVA in 1973, and joined IFDC as a consultant when that organization was formed in 1974. A recent accomplishment is that he edited and was chief author of an IFDC publication entitled "FERTILIZER MANUAL" published in 1979. This is a most excellent book, and I recommend it to all of you. The price is $15.00 per copy and it can be purchased from IFDC. Although this man has an endless list of accomplishments and contributions for our industry, he tells me that the one he feels was the most important was . . . . encouraging Frank Nielsson to invent the continuous drum ammoniator. We agree! Most of us would not be here today if that had not happened.

With no further ado, I bring you "Mr. Fertilizer," Travis P. Hignett. (Applause)

Fertilizer Studies For Developing Countries[1]

Travis P. Hignett[2]

At the 1975 Round Table Meeting I read a paper by Dr. McCune, Managing Director, on the planned activities of the International Fertilizer Development Center (IFDC). Now, 5 years later I am here to tell you something about what we are doing.

In 1975 we had a small staff housed in rented office space and a very small laboratory in space loaned to us by TVA. We now have 150 permanent employees of which 55 are professional chemists, engineers, agronomists, economists, or people trained in other scientific disciplines. They come from 20 countries. The Main Building was finished in 1977 and contains offices, laboratories, a small greenhouse, and a training center. The Pilot-Plant Building contains three pilot plants, offices, laboratories, and storage facilities.

We have two general types of projects classified according to financing; core-funded projects are aimed at problems that are common to numerous developing countries. Core research funds come from several governments and United nations agencies. "Special" or reimbursable projects are aimed at a specific problem, usually in a single country; they are financed by the client, or in the case of a poor country, by a donor. For example aid-giving agencies of the Dutch and German governments are financing projects in Sri Lanka and Upper Volta. Contractual arrangements at times preclude disclosure of detailed information about these special projects.

Improvement of Nitrogen Fertilizer Efficiency for Rice

Rice is the principal source of food in Asia and supplies 70% of the food grain in that populous continent. It is also an important source of food in South America and parts of Africa. Nitrogen is the most limiting nutrient element in rice culture. Urea is the principal form of nitrogen in Asia and is likely to account for 85% of the future supply in that continent. However, the efficiency of urea nitrogen fertilizer as used by Asian farmers probably is only 25%-40%. Actually, no one knows what the average efficiency of nitrogen use is because nearly all available data were collected at experiment stations or in greenhouse tests where growing conditions are near optimum. Ammonium sulfate is usually a more efficient source of nitrogen than urea but because of its low nitrogen concentration, its delivered cost is much higher unless credit can be taken for its sulfur content. Ammonium nitrate is generally considered unsuitable for flooded rice. So one of IFDC's first and most important projects was to improve the efficiency of urea nitrogen use on rice. The project is now being expanded to include upland crops.

Losses of nitrogen from applied urea can be caused by ammonia volatilization, nitrification-dentrification, leaching, and run-off. Preliminary results indicate that ammonia volatilization may be the most important source of losses in many cases. However all four types of losses could be prevented or greatly decreased in most soils by placing the urea in the reducing zone of the soil and maintaining reducing conditions by keeping the paddy flooded. Urea placed below the surface will quickly hydrolyze to ammonia and carbon dioxide, and the ammonium ions are absorbed by clay and other soil colloids thus preventing or retarding all four types of losses. Unfortunately, this seemingly simple solution is quite difficult. No simple method for placing fertilizers 8-10 cm deep in the mud of a rice paddy has been developed. The Japanese have developed the "mudball technique;" a mudball about 5-8 cm in diameter is formed by hand, a pocket is made by inserting a thumb, the pocket is filled with fertilizer; and then closed by more mud (see Figure 1). The mudballs are allowed to dry, and they are then pushed into the rice paddy soil manually. Usually, one mudball supplies fertilizer for four rice hills. This placement is illustrated by Figure 2. Mudballs using urea are quite effective in reducing losses and consequently increasing rice yields. However, since 62,500 mudballs are needed for 1 ha the procedure is highly labor intensive; and even in countries where labor is cheap and plentiful, it has not become popular.

IFDC has supplied "supergranules" or briquettes of urea of 1-, 2-, or 3-g size which can be placed manually like mudballs. Most of the supergranules supplied by IFDC were produced by Norsk Hydro in a pan granulation pilot plant. An Indian manufacturer (IFFCO) has produced briquettes. These materials have proven to be equally effective in many tests. For example, the same yield has been obtained with half as much manually placed nitrogen as compared with surface-applied urea [1]. The estimated nitrogen recovery (discussed later) was doubled or tripled in comparison with the usual farmer practice of broadcasting prilled urea in the floodwater of the rice paddy. However, the labor of manual placement is still a drawback.

The Chinese have developed a simple machine to produce briquettes at the village level from prilled urea or fertilizer mixtures. They have also developed a simple, manually operated machine for subsurface placement of briquettes or large granules. Figure 3 is a picture of such an applicator.

A substantial amount of nitrogen can be fixed by free-living, blue-green algae in paddy floodwater or by symbiotic relation of algae with Azolla, a small water fern which will grow in the floodwater. Growth of Azolla and algae requires an adequate supply of other nutrients, particularly phosphorus. However, addition of fertilizer N to the floodwater inhibits biological fixation of nitrogen. Subsurface placement of urea keeps the nitrogen out of the floodwater and thus permits biological nitrogen fixation to add to the total notrogen supply[2].

IFDC has also supplied slow-release nitrogen fertilizers such as sulfur-coated urea (SCU) for tests in cooperation with the International Rice Research Institute (IRRI) and other agencies. We have been particularly interested in large SCU, such as forestry-grade (about 4-6 mm). The larger granules require less sulfur and contain more N (39% versus 36% N) and therefore should be less expensive per unit of N as compared with the conventional size.

As compared with deep placement of large, uncoated urea granules, SCU has the following advantages:

1. There is no need to change farmers' practices; SCU can be broadcast in the floodwater which is the usual practice. No increase in farm labor or equipment cost would be required.
2. SCU supplies sulfur which is often deficient in developing countries.
3. SCU is less affected by exposure to humid atmosphere.

The disadvantages of SCU are:

1. Higher cost;
2. Limited commercial availability; and
3. SCU reduces the rate of biological fixation of N but not as drastically as prilled urea when both are broadcast and incorporated[2].

Production of either large urea granules or granular SCU in developing countries would require installation of granulation facilities because all present facilities in these countries use prilling. For this and other reasons IFDC encourages developing countries to install granulation facilities in new urea plants. To determine farmer acceptance of urea in granular form, IFDC has conducted surveys of farmers' opinions in Indonesia and the Philippines. The great majority of farmers (91% in the Philippines) said they would prefer granular to prilled urea if both were available at the same cost. Some of the reasons given, which will need further verification, were:

1. Easier to apply uniformly;
2. Penetrates the mud surface of the soil;
3. No leaf burn damage when used after the crop is well established; and
4. More effective.

Although no scientific test of agronomic results was made, the average yield of rice in the Philippines survey was 8% higher (381 kg/ha) for granular forestry-grade urea than with the prilled product when both were applied by broadcasting. Possibly the deeper penetration into the puddled soil of the rice paddy helps to limit ammonia volatilization loss.

IFDC and the International Rice Research Institute (IRRI) have jointly sponsored an International Network on Soil Fertility and Fertilization Evaluation for Rice (INSFFER) in which 11 rice-growing countries cooperated to test various new fertilizer materials and application methods. An average of 94 tests gave the following results[3]:

Type of Urea Application	Yield Increase kg of Rice/kgN
Prilled, best split	16.6
Mudball, deep placement	23.0
Supergranule, deep placement	21.1
SCU, broadcast and incorporated	23.6

The test results showed considerable variation in relative advantages of SCU and deep placement; the cause of these variations is being studied. Some additional countries have joined the network and tests are being continued.

The "best split" is a practice recommended to farmers but seldom used by them. It consists of broadcasting and incorporating (by harrowing) one-half to two-thirds of the nitrogen at the time of transplanting and broadcasting the remainder in the floodwater when the rice plant begins to form heads. Farmers' practices usually consist of broadcasting the fertilizer directly into the floodwater after transplanting either as a single or split application. Also the test results shown above were conducted with good water control which eliminates or minimizes losses by runoff and by nitrification-denitrification. Only about 30% of the rice farming has good water control. For these reasons results actually obtained by farmers are likely to be poorer and hence susceptible to greater improvement than the above data indicate.

Table 1 summarizes the results of a test carried out at the International Rice Research Institute (IRRI) in the Philippines in cooperation with IFDC[4]. The results show that the usual farmer practice, "delayed split," gave the lowest nitrogen recovery (23%-36%) and the lowest increase; deep placed supergranules gave the highest nitrogen recovery (75%-85%) and the best response. In this experiment the yield increase was nearly proportional to nitrogen recovery, as shown in Figure 4. The yield response increased from 14 to 29 kg of rice per kilogram of *applied* N as the N recovery increased from 30% to 80%. The yield response per kilogram of *recovered* N ranged from 47 to 36 kg of rice.

The advantages of doubling the nitrogen recovery by rice, or even increasing it by 10%-20% are potentially enormous. The manufacture of urea requires about 50 million Btu per metric ton of N. We cannot afford to use this energy wastefully. When improved efficiency is used to reduce the amount of nitrogen fertilizer used, the same yield can be obtained with about half as much nitrogen fertilizer which may put the cost within the reach of many poor farmers who cannot afford it. When using the same amount of urea, the yield increase may be substantial but not necessarily proportional to the increase in nitrogen recovery. In South Korea where farmers are already using over 140 kg of N per hectare of rice, the main advantage would be a reduction of N use.

A rough calculation was made of the potential benefit of increasing the nitrogen recovery by rice in Asia from 30% to 50% based on the following assumptions:

Area planted to rice in Asia	122.6 million ha
Average profitable use of recovered N (assumed)	20 kg/ha
N required at 30% recovery	67 kg/ha
Urea required at 30% recovery	145 kg/ha
Total urea required for rice in Asia (30% recovery)	17.8 million tons
Total urea required at 50% recovery	10.7 million tons
Urea saved per year	7.1 million tons
Energy saved — 163 trillion Btu/year =	172 million GJ
Value of urea saved at $250/ton (delivered) (Assuming no extra cost)	$1,775 million
Saving if SCU is used at 40% extra cost	$705 million

The above calculations may be fanciful but they show a goal worth striving for, even though it may require many years of research and farmer education. Even an average of one percentage point increase in nitrogen recovery would save $150 million worth of urea. If translated into increased rice yield on the basis of 35 kg of rice per kg of *recovered* N, one percentage point increase in N recovery (from 30% to 31%) would mean 2.8 million more tons of rice in Asia, worth $560 million at $200/ton.

Several other methods for improving the efficiency of nitrogen use are under study, including coatings other than sulfur and other methods for deep placement.

Phosphorus Fertilizer Studies

Phosphorus is the fertilizer nutrient that most often limits crop yields in many tropical countries including large areas of South America. Figure 5 shows results of "missing element" tests on one South American soil. Phosphorus was the most limiting element followed by sulfur, boron, and calcium. As these soils are quite acid, ground phosphate rock can be used to supply both P and Ca. Incidentally, the data in Figure 5 show that we should not confine our thinking to the primary nutrients—N, P, and K—for these tropical soils.

Phosphate rocks vary widely in reactivity, and several chemical tests have been used to measure reactivity. The European Economic Community (EEC) specifies solubility in 2% formic acid; phosphate rocks sold in the EEC for direct application should have a solubility of 50% or more in this reagent. The most reactive rocks by this test method are North Carolina, Gafsa (Tunisia), and Sechura (Peru); their solubilities in formic acid range from 85% to 72%. Florida and Tennessee rocks were in the range of 20% to 30% solubility. In field tests in Colombia the first crop response was proportional to the re activity and was 90% or more of that obtained with TSP for the more reactive rocks. Reactivity was less important for second and third crops or long season crops. For instance, in a long-term field experiment in Colombia with grassland, TSP was superior to rock phosphate only during the first crop; afterward all rock phosphates increased their effectiveness with time, approaching or surpassing the yields of TSP during the third and fourth cuts. The total yields for 14 cuttings (4 years) with all phosphate rocks were equal to or better than for TSP, and there was no significant difference between rocks of high and low reactivity as shown in Table 2. Similar results were obtained with a series of three bean crops.

Advantages of direct application of phosphate rock are:

1. Low cost, especially for indigenous rocks;
2. Low capital investment;
3. Little technical skill required;
4. Small energy requirement;
5. Rocks unsuitable for chemical processing often are suitable (high carbonate or high chloride rocks for example);
6. Avoidance of long delays for constructing processing equipment;
7. Low importance of economy of scale and capacity utilization; and
8. Supply of calcium and sometimes other nutrients in addition to phosphorus.

IFDC has studied the granulation of finely ground phosphate rock using 3%-5% of a soluble salt as a binder. Such granules disintegrate to a powder in moist soil or during rains in the case of surface applications. Granules of the usual size (6- to 16-mesh) are agronomically effective for surface application on grassland, but when incorporated in the soil they are much less effective for the first crop than the powdery material. IFDC has developed a process for minigranulation of ground phosphate using an experimental pinmixer. Minigranules (48- to 100-mesh) are dust free and agronomically as effective as ungranulated ground phosphate rock for mixed or surface application.

Granulation is an extra expense which is not always warranted, but may make the product more acceptable in some markets. Application of ground rock as a suspension may be attractive in areas where suitable equipment is available. TVA has demonstrated that suspensions containing 60% of ground North Carolina rock in water can be made and applied satisfactorily[5]. Satisfactory suspensions of ground rock and potash (0-12-12) and rock, potash, and elemental sulfur (0-10-10-5S) also were prepared. These possibilities may be of interest in some of the southeastern United States.

When using phosphate rocks of medium or low reactivity, it may be desirable to supply some water-soluble P_2O_5 for quick response in combination with ground rock for long-term effect. IFDC has prepared granular products of ground rock partially acidulated with sulfuric or phosphoric acid. Short-term response (6 weeks) was directly proportional to P_2O_5 water-solubility; long-term response has not been fully evaluated.

In Malaysia, granular mixtures in which the P_2O_5 is supplied by powdered phosphate rock are used to fertilize rubber and palm trees. IFDC has prepared granular mixtures ranging from 15-20-0 to 14-6-21 using Florida or Jordan phosphate rock, prilled urea, and potassium chloride. The mixtures were granulated in a 1-tph pilot plant shown in Figure 6. Some of the mixtures contained 3%-4% M_gO which was supplied by langbeinite ($K_2SO_4 \cdot 2\ M_gSO_4$) or kieserite ($M_gSO_4 \cdot H_2O$). Liquid phase for granulation was supplied by dissolving part of the urea in water to form a 75% solution which was sprayed onto the bed in the drum granulator and by steam which was sparged under the bed.

Direct application of phosphate rock is only one of several possible ways to utilize a phosphate deposit. IFDC has undertaken several projects to evaluate alternative methods for utilizing phosphate deposits, or to devise means for producing a specific product such as phosphoric acid, single superphosphate, triple superphosphate, or fused phosphate. The experimental work for these studies was carried out in bench-scale or pilot-scale equipment for beneficiation, acidulation, or thermal treatment. Phosphate rocks from numerous developing countries have been studied including Brazil, Colombia, Egypt, Mexico, Peru, Pakistan, Jordan, Israel, Sri Lanka, Senegal (tailings), Upper Volta, and Venezuela.

Other Activities

IFDC conducts training courses, seminars, and symposia on fertilizer-related subjects such as:

- Marketing and Distribution
- Plant Maintenance
- Manufacturing Technology
- Granulation
- Testing of New Products in the Tropics
- Special subjects as requested

Some of these courses are held in developing countries. Individual training programs are arranged to suit the needs of the individual.

Agronomic studies of new or modified products are carried out mainly in cooperation with international agricultural research centers in developing countries. IFDC personnel are stationed at some of these centers to help coordinate the studies with IFDC's programs. Through these centers, new products are tested by networks of national agricultural centers. Preliminary agronomic tests are carried out at IFDC Headquarters in the greenhouse or controlled-environment growth chambers.

Numerous studies are undertaken for developing countries or for specific organizations in developing countries such as:

- Prefeasibility studies for new plants
- Modification or expansion of present facilities
- Marketing assistance
- Assistance in planning national research center programs

REFERENCES

1. Roy, R.N., S. Seetharaman, And R.N. Singh. 1978. "Fertilizer Use Research in India," *Fertilizer News* Nov. 1978.

2. Roger, P.A., S.A. Kulasoorija, A.C. Tirol, and E.T. Craswell. 1980. "Deep Placement: A Method of Nitrogen Application Compatible with Algal Nitrogen Fixation in Wetland Rice Soils," Plant and Soil.

3. Parish, D.H., L.L. Hammond, and E.T. Craswell. 1980. "Research on Modified Fertilizer Materials for Use in Developing Country Agriculture" presented at 180th National Meeting of the American Chemical Society, Las Vegas, Nevada, August 24-28.

4. De Datta, S.K., and E.T. Craswell. 1980. "Nitrogen Fertility and Fertilizer Management in Wetland Rice Soils" presented at Special International Symposium on Rice Research Strategies for the Future, Los Banos, Laguana, Philippines, April 21-25 (Proceedings in press)

5. Achorn, F.P., and Homer L. Kimbrough. 1978. "New Processes and Products for the Fluid Fertilizer Industry-Phosphates" in NFSA Round-Up. Published by the National Fertilizer Solutions Association, Peoria, Illinois.

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1. Prepared for presentation at the Fertilizer Industry Round Table, October 28-30, 1980, Atlanta, Georgia, U.S.A.

2. Special Consultant to the Managing Director, International Fertilizer Development Center, Muscle Shoals, Alabama 35660, U.S.A.

Table 1

Effect For, Placement and Timing of Urea Application on Yield of Rice and Nitrogen Recovery[4]

Type of Urea Application[a]	Rice Yield[b] t/ha	Apparent N Recovery, %	Yield Increase, t/ha	Yield Increase kg rice/kg N
No nitrogen	7.2	——	——	——
Prills, farmer split[c]	9.2	23-36	2.0	14.2
Prills, best split[d]	9.7	35-44	2.5	17.7
SCU, forestry grade[e]	10.7	46.78	3.5	26.8
Superfranule[f]	11.3	75.85	4.1	29.1

a. Total N applied 141 kg/ha for two crops.
b. Sum of two crops, wet and dry seasons.
c. Delayed split; 2/3 of urea broadcast in floodwater 21 days after trans-planting and 1/3 when the rice begins to form heads (a common farmer practice).
d. Best split; 2/3 broadcast and incorporated by harrowing at time of transplanting and 1/3 broadcast in floodwater when the rice begins to form heads.
e. Broadcast and incorporated at time of transplanting.
f. Placed as shown in Figure 2 at time of transplanting.

Table 2

Relative Yield of Grass (Brachiaria Decumbens) from Application of Ground Phosphate Rocks (Ref. 3) (Sum of 14 Cuttings Over a 4-Year Period in a Field Test in Columbia; Average of Four Application Rates)

Phosphate Rock Source	Relative Yield % of TSP
Peru	103
Florida	105
Gafsa (Tunisia)	105
Huila (Columbia)	104
Pesca (Columbia)	105
Tennessee	96
No Phosphorus	37

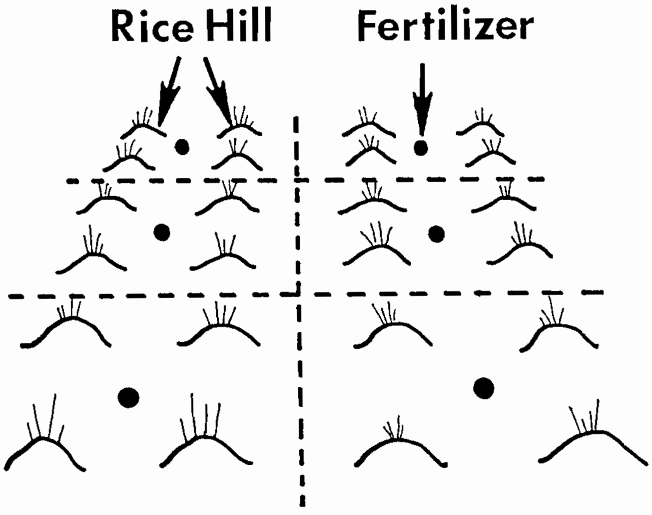
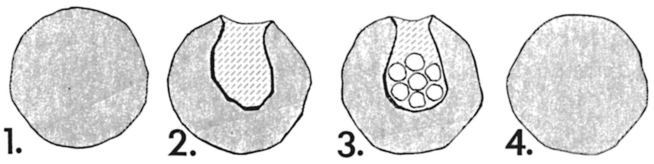


Figure No. 2
Fertilizer Placement in Rice Paddy



1. Make mudball 3cm in diameter
2. Make opening in center with thumb
3. Place fertilizer in center
4. Close opening

Figure No. 1
Placing Fertilizer in Mudball

Figure No. 3
Machine for Deep Placement of Supergranules

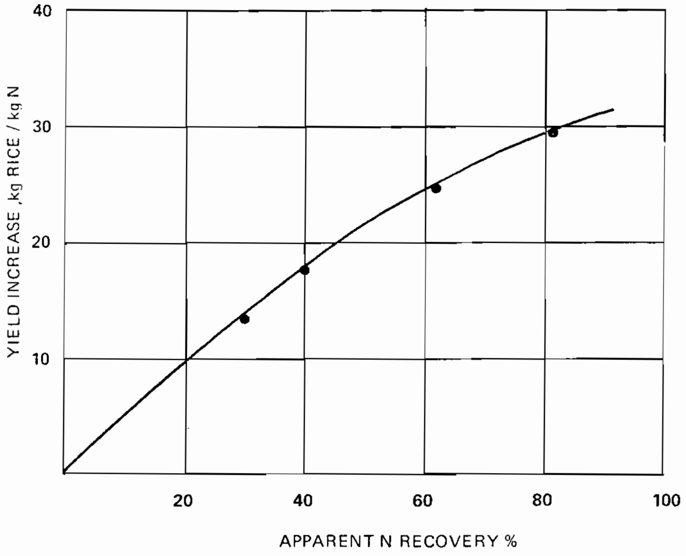


Figure No. 4
Apparent N Receovery Versus Field Increase In Rice

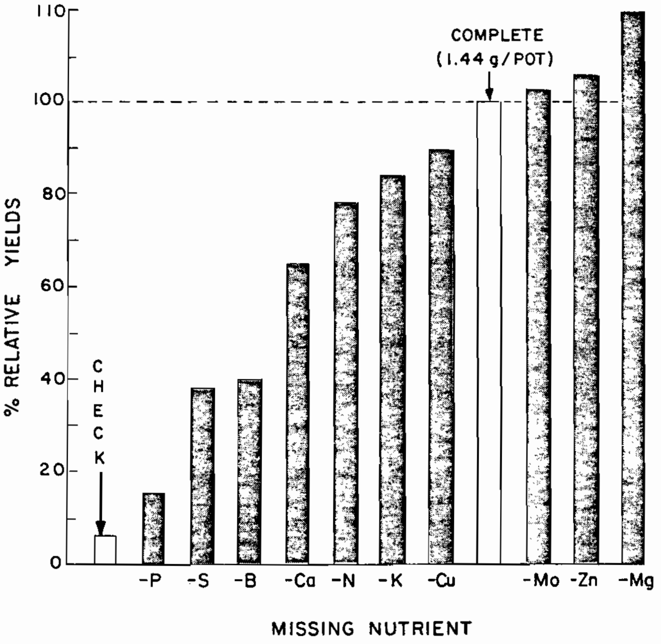


Figure No. 5
Effect of Missing Nutrients
on Yields in a Typical S. A. Soil

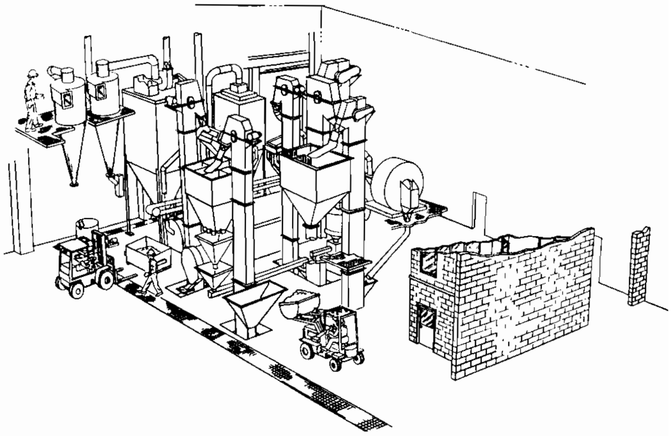


Figure No. 6
IFDC Granulation Pilot Plant

MODERATOR MEDBERY: Thank you very much Travis. (Applause). Are there any questions?

QUESTION—THOMAS J. PEARCE—ESTECH GENERAL CHEMICALS: At one time there was a considerable amount of Florida Phosphate Rock sold for direct application. Do you think there is any future for that?

ANSWER—TRAVIS HIGNETT: I do not think there is very much future for direct application of phosphate rock in the Midwest because it is a long way from either Florida or North Carolina and the more concentrated phosphates are likely to be more economical on the whole. There might be considerable possibility of using North Carolina Rock in the Southeast close to the source of it. Since North Carolina rock is one of the most reactive I think there might be a good possibility of local use in the Southeast area.

MODERATOR MEDBERY: Any other questions? Thank you. (Applause)

MODERATOR MEDBERY: The third paper of this afternoon, is on a very important topic, and one which has quite recently become a matter of serious concern to our industry. This is the Resources Conservation and Recovery Act, RCRA. Glenn Feagin, my colleague at IMC, has been devoting much of his time lately to interpretation of the act and working toward getting our plants in compliance with this act. Glenn is a native Georgian, raised in Americus, a town most notable, recently, as being only 8 miles from Plains. Glenn attended the Americus public schools and Georgia Southwestern College, served in the army in Europe during WW II, and returned to complete his education at the Georgia Institute of Technology. Glenn obtained the degree of Bachelor of Chemical Engineering in June 1949 and began work for IMC in July of that year. Since joining IMC over 31 years ago, Glenn has filled a very large number of assignments of increasing responsibility, including managing four different granulation plants. His present position is Manager of Fertilizer Technology in the Rainbow Division, stationed here in Atlanta. Please make welcome, Glenn Feagin. (Applause)

The Resource Conservation and Recovery Act (R.C.R.A.) How It May Affect You

Glenn A. Feagin

Sounds innocent enough, doesn't it? Conservation and recovery or recources — certainly a worthy program. No problems.

Dream on friend. This little time bomb may be one of the most important, expensive and controversial acts ever passed by Congress.

Let's look at some parts of this act. All quotes and definitions are taken from the May 19, 1980 Federal Register, Book 2. It only contains a total of 522 pages. Copies can be obtained from the Environmental Protection Agency who will enforce RCRA provisions.

From Page 33066, I quote: "Subtitle C of RCRA establishes a federal program to provide comprehensive regulations of hazardous waste. When fully implemented, this program will provide cradle-to-grave regulations of hazardous waste."

See! In just one step, we have gone from the conservation and recovery of resources to a cradle-to-grave regulatory system for hazardous waste.

The improper handling of hazardous waste should be prevented. No arguement. BUT!! How do you determine what is "hazardous waste" and what regulations are really necessary.

Let's look at just one part of the EPA program for determining what constitutes a hazardous waste.

The EPA definition of "Sludge" is given on page 33075, paragraph 63. It says: "Sludge means any solid, semi-solid or liquid waste generated from an industrial waste water treatment plant, water supply treatment plant or air pollution control facility.

On page 33079, EPA states: "A sludge is an RCRA solid waste irrespective of whether you:

1. Discard it.
2. Use it.
3. Reuse it.
4. Recycle it.
5. Reclaim it.
6. Store or accumulate it for purposes of 1 through 5 above.

Let's go on. EPA has determined that a RCRA solid waste is a hazardous waste if it is:

1. Any of the 360 compounds listed on page 33122.
2. Ignitable.
3. Corrosive.
4. Reactive.
5. Toxic.
6. Poisonous.

Get the picture? If you operate a pollution control system, the material you collect is considered under RCRA as a "solid waste", regardless of what use you make of it, and it is a hazardous waste if it exhibits any of the characteristics just listed.

These characteristics are discussed in detail on pages 33107 through 33116.

Corrision and toxicity will have the most affect on the fertilizer industry.

A "solid waste" under RCRA is considered corrosive if a "leachate" has a pH less than 2 or more than 12.5 or if the leachate corrodes steel at a rate greater than 1/4 inch per year.

A "solid waste" under RCRA is considered toxic if a "leachate" prepared with acetic acid contains more than 100 times the drinking water standard for 8 specific elements and 6 pesticides (see page 33122).

EPA defines "leachate" as any liquid which has percolated through or drained from a waste.

The elements of specific interest to us and the allowable concentration are:

ELEMENT	MILLIGRAM LITTER
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
2-4-D	10.0

Milligrams per liter is the same as parts per million.

With this limited background, let's see how this act can affect you.

You operate a small farm center and sell 2-4-D. This material is listed by EPA as hazardous material #PO35. You spill a 5-gallon can or worse a 55-gallon drum. You must clean it up so that a "leachate" from the spill area will contain less than 10 milligrams per liter of 2-4-D. Better do a good job.

If the contaminated material you clean up weighs more than 220 pounds, you must dispose of it in an EPA-approved manner.

That's easy to do—just put it in an EPA-approved container, find an EPA-approved disposal site that will accept it, fill out the EPA-approved shipping papers and ship it by an EPA-approved transporter.

Of course, you will have to give them the EPA number licensing you as a generator of hazardous waste. You didn't apply for one before August 19, 1980? Well, you are in trouble. You can apply for an emergency number and it probably will be granted. Better hurry! You can only store hazardous waste for 90 days without a storage permit.

When you find an EPA-approved disposal site, please let us all know where it is located. So far, all efforts to open new commercial disposal areas have failed.

You operate an acidulation unit reacting phosphate rock with sulfuric acid or phosphoric acid. Fluorine is liberated by the reaction.

To meet air pollution control standards, you scrub the gases with water in a venturi scrubber and collect H_2SIF_6 . . . hydrofluosilicic acid, which you have been selling to a metal cleaning company.

By EPA definition, this acid is a sludge. It's pH is less than 2; therefore, it is a hazardous waste.

It is possible that this operation may come under the phosphate mining and processing exemption recently passed, but a final ruling has not been made. But, I'm sure you will have your permit ready to file by November 19, 1980, just in case you are not exempted.

If you are not exempted, you must dispose of this material in an EPA-approved manner. It's easy — get your trucking company to register as a transporter of hazardous waste and your customer to register his plant as a storing location — Good luck!

You operate a small blending plant. You manufacture a fertilizer for corn which contains 1% zinc derived from zinc oxide.

Whether you know it or not, you may have been buying a zinc oxide that was collected in some type of air pollution control equipment.

Almost all zinc oxide contains some lead. Acetic acid will extract this lead and if the acetic acid leachate contains more than 5 milligrams per liter lead, your supplier must classify the product as a hazardous waste.

You have two choices—register your plant as receiving and storing hazardous waste or find a supplier who makes zinc oxide as his primary product. There are no regulations on how much lead his product can contain.

You operate dust collectors to help you meet EPA or OSHA dust standards and collect more than 2200 pounds of dust in anyone month (sludge as EPA calls it). You must determine if it is a hazardous waste.

If it is, you have to apply for a permit to generate, store and possibly treat hazardous waste. You haven't done this? You do have trouble. EPA says you must apply for a permit and cease the operation generating the hazardous waste until you obtain your permit.

It has been called to EPA's attention how absurd it is to call all materials generated in a pollution control device a waste. Hopefully, this will be changed and products which are sold for legitimate use will not be included.

Time will not allow me to cover the regulations covering recordkeeping, testing, security, training, reporting, plant closing plans, and insurance that you will have to obey if you handle hazardous waste.

To sum up: You must obtain an RCRA hazardous waste handling license if you:

1. Exceed the small generator exemption allowance.
2. Store hazardous waste.
3. Transport hazardous waste.
4. Treat hazardous waste.
5. Dispose of hazardous waste.

You have until November 19, 1980 to file.

MODERATOR MEDBERY: Thank you Glenn for your most interesting discussion on the subject of R.C.R.A. I am sure our Audience have some questions. Looks like they will need some time to digest the valued up-to-date information you so thoroughly discussed covering R.C.R.A. Thank you. (Applause)

MODERATOR MEDBERY: The final paper of this afternoon was authored by Hubert L. Balay and Jeffery L. Greenhill of the National Fertilizer Development Center, TVA, Muscle Shoals, Alabama. Hubert L. Balay is a field chemical engineer in the Process and Product Improvement Section of the TVA National Fertilizer Development Center at Muscle Shoals, Alabama. He has been with TVA since 1966. Balay is a graduate of the University of Arkansas. Before joining TVA he worked for 14 years with the Spencer Chemical Company in an ammonia plant and as a sales engineer. Balay has authored or co-authored 31 papers on fertilizer technology and has constructed and started numerous bulk blending, granulation, liquid, and suspension fertilizer plants. He has worked on plant operating and field application problems with TVA and Spencer Chemical Company. Mr. Greenhill is a native of North Alabama. He received a Bachelor's of Science degree in Chemical Engineering from the University of Auburn in 1979. He has worked at TVA since June 1979 as a field engineer. The paper will be presented by Mr. Balay. May I present Mr. Balay. (Applause)

Advantages Of Producing And Using Monoammonium Phosphate

Herbert L. Balay — Jeffry L. Greenhill
Presented by Jeffry L. Greenhill

Ammonium phosphate production has increased faster than production of other kinds of fertilizer since about 1960 when a practical and versatile process for production of economical high-quality granular products was introduced. The production increase has been mostly in granular diammonium phosphate (18-46-0 grade) made from wet-process phosphoric acid and ammonia. Recently, however, monoammonium phosphate has increased in popularity mainly because of its usefulness as a fluid fertilizer base.

Production of ammonium phosphates started in the early 1930's, and most of the early plants produced mainly straight monoammonium phosphate and mixtures of monoammonium phosphate with ammonium sulfate. Once again, large tonnages of monoammonium phosphate and monoammonium phosphate containing ammonium sulfate are being marketed. However, the predominant form of ammonium phosphate continues to be diammonium phosphate (18-46-0). Tonnage reporting services do not distinguish between diammonium phosphate and monoammonium phosphate except for direct application. Therefore, it is impossible to determine just how many tons of monoammonium phosphate are produced. It is known, however, that tonnages sold of monoammonium and monoammonium phosphate containing ammonium sulfate are increasing and are expected to continue to increase. This is because monoammonium phosphate has advantages over diammonium phosphate in every branch of production and use including ammonium phosphate production plants, regional granulation plants, bulk blend plants, fluid fertilizer plants, transportation, storage, and agronomics.

Advantages in Ammonium Phosphate Production

Most granular diammonium phosphate is produced by the slurry process developed by TVA. In this process phosphoric acid is ammoniated to an NH_3:H_3PO_4 mole ratio of 1.45:1 in a preneutralizer. This ratio is chosen because it corresponds to the high solubility point between the monoammonium and diammonium phosphate and allows a slurry with only about 20 percent water to be pumped to the granulator. Solubility of ammonium phosphate at various ammoniation rates is shown in Figure 1. An excess of ammonia is then added in the granulator to raise the NH_3:H_3PO_4 mole ratio of the product to about 2:1. A flow diagram of the TVA diammonium phosphate process is shown in figure 2. One of the major problems in operating such a plant is capturing ammonia escaping from the granulator. this is generally done by scrubbing the ammoniator off-gases with the incoming weak acid (30% P_2O_5) in a corrosion resistant scrubber. The scrubber solution is then added to a preneutralizer where it is mixed with stronger acid, ammoniated, and added back to the granulator as a slurry. The product produced is then dried, cooled, sized, and transported to storage.

The same equipment can be used to make monoammonium phosphate by merely operating the preneutralizer at an NH_3:H_3PO_4 mole ratio of 0.5:1 to 0.6:1, which produces a slurry similar in solubility (as shown in figure 1) to that at the 1.45:1 mole ratio, pumping the slurry to the granulator, and adding enough ammonia to bring the NH_3:H_3PO_4 mole ratio to 1:0:1 (1). The major advantage of using this system to produce monoammonium phosphate over production of diammonium phosphate is in scrubbing. Operating at the NH_3:H_3PO_4 mole ratio of 0.5:1 to 0.6:1 results in less steam generation from the preneutralizer because less chemical heat is liberated. Also, only the first hydrogen on the phosphoric acid molecule is replaced resulting in a reaction that more easily goes to completion in the granulator. This produces a more stable compound with less ammonia loss. It also simplifies removal of ammonia from the ammoniator off-gases. These gases can be scrubbed with conventional scrubbing equipment rather than with phosphoric acid. This also allows more flexibility in the concentration of the phosphoric acid used; high strength acid can be used if desired.

Nongranular monoammonium phosphate, which is valuable as an ingredient in granulation and fluid fertilizer plants, can be made in comparably simple plants (2). In general, nongranular processes are simplified by eliminating granulation, recycling, crushing, drying, and cooling steps. These systems produce a product which, although nongranular, has sufficiently good physical properties to permit storage, handling, and transportation without excessive caking or dusting. Four processes, Swift, Scottish Agricultural Industries, Fison, and Nissan are used to produce most granular monoammonium phosphate.

In the Swift process phosphoric acid containing 50 percent P_2O_5 is reacted with liquid ammonia in a two-fluid nozzle which discharges into a reactor pipe. The mixture is ejected into a cooling tower where a countercurrent air stream removes water vapor and cools the product. A product containing 3 to 5 percent moisture is produced (3,4).

The Scottish Agricultural Industries process consists of a vessel where phosphoric acid containing 50 percent P_2O_5 is neutralized with ammonia to an NH_3:H_3PO_4 mole ratio of about 1.35:1. The resulting slurry is mixed with more phosphoric acid in a blunger-like reactor which breaks the mass into small granules. The product usually contains 6 percent moisture (3,5).

The Fison process reacts phosphoric acid containing 50 percent P_2O_5 with gaseous ammonia under pressure. Reaction heat drives off part of the water as superheated steam. The slurry containing 9 to 10 percent water is released into a spray tower through a special nozzle where water is flashed. The particles then solidify by falling through a rising air stream (3).

The Nissan process reacts droplets of phosphoric acid in an ascending stream of air and ammonia (3).

Other advantages in the production of monoammonium phosphate over diammonium phosphate are: less ammonia must be shipped from areas where ammonia is produced to areas where phosphoric acid is produced; grades with plant food contents equal to or higher than 18-46-0 can be produced if reasonably pure acid is used; and finally, no fixed grade (such as with 18-46-0) has been established, leaving manufacturers free to make the grade which best suits their phosphate source and manufacturing method.

Advantages in Regional Granulation Plants

Until recently phosphoric acid has been used only in relatively small quantities in ammoniation-granulation plants because addition of a preneutralizer was expensive and its operation was often beyond the technical capabilities of the operating personnel. To use as much ammonia as possible when the acid was added directly to the granulator, the phosphoric acid was usually ammoniated to an NH_3:H_3PO_4 mole ratio of 1.5:1. This tended to limit the amount of phosphoric acid that could be used because, as shown in figure 1, the solubility of the ammonium phosphates at this mole ratio is high. This increased the solubility of ammonium phosphate in the mixture and the liquid phase of the mass being granulated. Also the critical relative humidity of the mixture was increased and storability of the product impaired.

During the last few years, however, operators of regional granulation plants have discovered that more phosphoric acid and sometimes more ammonia can be used if the acid is ammoniated to a mole ratio of 1.0:1 (monoammonium phosphate) rather than 1.5:1. The decreased solubility in going from a 1.5:1 to a 1.0:1 mole ratio assists granulation because the lower solubility of the monoammonium phosphate in the mixture allows more phosphoric acid to be used, reduces the recycle ratio, and produces a product which stores better.

Recently, development of the pipe-cross reactor which replaces the preneutralizer in regional granulation plants has allowed even more phosphoric acid to be used (6). The NH_3:H_3PO_4 mole ratio in the pipe-cross usually is held at 1:1 to prevent ammonia loss, to aid granulation, to decrease recycle rates, and to produce a product with a lower solubility and higher critical relative humidity. This can be done with the pipe-cross because most of the water added to the pipe-cross with the raw materials is flashed and a melt with only about 3 percent water is produced. Despite the low solubility of the melt at an NH_3:H_3PO_4 mole ratio of 1:1, the pipe-cross melt does not need additional water because it discharges immediately after completion of the reaction onto the rolling bed of solids in the granulator. This is in contrast to a preneutralizer where the ammonium phosphate slurry has to be kept at a minimum of 16 percent water so that it can be pumped to the granulator. Use of the pipe-cross melt process rather than a slurry process decreases equipment cost, simplifies operation, and allows drying of the final product to be eliminated or greatly reduced.

With the pipe-cross, monoammonium phosphate grades containing small amounts of sulfur have been produced in regional granulation plants; 12-48-0-3.8S and 11-53-0-2S grades have been produced in some quantity. These products have been found to be useful in bulk blends and as bases for fluid fertilizers.

Nongranular monoammonium phosphate from processes described previously can be used as an intermediate in granulation (7). Nongranular monoammonium phosphate is especially useful in high nitrogen grades. The amount of ammonia that can be used as a nitrogen source in high nitrogen grades is limited because when large quantities of ammonia are used, the heat and liquid phase generated are excessive. Usually as much nitrogen as possible is obtained from ammonia and the balance is obtained from ammonium nitrate or ammonium sulfate. Both of these materials, if used in quantity, degrade handling and storage properties of the product, and the nitrogen in these compounds is usually more expensive than the ammonia in monoammonium phosphate. If monoammonium phosphate is used as a phosphate source, ammonium nitrate and ammonium sulfate requirements are reduced because of nitrogen in the monoammonium phosphate.

Nongranular monoammonium phosphate is also useful as a phosphate source in high-analysis grades that cannot be formulated with triple and normal superphosphates because there is not enough room in the formula. Usually granular diammonium phosphate is used in these grades, but the granules of diammonium phosphate often are not covered during the granulation process. This causes segregation and poor appearance of the product. Nongranular monoammonium phosphate is sold as a substitute for powdered normal and triple superphosphates and can be useful as a substitute for these raw materials if the delivered cost is attractive. This is especially true in independent regional granulation plants that do not have access to supplies of normal or triple superphosphate or phosphate rock.

Advantages in Bulk Blends

Granular monoammonium phosphate is especially useful in bulk blending. Monoammonium phosphate has the advantage over diammonium phosphate (18-46-0) in that all of the popular ratios, even the 1:4:X and 1:3:X ratios, can be blended without an additional phosphate material (2). If ratios below 1:2.56 are blended from 18-46-0, granular triple superphosphate or some other phosphate material must be available. Additional nitrogen is sometimes required with monoammonium phosphate, but bulk blending plants usually have nitrogen available to blend the higher nitrogen ratios. This eliminates the need to ship and store one material. All of the ratios that can be blended from monoammonium phosphate has an advantage over triple superphosphate in that it contains 60-66 units of plant food per ton rather than 42-46 for triple superphosphate. This results in lower freight rates and less storage space requirements.

The 12-48-0 grade mixture of monoammonium phosphate and ammonium sulfate produced in pipe-cross reactor plants is especially useful for blending the popular 1:4:X ratios. This cuts down the number of materials required in the formula and helps alleviate segregation problems that still worry blenders.

Monoammonium phosphate is comnpatible with all fertilizer ingredients used in bulk blending. This is not true of diammonium phosphate. Diammonium phosphate as shown in Figure 3 has limited compatibility with normal and triple superphosphates (8). When diammonium phosphate is mixed with superphosphate, a reaction can occur in which ammonia is released from the diammonium phosphate and absorbed by the superphosphate. This releases the water of hydration from monocalcium phosphate monohydrates (superphosphates). This reaction wets the blend and helps form monoammonium phosphate crystals which can cause pile and bag set by creating bonds between the pellets. P_2O_5 water solubility can also be reduced because of conversion of monocalcium phosphate to dicalcium phosphate. These are normally slow reactions that usually do not interfere with bulk spreading; however, it can ruin bagged bulk blends.

The 1:5 and 1:4 ratios are natural ratios for monoammonium phosphate and monoammonium phosphate combined with ammonium sulfate and are also natural starter ratios when combined with potash. This allows monoammonium phosphate and monoammonium phosphate mixed with potash to be applied in the row as starter fertilizer and followed later with anhydrous ammonia. This can be done with diammonium phosphate; however, again either an excess of nitrogen usually must be applied in the starter or triple superphosphate must be shipped and stored to mix with the 18-46-0 grade. Also, as discussed later, placing diammonium phosphate near the seed can cause germination problems.

Advantages in Suspension Fertilizers

Use of monoammonium phosphate in manufacturing suspension fertilizers has done more to spur the return of monoammonium phosphate as a major fertilizer ingredient than any other factor. There are many reasons for this. A major reason is the low shipping cost of monoammonium phosphate as compared to fluid bases. Not only is monoammonium phosphate higher in analysis than any fluid base, but higher per ton shipping rates generally are charged by the railroads for fluids than for solids.

Monoammonium phosphate presents no cold weather storage problems. Storage of most fluid bases containing phosphates can be a problem in cold weather because they solidify or salt-out. Fluid bases that store well are expensive, and even these bases sometimes precipitate impurities which cause problems. This makes it difficult to buy fluid bases during discount periods and successfully store them until they are required in the spring.

The recent appearance on the market of high-horsepower, high-shear mixing equipment has made it possible to disintegrate granular monoammonium phosphate efficiently to produce suitable suspensions (9). Reaction of ammonia with the monoammonium phosphate to provide heat and increase solubility of the phosphate is required for this process. This is an additional advantage since the cost of nitrogen from anhydrous ammonia is usually lower than the cost of nitrogen in fluid bases and always lower than the cost of nitrogen in supplemental nitrogen sources such as urea or urea-ammonium nitrate solution.

Monoammonium phosphate alone is comparatively insoluble. As shown in Figure 1 only about 25 pounds will dissolve in 100 pounds of water at 32°F. If ammonia is added to raise the $NH_3:H_3PO_4$ mole ratio from 1:1 to 1.45:1, about 110 pounds will dissolve in 100 pounds of water at 32°F. Since the amount of solid that can be suspended is roughly the same regardless of how much material may have been dissolved. ammoniating to a mole ratio of 1.45:1 maximizes the total amount of plant food in a given amount of fluid fertilizer. Some producers sacrifice solubility slightly by ammoniating past the maximum solubility point to a mole ratio of 1.65:1 because the usual crystallizing phase at that mole ratio is diammonium phosphate. Diammonium phosphate crystals are less dense and better shaped for suspensions than monoammonium phosphate crystals. This also slightly decreases the cost of nitrogen in the fluid.

When the impurity content of nongranular monoammonium phosphate is kept low by using quality acid, the product is especially suited for fluids because the fine material will ammoniate more easily than granules, and less power is required to produce a suspension because granules do not have to be disintegrated. Because of the economics in its production, nongranular monoammonium phosphate should become an important fluid base.

Suspensions also can be produced by adding phosphoric acid to diammonium phosphate to reduce the $NH_3:H_3PO_4$ mole ratio from 2:1 to 1.45:1 (or 1.65:1); however, high-shear equipment and additional phosphoric acid alone are usually not sufficient to break down the diammonium phosphate pellets. A little extra acid and some ammonia must be added to provide enough heat and liquid phase to disintegrate the diammonium phosphate. This requires that both phosphoric acid and ammonia be stored.

Advantages in Transportation and Storage

Many of the advantages mentioned before are also advantages in storage and transportation. When P_2O_5 is required in a bulk blend or a granulation process, the high P_2O_5 content of monoammonium phosphate is an advantage over diammonium phosphate because 4 to 9 units more of P_2O_5 are shipped per ton of product. Monoammonium phosphate also has the same advantage over triple superphosphate because it not only contains 4 to 9 more units of P_2O_5, but 10 to 11 units of nitrogen are included.

The savings in shipping monoammonium phosphate over shipping a fluid base are even greater than the advantage over solid diammonium phosphate and triple superphosphate because the analyses of fluid bases are lower. Also, in the fluid plant a solid material which does not solidify, freeze, or salt-out, can be purchased during the discount period, and is available in quantity at the start of the fertilizer season is a definite advantage.

Monoammonium phosphate stores physically better than diammonium phosphate because it has a higher critical relative humidity (8). As shown in Figure 4, monoammonium phosphate has a critical relative humidity of 91.6 while diammonium phosphate has a critical relative humidity of 82.5.

When nongranular monoammonium phosphate is used in granulation plants to replace phosphoric acid, it can be stored in bulk in ordinary bins. This eliminates the special fiberglass tanks, the type 316 stainless steel tanks, or the rubberlined tanks required for phosphoric acid. Also nongranular monoammonium phosphate can be shipped in ordinary steel barges, rail cars, and ships which can then backhaul other materials.

Advantages in Agronomics

Monoammonium phosphate is superior to diammonium phosphate for both surface and row application. Agronomic studies show that loss of nitrogen after surface application on calcareous soil is less with monoammonium phosphate than with diammonium phosphate (10). Also, numerous studies show that diammonium phosphate placed in the row as a starter fertilizer can cause seed germination damage, probably as a result of the release of free ammonia from the secondary ammonia radical. This effect can be exaggerated when the starter fertilizer is poorly placed, as is too often the case. In addition (as mentioned previously) the lower nitrogen content of monoammonium can be beneficial because often less nitrogen is required in starter fertilizers than in blends made from diammonium phosphate alone and more ammonia can be used for side dressing.

Conclusion

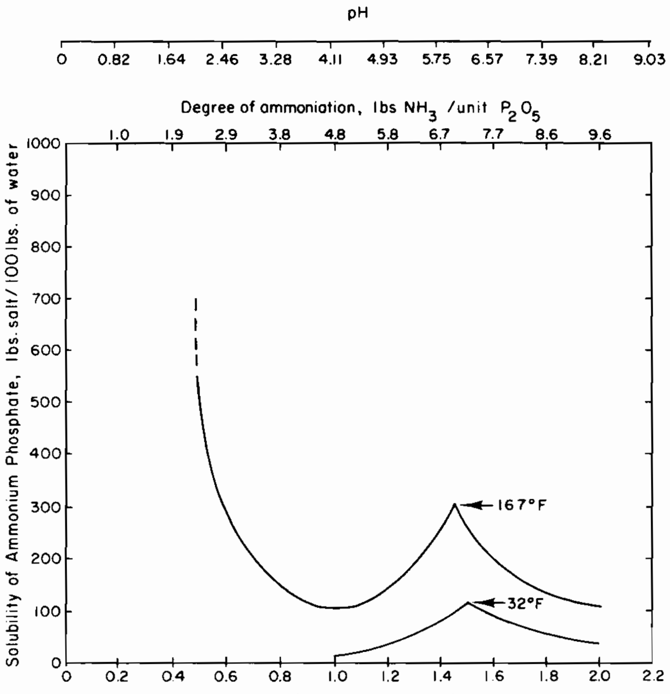
Many of the advantages of monoammonium phosphate are significant enough to cause one to wonder why monoammonium phosphate has not been a more popular fertilizer material. Among these advantages are ease and simplicity of production; superiority as an ingredient in starter fertilizer; usefulness as a base in fluid fertilizer; high critical relative humidity; high P_2O_5 analysis; high total plant food content; superior storability of fertilizers made from monoammonium phosphate and other fertilizer ingredients; and its availability in two forms, granular and nongranular. Presently, the tonnage of monoammonium phosphate used in manufacturing processes cannot be separated from those reported for diammonium phosphate; however, it is thought that significant tonnage of monoammonium phosphate is being used. An indication might be the increase in the amount of monoammonium phosphate used for direct application. It has been reported that the amount of direct application material which was primarily monoammonium phosphate increased from 86,000 tons in 1975 to almost 264,000 tons in 1979 (11). Presumably, a similar increase has occurred in the amount of monoammonium phosphate used in granulation, blends, and fluids and the amount used will continue to increase as the advantages of using monoammonium phosphate become better known throughout the fertilizer industry.

REFERENCES

1. Young, Ronald D. and G. C. Hicks. "Monoammonium in a TVA-Type Ammonium Phosphate Granulation System," *Commercial Fertilizer and Plant Food Industry,* February 1967.
2. Balay, Hubert L. and David G. Salladay. "Recent Developments in the Production and Use of Monoammonium Phosphate," *Proceedings of the 26th Annual Meeting,* Fertilizer Industry Round Table, October 26, 27, 28, 1976.
3. *Fertilizer Manual,* International Fertilizer Development Center, Muscle Shoals, Alabama, December 1979.
4. Mortenson, E. N. "Swifts Direct MAP Process," *Proceedings of the 20th Annual Meeting of the Fertilizer Industry Round Table,* 1970, 93-96.
5. Davidson, E. and I.S.E. Martin. "The 'Phosai' Form of Monoammonium Phosphate," *Proceedings of the 23rd Annual Meeting, Fertilizer Industry Round Table,* 1973, 88-115.
6. Achorn, Frank P. and David G. Salladay. "Production of Monoammonium Phosphate in a Pipe-Cross Reactor," *Proceedings of the 25th Annual Meeting,* Fertilizer Industry Round Table, November 4, 5, 6, 1975.
7. Brownlie, I. A. and R. Graham. "The Use of a New Form of Monoammonium Phosphate in Place of Superphosphate as a Means of Attaining Higher Concentration in Granular NPK Fertilizer," *ISMA Technical Conference Helsinki,* 1963, 3-1 to 3-26.
8. Hoffmeister, George, *Physical Properties of Fertilizer and How to measure Them,* TVA Bulletin Y-147, October 1979.
9. Balay, Hubert L. and David G. Salladay. "Producing and Marketing Suspension Fertilizer from Solids," *Situation 77,* TVA Fertilizer Conference, Bulletin Y-115, National Fertilizer Development Center, Muscle Shoals, Alabama.
10. Terman, G. L. and C. M. Hunt. "Volatilization Losses of Nitrogen from Surface-Applied Fer-

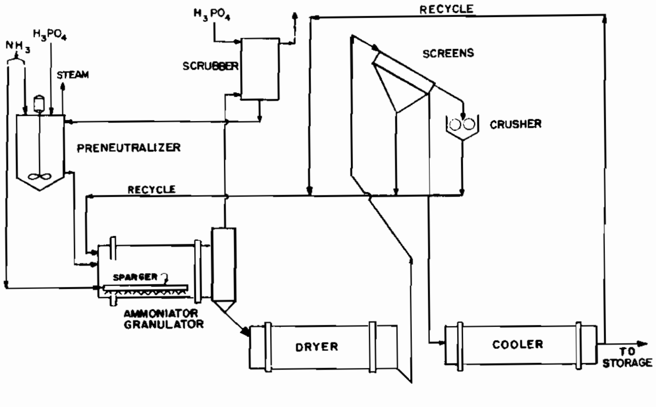
tilizers as Measured by Crop Response," *Soil Science Society of America Proceedings*, 28(8):667-672.

11. Fiscal Years 1975-1979 Consumption of Commercial Fertilizers, Annual Reports; Economics, Statistics, and Cooperative Services; U.S. Department of Agriculture, Washington, D.C.



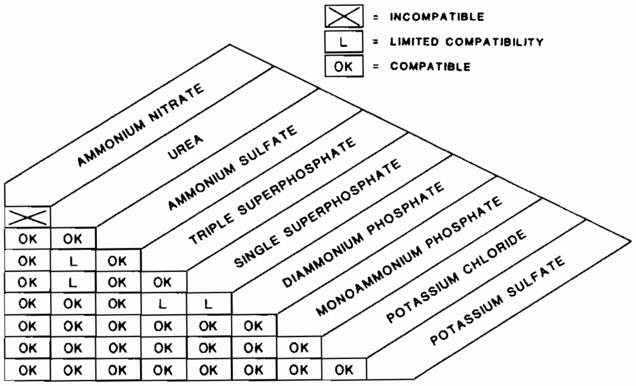
Effect of NH_3:H_3PO_4 Mole Ratio on Solubility of Ammonium Phosphate

Figure 1



PROCESS FOR PRODUCTION OF GRANULAR DIAMMONIUM OR MONOAMMONIUM PHOSPHATE

Figure 2

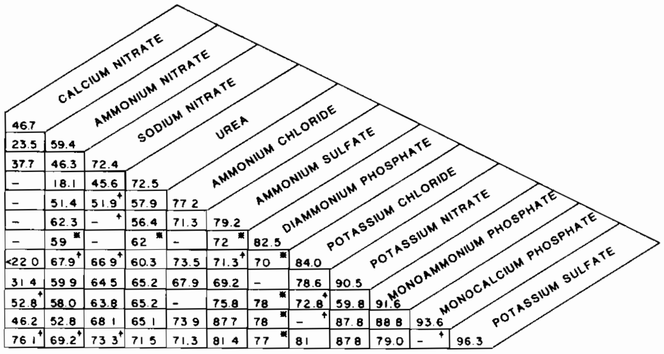


☒ = INCOMPATIBLE
L = LIMITED COMPATIBILITY
OK = COMPATIBLE

	AMMONIUM NITRATE	UREA	AMMONIUM SULFATE	TRIPLE SUPERPHOSPHATE	SINGLE SUPERPHOSPHATE	DIAMMONIUM PHOSPHATE	MONOAMMONIUM PHOSPHATE	POTASSIUM CHLORIDE
UREA	☒							
AMMONIUM SULFATE	OK	OK						
TRIPLE SUPERPHOSPHATE	OK	L	OK					
SINGLE SUPERPHOSPHATE	OK	L	OK	OK				
DIAMMONIUM PHOSPHATE	OK	OK	OK	L	L			
MONOAMMONIUM PHOSPHATE	OK	OK	OK	OK	OK	OK		
POTASSIUM CHLORIDE	OK	OK	OK	OK	OK	OK	OK	
POTASSIUM SULFATE	OK	OK	OK	OK	OK	OK	OK	OK

Figure 3. Chemical compatibility of blend materials.

Figure 3



	CALCIUM NITRATE	AMMONIUM NITRATE	SODIUM NITRATE	UREA	AMMONIUM CHLORIDE	AMMONIUM SULFATE	DIAMMONIUM PHOSPHATE	POTASSIUM CHLORIDE	POTASSIUM NITRATE	MONOAMMONIUM PHOSPHATE	MONOCALCIUM PHOSPHATE	POTASSIUM SULFATE
CALCIUM NITRATE	46.7											
AMMONIUM NITRATE	23.5	59.4										
SODIUM NITRATE	37.7	46.3	72.4									
UREA	–	18.1	45.6	72.5								
AMMONIUM CHLORIDE	–	51.4	51.9†	57.9	77.2							
AMMONIUM SULFATE	–	62.3	–†	56.4	71.3	79.2						
DIAMMONIUM PHOSPHATE	–	59*	–	62*	–	72*	82.5					
POTASSIUM CHLORIDE	<22.0	67.9†	66.9†	60.3	73.5	71.3†	70*	84.0				
POTASSIUM NITRATE	31.4	59.9	64.5	65.2	67.9	69.2	–	78.6	90.5			
MONOAMMONIUM PHOSPHATE	52.8†	58.0	63.8	65.2	–	75.8	78*	72.8†	59.8	91.6		
MONOCALCIUM PHOSPHATE	46.2	52.8	68.1	65.1	73.9	87.7	78*	–†	87.8	88.8	93.6	
POTASSIUM SULFATE	76.1†	69.2†	73.3†	71.5	71.3	81.4	77*	81	87.8	79.0	–†	96.3

* APPROXIMATE VALUES OBTAINED BY TVA. OTHER DATA ARE FROM LITERATURE (51).

† UNSTABLE SALT PAIR; VALUE GIVEN IS FOR THE STABLE PAIR.

Figure 4. Critical humidities of pure salts and mixtures at 86° F (values are percent relative humidity).

Figure 4

MODERATOR MEDBERY: Are there any questions? Bud, a real good job. Thank you. (Applause)

MODERATOR MEDBERY: We conclude our discussions for this afternoon. I wish to thank our excellent attendance and our speakers for a job well done.

See you all at the Cocktail Party at 6 P.M. I hope you can attend to enjoy an excellent social gathering to help you relax. Thank you again. Our Thursday Morning Final Session will start promptly at 9 A.M. (Applause)

Thursday, October 30, 1980

Final Session
Moderators:
Paul J. Prosser Jr. - Harold Green

MODERATOR PROSSER: Welcome to the Business Session of the 30th Annual Meeting of Our Round Table. We are delighted to have had such a fine response to our invitation here to Atlanta.

The first item, we usually try to do, will give you an idea of our financial status". I will read this to you.

Secretary-Treasurer Report

Paul J. Prosser, Jr.

Financial Statement

October 28, 1979 to October 24, 1980

CASH BALANCE — October 28, 1980		$10,457.78
Income October 28, 1979 - October 24, 1980		
Registration Fees — 1979 Meeting	$13,489.00	
Sale of Proceedings	1,932.71	
Total Receipts October 28, 1979 to October 24, 1980		$15,421.71
Total Funds Available October 28, 1979 — October 24, 1980		$25,879.49
Disbursements October 28, 1979 — October 24, 1980		
1979 Meeting Expenses	$ 1,368.78	
1979 Proceedings Including Printing, Postage, etc.	10,183.17	
Miscellaneous Expenses Including Postage, Stationery, Etc.	1,070.47	
Membership Letters, including Postage	716.92	
Directors Meetings	1,083.21	
1980 Meeting — Preliminary Expenses	149.67	
Disbursement Cocktail Party Fund	307.73	
Total Disbursements October 28, 1979 to October 24, 1980		$14,879.95
CASH BALANCE — October 24, 1980		$10,999.54
Less Reserve for Cocktail Party Fund		534.28
Total Cash Available October 24, 1980		$10,465.26

Respectfully submitted,

PAUL J. PROSSER, JR.
Secretary-Treasurer

MODERATOR PROSSER: Are there any questions about the Financial Report, Disbursements? If not, we will put this report in the record. (Applause)

Our next Order of Business, we have Nominations for Board of Directors and Officers. It is my pleasure to call on Director Wayne W. King, Chairman of our Nominating Committee. (Applause)

Nominating Committee Report

Wayne W. King - Chairman

Thank you Paul. Our Committee has met a number of times this year. including a meeting here yesterday. We nominate as follows:

For Chairman-Vice Chairman Frank P. Achorn.

For Vice Chairman-Director Harold D. Blenkhorn.

Will you Gentlemen please stand up. (Applause).

Do we have a "Second?" Yes we do, "many".

Opposed? Silence. (Applause). You are elected.

Congratulations: Frank P. Achorn - TVA, Harold Blenkhorn - Genstar Chemical, Ltd.

We also nominate to our Board of Directors:

Charles Littlejohn, Plant Supt.
Richmond Guano Co.
Richmond, Virginia

H. C. Mackinnon, Mgr.
Technical Sales
Agrico Chemical Co.
Tulsa, Oklahoma

Please stand up. (Applause).

Do we have a second? Yes we do, "many". Opposed? Silence. (Applause). You are elected.

Congratulations. We are very happy for you to join our Board of Directors. (Applause)

MODERATOR PROSSER: Thank you Wayne. As you know, for a long time, Tom Athey has been making arrangements for our yearly Round Table Meetings — hotel-meeting places — entertainment. During the past year Tom suffered some illness and was knocked out of action for a considerable amount of time. We are very fortunate that he has rallied in time to get down here and take care of things, for us again, in Atlanta. I think we ought to have a little applause for Tom, for years of, and most recent efforts he has made in this direction (Much applause). Tom, please come up here and tell us about next year's promising plans (Applause).

Meeting Place and Dates Committee

Tom Athey, Chairman

Thank you, Ladies and Gentlemen, for your kind welcome. I am coming along pretty good and I am very happy to be here with all of you again.

As you know, on the odd years, we always go to Washington. I have made arrangements for our 31st Annual Fertilizer Industry Round Table Meeting, to be held in Washington, at the Shoreham Americana Hotel, on Tuesday, Wednesday and Thursday, November 3-4-5, 1981. Registrations will start Monday Evening, November 2nd. We make one important request: Our Secretary's office will be sending Hotel Reservation Cards to you. Please return the cards promptly, because the Hotel has a cut-off date of three weeks for rooms and also there is another Convention coming in at the same time. I do not know how big the Convention is, however, I think we will be taken care of first because our Round Table has been coming to the Shoreham for a number of years. Thank you (Applause)

MODERATOR PROSSER: Tom Athey is also Chairman of our Entertainment Committee. Tom, please.

Entertainment Committee Report

Tom Athey, Chairman

On behalf of "our members", "our Board of Directors" and "our Officers," I wish to thank our "Hosts" for that "Beautiful Cocktail Party" last night. Needless to tell you "The Hotel Management" did a magnificent job and that all of us, enjoyed all of it (Applause).

Hosts

ATLANTA UTILITY WORKS
BEUMER CONSTRUCTION
SUBSIDIARY OF BEUMER MASCHIENFABRIK KG
C&I/GIRDLER INCORPORATED
COMMONWEALTH LABORATORY INCORPORATED
DAVY McKEE CORP.
FEECO INTERNATIONAL, INC.
FESCO, INC.
HAVER FILLING SYSTEMS, INC.
SUBSIDIARY OF HAYER & BOECKER
J&H EQUIPMENT, INC.
KIERNAN-GREGORY CORP.
PETROCHEMICALS COMPANY, INC.
THE PROCESSER COMPANY, INC.
EDW. RENNENBURG & SONS CO.
ST. REGIS PAPER COMPANY
BAG PACKAGING DIVISION
THE A.J. SACKETT & SONS CO.
STEDMAN MACHINE CO., INC.
UREA TECHNOLOGIES, INC.
WEBSTER INDUSTRIES, INC.
WHEELABATOR-FRYE INC.

MODERATOR PROSSER: Thank you Tom. Keep well. (Applause)

We have Director Walter Sackett Jr. coming to our platform to give us his report covering Public Relations. (Applause)

Public Relations Committee

Walter J. Sackett, Jr., Chairman

Thank you, Paul. We are now getting coverage from 24 different Industry Publications. I will appreciate mention of any that the Membership thinks I might have overlooked. We are spending about $500 of your money in advertising in "Fertilizer Programs" and "Farm Chemicals" Magazines. We are happy with the results. I hope you all saw the nice write-up in Farm Chemicals, on page 86, of the October 1980 issue.

It has been an eventful year. We learned of the passing of some our our good friends: Clyde Stevens, Dudley George and Dale Kieffer. We congratulate Travis Hignett on being The First Recipient of the A.C.S. Fertilizer and Soil Chemistry Division Merit Award. We also welcome "one old friend in Frank Achorn", picking up the Gauntlet from another "old friend — Frank Nielsson" as the Chairman. An award will be presented to Frank Nielsson, at the First Organizational Meeting in March, in as much as he could not be with us at this Meeting. I would also like to congratulate Harold Blenkhorn elected as Vice Chairman of our Round Table. Also Messrs. MacKinnon and Littlejohn as our new Directors. I would also like to say "Thanks to Paul Prosser, Joe Reynolds, Tom Athey, Al Spillman, Wayne King, and the rest of the group, for their support in my position whenever I needed it. (Much Applause)

MODERATOR PROSSER: Well, I think we are about ready to conclude this part of our Business Meeting. There is a note on our Program that asks if there are any questions or inquiries from the Membership. We would be delighted to try to answer any that you may have.

As you know Frank Nielsson, who has been the Chairman of our Round Table for the past two years, is quite a World Traveler and, under the guise of earning a living, is now on one of his "Global Jaunts." He was very distressed that he had to make that arrangement during this Meeting. As I mentioned the other day, as he gets older he is becoming more proficient at letter writing and has directions and instructions all over the place about this Meeting. We are sorry that he is not here but we are sure he is here in "Spirit". In view of the fact that you will not be able to "thank him personally", I offer you the opportunity to put on the "tapes— a round of applause" for "old Frank". (Applause—and lots of it!)

Now, we have one other item. I would like to report on the attendance. I congratulate you again on this fine showing. The total number registered is 376 and that includes nine paid, but no show.

The program will now continue. For the balance of the morning I would like to turn the podium over to Harold Green. Harold is the Goldkist Representative on our Board of Directors. I thank you very much. (Applause)

MODERATOR HAROLD GREEN: Thank you Paul. We will move into our program with continued emphasis on "Energy Conservation." "The Pipe Cross Reactor" continues to be a topic of interest at these "sessions". Papers have been given for the last four or five years. Today we have David G. Salladay who has been with TVA for six years, has authored or co-authored twenty papers, is well qualified, and will now present "Status of NPKS Ammoniation-Granulation Plants And The TVA Pipe Cross Reactor". Lets give David a welcome. (Applause)

Status Of NPKS Ammoniation Granulation Plants And TVA Pipe-Cross Reactor

David G. Salladay - Carl A. Cole, Jr.
Presented by David G. Salladay

The number of ammoniation-granulation plants producing homogeneous NPKS granular fertilizer dropped during the 1970's and there are many options concerning the status and future of this aspect of fertilizer production. During summer 1980 TVA surveyed these plants to document their current status and to confirm or change previous TVA estimates of the number of operating plants and the total annual tonnage produced. Previous TVA lists of NPKS granulation plants were updated by means of letters of inquiry to and telephone conversations with the plant production supervisors. About 90 percent of these company personnel contacted were able to provide their plant production tonnages.

The survey showed that during the last year 107 granulation plants operated by 37 companies produced 8.5 million tons of homogeneous NPKS granular fertilizers. Idle granulation plants for sale are not included in this total. Annual production of individual plants ranged from 18,000 to about 300,000 tons. Most of these plants are what TVA terms "regional" NPKS granulation plants as shown in Figure 1 with 8-ft diameter by 16-ft long ammoniator-granulators, about 60 tons/hour recycle capacities, and about 30 tons/hour production rates. A few of the plants surveyed, however, have larger ammoniator-granulators, about 11-ft diameter x 22-ft long, with production rates of 60 to 75 tons/hour. This total of 8.5 million tons/year is only homogeneous NPKS granular fertilizer. Any normal superphosphate (NSP), concentrated superphosphate (CSP), monoammonium phosphate (MAP), or diammonium phosphate (DAP) produced by these 107 surveyed plants, or other plants at their locations, were excluded. By comparison to this NPKS total, TVA estimates annual production of these other fertilizers to be 9.4 million tons of DAP, 1.5 million tons of MAP, 4.0 million tons of CSP, and 1.5 million tons of NSP[1]. The most popular grades produced are 6-24-24, 10-10-10, 13-13-13, 5-10-15, 10-20-20, 12-12-12, 3-9-18, and 3-9-9. Average annual production at an NPKS granulation plant is 81,000 tons. This average tonnage appears to have been increasing over the past decade, as a smaller number of plants have maintained about the same total annual production. Maximum annual capacity for a "regional" granulation plant having an 8-ft diameter x 16-ft long ammoniator-granulator is about 160,000 tons when routine maintenance and the summer turnaround are considered.

Table 1 show the locations of these plants by states. Twenty-seven states have NPKS ammoniation-granulation plants; 84 percent of these plants are east of the Mississippi River. Table 1 also shows which plants have installed pipe-cross reactors (PCR's). As of September 1980, 23 PCR's had been installed in NPKS granulation plants. Fifteen companies have installed PCR's in one or more of their plants; this is 40 percent of the companies operating NPKS granulation plants. About eight more PCR installations are planned or almost completed. These PCR's have produced millions of tons of product and provided extensive operating experience. The following is a review of the most significant results.

Design and Operation of the Pipe-Cross Reactor

Figures 2 and 3 show current PCR designs and the sleeve insert for the discharge end. Figure 4 shows location of the PCR in an ammoniator-granulator. Many producers are having the entire PCR fabricated of Hastelloy C-276 to ensure almost no corrosion problems during the PCR's life. Without sleeves a PCR has a normal operation range of only 1 to 2 (300,000 to 600,000 Btu/hr-in^2 heat flux). A 6-inch diameter PCR with a 4-inch removable sleeve has an operating range of 1 to 4.5 These sleeves also seem to result in more complete reaction of acids and ammonia. Some producers report lower ammonia losses when this sleeve is used, and the sleeve results in a better spray pattern onto the bed of solids in the granulator. Normal design recommendation for a typical NPKS granulation plant is a 6-inch diameter Hastelloy C-276 PCR with 5-inch and 4-inch inside diameter type 316L stainless steel sleeves for insertion in the discharge. Since nearly all acid has reacted by the time the reactants reach the discharge of the PCR, the stainless steel sleeves show almost no erosion-corrosion after 100,000 tons of production. Figure 5 shows such a sleeve after more than 50,000 tons of production.

Other design details and operating parameters of the PCR have been successful in field operation. For example, if the recommended heat flux range and melt temperature of less than 300°F. are maintained along with adequate phosphoric acid in the raw material feeds to the PCR, the Hastelloy C-276 reaction tube can produce at least 500,000 tons of product. A PCR operated in this manner in one plant produced this amount before being installed for continued use in one of the company's other plants. When reinstalled, this PCR showed no significant erosion-corrosion.

The erosion-corrosion rate of the PCR seems to accelerate as the melt temperature increases above 300°F. the amount of sulfuric acid in the feed increases above 50 percent, and the heat (of reaction) flux increases above 600,000 Btu/hr-in^2.

Resistance of Hastelloy C-276 to acid attack drops sharply above 300°F. and the manfacturer does not recommend the alloy for use above 300°F. Although this alloy is expensive, there may be cost savings by using cheap byproduct raw materials such as sulfuric acid. Replacing the PCR after only 75,000 or 100,000 tons of production may be economically inconsequental when compared to several dollars per ton savings in raw materials cost. A 6-inch diameter x 10-foot long PCR reaction tube replaced after every 100,000 tons of production still costs only 10 or 11 cents per ton of product.

More producers are adding all of the ammonia to the PCR. Although a more angular-shaped product results, ammonia losses are lower. One producer using the sleeve, the 5° incline of the PCR, and all of the ammonia fed to the PCR loses only 1 to 2 percent of the NH_3 fed in production of 8-24-24 grade product.

Reducing Dryer Fossil Fuel Heat and Electrical Requirements

The savings in fossil fuel heat input to dry fertilizer granules vary from one PCR installation to another. Some producers have completely shut off the burners in their dryers. Others have saved only about half of this heat input since the critical relative humidities of fertilizers produced must not be approached in their baghouses. TVA estimates that an average of about 80 percent of fossil fuel heat input to the dryer for conventional granulation has been saved by using PCR's.

Although plant electrical consumption per ton of product usually is about the same for either conventional or PCR melt granulation, in some cases the PCR has dramatically increased the plant's production rate. At one midwestern ammoniation-granulation plant, the PCR increased production of 6-24-24 grade from 25 to 38 tons per hour. If dryer capacity limits production in a conventional granulation plant, then PCR-melt granulation can result in such an increase in production rate. Electrical consumption of these NPKS granulation plants is in the range of 300,000 ±75,000 Btu/ton of product. If this 50 percent increase in production rate is applied to the midwestern plant, production cost would be reduced by about $1.45 per ton (assuming an electrical cost of 5 cents per kWh). Savings for production of 50,000 tons of this 6-24-24 grade would be $72,500.

Production of MAP, 11-53-0-2S, at a Regional NPKS Granulation Plant

Over the past three years a regional NPKS granulation plant has been upgrading its equipment, which includes an 8-ft diameter x 16-ft long ammoniator-granulator with a dam 3 ft from the discharge end. This granulator has a rubber lining and two ammonia sparger-steaming knives extending almost vertically into the bed of solids in the granulator. The plant also contains a 9-ft diameter x 60-ft long dryer with four cyclones and an 8-ft diameter x 54-ft long rotary cooler, also with four cyclones. Recycle capacity of this plant is about 90 tons per hour. Screening and size reduction equipment includes two oversize cagemills, two 4-ft x 15-ft Tyler Hum-Mer screens and a spare fines screen. This plant also has a second rotary cooler for product before it goes to the storage bins. A Hastelloy C-276 PCR which is 6 inches in diameter x 10-ft long has been installed and is designed according to current TVA recommendations. It has a centered sparger for aqua ammonia and a sparger for scrubber liquor located to the side of it on the flange at the feed end. Air flow in the ammoniator-granulator recently has been increased to 11,000 cfm. This exhaust air goes into a Venturi scrubber for ammonia scrubbing. Recycle control by means of a split valve on a product split duct also has been installed.

Raw materials for the granulation plant are supplied by two 30,000 gallon anhydrous ammonia tanks and a heated, sparged, rubber-lined phosphoric acid tank of 1,500 tons capacity. This plant has 21,000 tons of product storage.

During startup of the PCR in this plant, the first grade produced was a 11-53-0-2S produced at 12.5 tons per hour. The 6-inch pipe-cross reactor was equipped with a 4-inch type 316 L stainless steel sleeve in the discharge. This sleeve gave a heat flux of about 380,000 Btu/hr-in^2. The formulation contained 280 lb/ton of anhydrous ammonia, 2,050 lb/ton of 52.5 percent P_2O_5 phosphoric acid, and 78 lb/ton of 66° be. sulfuric acid. This particular startup was the most trouble free and easily executed. Company representatives attending this startup were extremely pleased with the initial production run for the 11-53-0-2S grade. The phosphoric acid feed was split 50/50 between the pipe-cross reactor and the ammoniator-granulator bed; later, when the production rate was increased to 16 tons per hour, a 60/40 phosphoric acid split was used. Plant personnel noted that there was far less airborne dust within the plant during these pipe-cross reactor tests than during conventional MAP production using the preneutralizer.

Use of Byproduct Sulfur Sources in the 16-8-8-XS Grade

An increasingly popular grade easily produced with the PCR process is 16-8-8-XS. Table 2 shows three formulations that have been used in commercial plants. These allow for ample use of byproduct sulfuric acid and ammonium sulfate. Although 16-8-8-XS grade formulations normally contain about 15 percent sulfur, fertilizer producers still hesitate to register sulfur content of this or other grades. A specified percentage of sulfur in a grade is a fourth constraint in the nominal grade, which may interfere with least cost programming with available raw materials. However, TVA expects sufur content of fertilizers to become increasingly important as atmospheric deposits of sulfur compounds onto the land are decreased by air pollution control regulations. Already about 45 percent of sulfur production in the United States is from secondary recovery sources[2]. These secondary sources are oil and gas production facilities, but high-suslfur coal in the eastern United States where most of the NPKS granulation plants are located should begin to contribute to this sulfur tonnage in the near future.

PCR Process Advantages over Conventional Bed Granulation

In past publications[3,4,5] TVA has reported advantages of the PCR process over conventional bed granulation. Table 3 lists advantages experienced by a fertilizer company that has been using a PCR for about three years. Especially significant are the first and last items on this list. Improved quality of the homogeneous granular fertilizer was directly reflected in a ninety percent decrease in customer complaints over the past year. Figure 6 is a photograph of a conventionally produced and a PCR processed 15-15-15 grade product from a company that recently installed a PCR. The larger-sized dust particles entering the baghouse result in almost 1,000 bags lasting longer than they did during conventional granulation. Probably not used as many small particles are abrading the fabric of the bags.

Another advantage often not considered is related to item three. With greater accuracy in formulating with the PCR process, fewer nutrients are given away by exceeding nominal quantities of nutrients in the grade.

Investment Cost and Payback

Installing a TVA pipe-cross reactor in an existing regional NPKS granulation plant is extremely attractive economically. Replacement cost of a typical granulation plant is about $10,000,000, and almnost $100,000 per year will be spent on equipment in a properly maintained plant. Thus, investment to retrofit a PCR into one of these plants is relatively small.

Table 4 entitled "Economics for PCR Installation"[6] shows energy savings, investment costs, and payback times. This typical PCR installation cost about $60,000. At last 1979-early 1980 prices, the PCR itself cost about $10,000. Normally an extra $50,000 is required for pumps, piping, meters, and valves. Since these installations are retrofits, exact equipment needs vary.

Payback time will vary normally be less than one year as shown in Table 4. This payback is calculated on the basis of eliminating steam and reducing fossil fuel drying from the granulation process. A conservative natural gas price of $2.68 per 1,000 cubic feet was used. If increased production rates reduce electrical consumption per ton of product, as discussed previously, or cheap byproduct raw materials can be used with the PCR, payback times of 3 to 4 months are obtained. Under such circumstances, many companies choose to add other needed capital investment to PCR projects. In some cases several hundred thousand dollars can be attached to the PCR installation project before the company's minimum acceptable return on investment is reached. In some cases installation of the PCR has significantly upgraded overall condition of the granulation plant. With an average sized plant producing 30 tons per hour of product, new investment in the PCR can be paid back in about 6 months from savings in fossil fuel drying and steam only. This payback period is very short for the fertilizer industry.

Summary

Of the 107 NPKS ammoniation-granulation plants producing about 8.5 million tons of homogeneous NPKS granular fertilizers, 23 have installed TVA PCR's. Use of byproduct sulfuric acid and ammonium sulfate in high nitrogen grades produced in PCR's is increasing. Annual per plant tonnage is increasing, enabling many of these plants to undertake more extensive maintenance and capital improvement programs. These NPKS granulation plants should continue to be an important part of the fertilizer production system in the United States.

Acknowledgement

TVA greatly appreciates the cooperation of fertilizer industry personnel in providing data for the NPKS ammoniation-granulation plant survey.

REFERENCES

1. *Fertilizer Trends 1979*, (Bulletin Y-150), National Fertilizer Development Center, Tennessee Valley Authority, p. 23 (January 1980).
2. *Chemical Marketing Reporter 217*, (54), pp. 9 and 64, (June 23, 1980).
3. Achorn, Frank P. and David G. Salladay. "Production of Monoammonium Phosphate in a Pipe-Cross Reactor," presented at the Annual Meeting of the Fertilizer Industry Round Table, Washington, DC, November 4-6, 1975.
4. Achorn, Frank P. and David G. Salladay. "Conservation of Energy in Ammoniation-Granulation Plants," presented at the Annual Meeting of the Fertilizer Industry Round Table, Washington, DC, October 25-28, 1977.
5. Salladay, David G. and Edwin D. Myers. "Use of TVA's Pipe-Cross Reactor to Conserve Energy in Fertilizer Granulation Plants," presented at the Fifth National Conference on Energy and the Environment, Cincinnati, Ohio, November 1-3, 1977.
6. Energy Conservation in Ammoniation-Granulation Plants," Centec Corporation, Reston, Virginia, and Fort Lauderdale, Florida, p. 23, (1980).

Table 1

NPKS Ammoniation-Granulation Plants and TVA Pipe-Cross Reactor Installations

State	NPKS Plants	PCR'(s)
Alabama	4	3
California	3	1
Georgia	12	1
Idaho	1	1
Illinois	5	2
Indiana	5	-
Iowa	1	-
Kentucky	4	-
Maine	1	-
Maryland	4	1
Michigan	3	1
Minnesota	1	-
Mississippi	4	-
Missouri	3	1
Nebraska	1	-
New Jersey	3	-
New York	5	-
North Carolina	11	2
Ohio	5	3
Pennsylvania	4	-
South Carolina	4	1
Tennessee	5	1
Texas	5	3
Utah	1	-
Virginia	8	1
Washington	1	-
Wisconsin	3	1
Totals	107	23

Table 2

Formulations for 16-8-8-XS Grade

Production rate, tons/hr.	25	25	15
Raw Materials, lb/ton			
PCR			
Phosphoric acid (54% P_2O_5)	220	150	195
Anhydrous ammonia	28	19	31
Sulfuric acid (72% H_2SO_4)	320	404	976
Anhydrous ammonia	80	101	244
Bed			
Phosphoric acid (54% P_2O_5)	80	150	105
Anhydrous ammonia	17	25	18
Normal superphosphate (18% P_2O_5)	33	33	-
Anhydrous ammonia	2	2	-
Ammonium sulfate (21% N)	1,066	988	400
Potash (60% K_2O)	267	267	267
Mole Ratios (NH_3:H_3PO_4)			
PCR	1.0	1.0	1.23
Bed	1.65	1.29	1.32
Overall	1.16	1.13	1.26
pH	4.8	4.8	5.3
Heat flux - Btu/hr-in^2	531,000	608,000	807,000

Table 3

Advantages of PCR Process over Conventional Bed Granulation

1. The PCR process gives a much more homogeneous chemical blend and uniform appearance thus restoring the traditional superiority of granulated fertilizer over blends which gradually eroded as high analysis materials such as DAP have been substituted in formulations.

2. Large amounts of acids can be used in formulations; this is an advantage when acids are relatively cheap. Use of large volumes of acid is also desirable when tank car demurrage becomes threatening.

3. Metering liquids is simpler, more precise, and allows better fine tuning of the process than is possible when weighing and handling dry materials.

4. A further advantage that follows item No. 3 is that dry material shrinkage is reduced because less dry material is handled.
5. Because there is less dry material handling, labor costs will be decreased and maintenance costs on handling equipment such as elevators and tractors should likewise be reduced.
6. When all anhydrous ammonia enters via the pipe-cross, N losses are significantly less than losses incurred during conventional granulation.
7. There is decreased use of fuel for drying when grades are properly formulated.
8. Chute plugging, caused by tacky ammoniated material (conventional bed formula), has been essentially eliminated because of flash drying of the product in the ammoniator during the PCR process.
9. The final product is harder and, therefore, not as dusty.
10. Increased production rates, in some cases, are possible.
11. Baghouse leakage of sub-micron particles is less than half that occurring during non-PCR operation.

TABLE 4

ECONOMICS FOR PIPE-CROSS REACTOR INSTALLATION

Plant Size Ton/Hr.	Plant Energy Costs $/Yr.		Energy Savings $/Yr.	Total Installed Investment	DCF* RATE OF RETURN (Escalation of Energy)		Payback Time Yrs.
	CONVENTIONAL	PIPE-CROSS REACTOR			0%	10%	
15	197.000	82,000	115,000	55,000	116%	126%	0.9
20	263,000	109,000	154,000	60,000	142%	152%	0.7
30	394,000	164,000	230,000	68,000	187%	197%	0.5
40	526,000	219,000	307,000	75,000	226%	235%	0.4

* DISCOUNTED CASH FLOW

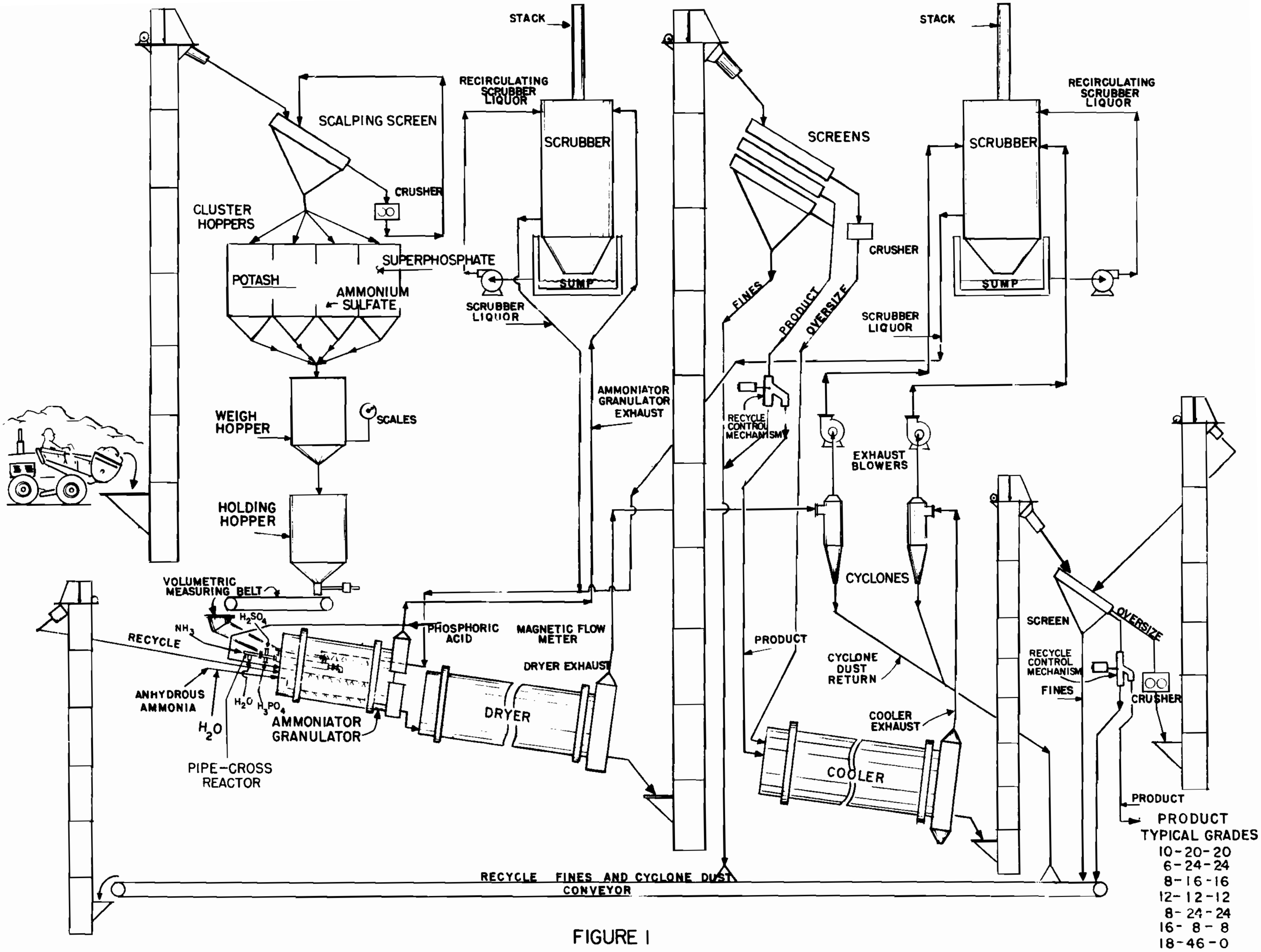
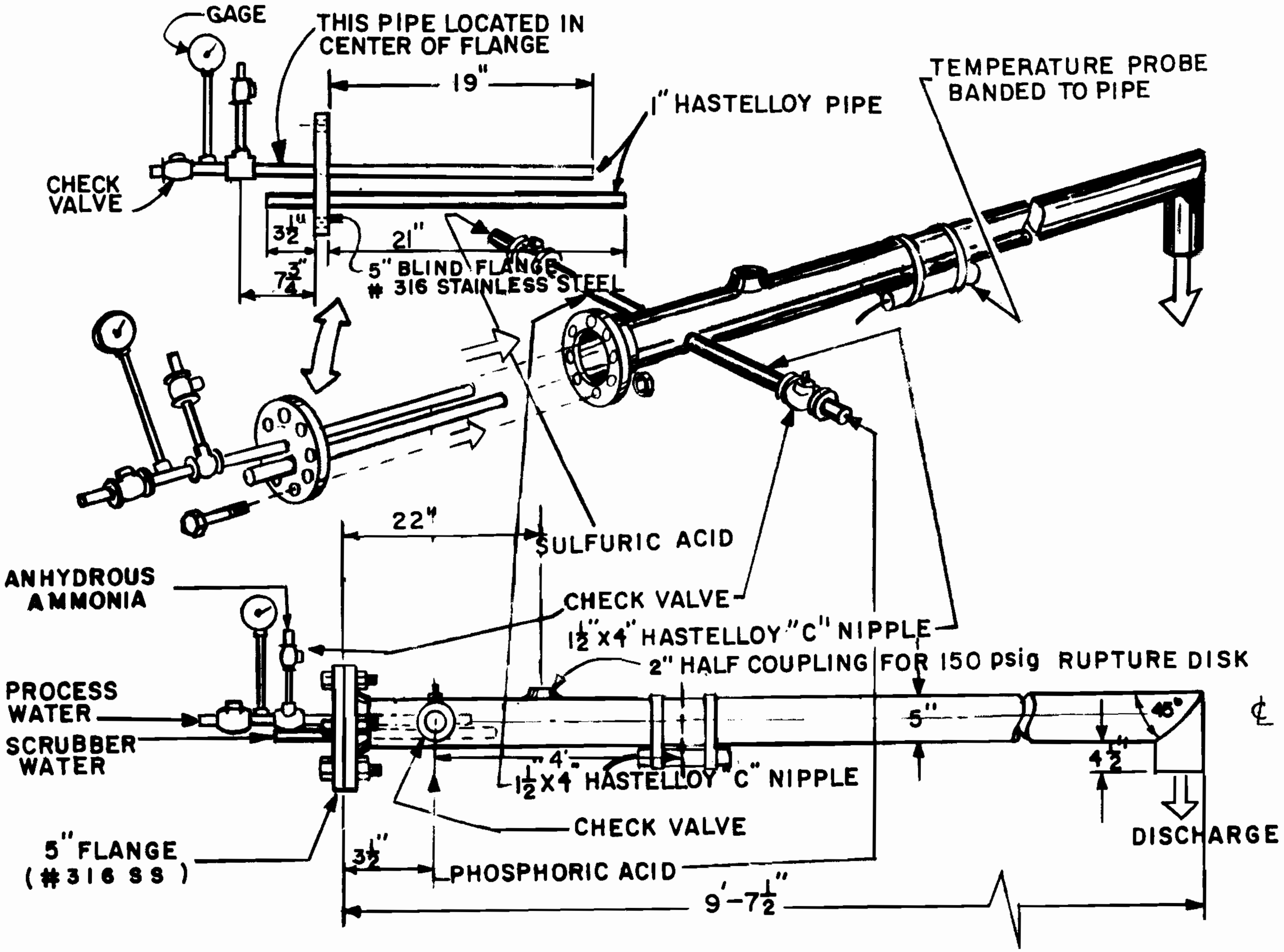


FIGURE I
AMMONIATION-GRANULATION PLANT WITH
PIPE-CROSS REACTOR



NOTE:
ALL HASTELLOY
C-276

FIGURE 2

PIPE-CROSS REACTOR

5 INCH DIAMETER HASTELLOY "C" REACTOR TUBE

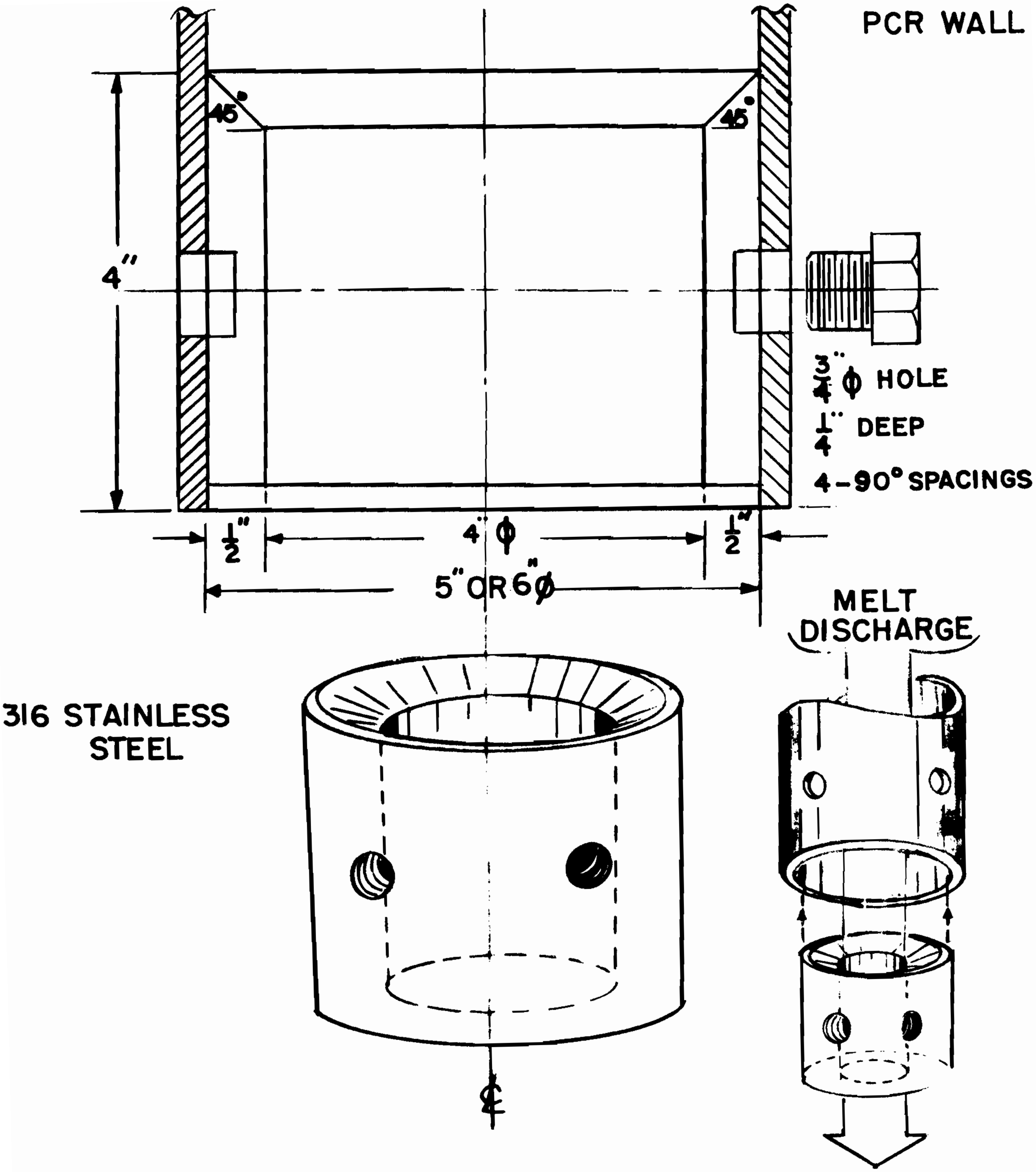
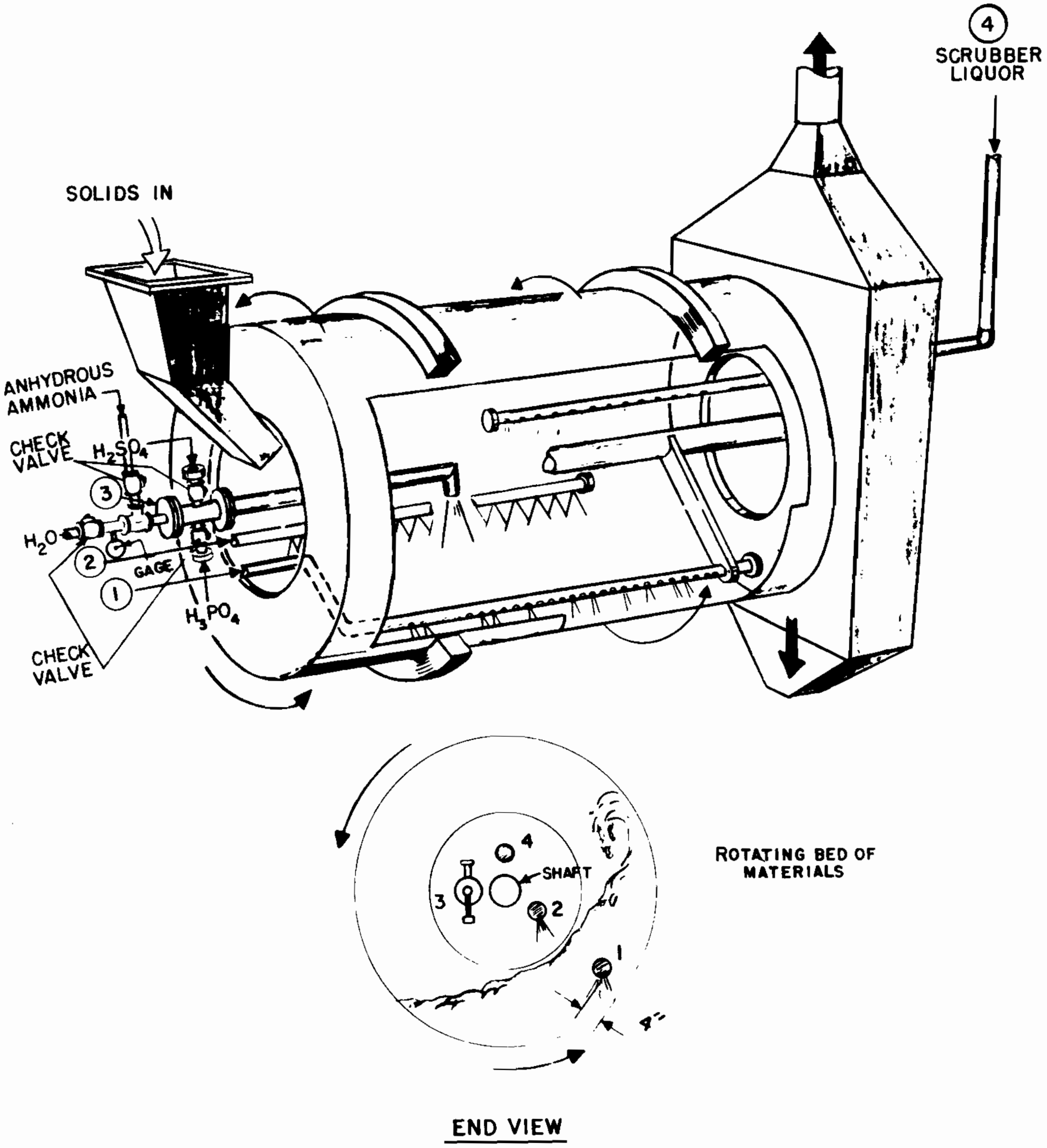


FIGURE 3

DISCHARGE NOZZLE FOR 5" OR 6" PCR.



①	AMMONIA SPARGER	LOCATED AT THE 4 O'CLOCK POSITION $4\frac{1}{2}$" FROM GRANULATION SHELL WITH HOLES FACING THE ROTATING STREAM OF MATERIALS. OVERALL LENGTH-12 FEET. ONE HUNDRED AND FORTY TWO $\frac{1}{16}$" HOLES ON ONE INCH CENTERS WITH SMALL QUANTITY OF WATER ADDED TO PREVENT CAKE AROUND SPARGER.
②	PHOSPHORIC ACID SPARGER	LOCATED TO DISCHARGE PHOSPHORIC ACID ONTO THE TOP AND NEAR THE CENTER OF THE ROTATING BED OF MATERIALS. OVERALL LENGTH-8.9 FEET. SIXTEEN $\frac{3}{8}$ INCH HOLES ON THREE INCH CENTERS.
③	PIPE-CROSS REACTOR	LOCATED TO DISCHARGE NEAR THE LONGITUDINAL CENTER OF THE BED AND AT A POINT ONE THIRD FROM THE BOTTOM EDGE OF THE BED OF MATERIAL IN THE GRANULATOR.
④	SCRUBBER WATER	LOCATED ABOVE THE BED IN GRANULATOR TO DRIBBLE SCRUBBER WATER ONTO BED.

FIGURE 4

LOCATION OF PIPE CROSS REACTOR IN ROTARY AMMONIATOR—GRANULATOR

Figure 5.

Stainless steel sleeve removed from pipe—cross reactor after 50,000 tons of production

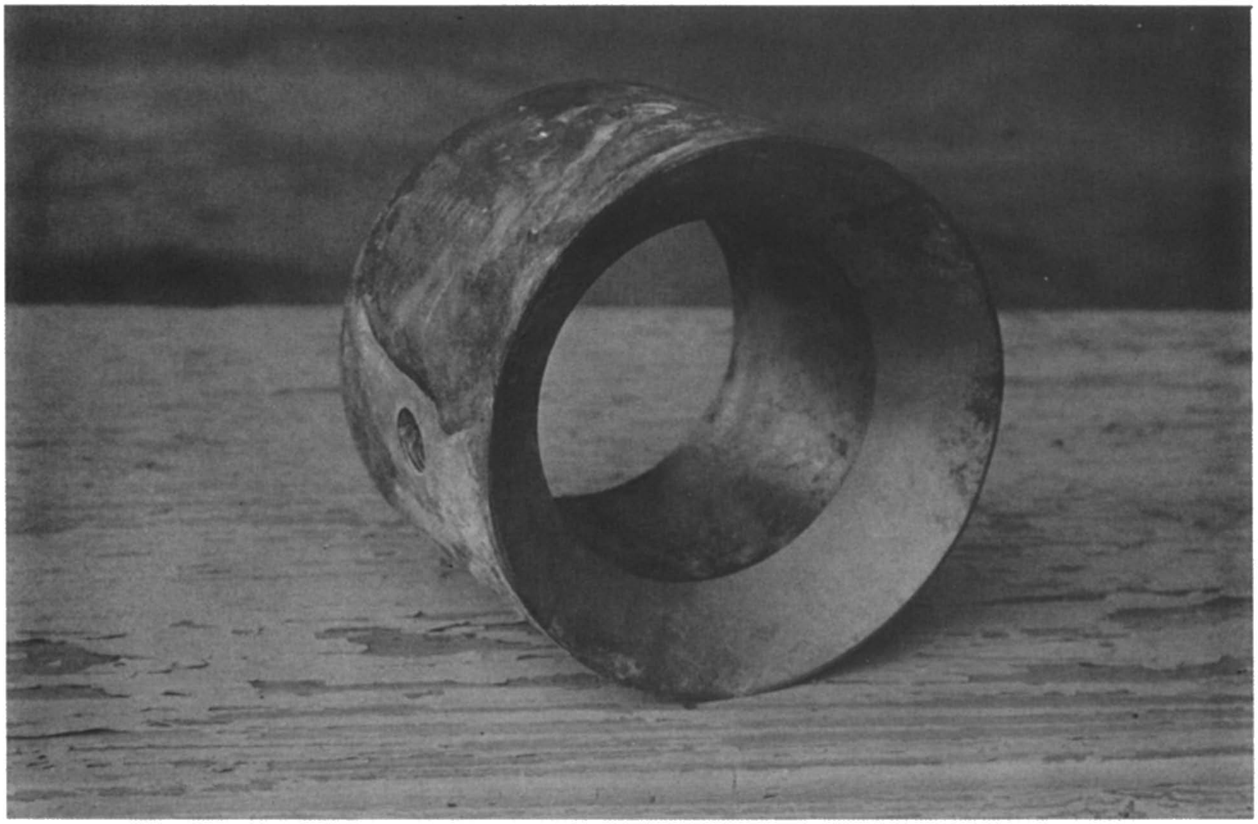
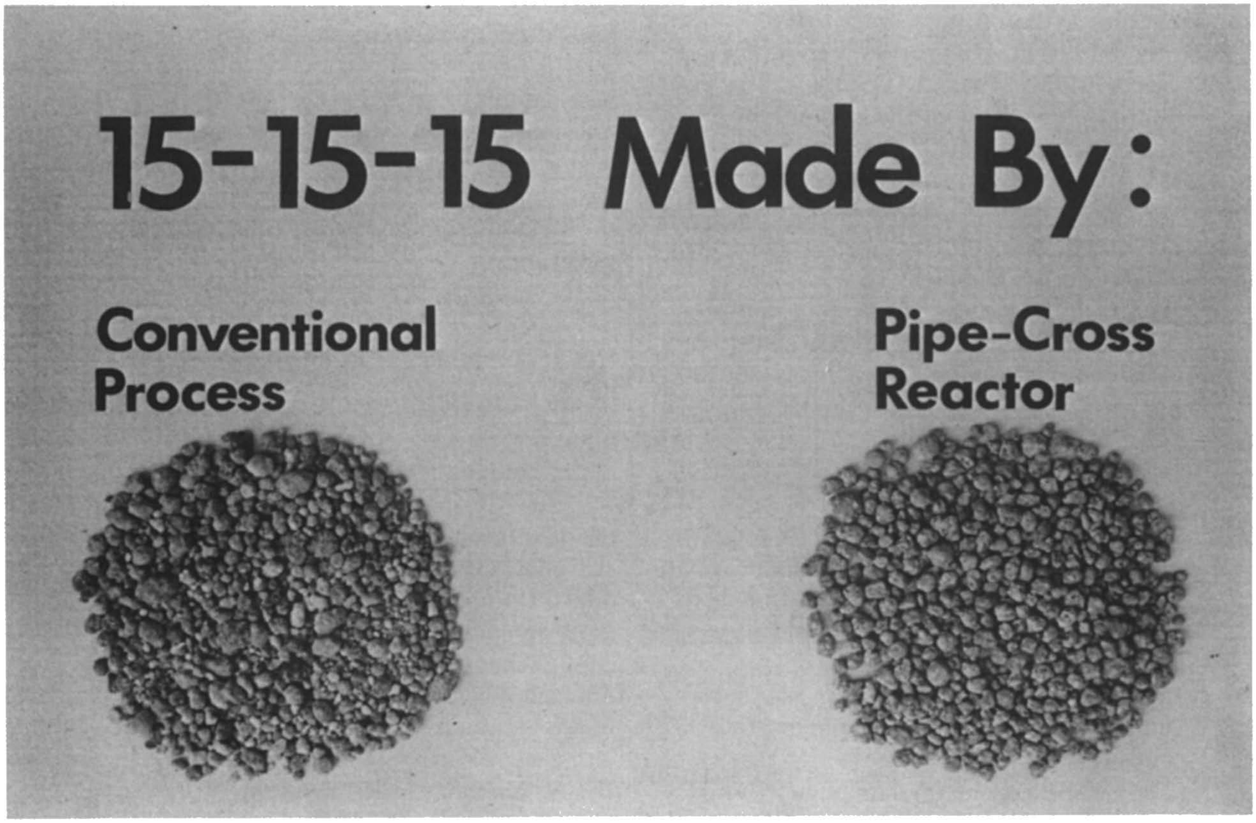


Figure 6.



MODERATOR GREEN: We will at this time entertain questions from the Audience. You did a good job David. Thank you. (Applause)

Next on your program we have a discussion on New Suspension Products and Processes Under Development by TVA. J.A. Wilbanks will present the Paper. Amos Wilbanks has been with Chemical Development, TVA for 33 years. He pioneered the development of "Fluid Fertilizers in the U.S." Amos, please. (Applause)

New Suspension Products And Processes Under Development By TVA

J. A. Wilbanks — L. C. Faulkner

Presented by J. A. Wilbanks

Introduction

A suspension fertilizer is a saturated solution in which small crystals of plant nutrients are suspended. Usually, attapulgite clay, which is mined in southern Georgia or northern Florida, is used as the suspending agent. Sepiolite and sodium bentonite clays, which are mined in the West, also have been used successfully as suspending agents. (Note Figure 1) During the past decade, extraordinary growth has occurred in the production and use of suspension mixtures. In 1969, only about 15% of the fluid fertilizers produced in the United States were suspensions. Recent USDA statistics, however, show that about 40% of the 4.4 million tons of fluid fertilizers produced in the United States in 1979 were suspensions. Some advantages of suspensions are as follows:

1. They can be produced from economical sources of plant nutrients.
2. They can be produced in easily operated plants of low-investment cost, usually with a minimum amount of labor per ton of product.
3. They can have high-analysis plant nutrient contents—almost double those of solution mixtures.
4. They are easy to transport and handle.
5. They can be uniformly broadcast with essentially none of the segregation problems that occur with bulk blends.
6. They are excellent carriers of micronutrients and allow small requirements of micronutrients to be uniformly applied.
7. They are excellent carriers of pesticides.

The original reason for making suspensions was to obtain higher analysis fluid fertilizers, especially those of high potash content. Later, suspensions were made both to obtain higher analysis fluid fertilizers and to allow use of wet-process orthophosphoric acid that contained impurities. Some plant nutrient concentrations of comparable solution and suspension grade ratios are presented in the following tabulation:

Ratio	Solution grade	Suspension grade
1:3:3	3-9-9	6-18-18
1:2:2	5-10-10	9-18-18
1:1:1	7-7-7	14-14-14
2:1:1	14-7-7	20-10-10
1:3:1	7-21-7	9-27-9

The average plant nutrient concentration of these solution grades is 26%; the average of these suspension grades is 43%.

Use of Solids in Production of Suspensions

In 1974, fertilizer dealers experienced an extreme shortage of nitrogen and phosphate base fluids for use in preparation of fluid fertilizers. Therefore, TVA conducted field and laboratory studies to find means of using then available sources of solid nitrogen and P_2O_5 in the preparation of fluid mixtures. In the TVA 10th Demonstration of Fertilizer Technology in October 1974, TVA exhibited procedures for use of various solid materials, such as granular ammonium phosphates, urea, and ammonium sulfate, in the preparation of suspension fertilizers[2]. Use of solid materials instead of base solutions offers some advantages in that solid materials usually have a lower delivered cost to the dealer and they are easier to store. Since 1974, use of solid materials in the preparation of suspension mixtures has become more and more popular in the fertilizer industry.

Use of Ammonium Phosphates

A sketch showing a relatively simple design of a plant for making suspension fertilizers from granular ammonium phosphates is shown in Figure 1. This design is similar to that used for preneutralizers in plants for production of diammonium phosphate (DAP). Two spargers are suspended in the mix tank, and ammonia is added through these spargers into the turbulent zone of fluid created by a conventional turbine agitator. The equipment, including the agitator, is simple in design and can be fabricated at local shops. Several companies make various types of lock-and-key plants that feature either high-intensity agitators or fluid grinders. Most of these plants work well in converting granular phosphates to suspensions. Figure 2 shows five types of mix tanks used in such plants.

In converting monoammonium phosphate (MAP) to suspensions, two important chemical factors must be considered:

1. Solubility of MAP in the fluid must be increased by adding ammonia. The resultant chemical heat of reaction and increased solubility cause the MAP granules to disintegrate if there is good circulation of the material through the pump and back to the mix tank.
2. Enough ammonia should be added to the fluid so that the major crystalline phase is small DAP crystals; these usually cause fewer problems with clogging of nozzles of application equipment than do MAP crystals.

The maximum solubility at 32°F. of a saturated ammonium phosphate solution (110 lb salt/100 lb H_2O) occurs when MAP is ammoniated to an $N:P_2O_5$ weight ratio of about 0.30. This, along with the further increase in solubility due to heating, causes the granules of MAP to disintegrate. In preparation of suspension fertilizers from MAP, however, ammoniation should be continued beyond the point of maximum solubility to an $N:P_2O_5$ weight ratio of about 0.333. At this $N:PP_2O_5$ weight ratio, most of the crystals present are tablet-shaped DAP crystals (Figure 3) which cause less difficulty with plugging of nozzles of application equipment than do the rod-shaped MAP crystals that are present at lower $N:P_2O_5$ weight ratios.

The major finished phosphate fertilizer product sold in the world today is granular DAP. Therefore, DAP is a readily available source of P_2O_5 for suspensions; however, the solubility of DAP is relatively low (about 35 lb salt/100 lb H_2O at $N:P_2O_5$ weight ratio of 0.40). To increase this solubility in preparation of suspension, some phosphoric acid usually is added to adjust the $N:P_2O_5$ weight ratio to 0.333. In most instances, excess phosphoric acid is added along with the appropriate amount of aqua or anhydrous ammonia to supply extra chemical heat to essentially dissolve granules of DAP.

Most suspensions produced from MAP and DAP have unpredictable and, in most instances, poor prolonged storage characteristics. During prolonged storage, thick gels form in some mixtures and this makes them very difficult to remove from storage tanks or to apply. Such mixtures also solidify in extremely cold weather. Therefore, suspension mixtures made from MAP or DAP should be applied soon after they are made. Small-scale tests, however, have shown that the presence of a small amount of polyphosphate (15% of the total P_2O_5) in ammonium phosphate-based suspensions improves their storage characteristics. Also, preliminary results of field storage tests indicate that mixtures produced from a TVA experimental fertilizer product, granular ammonium polyphosphate (APP), have good storage characteristics over prolonged periods. This granular APP contains 10 to 20% of its P_2O_5 as polyphosphate.

Use of Solid Urea

During periods of extreme shortages of urea-ammonium nitrate (UAN) solution, some producers have substituted solid urea (46%N) for the nitrogen solution[3]. Urea is produced in large quantities in the United States, and it is an excellent material for use in production of both clear liquids and suspensions. Companies that produce urea and UAN solution report that they have less difficulty in complying with environmental regulations in production of urea than they do in production of UAN solution. Most new plants will be producing urea in preference to ammonium nitrate and UAN.

Several companies have used prilled urea to produce suspensions. Microprills are small enough in size to be suspended in the mixture. These microprills are also small enough to pass through the flooding nozzles of application equipment. The standard size urea prills and granular urea are too large to be suspended in the mixture; therefore, a mixing procedure is used whereby the urea is dissolved in the water of the mixture prior to the addition of other materials. The following tabulation is a typical suspension formulation for an 11-11-11 grade in which standard size prills are used:

Material	Lb/ton of product
Water	623
Urea (46% N)	336
Clay	40
10-34-0	647
Potash (62% K_2O)	354

The materials are added to the mix tank in the same sequence as listed in the tabulation. With this formulation there is sufficient water to dissolve the urea. After all of the urea has been added, sufficient mixing time should be allowed to dissolve the urea; use of warmer water reduces this time. If microprills were used, the concentration of the grade could be increased to 15-15-15, and some microprills would remain undissolved but in suspension.

Use of Ammonium Sulfate

Several companies have used ammonium sulfate and 10-34-0 or 11-37-0 to produce grades, such as 10-24-0-4S, with a salting-out temperature of less than 32°F. The solubility of ammonium sulfate in NPK mixtures containing sulfur is very low; therefore, operators who need to supply sulfur from low-cost ammonium sulfate in amounts that exceed the solubility level have resorted to the production of suspensions rather than

	Pounds/ton of product			
Material	10-24-0-4S	14-7-7-13.5S	12-12-12-9.3S	12-6-6-11.5S
Ammonium sulfate	334	1125	775	959
10-34-0	1412	412	706	353
UAN (32% N)	——	9	19	13
Potash	——	226	388	194
Clay	——	20	20	20
Water	254	208	92	461

clear liquids. Suspensions, such as a 14-7-7-13.5S, 12-12-12-9.3S, and a 12-6-6-11.5S, have been produced using polyphosphate base solutions, such as 10-34-0 or 11-37-0. In the production of all of these mixtures, all the supplemental nitrogen is supplied by ammonium sulfate, and little or no UAN solution is required in the formulation. Typical suspension formulations that use ammonium sulfate to supply supplemental nitrogen are listed in the following tabulation.

Suspensions Currently Being Demonstrated by TVA

In keeping pace with the increased demand for suspension fertilizers, TVA has several of these products in various stages of development. The three suspension fertilizers that are now being produced in TVA demonstration-scale plants are as follows:

1. Ammonium orthophosphate suspension (13-38-0, 1.5% clay).
2. Nitrogen fluid clay (9-0-0, 25% clay).
3. Urea-ammonium nitrate suspension (31-0-0, 1.5% clay).

Ammonium Orthophosphate Suspension

TVA has a demonstration-scale plant in operation for the production of a good quality 13-38-0 grade ammonium orthophosphate base suspension by a three-stage ammoniation process. The source of phosphate for this process is merchant-grade (52-54% P_2O_5) wet-process orthophosphoric acid. Figure 4 is a flow diagram of the process. The first stage is a boiling reactor that is usually operated at a temperature of about 230°F. and at a pH of about 5.4, which gives an $N:P_2O_5$ weight ratio of 0.23. Under these conditions, magnesium, iron, and aluminum impurities are usually precipitated in a form that will avoid formation of gels during storage of the suspension. The second stage is operated at a temperature of about 200° to 210°F. and at a pH of about 6.5. This results in an $N:P_2O_5$ weight ratio in the range of 0.30 to 0.33. Fluid from the second stage is cooled rapidly in an evaporative cooler. This rapid cooling results in formation of small crystals in the suspension. In the third ammoniation stage, additional ammonia is added to raise the pH to between 7.1 and 7.5 and to convert essentially all of the MAP to DAP. The resulting 13-38-0 grade product then is cooled in this stage to about 140°F. by means of water flowing through a helical cooling coil. Gelling clay is added to the material in a clay-mix tank which is equipped with an agitator and a circulation pump. The final suspension product is cooled further in the clay-mix tank to about 120°F. by means of water flowing through a helical cooling coil. One company in the Midwest uses the process to produce a 12-35-0 grade. Two other firms are seriously investigating use of this process.

One production test was made in this demonstration-scale plant to test the use of a commercial wet-process phosphoric acid that contained only about 40% P_2O_5 as feed acid to produce a nominal 13-38-0 suspension fertilizer. Even though there were some initial mechanical difficulties with the plant, no unusual difficulties were encountered with respect to the strength or quality of the acid. Storage tests of the products indicated that their quality was typical of suspensions made routinely with acid containing 54% P_2O_5. The viscosity of one of the product samples that was near the desired grade was slightly higher than the desired viscosity; however, this could be corrected easily in routine operation by decreasing the amount of clay in the product. Also, the use of dilute acid should not present a problem with the water balance in the plant; the addition of about 3 gallons of water per minute was needed in the first-stage reactor to maintain product grade at a production rate of 15 tons per hour. This is an important factor because some flexibility in the permissible water addition is needed to allow additions of surplus wash water to the first-stage reactor to avoid loss of plant nutrients from the process.

Fluid Clay

The suspending agent most frequently used in the production of suspension fertilizers is an attapulgite-type clay that is normally received dry in bulk or bags. The use of dry clay in suspension fertilizers can be an arduous and dusty operation. Also, about 5 minutes or more is required to mix the dry clay with water to ensure gelling of the clay. Because of these disadvantages of using dry clay, more suspension producers are showing interest in using predispersed fluid clay[4].

Fluid clay usually is made either with water or urea solution containing a dispersing agent and about 25% clay. Without a dispersing agent, about 10% clay is the maximum amount that can be incorporated in water if the material is to have good handling characteristics. Fluid clay is being produced by both batch and continuous processes. TVA uses a continuous process to produce a nitrogen-fluid clay slurry containing 9% nitrogen from urea and 25% clay. About 11 pounds of tetrasodium pyrophosphate (TSPP) is used per ton of product as a dispersing agent. Other dispersing agents could be used; however, TSPP is readily available at a comparatively reasonable price.

Figure 5 is a flow diagram of TVA's 10-ton-per-hour demonstration-scale plant for making nitrogen fluid clay (9-0-0, 25% clay). In this plant, 20% TSPP solution, 75% urea solution, and water are metered continuously into a mixing funnel which discharges simultaneously with preweighed dry clay into a dispersing tank. The retention time in this tank is about 1.7 minutes. The clay is well mixed with the solutions by means of a small propeller-type agitator having a tip speed of 35 feet per second. The clay slurry overflows from the dispersing tank through a trough which discharges at the bottom of the mix tank near the suction side of a centrifugal pump where it is recycled through the mix tank. The pump is rated at 350 gallons per minute and has an impeller tip speed of about 50 feet per second. Additional mixing and shear are provided in the mix tank by a turbine-type agitator having a tip speed of about 92 feet per second. The mix tank provides a retention time of about 8.5 minutes. From the mix tank, the product is pumped to storage.

When fluid clay is produced, the entire mix system must be clean and free of fertilizer salts, such as ammonium nitrate, potassium chloride, and ammonium phosphates from mixed grades. As little as 0.3% UAN by weight mixed with fluid clay slurry will gel much of the clay into soft but solid, lumps that will plug pipes and pumps.

Advantages of fluid clay are (1) it is not dusty; (2) it is easy to pump and handle; (3) it stores well in cold weather; and (4) its use, for many suspension grades, requires less clay per ton of product than that needed when using dry clay to produce satisfactory suspension products. Although fluid clay is thixotropic, the gel is easily broken by agitation. Fluid clay, however, has several disadvantages. As a 25% clay concentrate, it is gelled almost instantly by slight contamination with any electrolytic fertilizer salts; therefore, clean and separate storage tanks, as well as lines and pumps, are required to prevent contamination. The viscosity of the material increases significantly during storage for extended periods in hot weather. If water is used to make the clay slurry instead of urea solution, the nitrogen-free slurry will freeze at 32°F. and can rupture storage tanks or lines.

Urea-Ammonium Nitrate Suspension Fertilizer

With slight modifications, the TVA demonstration-scale plant for producing nitrogen-fluid clay (Figure 5) can be used to produce UAN suspension (31-0-0, 1.5% clay). These changes include addition of a second centrifugal pump with an impeller having a high tip speed (about 75 ft/s) for gelling the clay and adding a UAN solution feedline. The UAN and dispersed clay slurry mix in a short pipe which discharges directly into the gelling tank near the suction side of the second pump. A flow diagram of the TVA demonstration-scale plant for production of about 30 tons per hour of 31-0-0, 1.5% clay, UAN suspension is shown in Figure 6.

One of the main uses of UAN suspension will be as a source of supplemental nitrogen and supplemental clay at plants producing high-nitrogen suspensions from base grades. In making such grades with the usual nitrogen solutions, additional clay frequently must be included in the formulations. Usually the formulations call for insufficient water in which to gel dry clay or to allow use of fluid clay, and attempts are made to gel dry clay in UAN solutions. Experience demonstrates that this is very difficult without violent and prolonged agitation. As a result, solids in products made in this manner settle during transportation of the suspension to the field. Another expected use of UAN suspension is in the production of low- or no-phosphate grades and nitrogen-limestone mixtures.

Suspensions Currently in the Experimental Stage at TVA

Experimental test work on the following suspension products is now being carried out in the pilot plants at TVA:

1. Ammonium polyphosphate suspension fertilizer (9-32-0, 2½% clay) made with merchant-grade wet-process orthophosphoric acid.
2. Ammonium orthophosphate base suspension (11-39-0, 1% clay) made by a two-stage ammoniation process with fluosilicic acid added as a crystal modifier.
3. Urea-ammonium sulfate suspension (29-0-0-5S, 2% clay) made with urea solution and sulfuric acid.
4. Suspension fertilizer (17-22-0, 1% clay) made with byproduct urea phosphate mother liquor.

Ammonium Polyphosphate Suspensions

Base suspensions containing polyphosphate have an advantage over those that contain their P_2O_5 in only orthophosphate form in that they can be stored satisfatorily at much lower temperatures. In the TVA 12th Demonstration of Fertilizer Technology in 1978[4], an exhibit was shown of a process, then under study, that involved two-stage ammoniation of ortho-phosphoric acid (in a preneutralizer followed by a pipe reactor) to produce an APP fluid that then was cooled and combined with clay to yield a suspension. Subsequent studies, however, have shown that a preneutralizer stage is not necessary and the phosphoric acid now is ammoniated only in a pipe reactor. Only phosphoric acid from Florida rock has been tested thus far with this process.

A flowsheet of the current process is shown in Figure 7. The process involves, first, the preheating of acid and vaporizing of liquid ammonia, both by use of process heat. The heated acid is ammoniated in a pipe reactor to produce a melt which is dissolved in water in a dissolution tank to form an APP fluid; free ammonia in the pipe reactor discharge reacts with the fluid in the dissolution tank to give a liquid with a pH of 6. This liquid then is cooled in an evaporative-type cooler, and clay is incorporated to yield the base suspension. An important feature of the process is that no external heat is required. The process is designed to obtain maximum utilization of the heat generated by ammoniation. The pilot-plant product has a nominal grade of 9-32-0, 2½% clay, and contains about 25% of the P_2O_5 as polyphosphate. The product has good physical properties. At temperatures as low as minus 5° to minus 15°F., viscosities are low and the suspension is pourable. In the current studies, the suspension grade is maintained at the relatively low level of 9-32-0 to avoid the presence of crystals in the evaporative cooler. The absence of crystals should allow use of cooling equipment, such as a packed tower, that is generally available at small liquid fertilizer plants, and thus should minimize investment costs for installation of the process at those plants. A small amount of crystals may form subsequently in low-temperature storage (32°F.); however, these crystals have been found to be relatively small (20 mesh) in size and should cause no difficulties. The $N{:}P_2O_5$ weight ratio of the suspension is closely controlled to ensure a relatively low crystallization temperature.

The 9-32-0, 2½% clay, base suspension can be applied directly to the soil or can be used in preparation of mixed suspension products of various ratios by simply blending it with nitrogen base suspension (31-0-0, 1.5% clay) and potassium chloride (62% K_2O; 98% -28 mesh). Typical satisfactory grades made in the laboratory have included 14-14-14, 18-18-0, 10-10-20, 5-15-30, 18-9-9, and 21-7-7. In tests of the preparation of these grades, no clay other than that in the 9-32-0 and 31-0-0 was required. TVA has plans for a second phase of the study in which the concentration of the APP suspension will be increased to the highest possible level. For this phase of the study, the suspension will contain crystals as produced; therefore, it is anticipated that a type of cooler that can cool a fluid containing crystals will be required. This type of cooler generally is not available at small fertilizer plants. A packed-tower evaporative cooler is generally used in these plants.

11-39-0 Ammonium Orthophosphate Suspension

Production of 11-39-0, 1.5% clay, ammonium orthophosphate base suspension fertilizer by a process with two stages of ammoniation was started by TVA in 1974. A flowsheet of this process is shown in Figure 8. The static storage properties of the suspension produced by this process were satisfactory. However, vibration during rail shipment caused settling of rodlike crystals of MAP in the suspension. Removal of the crystals from the returned tank cars for reprocessing was expensive and caused considerable difficulty. This crystal settling problem was overcome by development of the previously described three-stage ammoniation process (Figure 4) for production of a 13-38-0 grade suspension containing 1.5% clay.

Recently, a new procedure has been developed that requires only two stages of ammoniation, and yet results in production of a satisfactory 11-39-0 suspension containing 1.0% clay. A flowsheet of this process is shown in Figure 9. The technique used in this new process involves the addition of about 0.4% by weight of fluosilicic acid (H_2SiF_6) to the suspension as a crystal modifier. Numerous tests in bench-scale work have shown that the most effective point for adding the fluosilicic acid is after ammoniation and cooling. Addition of the acid before this point in the process has been ineffective.

The fluosilicic acid acts as a crystal modifier and causes the MAP crystals, which grow as the product cools, to develop as thin needles instead of the usual thick rods. The thin needle-shaped crystals are much more resistant to vibrational settling in the product suspension than are the rod-shaped crystals. The microscopic appearance of the modified MAP crystals is shown in Figure 10 along with other larger crystals.

Advantages of the new two-stage ammoniation process using fluosilicic acid, compared with the previously described three-stage ammoniation process, include (1) it eliminates one ammoniation stage and the attendant required cooling, and (2) it gives a lower $N{:}P_2O_5$ ratio in the product. A disadvantage of the two stage process is the necessity of obtaining and handling fluosilicic acid.

The viscosity of the 11-39-0 suspension after storage at 32°F. has been in the 2000- to 3000-centipoise range and is somewhat higher than the maximum desirable viscosity of 1500 centipoises. However, the product handles very well even at the higher viscosities.

Essentially no difficulties have been encountered in making a satisfactory product in batch-type tests using bench-style equipment. However, some difficulties have been encountered in making a good product by a continuous process in the pilot plant. These problems have included both high viscosity and excessive vibrational settling of the product. TVA plans to continue development work on this process in an effort to overcome these problems. This process was demonstrated on a pilot-plant scale during the TVA 13th Demonstration of Fertilizer Technology in October 1980[5].

Urea-Ammonium Sulfate Suspension

Farm soils in some areas of the country have become deficient in sulfur and could benefit from application of fertilizers containing this nutrient. TVA is interested in developing methods for production of both solid and fluid fertilizers that contain sulfur. One such fluid fertilizer now under development is urea-ammonium sulfate suspension (29-0-0-5S, 2% clay). During 1980, bench-scale studies of the production of this suspension resulted in an improved process being developed. The improved process (Figure 11) uses two stages of controlled cooling to overcome problems encountered with scaling of heat-exchanger cooling surfaces and plugging of the evaporative cooler when the process was carried out with single-stage cooling. Modifications for two-stage cooling were made in the pilot plant, and initial tests show no difficulty with scaling of heat-exchange surfaces. The improved process also was demonstrated on a pilot-plant scale during the TVA 13th Demonstration of Fertilizer Technology in October 1980[5].

Suspensions from Byproduct Urea

Phosphate Mother Liquor

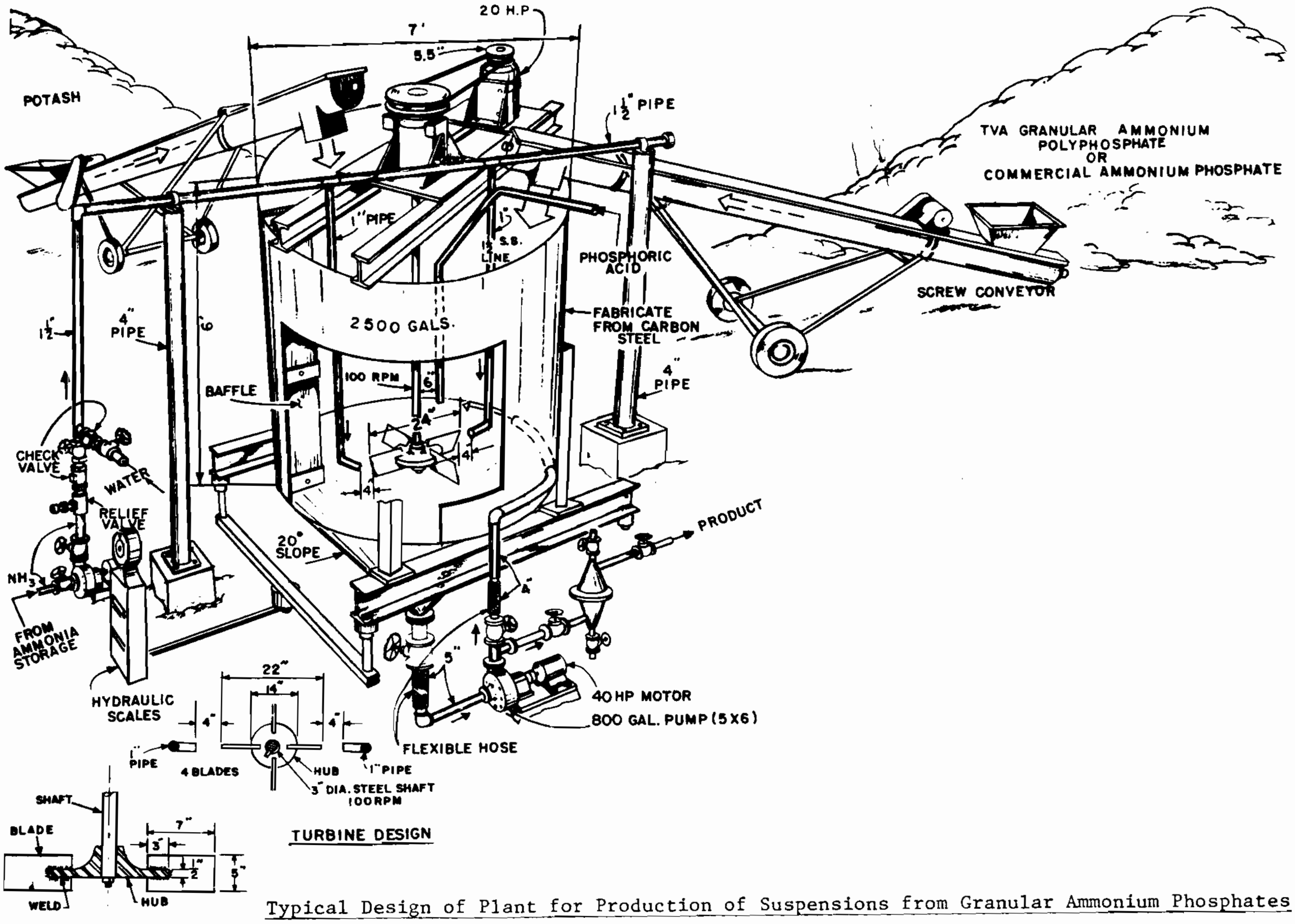
In one of TVA's pilot plants, urea-ammonium polyphosphate liquid fertilizer (15-28-0) is produced from urea, ammonia, and merchant-grade (54% P_2O_5) wet-process phosphoric acid. In this process, a byproduct mother liquor of about 8-24-0 or 9-33-0 grade is produced. The mother liquor contains about 20% of the P_2O_5 and most of the impurities originally contained in the wet-process acid. Byproduct mother liquor can be ammoniated to produce suspension fertilizer grades, such as 13-20-0, 15-23-0, or 17-22-0. A flowsheet of a parocess for making 17-22-0, 1% clay, from ammonia, mother liquor (8-24-0), and fluid clay (9-0-0, 25% clay) is shown in Figure 12.

Future of Suspensions

According to 1979 USDA data, there was about 4.4 million tons of fluid mixtures produced in 1979. Suspensions accounted for about 40% of the total fluid mixtures. The growth of suspensions should continue because of their many advantages. They can be produced from low-cost raw materials in simple plants with minimum labor. Suspensions are probably the best mixed fertilizers for use as carriers of micronutrients and pesticides. They are well suited for use in making NPK mixtures. Also, it is believed that the introduction of new suspension materials by TVA, such as high nitrogen suspension (31-0-0, 1.5% clay) and fluid clay (9-0-0, 25% clay), will further simplify production of suspension mixtures.

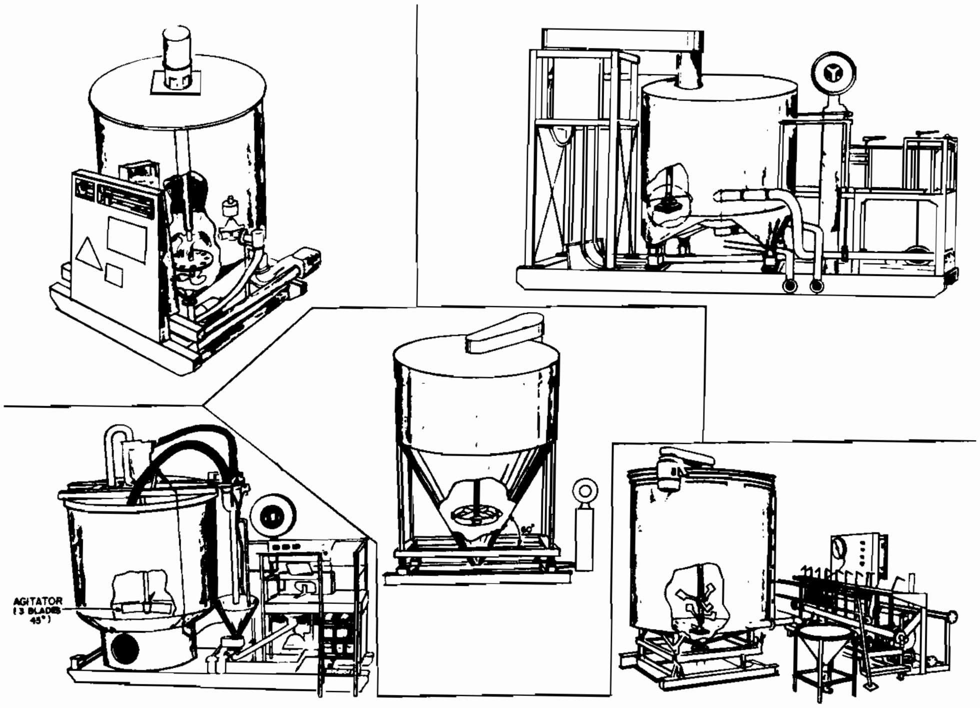
REFERENCES

1. Achorn, Frank P. "Suspension Fertilizers — Update 1980." Presented at Iowa Fertilizer and Chemical Association Gateway Center, Ames, Iowa, January 29, 1980.
2. "New Developments in Fertilizer Technology," Tennessee Valley Authority Bulletin Y-81 (10th Demonstration, October 1974, Muscle Shoals, Alabama).
3. Lewis, Josiah S., Jr. "Alternate Sources of Materials for Fluid Fertilizer Industry." Presented at NFSA Roundup, St. Louis, Missouri, July 24-25, 1974.
4. "New Developments in Fertilizer Technology," Tennessee Valley Authority Bulletin Y-136 (12th Demonstration, October 1978, Muscle Shoals, Alabama(.
5. "New Developments in Fertilizer Technology," Tennessee Valley Authority Bulletin Y-158 (13th Demonstration, October 1980, Muscle Shoals, Alabama).



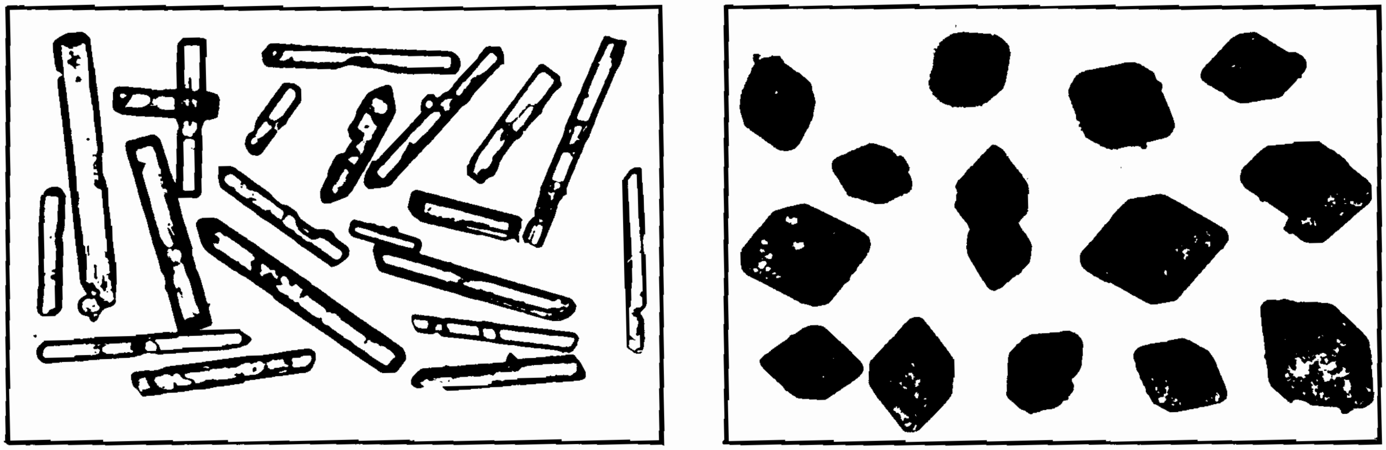
Typical Design of Plant for Production of Suspensions from Granular Ammonium Phosphates

Figure 1



Five Types of Mix Tanks for Production of Suspensions

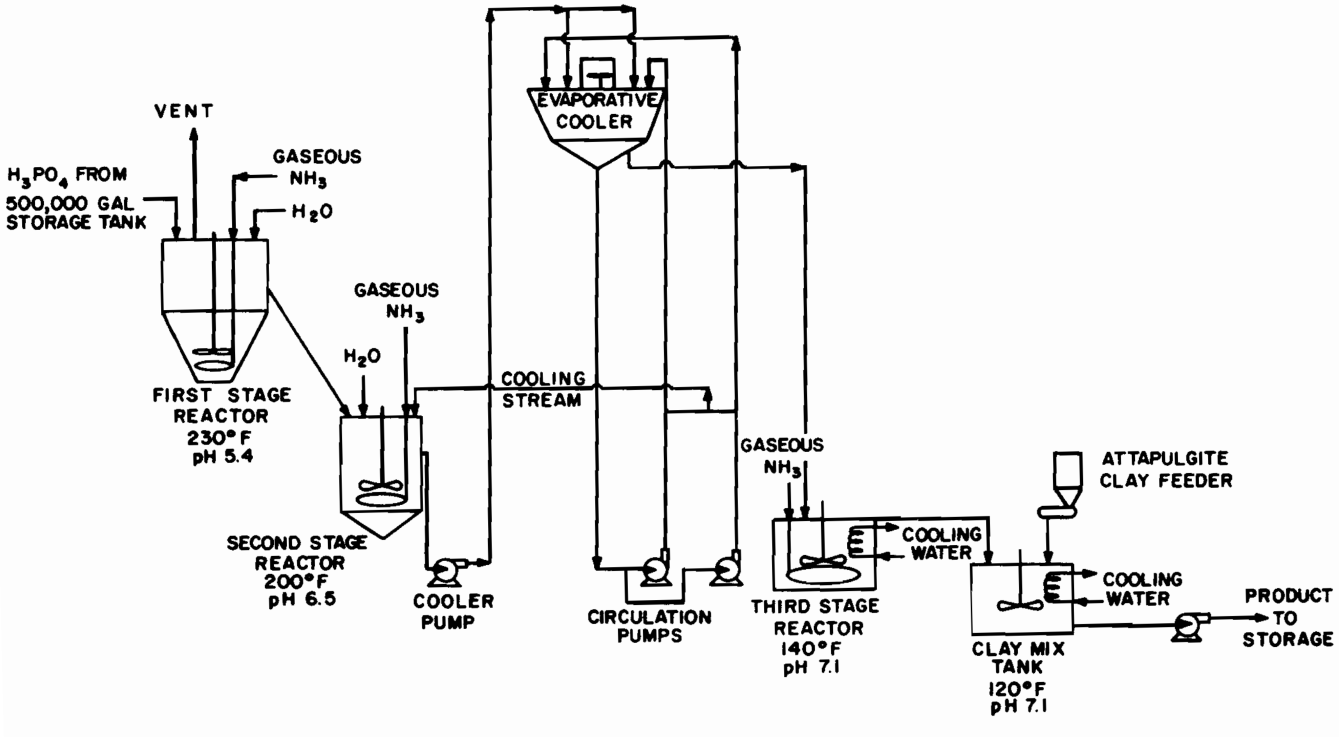
Figure 2



MONOAMMONIUM PHOSPHATE **DIAMMONIUM PHOSPHATE**

Microscopic Appearance of Monoammonium Phosphate and Diammonium Phosphate Crystals

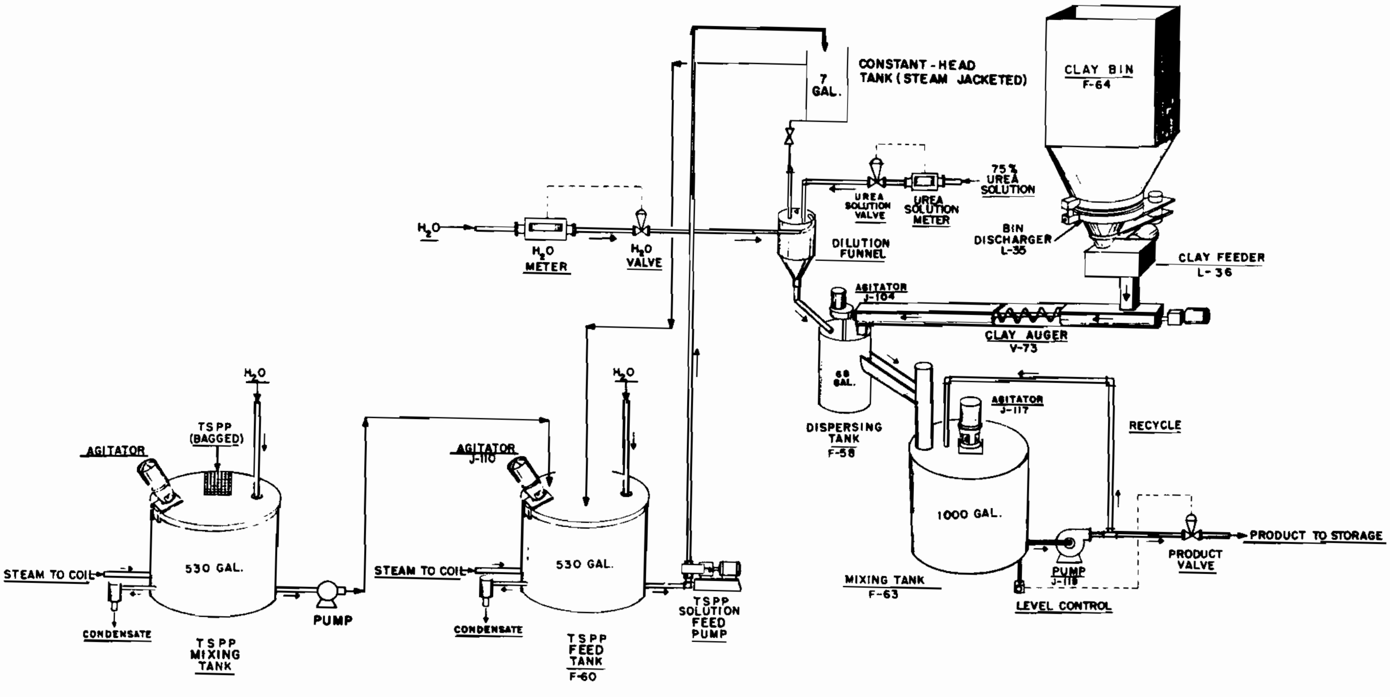
Figure 3



TVA Demonstration-Scale Plant for Production

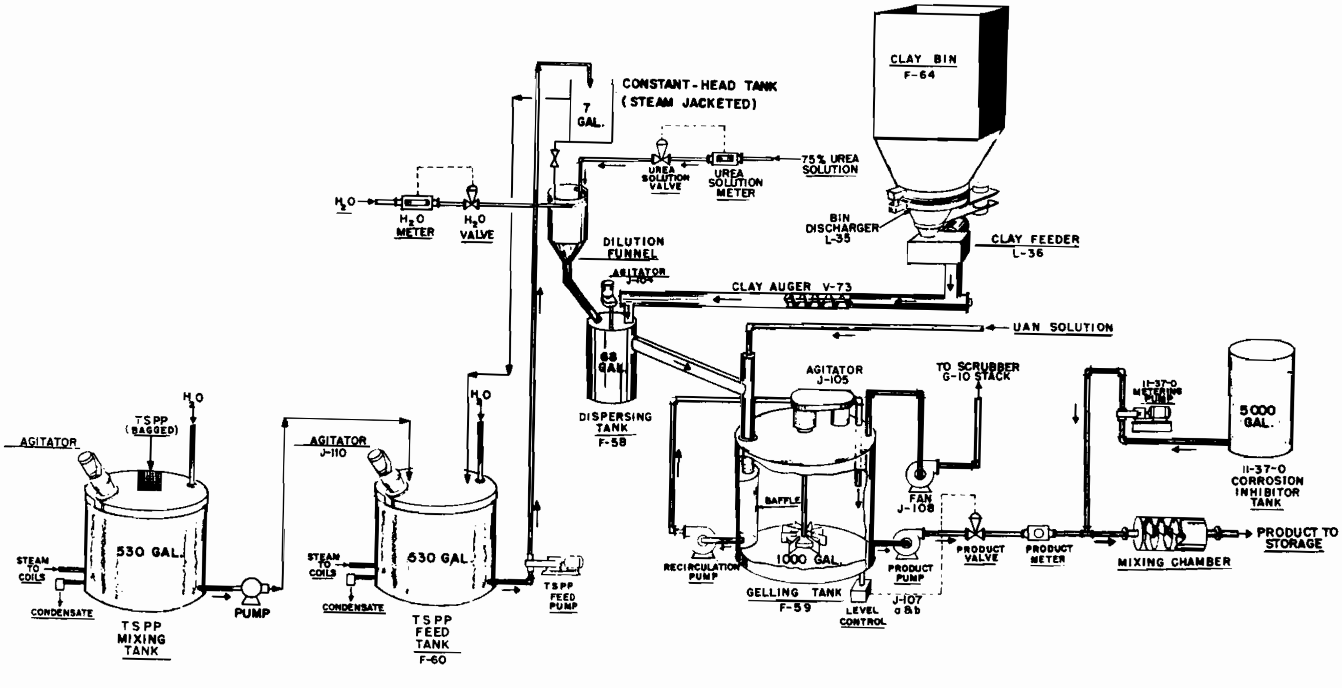
of 13-38-0 Ammonium Orthophosphate Suspension Fertilizer

Figure 4



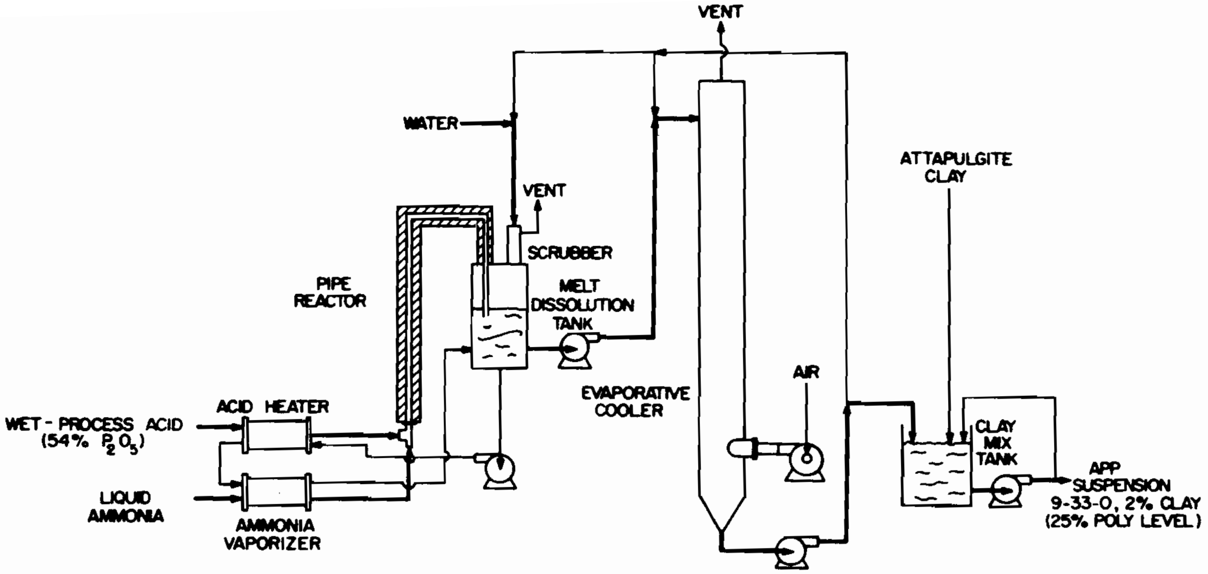
TVA Demonstration-Scale Plant for Production of Nitrogen Fluid Clay

Figure 5



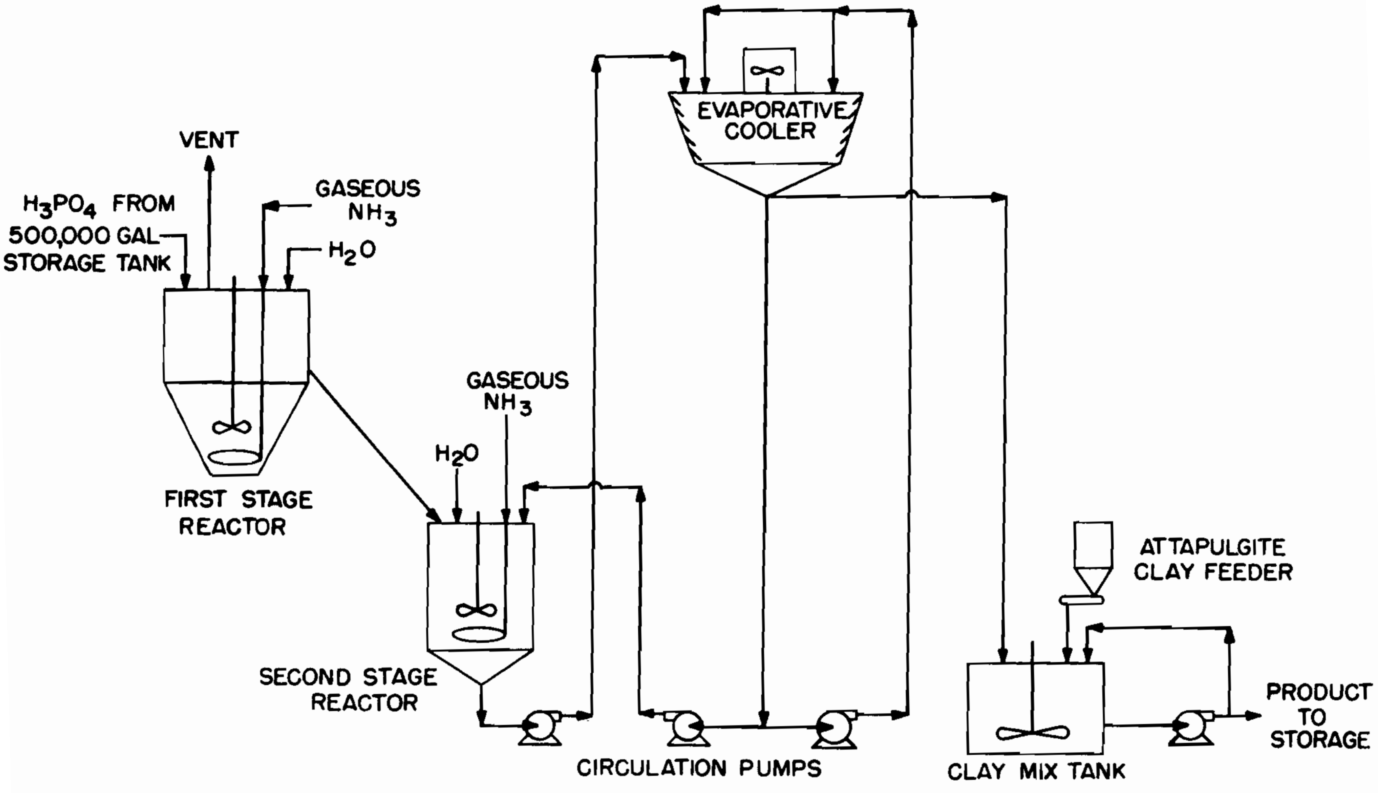
TVA Demonstration-Scale Plant for Production of Urea-Ammonium Nitrate Suspension Fertilizer

Figure 6



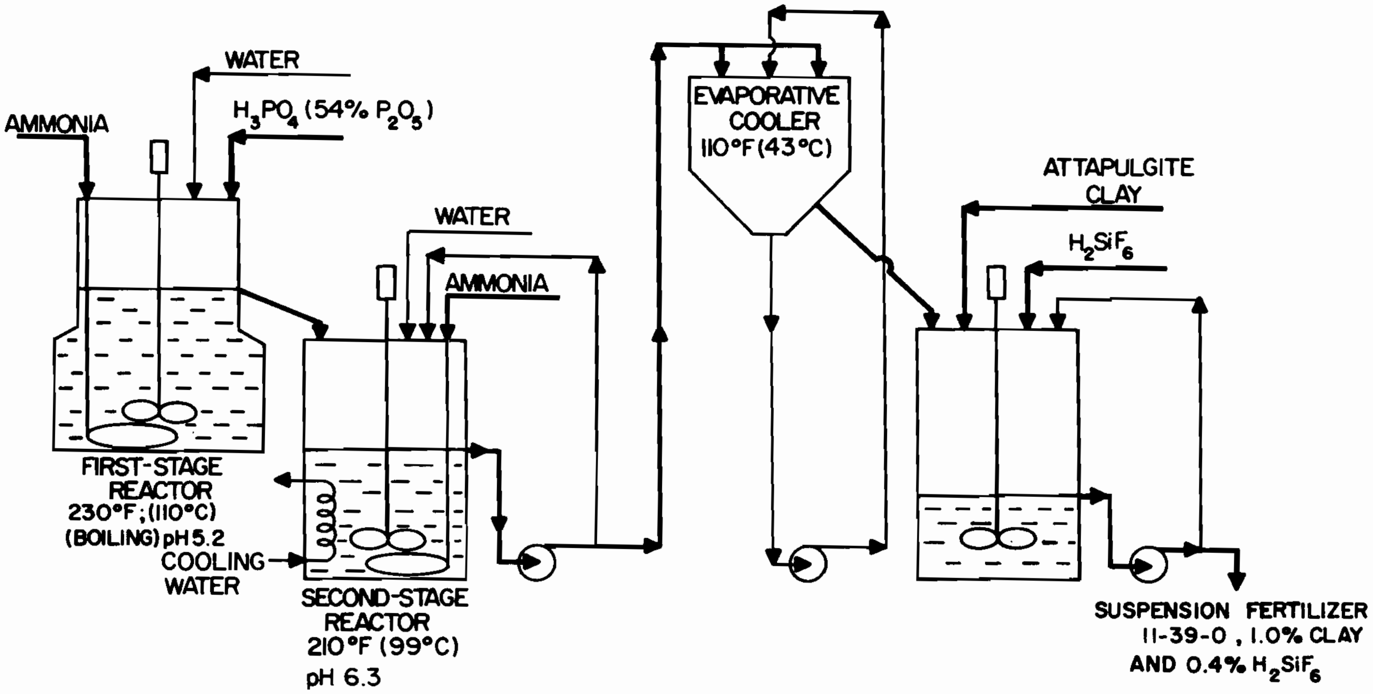
TVA Pilot Plant for Production of Ammonium Polyphosphate Suspension Fertilizer from Merchant-Grade Wet-Process Phosphoric Acid

Figure 7



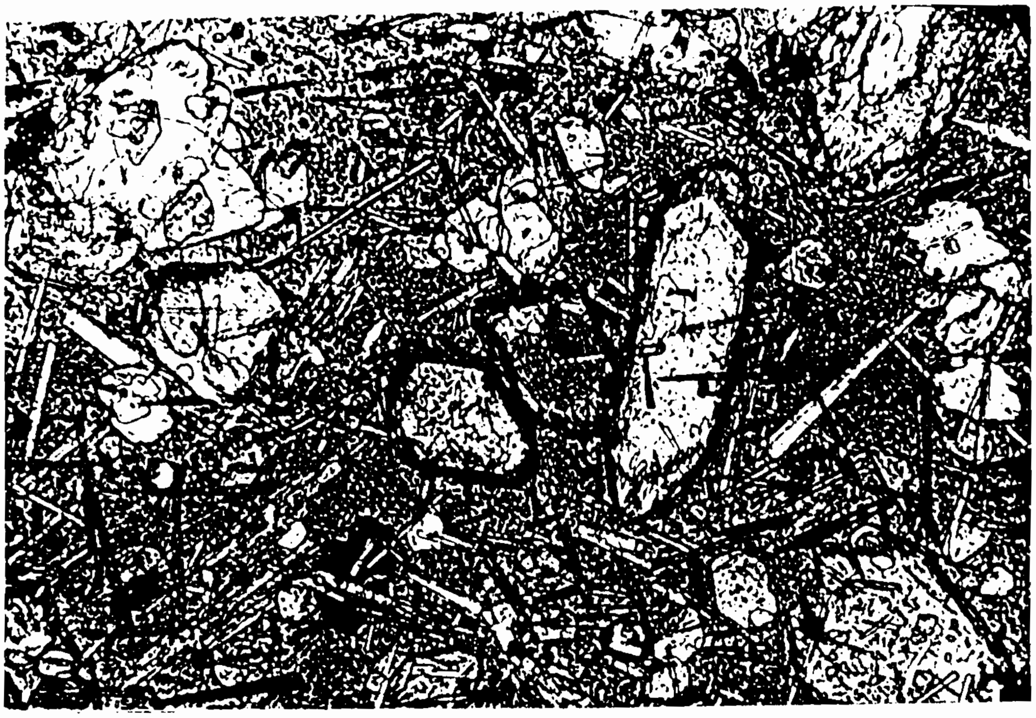
TVA Demonstration-Scale Plant for Production of Ammonium Orthophosphate Suspension Fertilizer by a Process with Two Stages of Ammoniation

Figure 8



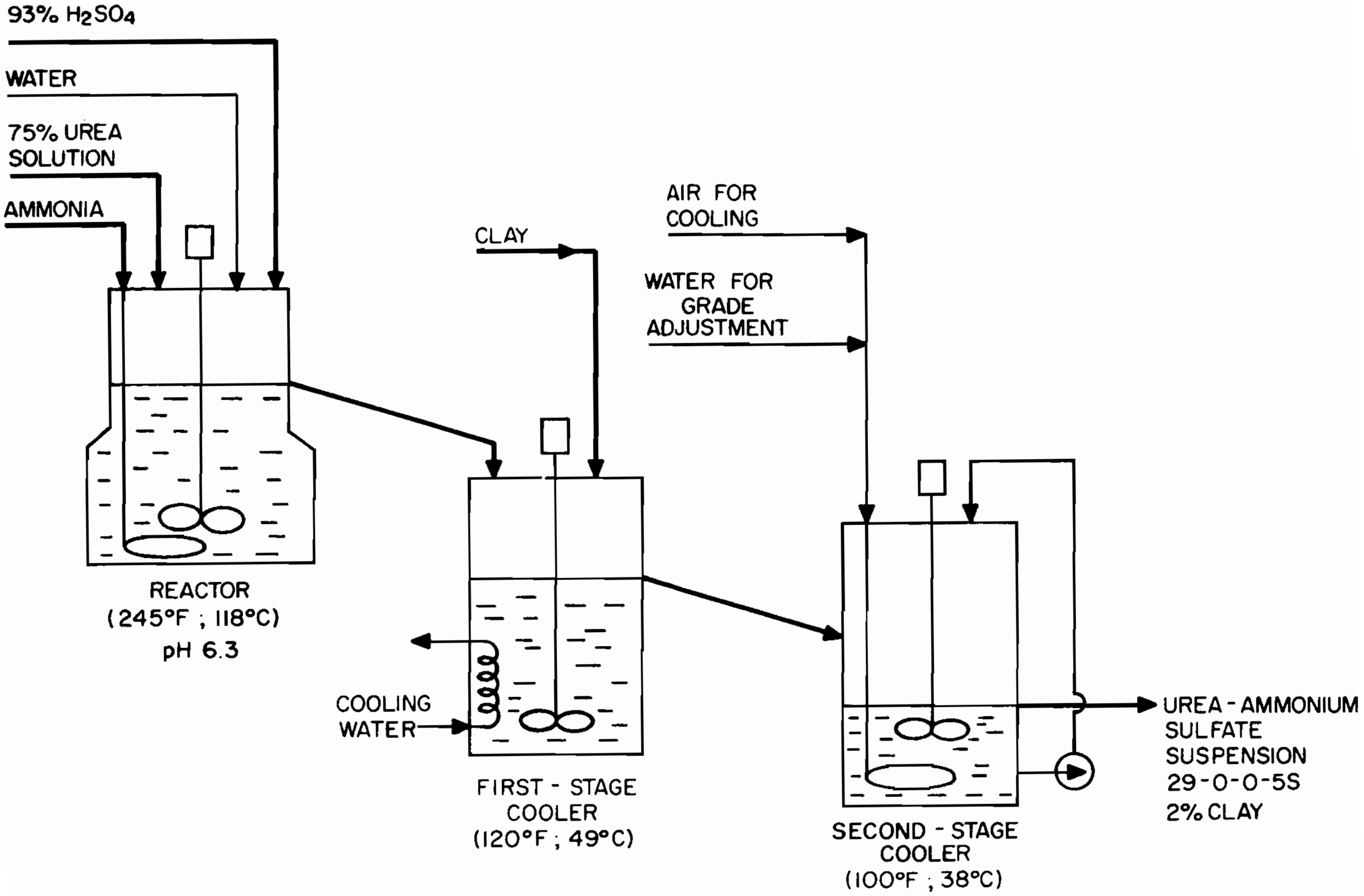
TVA Pilot Plant for Production of Ammonium Orthophosphate Base Suspension with Fluosilicic Acid as a Crystal Modifier

Figure 9



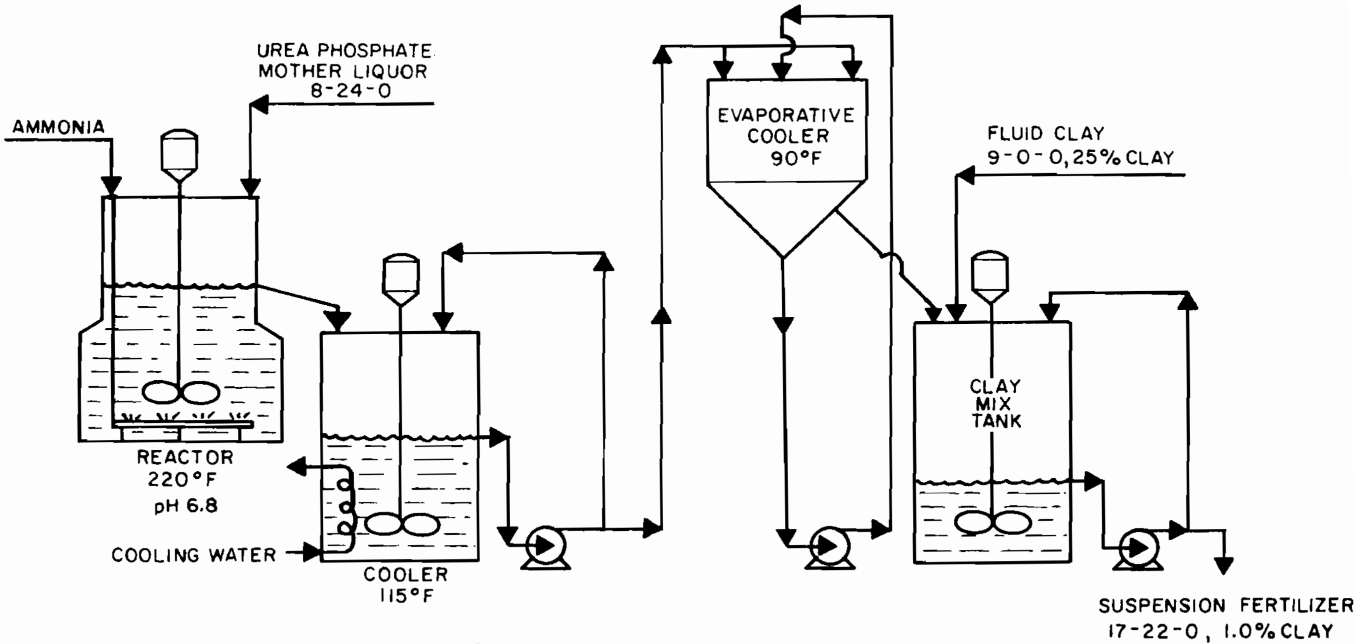
Microscopic Appearance of DAP and Modified MAP Crystals in 11-39-0 Containing 0.4% H_2SiF_6

Figure 10



TVA Pilot Plant for Production of Urea-Ammonium Sulfate Suspension Fertilizer

Figure 11



TVA Pilot Plant for Production of Suspension from Urea-Phosphate Mother Liquor (17-22-0, 1% Clay)

Figure 12

MODERATOR GREEN: Do we have any questions for Amos at this time? You did a good job and we all thank you. (Applause)

We have another one of those "Good Guys" from TVA. Luther Nunnelly will discuss "TVA's New Granulation Process with Evaporative Cooling". Luther has been with TVA for 28 years. Let's give Luther a warm welcome. (Applause)

Tennessee Valley Authority's New Granulation Process With Evaporative Cooling

A. R. Shirley, Jr. — L. M. Nunnelly
R. S. Meline — F. T. Carney, Jr.

Presented by L. M. Nunnelly

Introduction

The Tennessee Valley Authority (TVA) has developed a new melt granulation process that uses evaporative cooling to remove a significant portion of the heat released by the solidification of melt in a granulation drum[1, 2, 3, 4, 5, 6]. The falling curtain-evaporative cooling process is a direct outgrowth of the technology that TVA developed for production of controlled release fertilizers by spray-coating sulfur onto a granular substrate, such as urea or other fertilizer material[7, 8, 9, 10, 11, 12]. Much of the technology in the new process is essentially the same as that developed for production of controlled release fertilizers; however, in the new process, a finely divided mist of water is sprayed into the airstream passing through the rotary drum. As this water evaporates into the airstream, it absorbs a significant portion of the heat released by the solidifying melt. About two-thirds of the heat released in the drum is removed by a combination of the evaporation of water, the increase in the temperature of the airstream passing through the drum, and the loss of heat through the shell of the drum. The remaining heat is removed from the process by fluid-bed cooling of the granulator product.

TVA's first experimental work with the falling curtain-evaporative cooling process was in a modified sulfur-coated urea pilot plant in the fall of 1976. In that work, elemental sulfur was successfully granulated in a rotating drum at a rate of 1 ton an hour. Results of that work enabled a private company to build and to operate successfully a 20-ton-per-hour sulfur granulation plant. This same company later built a three-train, 60-ton-per-hour sulfur granulation plant that began operation in 1979[13].

In December 1978, TVA further modified the sulfur-coated urea pilot plant and tests were made to study granulation of urea by the falling curtain-evaporative cooling process. Granular urea with very good physical properties was produced in this modified pilot plant at production rates up to 1100 pounds an hour. Results of this preliminary work were very promising, so TVA built a 2-ton-per-hour pilot plant to further study the granulation of urea and other fertilizer materials. Granulation of urea by the falling curtain-evaporative cooling process in the new pilot plant was demonstrated to industry representatives and to the general public at TVA's 13th Demonstration of New Developments in Fertilizer Technology which was held at the National Fertilizer Development Center in Muscle shoals, Alabama, October 6 and 7, 1980[14].

Process Description

A flow diagram for granulation of urea by the falling curtain-evaporative cooling process is shown in Figure 1. The heart of the new process is a rotary drum with specially designed internals that form a falling curtain of seed granules and recycled undersize onto which the melt is sprayed. Operation of the drum is illustrated in Figure 2. Operation of the drum is illustrated in Figure 2. As the drum rotates, granules are elevated from the bed by lifting flights, and then the granules discharge onto inclined collecting pans. The material flowing from the collecting pans forms a dense curtain of granules. Sprays of molten urea are directed onto this curtain. As the melt strikes the surface of the granules, it quickly solidifies forming a coating on the granules. Thus, product granules of the desired size range are produced by application of successive coatings of melt onto the seed and recycle granules, and no agglomeration occurs.

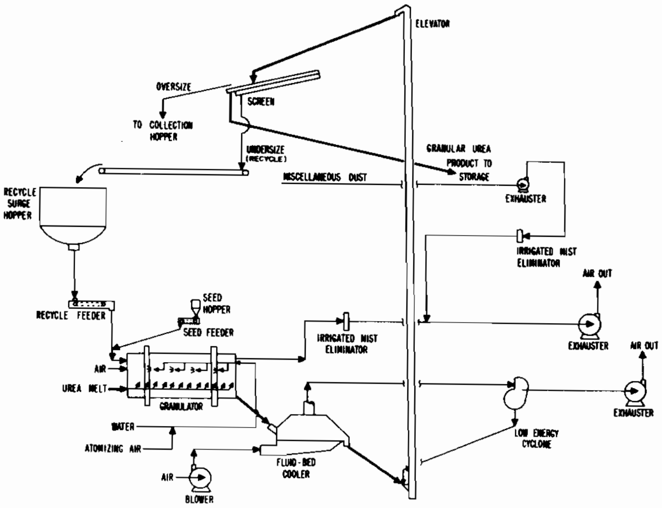


FIGURE 1

Granulation of Urea by the Falling Curtain-Evaporative Cooling Process

Figure 1

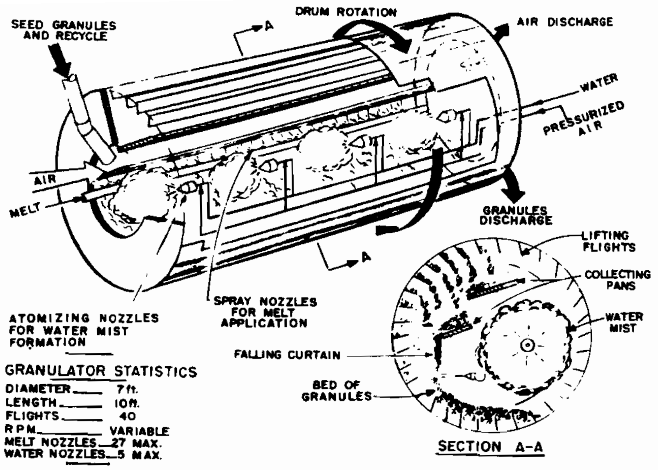


FIGURE 2

Schematic Diagram of Granulation Drum

Figure 2

As shown in Figure 1, undersize material from the screen and seed particles are fed to the granulator drum. Undersize material is conveyed to a recycle surge hopper from which it is fed back to the granulator at a metered rate. Seed particles are metered into the granulator drum to replace the product taken out of the system on a granule-to-granule basis, thus maintaining approximately a constant number of granules in the process streams. At present, microprills of urea are being used as seed. Test work has shown, however, that crushed oversize or crushed product can be used for seed if the dust is separated from the crushed material. In recent work, oversize material has been remelted and regranulated. Seed should be predominantly in the size range of 20 to 35 Tyler mesh (0.84-0.42 mm dia). The size of the product can be varied from that of large prills to that of very large granules by changing screen sizes and making the necessary adjustments to the seed feed rate.

The urea melt is usually sprayed onto the granules in the granulator drum at temperatures between 275° and 300°F., and they normally leave the cooler at temperatures between 120° and 150°F. When melt is sprayed at 300°F. and granules leave the cooler at 140°F., about 176 Btu of heat per pound of urea granulated is released. This includes heat of fusion, about 104 Btu per pound, and heat released in cooling of melt and subsequent cooling of granules. The pilot plant was designed so that about 68 percent (512,000 Btu/h) of the heat released in the granulator drum is removed by the combination of water evaporation, increase in temperature of the airstream passing through the granulator, and losses through the shell of the drum. The remaining 32 percent (240,000 Btu/h) of the heat is removed in the fluid-bed cooler. The relatively large transfer of heat in the granulator is possible while maintaining relatively low airflow rates (3500 ft^3/min) at the design production rate (2 tons/h) because of the very finely atomized water that is evaporated in the airstream. At an air discharge temperature of 120°F., the water absorbs about 1068 Btu for each pound of water evaporated. Typically, between 15 and 19 gallons of water is evaporated in the drum for every ton of granular urea produced.

Since urea is hygroscopic, water is sprayed in areas of the drum that are free from falling urea to prevent direct contact of the granules with the water mist. Also, the humidity in the air, and consequently the proportion of water spray, must be controlled to avoid exceeding the critical humidity of urea. For example, granules discharging from the drum at 206°F. would begin to absorb moistures from contacting air with a relative humidity of 34 percent or 0.27 pound of water per pound of dry air. Recycle granules entering the drum at 140°F. would begin absorbing moisture from contacting air at 58 percent relative humidity or 0.081 pound of water per pound of dry air. Since air absorbs moisture as it passes through the granulator and thus exits with a higher moisture concentration, the air is directed through the drum cocurrently with the urea to reduce chances of moisture being absorbed by the recycle entering the feed end of the granulator. The pilot plant was designed for relative humidity in the air leaving the granulator to be no greater than 40 percent for air at 120°F. (0.03 lb. water/lb dry air).

Pilot-plant work has shown that the uniformity of size of the final product can be controlled by the ratio of the recycle feed rate to the melt spray rate. The recycle consists only of undersize granules, and the rate at which recycle granules are fed to the granulator is controlled by a scale-mounted belt feeded. As the amount of recycle is increased for a given spray rate, the size of the product becomes more uniform. Data from the pilot plant indicate that oversize generated is about 1 percent of the melt spray rate at a recycle-to-melt ratio of about 1:1. Higher recycle rates make the product extremely unfirom in size, which could be undesirable for some uses, such as for size matching with other fertilizer materials in bulk blending. Lower recycle rates increase oversize production. Any oversize that is not used for seed generation must be remelted and regranulated. This requires additional energy consumption and increases biuret content of the final product; both are undesirable.

The air leaving the granulator is washed with recycle scrubber solution, and the resulting spray particles are collected in an irrigated mist eliminator. Initial results in the pilot plant indicate that dust formation in the process is less that 2 percent of the urea granulation rate. Particles emitted from the fluidized-bed cooler are collected in a low-pressure-drop horizontal cyclone and are fed back into the elevator. Dust collected from miscellaneous points in the system also is washed out of the air by a system similar to that used to remove particles in the exhaust air from the granulator.

Pilot-plant tests of urea granulation have shown that the process can be used to consistently produce urea that is hard and spherical. Typical minus 7 plus 8 Tyler mesh (2.8-2.4 mm dia.) product granules have a bulk density of 48 pounds per cubic foot, a crushing strength of 7 pounds, and a sphericity of about 90 percent. The moisture content of the granules is normally between 0.1 and 0.3 percent. The process appears to be easy to control and manpower requirements in a large plant should be about the same as those for other granulation processes. Overall energy consumption and initial capital expenditures for this process should be lower than those for other granulation processes.

Pilot-Plant Equipment

The granulation drum (Figure 2) is 7 feet in diameter and 10 feet long; the retaining ring at the discharge end is 5 inches high. Forty lifting flights are installed in the drum, at 9-degree intevals. The flights are straight with flat surfaces 3 inches wide and 9 feet long. They are installed parallel to the axis of the drum and are canted 15 degrees forward from the perpendicular with the shell of the drum. Two collecting pans are installed parallel to the axis of the drum. Both pans are sloped counter to the direction of rotation of the drum at an angle so that the granules will cascade down them. Each pan catches some of the material discharged from the lifting flights. All granules discharging from the top pan fall to the bottom pan, and the granules discharging from the bottom pan provide a curtain of falling granules onto which the molten urea is sprayed. The collecting pans catch the granules after only a short fall and break their momentum before they can develop enough force to shatter on impact and create dust. In addition, the pans provide a large area of the granulator in which heat transfer can occur by air-to-granule contact, but without allowing the granules to pass through the water sprays located underneath the pans. The double-pan configuration is designed to increase airflow between the area where most air-to-granule contact occurs and the water evaporation area of the granulator.

Molten urea is distributed in the granulator atgage pressures up to 500 pounds per square inch through a steam-heated header which can contain up to 27 spray nozzles. The urea melt is obtained from a single-pass steam-heated melter and is filtered before being pumped to the spray header to remove any particles that would plug the spray nozzles. The purpose of the melter in the pilot plant is to provide urea melt that simulates the melt that would be obtained directly from a urea-plant evaporator in a large plant. The molten urea supplied by the melter is collected in a small tank. This tank and the melt piping are designed to minimize biuret formation by retaining urea in the molten state less than 30 seconds. Molten urea is pumped to the header by a double-acting piston pump. For flexibility, the pump is driven by a piston-type air motor. The flow rate of urea is indicated by a turbine flowmeter and is manually controlled by changes in pneumatic pressure to the air motor. The pump and all high-pressure valves are submerged in a constant-temperature oil bath. All molten urea piping is jacketed, and all equipment in contact with molten urea is made of Type 316L stainless steel, except the pump which is made of Type 303 and Type 304 stainless steels. The water for evaporative cooling is metered to wide-angle pneumatic atomizing nozzles with round spray patterns that spray in the drum countercurrent to the air being pulled through the drum.

Air for fluidization and cooling in the fluid-bed cooler is provided by two centrifugal fans (a blower and an exhauster). The damper arrangement in the ducts allows close control of airflow through the cooler. A horizontal cyclone removes any seed-size particles in the air leaving the cooler, and the particles collected are returned through an airlock to the elevator. The elevator is a continuous-discharge-type unit that is operated at a slow speed to prevent breakage of the material being handled. The screen is a double-deck, gyrating-type unit. Screen sizes are changed as necessary to obtain the size of product desired. After screening, the product is collected in a product hopper and is later transported to storage. Undersize leaving the screen is transported by a belt conveyor to the recycle surge hopper which has a capacity of about 3.2 tons of urea.

The seed-particle feeder and the recycle feeder have variable-speed belt controls and are mounted on scales for rate determination. The low-pressure-drop, wire-mesh mist eliminators are mounted in tanks 3 and 2½ feet in diameter. The tanks, the mist eliminators, the ceentrifugal exhaust fans, and the inline centrifugal pump used for pumping scrubber solution are all constructed of stainless steel.

All rotary equipment is driven by totally enclosed fan-cooled motors. Instruments and access points are provided throughout the pilot plant to facilitate the taking of data and samples.

Plans

The new pilot plant has been operated only a few times; therefore, there has been only limited opportunity to test optimum values for the various process variables. Researchers, however, have been able to determine that the process has considerable operational latitude because wide fluctuations in the operating conditions have caused very few product quality changes or operational problems. TVA will continue to develop the process by further defining and optimizing the process variables in order to improve the product and to minimize production costs.

REFERENCES

1. Blouin, Glenn M., "Apparatus for Applying Coatings to Solid Particles," U.S. Patent No. 3,877,415, April 15, 1975.
2. Blouin, Glenn M. "Method for Applying Coatings to Solid Particles," U.S. Patent No. 3,991,225, November 9, 1976.
3. Shirley, Arthur Ray, Jr., "Granulation and Coating by Improved Method of Heat Removal," U.S. Defensive Publication T980,005, March 6, 1979.
4. "New Developments in Fertilizer Technology," 11th Demonstration, October 5-6, 1976, Tennessee Valley Authority, Muscle Shoals, Alabama (TVA Bulletin Y-107).
5. Shirley, A. R., Meline, R. S., Nunnelly, L. M., and McCamy, I. W., "Fixed Falling Curtain Granulation of Urea Using Evaporative Cooling," Tennessee Valley Authority, Muscle Shoals, Alabama, October 1979 (TVA Circular Z-100).
6. Shirley, Arthur R., Jr., "Granulation and Coating by Improved Method of Heat Removal," U.S. Patent No. 4,213,924, July 22, 1980.
7. Blouin, Glenn M., and Rindt, Donald W., "Method of Making Sulfur-Coated Fertilizer Pellet Having a Controlled Dissolution Rate," U.S. Patent No. 3,295,950, January 3, 1967.
8. Engelstad, O. P., Getsunger, J. G., and Stangel, P. J., "Tailoring of Fertilizers for Rice," Tennessee Valley Authority, Muscle Shoals, Alabama, December 1972 (TVA Bulletin Y-52).
9. Blouin, G. M., "Sulfur-Coated Urea: Estimated Cost in a Developing Country," Tennessee Valley Authority, Muscle Shoals, Alabama, October 1974 (TVA Bulletin Y-82).
10. Shirley, A. R., Jr., and Meline, R. S., "Sulfur-Coated Urea from a 1-Ton-Per-Hour Pilot Plant," *Advances in Chemistry Series, 140* pp 33-54 (1975).
11. "New Developments in Fertilizer Technology," 12th Demonstration, October 18-19, 1978, Tennessee Valley Authority, Muscle Shoals, Alabama (TVA Bulletin Y-136).
12. Myers, F., Russel, D. A., and Young, R. D., "Sulfur-Coated Urea: Technical Update," Tennessee Valley Authority, Muscle Shoals, Alabama, December 1979 (TVA Circular Z-102).
13. "Sulfur Shippers Favor Procor Unit," *Can. Chem. Process. 63* (3) 20-22 (May 1979).
14. "New Developments in Fertilizer Technology," 13th Demonstration, October 7-8, 1980, Tennessee Valley Authority, Muscle Shoals Alabama (TVA Bulletin Y-158).

MODERATOR GREEN: Thank you Luther. Are there any questions. (Applause)

QUESTION FROM CHARLES CHURCHMAN—BADGER-AMERICA, INC,: How big can you make the granules?

LUTHER NUNNELLY: Well, I do not know just yet how big. We have not gotten that far. Any particular pilot plant would determine just how large the fluid bed cooler can fluidize and cool. The larger the particle the harder it is to cool. We go up to four to five mesh, however, we have not gotten beyond that.

QUESTION FROM CHARLES CHURCHMAN: Would you like to hazard a guess as to how large you can make the granule before the particles stop being spherical?

ANSWER—LUTHER NUNNELLY: Three quarter inch. That would be a guess.

MODERATOR GREEN: Any more questions?

QUESTION FROM ANDRE KAYAERT—NSM-HOLLAND: Just comparing processes: If you compare this process with the NSM fluidized bed process, it occurs to me that there is a basic drawback in this process in that you evaporate urea up to 99.5% and, after that, you use water to cool down all of the heat you have put into it. Don't you think that this is a very basic drawback of this system? I hope you do not think that we Dutch guys cross the ocean just to make nasty remarks, but I would like to hear your comment on this.

ANSWER—LUTHER NUNNELLY: Well, I mentioned that 68% of the heat that was released in the granulator was released by the evaporation of water and through the shell orifaces into the cooling of the air. Of course the remainder of it is carried over into the fluid bed cooler. How, coming out of the cooler at about 140° is a little hot. If I understand your comment right, about the cooling, I do not see a problem there right now!

ANDRE KAYAERT: Perhaps I did not make my point clear. In the case of the NSM process, you evaporate only in one stage, the urea, up to 95% and then you leave 5% of the water in the urea melt which cools through the granulator. You do not need the second evaporator for the urea solution up to 99%.

ANSWER-LUTHER NUNNELLY: Well, in the pilot, we do not have a concentrator. Later on, we will add water back to the solution just to see what concentration we can work with on that. We expect that we can flash off some water through the sprayers, but we do not yet know how much. Just how it will affect the cooling, whether we can reduce the water that is sprayed into the drum, I think possibly that would just allow us to cool it further down.

MODERATOR GREEN: Any other questions, Thank you Luther. (Applause)

This year, as well as previous years, we owe many thanks to the people of TVA for their time and talents that have made the Round Table what it is. At this time let us give a "round of applause to the Guys in TVA". (Much Applause). Frank Achorn will wrap up this 1980 Session — 30th Annual Meeting. (Applause)

VICE CHAIRMAN FRANK ACHORN: I want to pay "particular respect and gratitude" to you Gentlemen who have sat on your rear ends for this long time! For you who are always here to the very end—we will have our 31st Annual, at the Shoreham Americana Hotel, in Washington, D.C., Tuesday, Wednesday and Thursday, November 3-4-5, 1981. I assure you we will not have any rain storms within the building in which we are presenting the papers and we will have slide projectors and all the rest of the equipment working well.

Many thanks to all of you for attending this excellent meeting and "our special thanks" to "our Overseas Visitors". You have come a long way and we appreciate your "attendance" each time. For you local people keep up the good work. We will see you next year. (Much, much and much Applause!!)

Comments By Albert Spillman

Editing Chairman

I am sure you will find our Proceedings, covering our 30th Annual Round Table Meeting, held in Washington, D.C. October 28-29-30, 1980, helpful in "Your Day to Day Operations".

We has an excellent, five session Program attended by a good interested attendance. There was much applause and much comment, "complimenting our Speakers' discussions and our well planned meeting schedule".

I am going to repeat what I said commenting on last year's 29th Annual Meeting. My pleasure, again, as it has been since Our Round Table started 30 years ago, to supervise, edit, organize and deliver to our printer approximately 450 thoroughly checked script sheets covering all of the activities, talks, slides and questions and answers.

All of my contacts, with many of you, by "correspondence, telephone, etc.", asking for answers necessary to permit our proceedings to be published accurately as possible, sent me their replies within a reasonable time, considering, being away from your office when necessary.

My thanks to "all of you, our Chairman, Directors, Moderators, Speakers, Secretary-Treasurer — Paul Prosser, Jr., his most cooperative Secretaries, our Printer, Tom Sabia, Manager of Quickee Offset, Inc., Baltimore, Maryland and his most accommodating office." To all of you I say "Much Appreciation.".

Hope you can attend "Our 31st Annual Round Table Meeting" to be held in Washington, D.C., Shoreham-Americana Hotel — Tuesday, Wednesday, Thursday, November 3-4-5, 1981. You can register Monday Evening, November 2, 1981. We promise you another most interesting meeting. Thank you.