PROCEEDINGS
OF THE
27th ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1977

October 25, 26, 27, 1977

Shoreham-American Hotel
Washington, D.C.

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Tuesday, October 25, 1977

Morning Session
Rodger C. Smith, Chairman

William F. Sheldrick, Moderator

OPENING REMARKS- CHAIRMAN SMITH: Good Morning, Ladies and Gentlemen.

Let me welcome you to this twenty-seventh Annual Fertilizer Industry Round Table. It is pleasing to see this large gathering intent once again on sifting genuine progress from the production experience and technology research of fellow participants — progress in terms of more productive fertilizers, more easily handled and more efficiently manufactured. At this Round Table, it is good to see well represented granulators, blenders and fluid mixers. It is equally good to see represented manufacturers of basic raw materials; also to again have the engineering companies who contribute so much to efficient plant operations. In addition to the North american fertilizers industry, it it good to have our friends from several other countries. Let me recognize and welcome those of you from overseas who contribute so much annually to the success of the Round Table. Let us do anything we can to make your visit pleasant and productive.

The Round Table has long since been the forum of fertilizer technology in North America. The Round Table and the ISMA technical committee are the two outstanding forums of fertilizer production and development worldwide. Your Board of Directors has again diligently attempted to offer you a worthwhile agenda. Your presence endorses the success of that effort.

We represent a large industry with an important mission. Fertilizer use in the United States alone is over 50 million tons annually. When you consider that at least 40% of crop production is attributed to fertilizer use, and higher for many crops, the importance of our addressing production and product improvements annually is easily recognized.

We meet at a critical time for U.S. and world agriculture. With grain harvests about completed in the Northern Hemisphere, world food supplies are nearing the second highest level on record. U.S. is producing record or near record amounts of wheat and feed grains. With weather good for the third year in a row, Russia is expecting substantial wheat and other crops to increase their reserves. India, usually a large importer of grain, has had a favorable monsoon season with prospects of a good harvest. Bangladesh, Turkey and China have favorable crops.

World agriculture and the fertilizer industry operate continuously in a delicate balance. Good crop yields, the object of fertilizer use, replenish food coffers. This in turn can increase purchasing power for fertilizer or, on the other hand, can cause governments to allocate less foreign exchange or otherwise give less encouragement to fertilizer purchases or production. Agricultural exports are similarly influenced by crop yields. Although local variations occur, we can all be assured of long term growth of fertilizer consumption more or less in relation to population increase and to farm income. Our products are basic to human nutrition and well being. For that reason, it is a basic and growth industry.

It is in this sort of climate that world food strategists continue to debate the subject of world grain reserves. It is also in this climate, with more specific definition and constraints, that the U.S. administration and congress have revised the farm program. The program attempts to respond to what farmers have come to regard as unsatisfactorily low grain prices, to national food needs and to the prospects for export of grains and other agricultural products. Among other effects, it will have some influence on fertilizer use in the United States this fall and next spring. Also, it will have secondary effect on fertilizer use in some other countries.

For these reasons, your Board of Directors sought a key official of the administration to help us better understand the 1978 farm program and to better estimate agricultural developments in the next few years. To fulfill this assignment we are fortunate, indeed, in having with us the Director of Economic, Policy analysis and Budget; United States Department of Agriculture — Mr. Howard W. Hjort.

Mr. Hjort was appointed the Director of Agricultural & Economics on March 10, 1977 by Secretary Bergland.

As Director of Agricultural Economics, Mr. Hjort is the Secretary's chief economic advisor. He is in charge of five U.S.D.A. agencies — the Economic Research Service, Co-operative Service, Statistical Reporting Service, the Office of Budget, Planning and Evaluation, and the Economic Management Support Center. The New World Food and Agricultural Outlook and Situation Board also reports to him. He has departmental responsibilities for economic analysis, policy appraisal, budget, outlook and situation reporting, remote sensing and weather-related activities.

Mr. Hjort was born in Montana where he operated a grain and livestock farm for two years before entering Montana State University, where he obtained Bachelor and Master degrees in agricultural economics. He did further graduate work at North Carolina State University.

In 1956 he joined he Department of Agriculture asnomics. He did further graduate work at North Carolina State University.

In 1956 he joined the Department of Agriculture as a student trainee. He then served with U.S.D.A.'s Economic Research Service at Bozeman, Montana and Raleigh, N.C. before being transferred to Washington, D.C. in 1963 as a Staff Economist in the Office of the Director of Agricultural Economics. In 1965, he was named Director of U.S.D.A.'s Program Planing and Analysis Staff. In 1969 Mr. Hjort accepted a two - five year assignment with the Ford Foundation in New Delhi, India, where he worked with the Indian government officials to improve the planning and analysis system for the National Family Planning Program and on The Agricultural Development strategy for the Fifth Year Plan.

He returned to the United States in 1972 to become Vice President and partner in the agricultural consulting firm of Schnittker Associates in Washington.

It is a pleasure to introduce to you — Mr. Howard W. Hjort. [Applause]

Keynote Speaker

Howard W. Hjort

Thank you Rodger. Let me begin by extending to you greetings from the Secretary of Agriculture. The Secretary was asked to come and address the group. Unfortunately, he had another committment. I talked with him just a few moments ago, and he's off this morning to fulfill that other committment out of town. So I'm here, but I do want to leave you with his regards.

Let me begin by reviewing world food and agriculture situation and outlook with a little bit of historical perspective because it is that situation, it is events that influence policies not the other way around.

Between 1972 and 1976 there were two major factors that influenced the world agricultural plan. One— strange weather patterns worldwide. Second, the increase in petroleum prices. All of you are very familiar with what happened with your industry because of the latter, and you're also familiar with what the relationship is between weather, prices and the demand for fertilizers. The current situation is generally characterized by most as having an agricultural plan that is again showing characteristics of excess supply, a condition that characterized that industry for years prior to 1972. The current situation started to develop in 1975 when world rice production was record high, a significant increase over the 1974 outturn. Sufficient supply of rice to add to world stocks and rice prices started moving downward. Rice is, of course, the major food grain in the world.

The second shoe fell within the grain sector when the world wheat crop was not only record high, but the change from 1975 to 1976 was the largest the world had ever seen. In terms of metric tons a little more than 60 million, in terms of bushels about 2.3 billion bushel increase from one year to the next. Now just think of that for a moment and put it in this kind of context. The United States is a fairly large producer of wheat, but the most we've ever produced in this country is 2.15 billion bushels of wheat. So if the United States wouldn't have produced any wheat at all in 1976 the world would have had a little more wheat in that year than it had the previous year. In consequence even though world consumption increased rather rapidly over the year that ended this summer the increase in world wheat stocks was the largest from one year to the next that we've ever seen.

Coarse grains — as recently as a year ago, even nine months ago, the coarse grain situation was perceived to be relatively tight. The price was high relative to food grain prices. Wheat prices have already come down, and wheat again by the fall of 1976 was back to where it had been relative to the coarse grains in 1972; that is, competitive with feed grain; and wheat was moving into feed grain markets. As the year progressed and it became increasingly evident that the 1977 world coarse grain projection was again going to be relatively high, feed grain, coarse grain prices started to drop sharply.

The situation today as contrasted to two years ago, we had about 125 million tons of old crop beginning stocks two years ago. Now we have something on the order of 163 of wheat and coarse grain. When you put rice on top of that, it was about 135 million to 183 million tons. Now that increase isn't very large on a world scale, but yet let's stop a moment and see how large that is. The world now in terms of total grain and counting rice on its rough basis consumes in excess of 1.4 billion bushels. So an increase in stocks of 50 million tons or so is not very much at all. Yet it's enough to change the world's perception. Two years ago when it was 125-135 million tons the perception was one of scarcity, high and eratic prices, stories being repeated that the world was losing its capacity to feed itself. Now two years later all of a sudden the whole thing is characterized as excess supply, low prices, gluts, surpluses, high governmental outlays to protect farm income and so on. It is truly a very thin line between too little and too much.

Let's go on to the oilseeds, and I'll be relatively brief on the rest of these. We came out of a relatively tight situation in the year that we've completed. Stocks were pulled down to bare minimal levels. We had a flurry, and just a few months ago people were concerned that there were going to be insufficient supplies of oilseeds to carry us through this market without extremely high prices; and the prices did move up very sharply. They came crashing down at about the same rate as they went up when it became clear that the 1977 world oilseed production level would be clearly record high. There will be an increase in world oilseed stocks this year. Prices are depressed. Demand will be relatively strong. Even so I don't believe that the level of stocks at the end of this marketing year will be as high as they were two years ago. In short I wouldn't characterize the world oilseed situation as being in great excess supply.

Cotton — This year world production may not quite be record high, but it will be very close to 1974 and sharply above the '75 and '76 levels. There will be an increase in world cotton stocks. Prices have come down sharply.

Sugar — It wasn't only this year but the year before, but again it wasn't very many months ago really, that sugar prices were extremely high. Now they are very low, and you have international sugar agreement discussions and so on and a lot of activity here in the United States in trying to do something about that situation.

Coffee has gotten its share of attention this last year. In our balance of trade accounts it comes in for its share. Our favorable balance on the agricultural account which has been a major plus came off from about 12 billion in the year that ended a year ago to about 10½ this year, not because the value of our exports went down; no, as a matter of fact, they at least maintained and very likely set an all time record high of about 24 billion dollars; but the price of coffee went up, cocoa, and so the value of our imports went up relative to the value of our exports and the surplus on the trade account came down to about 10½ billion. Even in coffee it does seem that there will be an increase in production, still a relatively tight situation worldwide; and there will be for a while. So it goes for the major crops.

Livestock sectors — A few years back a strange thing happened. The beef cattle cycles peeked at about the same time in almost all of the major exporting countries in the world. That phenomena doesn't happen very often, but it did send off liquidation phases which were combined with relatively high feed costs here in particular because we let our prices run through a wider range than most other countries do. We've had a more rapid decline in beef cattle inventory than the last three years. Not only the most rapid rate of decline, but the absolute reduction in the number has been larger than in any three year period in history. It appears now that we may be approaching the bottom of the cycle, and on a U.S. and world basis it would appear that beef prices may have bottomed out and may be starting again to increase.

Poultry and broiler production continues to be the most rapid growth segment of the livestock sector on a world scale. In this country they continue to produce a record quantity of broilers each one of these years, and that situation is in prospect again for 1978.

Our pork producers have been given relatively favorable relationships between feed costs and the price of hogs, and at the present time have kicked off a very sharp expansion. We anticipate about 10 percent increase in farrowings for the next year and that should be enough to more than offset the decrease in beef production that is expected in 1978 so we very likely will end up again with near record meat supplies.

So much for the food situation. It does seem to me that there is a basic lesson to be learned, that weather is the major factor with respect to the year to year variability in world production. Fertilizer is one of the key factors in the change in yields over time. But there is a relationship between weather on the one hand and the rate of growth and demand for fertilizer on the other. We don't have to think back very far to when we all discovered that fertilizer demand can actually be trimmed back if prices get too high. We did find out that there is a fairly sensitive relationship between the price of grain and the price of fertilizer. Part of that change was simply because the prices moved up so rapidly. There were many countries of the world that had been subsidizing the use of fertilizer, and it was probably very sound policy on their parts to do so. When you had fertilizer prices doubling in a short period of time, all moving up very rapidly, the cost of maintaining that policy became prohibitive especially since that policy was being challenged at the same time that there were heavy demands on treasuries for high priced food imports and high priced petroleum imports. Who knows how many years of growth in the demand for fertilizer were lost during that period of time?

When supplies are tight and prices are high and eratic, farm policies aren't really important. Nobody pays much attention to them. If the price is well above the market support level that the government provides and above the level of income protection that a government provides, then nobody is very concerned and debates aren't very interesting on the proper components of farm policy; but during those circumstances and those situations food policy is terribly important and food policy becomes dominant.

When you get into a situation such as we are today, all of a sudden farm policies and programs become very important and nobody is very concerned about food policies in the sense of their impact on customers.

I think we are moving in the U.S. and probably on the world scale toward looking at these policies in what I would say to be their proper relationship, and that is, to move from nutrition policies to food policies to farm policies; so if one wants to be a little more explicit, I think we are moving to a time when nutrition policies will determine food policies and food policies will determine farm policies. Certainly they are very closely intertwined; they have to be, and there is no sense ignoring this relationship. One might as well look at them and take them into account in formulating programs and policies.

So there it was. With that kind of background we had the task this year on very short notice to put forward farm program policies and food policies that would carry us over the next four year period. The basic objective that we used in trying to formulate those proposals is a fairly simple one, and it goes something like this — protect producers and consumers from economic and natural disaster. If we start from the proposition that weather is the key factor with respect to year to year variability in production and if we also admit that none of us so far have been able to control the weather, then it seems to me we have to start from the proposition that you need farm programs and food programs that can accommodate these uncontrollable and significant year to year variations in the situation and outlook.

I do believe that the people in this room can clearly appreciate that extreme moves in prices are not good for your industry, and I will argue that the same is true with respect to the food and agricultural sectors. The extreme moves are not good for the long term growth and well-being of people in the world, be they producers or consumers.

So with that simple objective the first thing we did was realize that the Secretary of Agriculture had the basic authority that was needed without going to the Congress to capture some of that excess from 1976 and place it in a food grain reserve. So in April we announced we were going to do so on terms and conditions that encourage producers to place excess wheat in reserve. They continue to own it, but there is an incentive for them to hold it until prices move to 40% above the current loan rate, and there are disincentives for them to hold it after the price gets to 75% or more above the loan rate. Now in dollars and cents for wheat that means with a $2.25 market support level, about $3.15 is the level that you encourage farmers to hold, and you discourage them by calling in the loan at about $4.00 a bushel. The Congress picked that program up and put it into the law, and so now we have the hand of the Congress that is laid on top of that.

Later on we expanded that committment to a reserve to include a feed grain as well as a food grain reserve. At the present time the committment is that we will have 30-35 million tons of grain in reserve prior to the beginning of the 1978 crop year. For wheat, barley and oats that's June 1, 1978. For corn and sorghum it's October 1, 1978. This is the first time to my knowledge that the United States Government has ever made a committment to reserves. There have been many times in the past year we've had what people would characterize as surpluses; but when we had surpluses, we had a surplus disposal policy and that meant anytime the price moved up a little the Government sold grain into the market. That is a disposal policy and that was the policy that was followed by the previous Administration.

The consequence of not having any inventory to sell is what? You men are businessmen. If you don't have any inventory, are your salesmen successful salesmen? The only alternative you have if you don't have inventory and you're in an industry where you can't control production is export controls. It is no surprise, should never be any surfprise, why we had fertilizer export controls during that period of high prices. There is one point where policy is important. A reserve is an edge against export controls. It is terrible important from an export strategy and from a world strategy. We have to export food and agricultural products to have a healthy agriculture or even to have a healthy economy. I've already talked about the favorable balance of trade. The nonagricultural account is not favorable by any means. So we need a policy that encourages agricultural exports. A reserve simply encourages exports because it gives those who rely upon us some degree of assurance that they can depend on us. If you don't have an inventory, you don't have reserves; and you just go from year to year. Then when the weather is bad, you are not going to be able to deliver. It's that simple.

In addition to reserves that do provide some protection to producers while you are accumulating them you take that excess off the market, and it's available to protect against the extremes in prices on the high side when the weather is bad. You also need some kind of protections for your basic agricultural plan. The way the United States has done that over the last decade and a half is by having a lower market support price for our grain than the income protection level. That concept was extended in the 1977 Act. The terminology has changed over time, but in the 1973 Act the term a target price as distinct from a loan rate was picked up and that terminology even was continued in the 1977 Act. That bill in its basic respects is an extension of the farm policies that we've had since 1964. Now there's a lot of impression that farm policies in this country changed in 1975—'76. They didn't. That law was there. It was always there, but we didn't need them because events changed; and so in effect the farm programs were set aside instead of program acreage being set aside.

The market support levels in the 1977 Act are higher than they have been. At the same time I do not believe that they leave us in a position of being unable to compete in international markets, and that is the key criteria. That's a judgement question in part, but one can also indentify the levels of market support prices that are being provided by other countries in the world; and when one does that, I frankly do not worry about a $2.00 market support price on corn. Corn is the key in this country, and all of the other grain market support levels are geared to the price of corn in this bill.

If we're wrong, there is a provision in the law that permits those market support levels to be reduced. That market support price for corn can go down as low as $1.75, and for wheat it can go as low as $2.00. Now we've had wheat available to anybody in the world this summer at a price just a penny or two above $2.00 a bushel national average, and we've had places out in the country where that wheat is sold for as little as $1.85 a bushel. I don't know of any country in the world that can produce wheat at U.S. $2.00 a bushel plus freight to their country. If they count their full cost of production, I don't know of any. I don't know of any importing country, major ones, that support the price of wheat at that low level. Now one can say that means that we're competitive. Maybe it means we're too competitive. It's an important question because there is one thing that most everybody agrees upon, and there are few things most people agree upon, but one is that the developing countries of the world will have to increase their production persistently and very significantly over the years to come. They'll have to increase at a more rapid rate than will the developed countries.

Now if you're in a situation, and if you're a finance minister, where resources are scarce, and they're always scarce, and you can buy wheat at less than it can be produced in your own country, it is difficult to earmark those additional resources for agricultural development. So there's always two sides to every coin. There's some place where that price level is the proper one, and it changes all the time and none of us know precisely where it is. As I say, I do not believe those levels of market support prices that are in that bill leave us in a situation where we are not competitive in world markets. According to our farmers we clearly can't produce at those levels, but in this country we provide protection to income by a target price concept which means a deficiency payment. If the market price isn't as high as the target price, then the Treasury makes up the difference in a check. The target prices in this bill are but a little higher than they were in the 1973 Act. For example, the '73 Act had a target price of $2.47 a bushel for '77 crop wheat. The Congress changed that law, amended it to say $2.90 for 1977 crop wheat. They also set $3.00 a bushel for 1978. Now the $3.00 a bushel for wheat covers the same components of cost of production as does $2.10 a bushel or $2.22 for sorghum or $2.25 for barley or $.52 for cotton. In other words there is a commalty in this bill that hasn't been in the past one; and that is, that whatever standard you use to guide the level of protection on income, the prevention of economic disaster to the producer, you apply that uniformly to all the major crops.

Those target prices do not cover the full cost of production for all producers. They do cover the out of pocket costs. They include allowance for machinery depreciation and interest on that machinery. They do cover overhead. They do include a return to management, and they cover a partial return to land. Therein lies a key source of difficulty in using a cost of production standard and that is the valuation or the return that is provided to land. I personally believe that the levels that are provided, if one recognizes that these are minimum levels of protection, the current rate of return between 3 to 4% on land is about as one could expect. Otherwise you'll be guaranteeing a rate of escalation in land prices that makes investment in U.S. agricultural land very attractive and that in turn leads to significant potential problems in terms of the structure of agriculture.

The rest of the farm bill is similar. There is one other significant change that is designed to give the farmer greater flexibility in the use of his resources than ever before. For years and years the farm programs have been administered on the basis of allotments or bases. What one did in the past influenced what he could do under the program. If he had to set aside land, it had reference to his allotment. The allotments were based upon a pattern of production that existed in the case of wheat and cotton back in '53 and '54 and for feed grains in 1959-'60. How the present pattern of production in the United States is very different than it was back in the '50s and so this bill has a different twist to it. It says let the programs operate on the basis of what the person wants to do, deems desirable to do, in the year of concern. So the old allotments and bases don't really have any relevance to the present set of programs. When you have set aside, as we have announced for wheat a 20% set aside, and we're working on the question for feed grains, the person complies with the requirement for setting aside whatever percentage is required. For example, if a person decides, based upon the land resources he has, his looking at market prices and expectations and knowing what the provisions of the farm program are, that he should plant 100 acres of wheat, then he has to set aside 20. Now it doesn't make any difference to us if he planted zero wheat last year of 1,000 acres of wheat last year. He is free to use those resources. They're his and he's the one that should decide how to use them.

As I said, we have announced a set aside program for 1978 crop wheat. That decision was made on the basis of very early estimates, and very uncertain estimates, but it does appear that even with our committment to reserves and our committment to stocks that if there had not been a set aside, the odds were high that there would be another increase in wheat stocks. Even at 20% if the weather's just a little better than average, we very likely will have an increase; unless on the other hand the weather is bad here or somewhere else in the world, then we'll draw down stocks. With the committment to reserves that has been made and the committment to stocks, we would appear to be adequately protected against one bad year, as bad as any we've had. So your odds of having a set aside and its potential for extreme moves in prices rests upon those odds associated with having two bad years back to back. Now the world did have that in 1974 and 1975, but the odds are relatively low. If that does happen, there is no set aside program that anybody can formulate in one country of the world that is going to make any real difference. When you have a situation where under a set aside on wheat you may make 10 to 15 million tons difference at the most, 10 I would say at the most, you won't even get 10 in a 20% wheat program, 10 million tons difference in production; but even if you did, think of that in terms of the year to year change. We've just seen over 60 million tons difference from 1975 to 1976, basically weather related.

In closing let me talk briefly about the international side of it. Our basic ideas and concepts with respect to reserves have been tabled in principle and were discussed most recently at London under the auspices of the International Wheat Council. There will be another discussion session coming up very soon that will lead to the resolution of the question — "Should we enter into a negotiating session with respect to an international wheat agreement?" A major component of those discussions is the question of an international wheat reserve, international food grain reserve. It is my understanding that those discussions have proceeded in a very positive way, and we're hopeful that they can be successful. Our position, I think, is very clear on that. We believe that importing and exporting countries should share in both the costs and the benefits of reserves. We have also taken the position that if the world agricultural plan is out of adjustment and if production is chronically in excess of requirements that it shouldn't be only the responsibility of the United States to bring that plan back into line. So when we formulate set aside programs, it is not with a view toward correcting the world's excess if such is the case, but it is for us to do what we perceive to be our fair share if you will.

On the sugar agreement it does seen to be that those negotiations have moved forward and leave most parties relatively optimistic that there will be an agreement. In one way or the other our prices will be moving up to the target level; that is, either in the international agreement or in the new farm bill.

We have approached and we are continuing to work at the multilateral trade negotiations, the M.T.N., those negotiations had been at dead center and nothing was happening for some time. That impasse has been broken, and at least people are talking together and moving forward toward the time when very soon we'll be making requests and engaging in serious talks and negotiations in that context.

Finally, in connection with our responsibilities to The World Food Council the Secretary was at Manila. The Administration has been trying to take a positive attitude toward working with everyone. These are common problems. It's not just a problem of developing countries or developed countries. These are world problems, and we believe that we should approach them in a positive manner and seek realistic solutions to them. The President himself is very interested in having our food assistance programs reviewed, our policies with respect to world hunger and so on. I'm sure before long we will see initiatives and new efforts in connection with those areas. With that I leave you.

CHAIRMAN SMITH: Thank you very much, Mr. Hjort. That was very informative and useful. I'm sure we all agree very much, Mr. Hjort, that it is important to farmers, to consumers and to the agricultural supply industry that there be a certain degree of continuity in farmers' wellbeing and economic situation from one year to another. We also agree and have come to realize quite fully in the last few years that fertilizer is price sensitive, something that was not too evident before because the prices were always so extremely low in relation to all other farm related prices. We agree fully that it is good for all concerned that there be a certain degree of continuity in the relationship between agricultural supply prices and farm product prices.

I am pleased that Mr. Hjort mentions that there is progress on the international scene, after a few years some initiatives made, but because of the improved supply situation, I believe, these have languished as he indicated. Certainly it is good to know that these initiatives are moving forward.

Perhaps Mr. Hjort would accept two or three questions. Do any of you have one?

CHAIRMAN SMITH: I noticed that there was an article in the New York Times this past Sunday quoting Mr. Hjort and the Secretary. Let me read one paragraph. Maybe you've covered it. "And instead of paying wheat subsidies based on allotments next year the Agricultural Secretary will base them on a world usage of 1.8 billion bushels. If the total American wheat crop exceeds 1.8 billion bushels the subsidy paid each farmer will be reduced a percentage of that excess." Now I don't know if that's a fair question or not. Do you want to comment any further on it?

MR. HJORT: What they are referring to there is that under the bill if the 1978 wheat crop is less than 1.8 billion bushels then the target price which is the level of protection to producers' income goes up to $3.05. If the production is more than 1.8 billion bushels then the target price is $3.00. Now what that means is that a person is protected based on his normal yield and under the new program X a proportion of the acres that he has planted for harvest in that year of concern X the difference between the market price and that target price. So our producers can qualify for a guarantee to have 100 percent protection on their acreage. If they don't go to that extra step to qualify for the 100 percent the amount that they receive will be based upon the relationship or the ratio that results from looking at the acreage that would be required to satisfy the needs of the United States including exports and so on and what has actually been planted and harvested. If that turns out to be 90 percent or 95 percent whatever that percentage is will determine what proportion of a person's acreage will be covered under the program.

CHAIRMAN SMITH: Let me ask one further which may or may not be a fair question; I'm not sure. Do you have reasonable confidence that the program as it's now constituted will in fact result in roughly 20 percent reduction in wheat acreage? Do you think it's really likely to happen?

MR. HJORT: No, we really don't. You will have a relatively high rate of participation in a wheat program because the difference between the market support price and this target price is high, and he qualified for that target price payment by participating in a set aside program. So we believe that there will be a high percent of participation. We conclude roughly something like this — that a 20 percent set aside requirement would mean a reduction in acreage of about 15 percent and a reduction in production of 8 to 10 percent, something like that.

That's another major point. Realism suggests that when producers take land out of production they are going to take land that is of the lowest productivity. In addition on those lands experience has told us that the land that they keep in production they do tend, given any relationship between fertilizer price and grain price, they tend to fertilize those acres that they do keep a little more heavily. For both those reasons you end up with a relatively small change in production for a given set aside requirement. Now we're not concerned; as a matter of fact, we're encouraging people to take that land out of production first that really doesn't belong in production. Under the previous programs farmers used to have to sign this thing that said they had taken land of average productivity out of production, and I've quipped a few times some poor fools did. We've tried to take that out of there because you might as well try to improve the quality of our basic land resource. So we've even gone one step farther. We've said, "If you want to put that land into a permanent or enduring cover, a practice of some kind, conservation practice, you'd be eligible for the cost share benefits under the A.C.P. program, the programs we have to do that." So I think that's an important point. You do want to take advantage of this and pull those lands out that are not very productive, but you need to recognize that if you do that your reduction in production will not be all that great.

FRANK ACHORN: Do you put any limits on your food reserve program?

MR. HJORT: Yes, we did. Out of that 30 to 35 let me stay at 33 for just a moment, 33 million tons. Fifteen of that would be wheat and about nine of that fifteen would be in the farmer owned component of the reserve. The other six would be in emergency international food reserve owned by Commodity Credit Corporation, owned by the Government, the taxpayers. That would be available for certain nonmarket considerations unless and until we get an international agreement. Then with that it could probably be used to fulfill some of our obligations under that. The other component of the reserve is about one million tons rice and seventeen or so feed grains with almost all of that being in farmers' hands. We don't want the stuff in Government ownership. We don't want to be getting into this business of building bins and so on. So we've tried to design these programs to make it attractive for a producer to hold it and have incentive and encouragement for him to release it when market prices rise to a certain level.

QUESTIONS FROM THE AUDIENCE: Mr. Hjort, with the reserve it seems to me it makes it more viable to enter into long term contracts with other nations, such as Russia. Is it the Department's intention to pursue this?

MR. HJORT: It is absolutely right. You just have to have a reserve of some kind to be able to think about providing the assurance either formally in agreements or understandings, whatever it is. First I would take from the food aid side. We've had the authority it turns out for years and years to have multiyear agreements under Public Law 480, but seldom have they been used. Now I've lived in some countries, and I've talked to several planning commissions and finance ministers and so on and I know it's very, very difficult to base a component of your development plan on P.L. 480 if you have to deal only with annual contracts and especially when that basic P.L. 480 has a clause in it that says the commodity shall be provided for food aid and food assistance if they're in excess of domestic and normal commercial requirements.

Now there were some small changes made in the Law this time to add developmental purposes, but there is one of the first places where I'm encouraged and I think we're moving forward — the ideal of multiyear contracts. Tie in with their development plans, tie to their development objectives, work with them and let this food aid be used to move toward those objectives in a consistent way. Give them the assurance and the stability needed. That's partly why I said food policy is very likely to be dictating farm policy. If you make that committment for five years then you have to be able to live up to it, and that means it feeds right back into your set aside policies, your whole farm policies reserves and all the rest of it. As far as the commercial markets, and so on, we are continuing to explore that possibility. As you know, we have understandings from the previous Administration with several countries, with Japan and Taiwan, and in some cases these are understandings with the private trade. Norway is like that for example, Israel and so on. There is a lot of interest in it; but basically what it amounts to is if we're going to be successful in international markets, we just have to be able to convince those who rely upon us that we will be a reliable supplier. On one hand that means we have to have a supply to be able to supply, and it also means that our products have to be quality and I think we've made important moves on both those fronts.

CHAIRMAN SMITH: Are there other questions? If not, Mr. Hjort, we certainly appreciate very much your taking time from an extremely busy schedule that you have to meet with us this morning and to give us what I think was a very comprehensive and informative picture of agricultural policy today and your forward planning. We appreciate it very much indeed. We'd be happy to have you stay with us for our continuing program. If not, we fully understand. In any case we certainly appreciate it. [Applause]

CHAIRMAN SMITH: Our moderator for the rest of the morning is Bill Sheldrick, a longstanding, active participant and director of the Round Table, and I add very fortunately is a most genial chap. When with Fisons Ltd. in England he usually found a way to attend these meetings. He is now Chief of the Fertilizer Unit, World Bank, here in Washington. Bill has contributed much to the fertilizer industry and is now doing a magnificent job at the World Bank. Bill, will you please take over? [Applause]

MODERATOR WILLIAM F. SHELDRICK: Mr. Chairman, members of the Round Table. I would just like to say that I very much appreciate the opportunity to act as moderator this morning. I'm not a U.S. National. I'm not actively in the U.S. fertilizer business, but I have been associated with the Round Table for many years. I think it is a unique organization that allows people like myself to in some way get involved. So I really do appreciate this honor.

It has been customary on the first morning of our meetings to take a broad look at the fertilizer scene both nationally and internationally, and it has, in fact, become more customary to look at the NPK situation. So we have three papers this morning that look at nitrogen, phosphate and potash in turn. We're also going to have a look at some of the possibilities for new technology and possibilities that exist for making ammonia from gasification of coal. So I think that you should find it a very interesting morning.

Our first speaker this morning is Bill Threadgill. He's down on our program as William Threadgill; and when I asked him if he didn't mind me being personal and calling him Bill, he said it's a mistake actually the William; his name is Bill. So it's Mr. Bill Threadgill. He's going to talk about the nitrogen supply-demand into the 1980's. Bill is a graduate of the University of Oklahoma in chemical engineering. He's the group vice president of his company, Farmland Industries, and he's responsible for three divisions — the fertilizer division, seeds and agricultural chemicals. Farmland is, of course, the largest cooperative, and it's certainly one of the largest producers of nitrogen. So I am sure that Bill can speak in a very authorative manner about the future supply situation. Bill please come to the rostrum to present your paper. [Applause]

Nitrogen Supply-Demand to 1980's

Bill W. Threadgill

Thank you Bill. Good Morning. I'm certainly glad to be here today to be part of this "Round Table" discussion. I think the topics which we will discuss today are the most frequently discussed subjects of the present AG era. This subject is not only discussed at hundreds of monthly board meetings but is also the topic of thousands of farmer bull sessions. As we know, the infinite number of variables which affect the future of N-P-K prevent clear cut answers to the questions or solutions to the problems. The only thing we know for sure is that the farmers are asking the same questions which we and other boards of directors ask. What? When? How much? Cost?

I have been asked to discuss the "Nitrogen Supply-Demand Situation Through the 1980's". I want to stress the "through 1980's". That means we are looking down the road 13 years. I am sure that we all agree that 13 years is not far away. All we have to do is stop and think back to 1964 to realize how quick we will be through the 1980's.

In today's rapidly changing world, I wonder if we can imagine what the next 13 years hold for U.S. agriculture. Let me point out what I mean by reviewing what has happened in the past 13 or so years.

Since the '60's, agriculture has become the bulwark of the U.S. Economy. Our 2.8 million farms constitute one-fifth of all the private business in this nation. Farmers this year will spend about $85 billion on production expenses and another $40 billion on family living. They operate more than 4 billion tractors and about 3 million trucks. They maintain assets of around $600 billion and pay interest on more than $90 billion in loans. The production, processing and distribution of food and fiber accounts for one-fifth of the U.S. gross national product and provides jobs for 15 million people — more than 15 percent of civilian workers.

Exports have become basic to U.S. farm growth and income. Farmers harvested 337 million acres last year — the most in two decades, and about 100 million of those acres produced for export. That is double the number in the late 1950's and half again the acreage for export late in the 1960's.

Exports this year will total about 100 million tons — double the volume of the middle 1960's. U.S. farmers have been exporting one-half or more of their wheat, soybeans and cattle hides; one-third of their cotton and tobacco; a fourth of their feed grains and sizeable share of many other commodities.

Farm export value this fiscal year is expected to be a record $24 billion. This is the fourth consecutive year of foreign shipments above $21 billion. It is triple the value of those exports just five years ago. Exports alone now bring in about one-fifth of farm income and generate more than one million jobs, on and off the farm.

There is no magic to the rapid rise in U.S. farm exports over the past five years. You are familiar with the story. Rising populations and rising incomes throughout the world created demand for more food. Crop shortfalls in major regions dropped production below that demand. Here at home, more competitive pricing policies for U.S. farm products starting in the mid-1960's pointed agriculture toward the foreign market. When the big export opportunity came, U.S. farmers seized it, putting all their resources to work filling the gap between global supply and demand.

You can see by this review how quickly agriculture has changed and how fast new problems which affect the total world of U.S. agriculture arise. Now let me address myself to one small segment of this massive industry we call U.S. agriculture. The "supply-demand situation of nitrogen through the 1980's."

Many dramatic changes in fertilizer production are taking place in anhydrous ammonia production and consumption throughout the world . . .

Slide No. 1 illustrates the dramatic increase in nitrogen consumption world-wide since 1960. You will notice that last year, the world consumed 43 million metric tons of N, about four times the amount consumed in the United States and Canada. From the very beginning of synthetic ammonia production, more than 64 years ago, the industry has expanded to an output of nearly 200,000 tons daily. There is no other fertilizer which has played a more important role in increasing the food supply of the world and protein content of grain.

The current world ammonia capacity stands at almost 92 million metric tons of ammonia or 75 million metric tons equivalent N.

In addition, during the next four years to 1980-81, some 105 new plants are scheduled to be built, bringing total world capacity to approximately 98 million metric tons of N, an increase of 23 million metric tons.

Of particular significance is the change in regional distribution of this huge increase in capacity. Many countries which have imported nitrogen in the past will soon be exporting a substantial volume.

For example, Indonesia and Mexico will become substantial exporters. In addition, the two largest import markets for solid nitrogen, the people's republic of China and India, will reduce substantially the gap between domestic production and consumption, exporters of solid nitrogen materials, such as Japan and West and East Europe, will soon find increasing competition from the gas-rich countries from the middle East and north Africa. Already, producers in Japan have shut down several uneconomical ammonia-urea plants.

Large scale expansion of ammonia capacity is also taking place in Russia, where some 32 new generation centrifugal plants are planned to be on stream by 1980. It is estimated that by 1980, around 2.75 million metric tons of N as ammonia and urea materials will be exported from the USSR.

If all of the ammonia plants scheduled to come on stream in the world operated at the high level of efficiency of those of those in Canada and the United States, there would be a seemingly overwhelming tonnage available which probably could not be consumed . . . .

Slide No. 2 shows the relationship of world ammonia supply and demand to overall capacity. These figures indicate that supply will run only about 56% -60% of nameplate capacity. Many of these new plants are in areas short on skilled labor and their utility infrastructure is not substantial enough to support a higher level of production . . . .

Slide No. 3 illustrates the consumption of N in the United States. Although many experts were predicting that the United States' farmers would use more moderate amounts of fertilizer this year as compared to last year, it was gratifying to find that nitrogen use was up 6% to approximately 9 & 10 million metric tons of N . . .

Slide No. 4 illustrates the supply-demand situation in the United States. Please note that the effective synthetic ammonia capacity this past year was approximately 13 million metric tons of N and, about 9 million of that was used for fertilizer consumption. By and large, effective capacity was very much in balance with total demand as you can see from where the lines cross . . .

Slide No. 5 [Table] shows the specific uses of ammonia in the U.S. for the years 1973 through 1977, as well as the forecast for 1980. Of particular significance this year was the 6 percent increase in consumption for fertilizer use with a modest increase in feed and industrial use (approximately 25% of the total synthetic production). We are pleased to see that there have been inventory reductions and the industry finished the year in good position. It may be surprising for some of you to see that almost 8 percent of total production is lost during conversion to other forms of nitrogen products and through storage and handling. You can also see that exports and imports are approximately equal at this time, that is approximately 1 million metric tons per year.

I know that all of you will be interested to look at the forecast of nitrogen balance for 1980. The last column shows these figures.

First of all, United States' fertilizer nitrogen consumption should rise to about 11.2 million metric tons of N. This estimate is based on an increase at a compounded rate of only 4 percent per year. Although the rate of consumption of nitrogen has been in excess of 6 percent during the past two years, the huge harvests of wheat, corn and other feed grains, not only in the United States and Canada, but also in many other areas of the world, have resulted in dramatic increases in the carryover of grain stocks on a world-wide basis. The U.S. wheat crop this year will be about 2.4 billion bushels and the corn crop will be about 6.1 billion bushels. World wide supplies seem more than adequate and prices expected to remain relatively depressed.

Summing it up, with an ammonia plant capacity of about 23.3 million short tons, operating at 89 percent efficiency, and with a very small increase in imported ammonia, inventories on hand at the end of the fertilizer season should rise by 800,000 tons.

Now, let's add the total U.S. production to the nitrogen imports that may come into the United States from new plants which are now on stream or will be coming on stream within the next three years. If these foreign plants operate at 90 percent of design, there could be available an additional 4.5 million metric tons in 1980, an excess of 2 to 3 million metric tons of N.

There are several possible alternates to absorb this potential oversupply. I want to review five of these.

First, the U.S. can increase exports in some form of nitrogen materials, as ammonia, urea and DAP.

A second possible alternative would be to decrease gas availability in the United States, curtailing production.

The third alternative is the most realistic. Producers will be forced to make economic evaluations of the old plants where increased costs will make them essentially non-competitive. In 1976, 57 percent of capacity is on natural gas supplies with costs of less than \$1.00/MCF. Compare this with the situation in 1978, where only 15 percent of capacity will be at less than \$1.00/MCF. Government regulating agencies have indicated that the prices of natural gas will be increased to a level (\$1.75 - \$2.10/MCF), causing production costs to pyramid. Costs of new plants are going up . . .

The fourth alternative relies on plant obsolensence. There are 110 ammonia plants now operating in the United States. It appears that within five years, 18 of these may become non-competitive.

The fifth alternative involves nitrogen consumption by the farmers. If farmers used the amounts of nitrogen which are recommended by the various agricultural colleges and experiment stations, nitrogen consumption within the next five years would be increased by an additional 1 to 2 million metric tons per year.

Obviously, growers have a long way to go in reaching optimum levels of production through nitrogen fertilization. We know that the cornbelt is by far the largest consuming area using over 1.5 million metric tons of N. As expected, corn is the principal consumer of nitrogen fertilizer, with wheat ranking second.

If one or more of the alternate suggestions are implemented, it is likely that the apparent capacity which will become available, could result in supply-demand balance as early as the 1980-81 season.

Gentlemen . . . in the last few minutes, we have discussed the expected growth pattern of the world's nitrogen industry. We reviewed the consumption rates of the U.S. and world. We also talked about the new production which is expected to come on line in the U.S. as well as in other nitrogen fertilizer producing countries. And we concluded that by 1980 or 1981, the nitrogen supply-demand could be balanced.

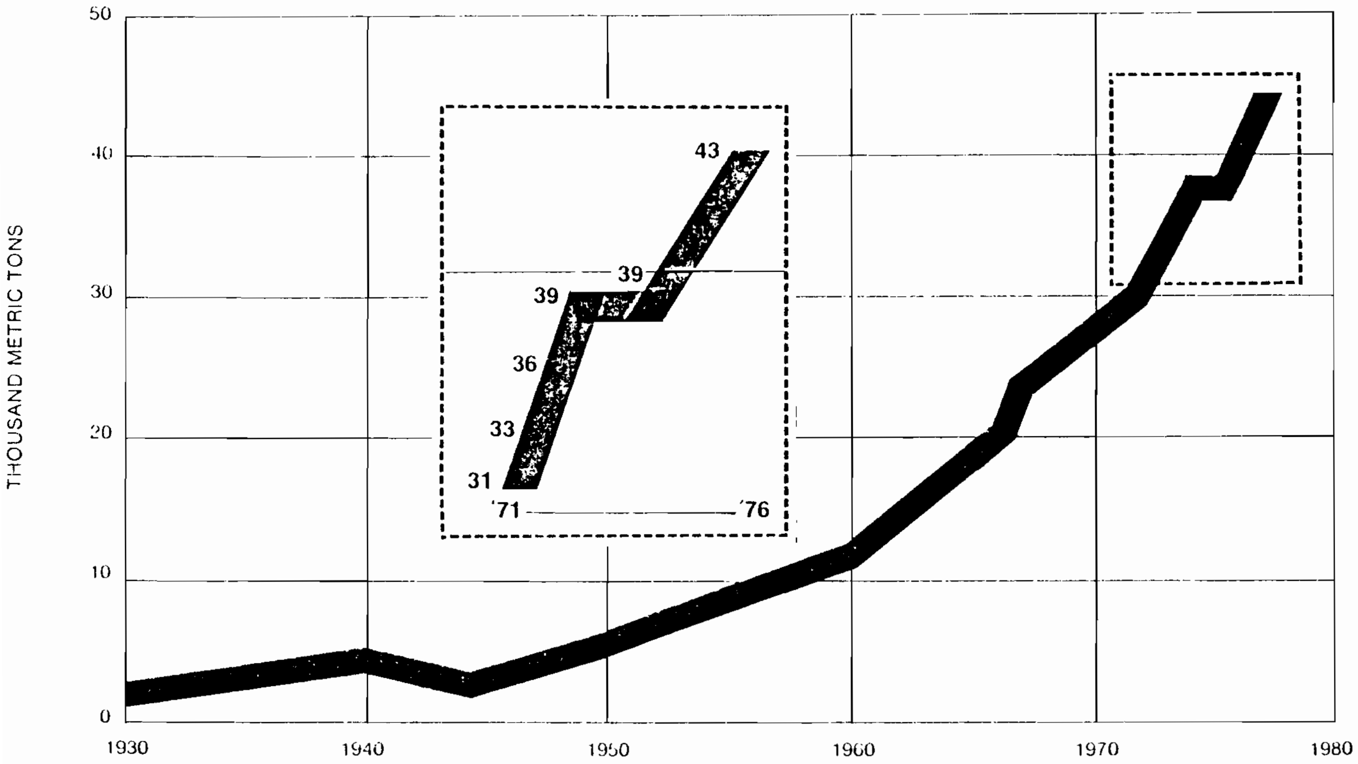
But, let's not be lulled into thinking that the nitrogen industry is so astute that it will escape the perils of the future. There will be growth pains dictated by energy policies and farmer practices. However, the future looks as bright as ever. I heard on the news that by the year 2000, there will be 179 million more people in the U.S.

Gentlemen . . . these people have to eat and that looks like a pretty good market to me. Thank you. [Applause]

Note: Slide #1 thru #5
continued on pages #11 thru #13

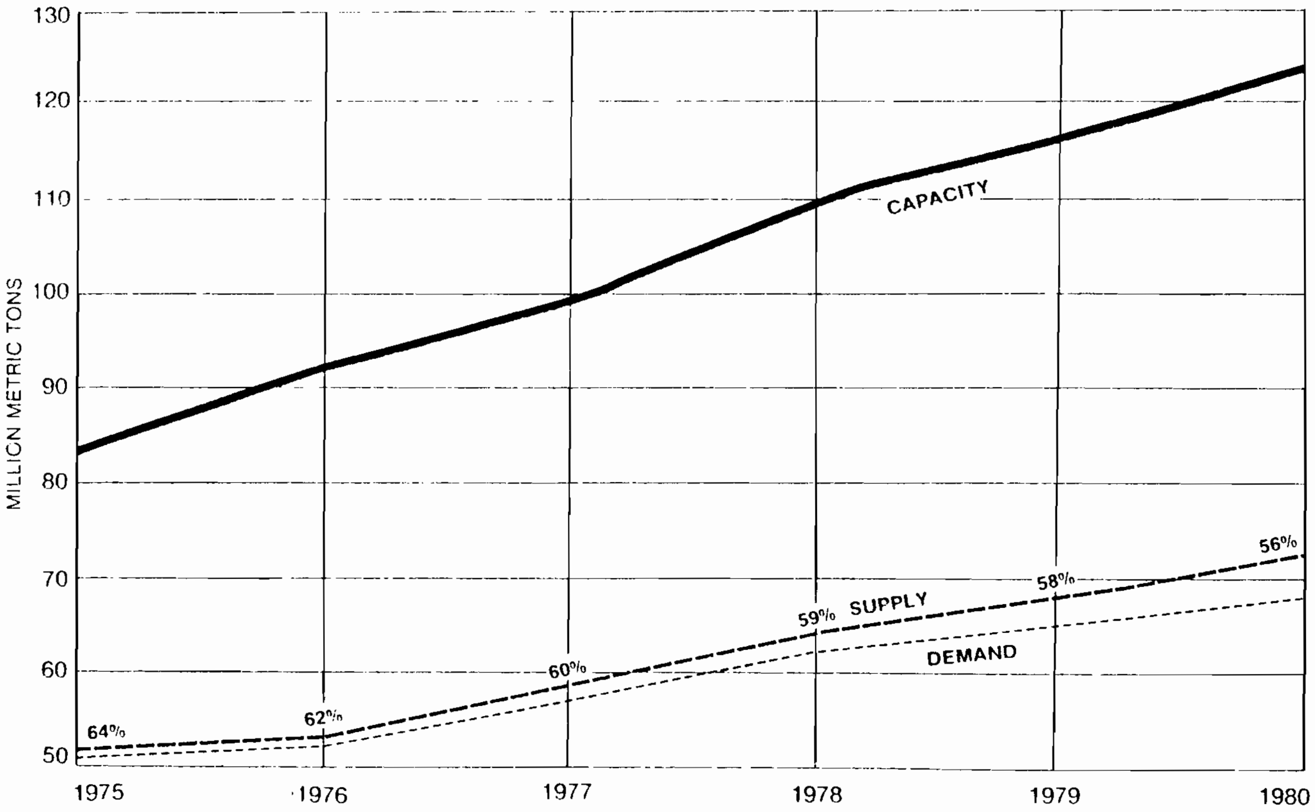
SLIDE NO. 1

WORLD NITROGEN CONSUMPTION



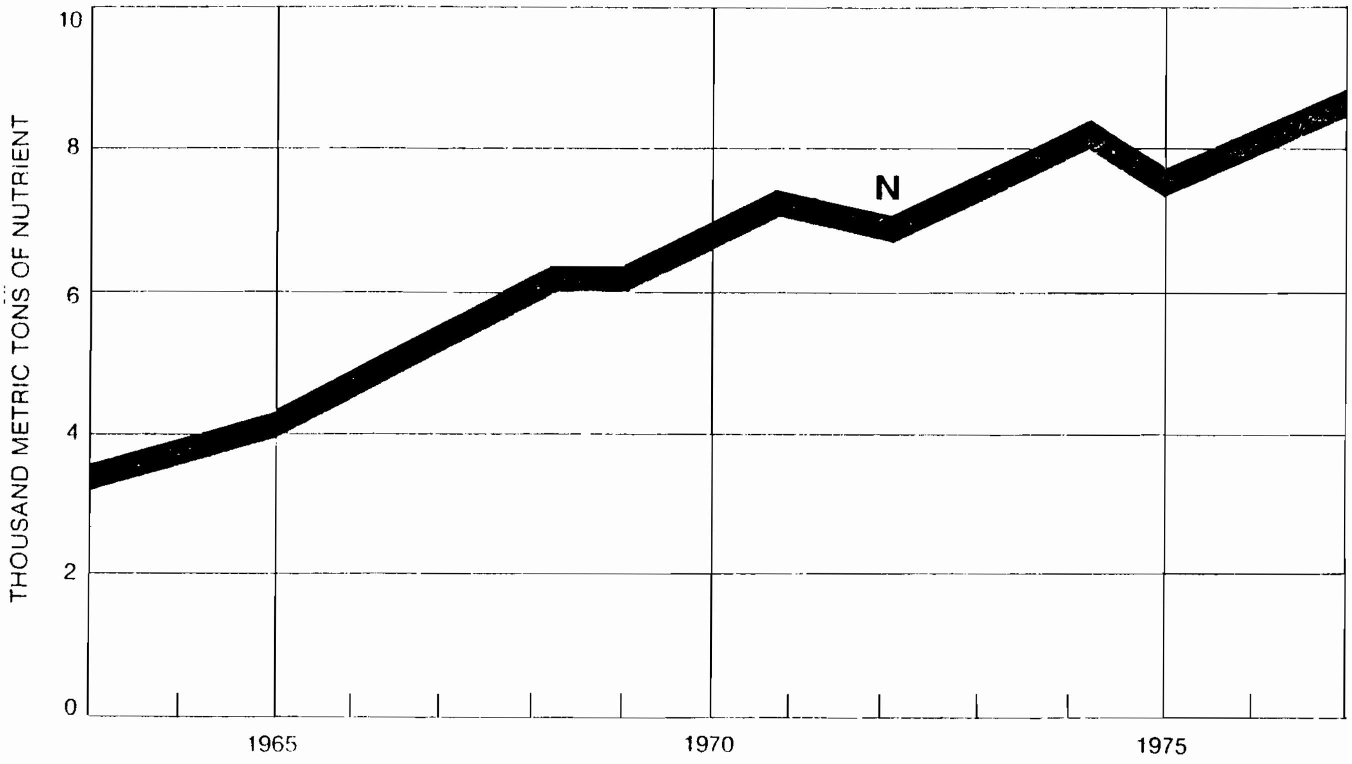
SLIDE NO. 2

WORLD AMMONIA SITUATION SUPPLY-DEMAND OUTLOOK



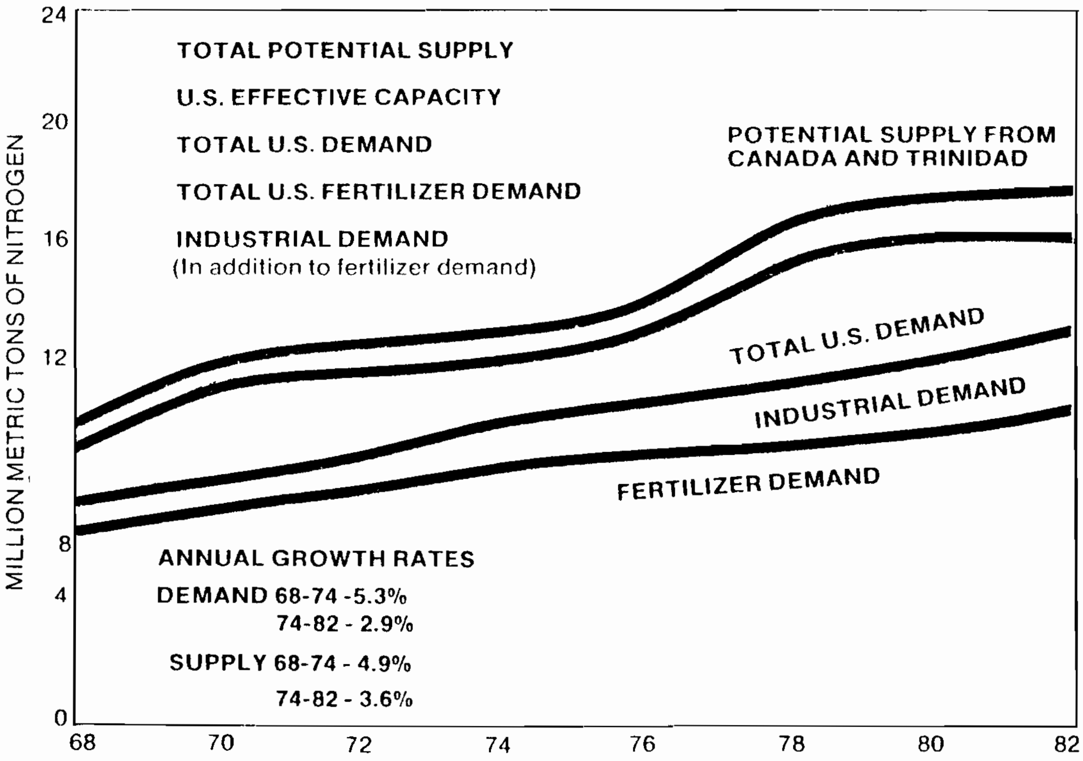
SLIDE NO. 3

UNITED STATES NUTRIENT CONSUMPTION



SLIDE NO. 4

UNITED STATES NITROGEN SUPPLY/DEMAND



SLIDE NO. 5

U.S. NITROGEN SUPPLY/DEMAND BALANCE

(THOUSAND METRIC TONS OF NITROGEN)

	1972/73	1973/74	1974/75	1975/76	1976/77	FORECAST 1979/80
USES						
Fertilizer Consumption	8,295	9,124	8,608	9,381	9,944	11,186
Feed and Industrial Uses	2,500	2,650	2,600	2,903	3,200	3,750
Inventory Change (Est.)	197	19	919	414	200	1,000
Losses (8% Syn. NH^3 Prod.)	990	1,020	1,030	1,058	1,130	1,400
Export	1,508	1,244	1,093	1,113	1,000	1,000
TOTAL	13,490	14,057	14,250	14,869	15,474	18,336
SOURCES						
By-Product and Organic	200	200	200	200	200	200
Synthetic Prod. (89% Capacity)	12,408	12,785	12,869	13,454	14,318	16,981
Imports	882	1,072	1,181	1,215	956 a	1,155 a
TOTAL	13,490	14,057	14,250	14,869	15,474	18,336
OPERATING RATE						
Synthetic Capacity (340 D/Y)	13,530	14,390	14,390	15,117	16,088	19,080
NH^3 Equivalent	16,507	17,556	17,556	18,443	19,627	23,278

a Needs based on all other projections on the table.

SOURCE. Various Government Statistics.

MODERATOR SHELDRICK: Bill, I wonder if you would care to come and sit up here to perhaps take a few questions. We've had an excellent presentation, gentlemen, and I know from the work that we're doing in the World Bank some of these very, very important issues have been raised. The one I'm interested in particularly is the supply of nitrogen from the U.S.S.R. I think Bill mentioned 30 odd plants. I read recently that the 40th plant had just been announced. Plants to be built according to mainly U.S. technology financed by the Japanese, I think. Somehow we're going to have about three million tons of ammonia available; and as far as we can see, it hasn't any home as urea; and pipelines and terminals are being built, and this ammonia has to come onto the market somehow and somewhere. One of the things we don't know is the timing of this. Is the Russian program going according to plans? Is it going to be delayed? Bill did mention a figure of, I think, 350,000 tons coming in from somewhere in the late '70's; and if I can perhaps open the discussion, I would like to ask him if he has any more information on this particular scene.

MR. THREADGILL: Well, in regards to my information, as far as the 350,000 tons is concerned, officially no; but by a very direct source I understand that we will have about that much beginning to come on in January which this guy says may be a little bit later but would have that much availability by then. That's about the extent that I know about it. I've seen this speculation by a number of people, enough that I believe it.

MODERATOR SHELDRICK: Thank you, Bill. Well, gentlemen, can we have more questions please. It seems as if you've answered all the questions that would have been asked, I think, in your talk; but I think perhaps it is the sort of information one has to look at and think about and reflect on it. If there aren't any more, I'll now proceed to make my own presentation.

Rodger has introduced me in much more glowing terms then I feel I would have liked. So, Bill Threadgill if you'll stay with us. Thank you. [Applause]

Phosphate Supply-Demand To 1980's

William F. Sheldrick

INTRODUCTION

The main purpose of this short paper is to present phosphate supply/demand projections into the 1980's but, before doing this, it is useful and important to look back at previous performance in projecting future demand and also to explain the basis for the current projections.

Forecasting of future fertilizer demand has up to now usually been a relatively simple matter very often only requiring a new or unique equation or a crystal ball, or perhaps just a "gut" feel. The era of the world food crisis in 1972-1974 saw a plethora of new projections from both international agencies and industrial associations and so-called experts on the subject. Such statements as "there will never be enough fertilizer again" were well publicized, and it was small wonder that the extreme and often ill-founded statements on this subject did much to promote the panic-buying that occurred during this time and evolved a major resolution from the World Food Council that the international agencies should carry out an authoritative analysis of the future supply/demand situation which would help to avoid cyclical imbalances. As a result of this, the UNIDO/FAO/World Bank Fertilizer Working Group meets twice a year to harmonize supply/demand projections and the work of this Group and their latest forecasts on supply/demand are discussed later.

ANALYSIS OF PAST PERFORMANCE IN PROJECTING PHOSPHATE DEMAND

A survey has been carried out of the demand projections that were made between 1963 and 1973 by the main international agencies, some industrial associations and one or two well-known experts in this field.

In Figure 1, these past projections are plotted together with actual consumption up to 1976, and it is extremely interesting to see how in fact these figures compare. Up to about 1965, demand projections were circumspect assuming that demand would increase at about 6% per annum. In the event, these projections were reasonably accurate as demand increased on a world basis by 6.5% on average per annum between 1963 and 1970.

After 1968, however, projections were much more optimistic and whereas between this period and 1974 the average growth rate continued at about 6.5%, the average projection anticipated a growth rate of about 9%. In 1972, which was a particularly bountiful year for new projections, the average annual increase in demand anticipated for the next eight years was about 8% but the regression that occurred in 1974 obviously dampened the optimism of the analysts and the revised projections that have been made after 1975 show only a growth rate of 6%.

Although in terms of annual growth rates, the differences between these figures may appear to be small, on a compounded basis they are soon expanded to very significant differences. For example, whereas it was predicted in 1973 that the world demand for phosphate would grow to about 38-40 million tons by 1980, three years later the same analysts predicted that demand will now only reach 35 million tons. Not all of this difference can be accounted for by the fall in demand that occurred in 1974/75.

North America

Our performance in predicting phosphate demand in North America has been similar to that for the world. Once again, a great deal of optimism and, in the event, consumption falling well below anticipated demand. The experience of the last few years has clearly demonstrated that we have been particularly unsuccessful in predicting future demand for phosphate and no doubt this must be one of the contributing factors to the over-capacity situation for phosphates today.

One of the greatest errors arising in forecasting fertilizer demand is that planners fail to differentiate between fertilizer need and fertilizer demand. This was certainly the case a few years ago, although it does appear in the light of past experience, that much more attention is now being given to this difference today. Fertilizer need and requirement is the level of nutrients to achieve an adequate level of food supply to support the population. Demand or sometimes "effective demand" as it is known, is the quantity of fertilizer that the farmer is expected to buy, taking into account all the constraints of infrastructure as well as availability of fertilizer at the farm level. In developing countries in particular, limitations in fertilizer infrastructure are proving an increasing constraint to fertilizer usage.

UNIDO/FAO/WORLD BANK FERTILIZER WORKING GROUP

One of the main functions of this Group is to prepare authoritative five year supply/demand balances for fertilizers and also long-term demand forecasts. The projections are used as a basis for discussion at the World Food Council and the FAO Fertilizer Commission. Recently UNIDO has also agreed that the supply/demand projections of the Group will be used as a basis for the UNIDO Fertilizer Consultation meetings which are examining long-term fertilizer requirements until the year 2000. Apart from the International Agencies, most of the fertilizer Industrial Associations and certain Governmental Agencies are represented in the Group.

Basically, the operation of the Group is based on a Delphi system of analysis by which contributions are obtained from the leading sources of fertilizer statistics from Industry and the International Agencies. Up to now, these meetings have been convened very successfully to produce harmonized supply/demand projections for the next five year period which are used as a basis for international planning. One obvious advantage of this system is that it combines several different types of analysis and methodology and the judgement of about 20 of the world's leading fertilizer analysts.

A major objective of the Group is to provide reliable information on the supply/demand situation which will help to reduce the cyclical imbalances which have plagued the fertilizer industry in the past.

WORLD PHOSPHATE FERTILIZER SUPPLY CAPABILITY

Supply/demand and balances for phosphate fertilizers, prepared by the UNIDO/FAO/World Bank Fertilizer Working Group and which were presented to the FAO Fertilizer Commission meeting in Rome in September 1977 are attached. Explanatory notes on the assumptions on which the projections are based are also given.

World Situation

It is estimated that in 1976/77 there was a surplus supply capability for fertilizer phosphates over demand of about 3 million tons of P_2O_5. Most of this occurred in North America and Western Europe and to a lesser extent in North Africa.

World use up to the mid-1980's is expected to increase at an average rate of 5.5 — 6.0% which is lower than historical growth rates. Most of the growth in anticipated consumption will take place in Eastern Europe (Including the USSR) and Developing Countries. If further plants are not closed, the current oversupply of phosphate will persist for several years but will gradually decrease to about half a million tons of surplus by 1981/82. The major surplus regions are North America, Africa, Western Europe and the Near East. The deficit regions are Eastern Europe, Latin America and Asia, and it seems most likely that these deficits will be met by material from the USA and North Africa. The trend towards placing new capacity where the rock is located will continue.

The preliminary results that we have received for phosphates for 1976/77 indicate that growth rate in demand for that year may be slightly higher than projected in the tables. This, together with the fact that close-down of some plants may occur more quickly than projected in areas such as Western Europe could bring about a balanced situation a year or so earlier than is projected.

North America

It is forecast that phosphoric acid capacity and the potential supply situation will remain fairly steady over the next five years increasing only slightly. Demand in North America is forecast to increase at about 3-3.5% which would leave a surplus for export from existing capacity of about 2.6 million tons by 1981/82. North America (the USA) should retain its position as the largest exporter of phosphate fertilizers, but bearing in mind that a significant part of this P_2O_5 — 0.7 million tons by 1981 — could go to the USSR through the Occidental contract, the quantity of P_2O_5 available for export elsewhere may diminish.

Western Europe

No significant increases in phosphate processing capacity are projected for Western Europe, and it is expected that the total potential supply of phosphate within that area will remain more or less constant. Although the preliminary 1976/77 figures now available are also more encouraging, we have projected an average growth rate for Western Europe over the next five years of about 3.5%. Demand for phosphate fertilizer fell very sharply in 1974/75, and is not expected to attain the 1973/74 consumption figures again until about 1979/80. There will be a surplus of phosphate fertilizer in Western Europe over the next five years which may be aggravated by the fact that Europe has recently been importing significant quantities of phosphate intermediates and will probably continue to do so. It seems unlikely for cost disadvantage reasons that there will be any significant increase in facilities for the processing of phosphates in Europe and, in time, Western Europe is most likely to become a net importer of processed phosphates for fertilizers.

Eastern Europe

Eastern Europe, including the USSR, has been the largest consumer of phosphates in recent years. Unlike the other two big regional consumers, Western Europe and North America, the upward trend in Eastern Europe phosphate consumption was not interrupted as a result of the 1973/74 phosphate price increases. In the last few years, the average regional consumption has increased at about 7% and is expected to retain this growth rate over the mext five years or so. Information on this area is not freely available, and although it is known that Russia has large quantities of phosphate rock and apparently surplus mining capacity, the processing of some of the new rocks is proving very difficult, and this may be constraining the production of phosphate fertilizers. On the other hand, the National Plan calls for a large increase in phosphate fertilizer use and based on this, Eastern Europe is expected to show an increasing deficit in phosphates into the 1980's. This view is supported by the fact that Russia has contracted to purchase large quantities of phosphoric acid from the USA as part of the Occidental contract. There is also a new contract with Morocco to purchase large quantities of high grade rock which could be extended to include processed phosphates.

Africa

Phosphoric acid capacity will increase significantly in North Africa as new plants to rock producing areas come on stream over the next few years. In absolute terms, consumption will increase much less so that Africa will become a major exporter of processed phosphates as well as phosphate rock.

Latin America

Both capacity and consumption will develop rapidly in Latin America influenced mainly by the situation in Brazil. The region will continue to be a major importer of phosphate fertilizers well into the 1980's, most likely from the USA and Africa.

CONCLUSIONS

Although there would appear to be ample supplies of phosphate fertilizers over the next few years, the surplus will gradually diminish leaving a balanced situation around 1982. There will be some changes in trading patterns during this period with several rock producing countries either continuing or commencing to become more vertically integrated to produce and export processed phosphates.

The situation, however, leaves no room for complacency for a 1% increase in phosphate demand per annum, perhaps accompanied by early closure of smaller uneconomic plants, might well bring forward a balanced situation by about 1978/79. Bearing in mind the lead time of several years required to plan and build new phosphoric acid facilities, it is important that the supply/demand situation over the next two or three years should be carefully monitored to ensure that supply and demand do not prematurely and unexpectedly become out of balance. If this happened, we might have a similar situation to that prevailing in 1973/74. [Applause]

Table 1
WORLD PHOSPHATE FERTILIZER SUPPLY, DEMAND AND BALANCES

(Million Metric Tons of Nutrient)

	75/76	76/77	77/78	78/79	79/80	80/81	81/82
A. DEVELOPED MARKET ECONOMIES							
North America							
Phosphoric Acid Capacity	8.72	9.56	9.58	9.59	9.59	9.82	9.82
Phosphoric Acid Production	6.31	7.43	7.77	7.86	7.86	7.94	8.02
Other P_2O_5 Production	1.00	0.96	0.94	0.90	0.87	0.84	0.81
Total Phosphate Fertilizer Production	7.31	8.39	8.71	8.76	8.73	8.78	8.83
Consumption	5.26	5.28	5.49	5.69	5.89	6.03	6.18
Surplus (Deficit)	2.05	3.11	3.22	3.07	2.84	2.75	2.65
Western Europe							
Phosphoric Acid Capacity	5.00	5.16	5.37	5.52	5.75	5.75	5.75
Phosphoric Acid Production	1.57	3.88	3.98	4.10	4.25	4.34	4.36
Other P_2O_5 Production	3.52	3.44	3.36	3.27	3.18	3.09	3.01
Total Phosphate Fertilizer Production	5.09	7.32	7.34	7.37	7.43	7.43	7.37
Consumption	5.09	5.50	5.80	6.00	6.20	6.40	6.60
Surplus (Deficit)	0.00	1.82	1.54	1.37	1.23	1.03	0.77
Oceania							
Phosphoric Acid Capacity	0.20	0.20	0.20	0.21	0.21	0.21	0.21
Phosphoric Acid Production	0.05	0.12	0.12	0.13	0.13	0.13	0.13
Other P_2O_5 Production	0.77	0.92	1.01	1.11	1.20	1.24	1.27
Total Phosphate Fertilizer Production	0.82	1.04	1.13	1.24	1.33	1.37	1.40
Consumption	0.85	1.00	1.10	1.21	1.31	1.36	1.40
Surplus (Deficit)	(0.03)	0.04	0.03	0.03	0.02	0.01	0.00
Other Developed Market Economies							
Phosphoric Acid Capacity	1.36	2.16	2.17	2.17	2.24	2.24	2.24
Phosphoric Acid Production	0.52	1.04	1.28	1.35	1.37	1.40	1.40
Other P_2O_5 Production	0.47	0.46	0.46	0.45	0.44	0.43	0.41
Total Phosphate Fertilizer Production	0.99	1.50	1.74	1.80	1.81	1.83	1.81
Consumption	1.00	1.06	1.10	1.14	1.18	1.22	1.27
Surplus (Deficit)	0.01	0.44	0.64	0.66	0.63	0.61	0.54
Total Developed Market Economies							
Phosphoric Acid Capacity	15.28	17.08	17.32	17.49	17.79	18.02	18.02
Phosphoric Acid Production	8.45	12.47	13.15	13.44	13.61	13.81	13.91
Other P_2O_5 Production	5.76	5.78	5.77	5.73	5.69	5.60	5.50
Total Phosphate Fertilizer Production	14.21	18.25	18.92	19.17	19.30	19.41	19.41
Consumption	12.18	12.84	13.49	14.04	14.58	15.01	15.45
Surplus (Deficit)	2.03	5.41	5.43	5.13	4.72	4.40	3.96

Table 2
WORLD PHOSPHATE FERTILIZER SUPPLY, DEMAND AND BALANCES
(Million Metric Tons of Nutrient)

	75/76	76/77	77/78	78/79	79/80	80/81	81/82
B. DEVELOPING MARKET ECONOMIES							
Africa							
Phosphoric Acid Capacity	1.33	1.53	1.60	1.60	2.58	2.86	3.19
Phosphoric Acid Production	0.33	0.92	1.05	1.08	1.37	1.75	2.01
Other P_2O_5 Production	0.09	0.20	0.20	0.21	0.22	0.22	0.22
Total Phosphate Fertilizer Production	0.42	1.12	1.25	1.29	1.59	1.97	2.23
Consumption	0.37	0.42	0.47	0.51	0.55	0.60	0.65
Surplus (Deficit)	0.05	0.70	0.78	0.78	1.04	1.37	1.58
Latin America							
Phosphoric Acid Capacity	0.88	0.92	0.93	0.93	1.46	2.19	2.19
Phosphoric Acid Production	0.48	0.42	0.44	0.44	0.61	0.97	1.24
Other P_2O_5 Production	0.38	0.42	0.42	0.42	0.42	0.42	0.42
Total Phosphate Fertilizer Production	0.86	0.84	0.86	0.86	1.03	1.39	1.66
Consumption	1.51	1.77	1.96	2.14	2.33	2.51	2.67
Surplus (Deficit)	(0.65)	(0.93)	(1.10)	(1.28)	(1.30)	(1.12)	(1.01)
Near East							
Phosphoric Acid Capacity	0.79	0.98	0.98	1.13	1.17	2.25	2.25
Phosphoric Acid Production	0.41	0.47	0.53	0.59	0.65	0.99	1.31
Other P_2O_5 Production	0.14	0.22	0.22	0.22	0.22	0.22	0.22
Total Phosphate Fertilizer Production	0.55	0.69	0.75	0.81	0.87	1.21	1.53
Consumption	0.68	0.84	0.94	1.03	1.13	1.23	1.31
Surplus (Deficit)	(0.13)	(0.15)	(0.19)	(0.22)	(0.26)	(0.02)	0.22
Far East							
Phosphoric Acid Capacity	0.61	1.21	1.21	1.32	1.32	1.44	1.44
Phosphoric Acid Production	0.43	0.62	0.80	0.88	0.91	0.95	0.99
Other P_2O_5 Production	0.17	0.19	0.26	0.32	0.37	0.39	0.42
Total Phosphate Fertilizer Production	0.60	0.81	1.06	1.20	1.28	1.34	1.41
Consumption	1.12	1.27	1.50	1.73	1.97	2.08	2.25
Surplus (Deficit)	(0.52)	(0.46)	(0.44)	(0.53)	(0.69)	(0.74)	(0.84)
Total Developing Market Economies							
Phosphoric Acid Capacity	3.61	4.64	4.72	4.98	6.53	8.74	9.07
Phosphoric Acid Production	1.65	2.43	2.82	2.99	3.54	4.66	5.55
Other P_2O_5 Production	0.78	1.03	1.10	1.17	1.23	1.25	1.28
Total Phosphate Fertilizer Production	2.43	3.46	3.92	4.16	4.77	5.91	6.83
Consumption	3.68	4.30	4.87	5.41	5.98	6.42	6.88
Surplus (Deficit)	(1.25)	(0.84)	(0.95)	(1.25)	(1.21)	(0.51)	(0.05)

Table 3
WORLD PHOSPHATE FERTILIZER SUPPLY, DEMAND AND BALANCES
(Million Metric Tons of Nutrient)

	75/76	76/77	77/78	78/79	79/80	80/81	81/82
C. CENTRALLY PLANNED ECONOMIES							
Socialist Asia							
Phosphoric Acid Capacity	0.06	0.10	0.10	0.10	0.21	0.21	0.21
Phosphoric Acid Production	0.01	0.02	0.03	0.03	0.06	0.10	0.11
Other P_2O_5 Production	1.45	1.69	1.77	1.86	1.93	2.14	2.27
Total Phosphate Fertilizer Production	1.46	1.71	1.80	1.89	1.99	2.24	2.38
Consumption	1.48	1.64	1.75	1.86	2.10	2.25	2.40
Surplus (Deficit)	(0.02)	0.07	0.05	0.03	(0.11)	(0.01)	(0.02)

(CONTINUED ON NEXT PAGE)

Table 3 CONTINUED
WORLD PHOSPHATE FERTILIZER SUPPLY, DEMAND AND BALANCES
(Million Metric Tons of Nutrient)

Eastern Europe							
Phosphoric Acid Capacity	4.29	4.51	4.71	4.96	4.99	5.98	6.31
Phosphoric Acid Production	3.16	3.50	3.70	3.86	3.98	4.35	4.80
Other P_2O_5 Production	3.61	3.61	3.61	3.61	3.61	3.61	3.61
Total Phosphate Fertilizer Consumption	6.77	7.11	7.31	7.47	7.59	7.96	8.41
Consumption	6.73	7.50	8.08	8.65	9.23	9.80	10.40
Surplus (Deficit)	0.04	(0.39)	(0.77)	(1.18)	(1.64)	(1.84)	(1.99)
Total Centrally Planned Economies							
Phosphoric Acid Capacity	4.35	4.61	4.81	5.06	5.20	6.19	6.52
Phosphoric Acid Production	3.17	3.52	3.73	3.89	4.04	4.45	4.89
Other P_2O_5 Production	5.06	5.30	5.38	5.47	5.54	5.75	5.88
Total Phosphate Fertilizer Consumption	8.23	8.82	9.11	9.36	9.58	10.20	10.79
Consumption	8.21	9.14	9.83	10.51	11.33	12.05	12.80
Surplus (Deficit)	0.02	(0.32)	(0.72)	(1.15)	(1.75)	(1.85)	(2.01)

Table 4
WORLD PHOSPHATE FERTILIZER SUPPLY, DEMAND AND BALANCES
(Million Metric Tons of Nutrient)

	75/76	76/77	77/78	78/79	79/80	80/81	81/82
3. WORLD TOTAL							
Phosphoric Acid Capacity	23.24	26.33	26.85	27.53	29.52	32.95	33.61
Phosphoric Acid Production	13.27	18.42	19.70	20.32	21.19	22.92	24.35
Other P_2O_5 Production	11.60	12.11	12.25	12.37	12.46	12.60	12.66
Total Phosphate Fertilizer Production	24.87	30.53	31.95	32.69	33.65	35.52	37.03
Available Supply	23.75	29.31	30.67	31.38	32.30	34.10	35.55
Consumption	24.07	26.28	28.19	29.96	31.89	33.48	35.13
Surplus (Deficit)	(0.32)	3.03	2.48	1.42	0.41	0.62	0.42

1/ Forecasted total phosphate fertilizer production is made up of wet process phosphoric acid production (100%) and other P_2O_5 production consisting of single superphosphate (100%), basic slag (100%) and, to avoid double counting, the phosphate rock contribution **into the manu**facturing of concentrated superphosphates (30%) and nitrophosphates (60-100%, depending on region).

The forecasts: In the case of most countries, it is reasonable to assume that the phosphate fertilizer industry operated at close to 100% of effective capacity (as opposed to nominal capacity given in this table) in 1973/74. In our projections, we have therefore calculated the potential production from new capacity coming on stream after 1973/74 and added it to actual production in 1973/74. Some reductions from the 1973/74 levels of single superphosphate and basic slag production have however been assumed. For new plants coming on stream, the escalation of capacity utilization is assumed at 40, 80 and 90% in developed countries and at 35, 70 and 80% in developing countries and Socialist Asia for the first year, second year, third year and thereafter, respectively. In countries with phosphoric acid plants starting up during 1972/73 or 1973/74, a similar adjustment has been made to the 1973/74 production level. Non-fertilizer uses of phosphoric acid have been assumed for developed countries only (10%); losses in the production process are estimated at 6% for all regions.

For past production, the figures are estimated actual production except for phosphoric acid where an adjustment for net trade has been made in order to add up with "Other P_2O_5 Production" to FAO's figure for "Total Phosphate Fertilizer Production" which includes finished fertilizer materials only.

2/ 96% of world production, reflecting past experience, to account for normal stock increases, transportation and distribution losses and the time lag between production and consumption. In the past 8 years, this ratio has varied between 94% and 98%.

3/ Through the adjustment explained in footnote 2/, the world balance of "Available Supply" and "Consumption" is not equal to the sum of the regional balance of "Production" and Consumption".

Source: Actuals: FAO
Forecasts: UNIDO/FAO/World Bank Working Group on Fertilizers

Figure 1
PROJECTIONS OF WORLD P_2O_5 DEMAND

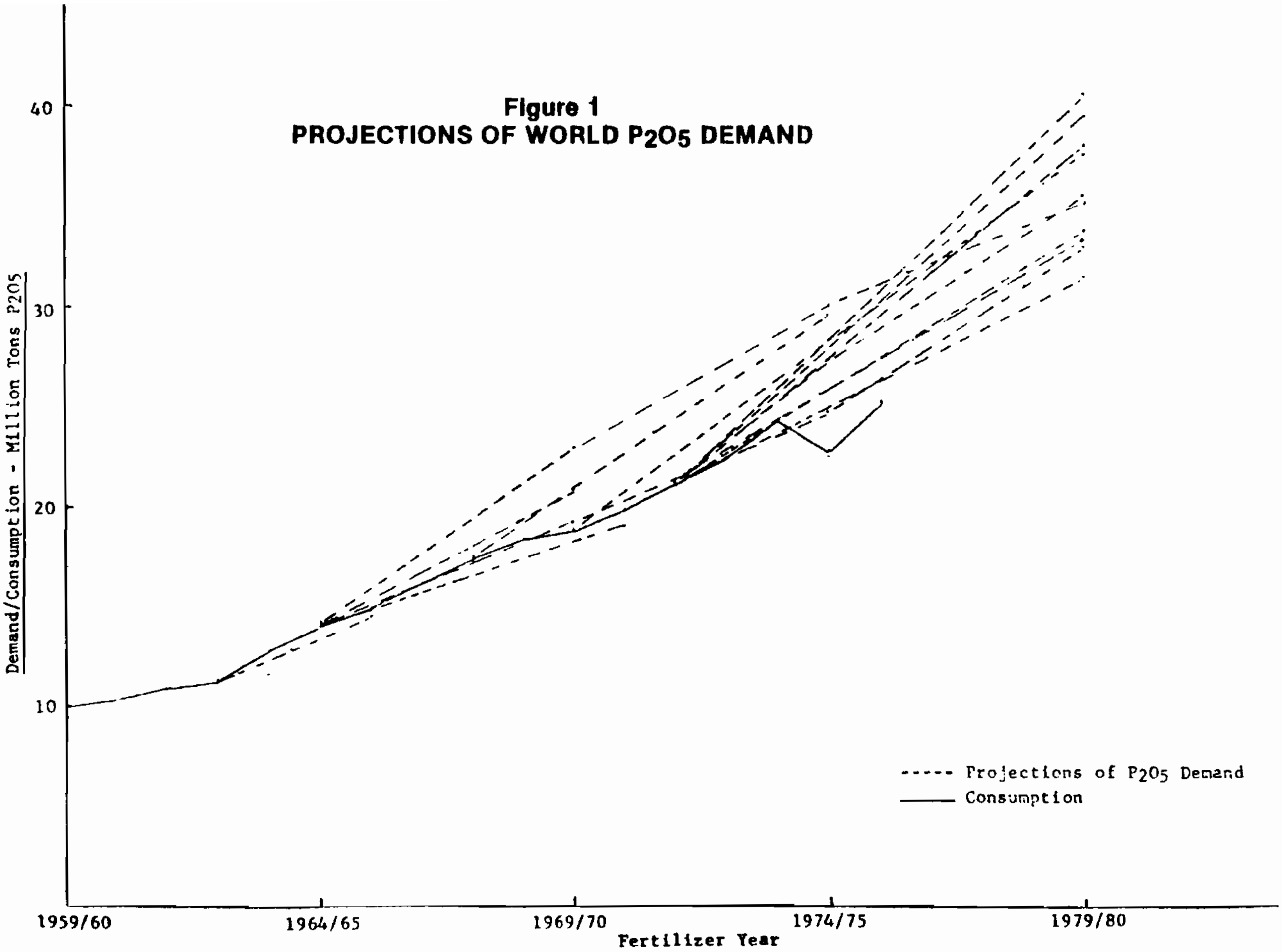
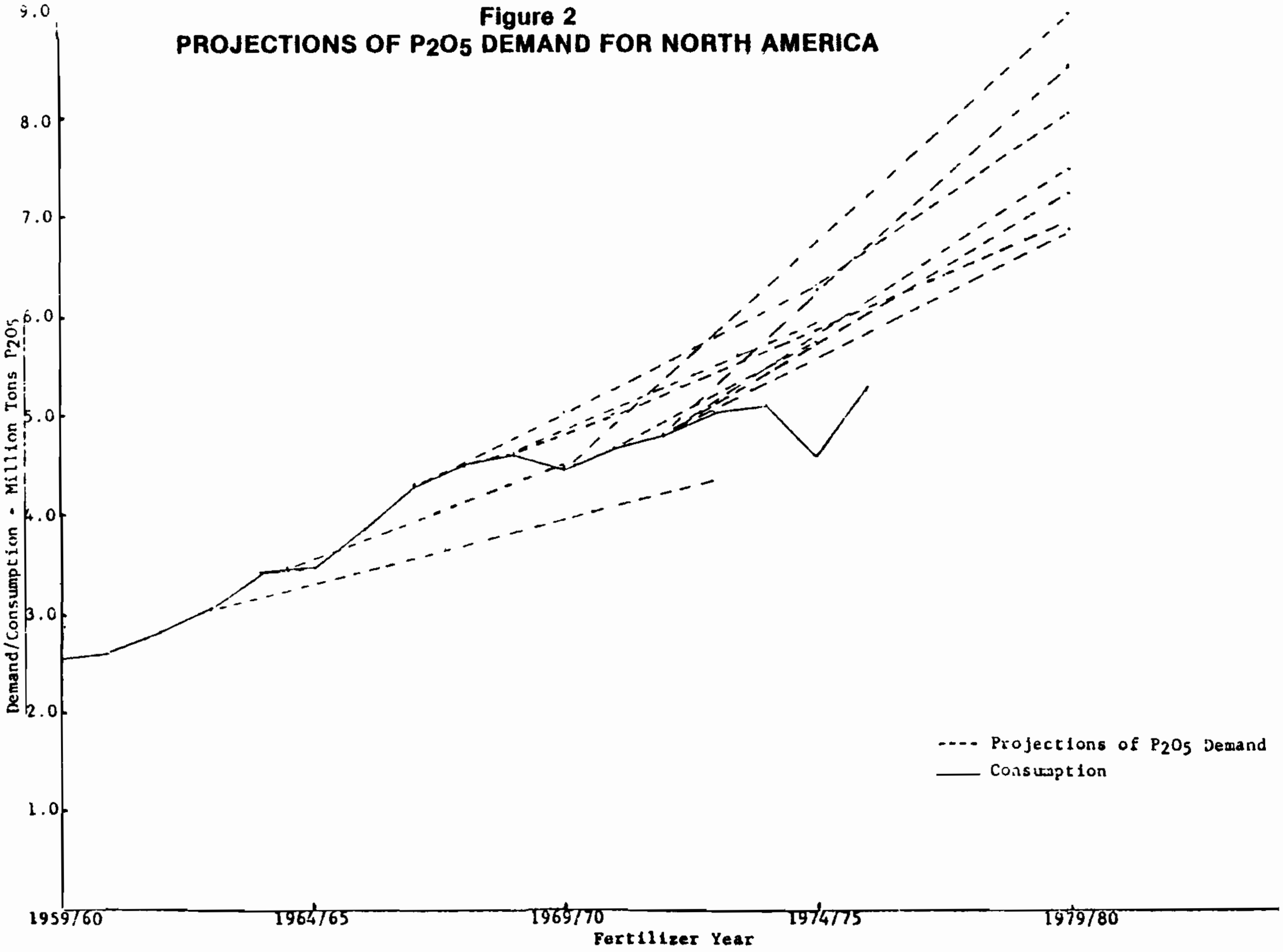


Figure 2
PROJECTIONS OF P_2O_5 DEMAND FOR NORTH AMERICA



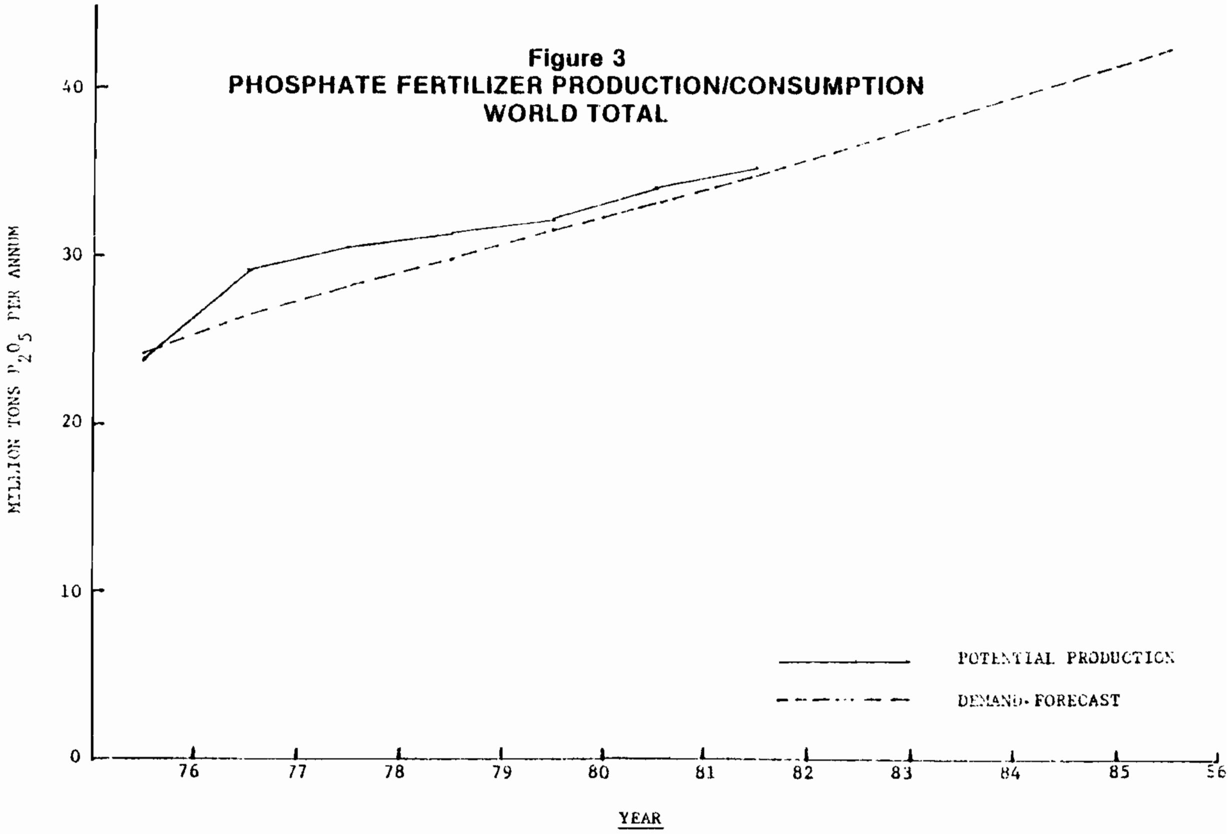


Figure 3
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
WORLD TOTAL

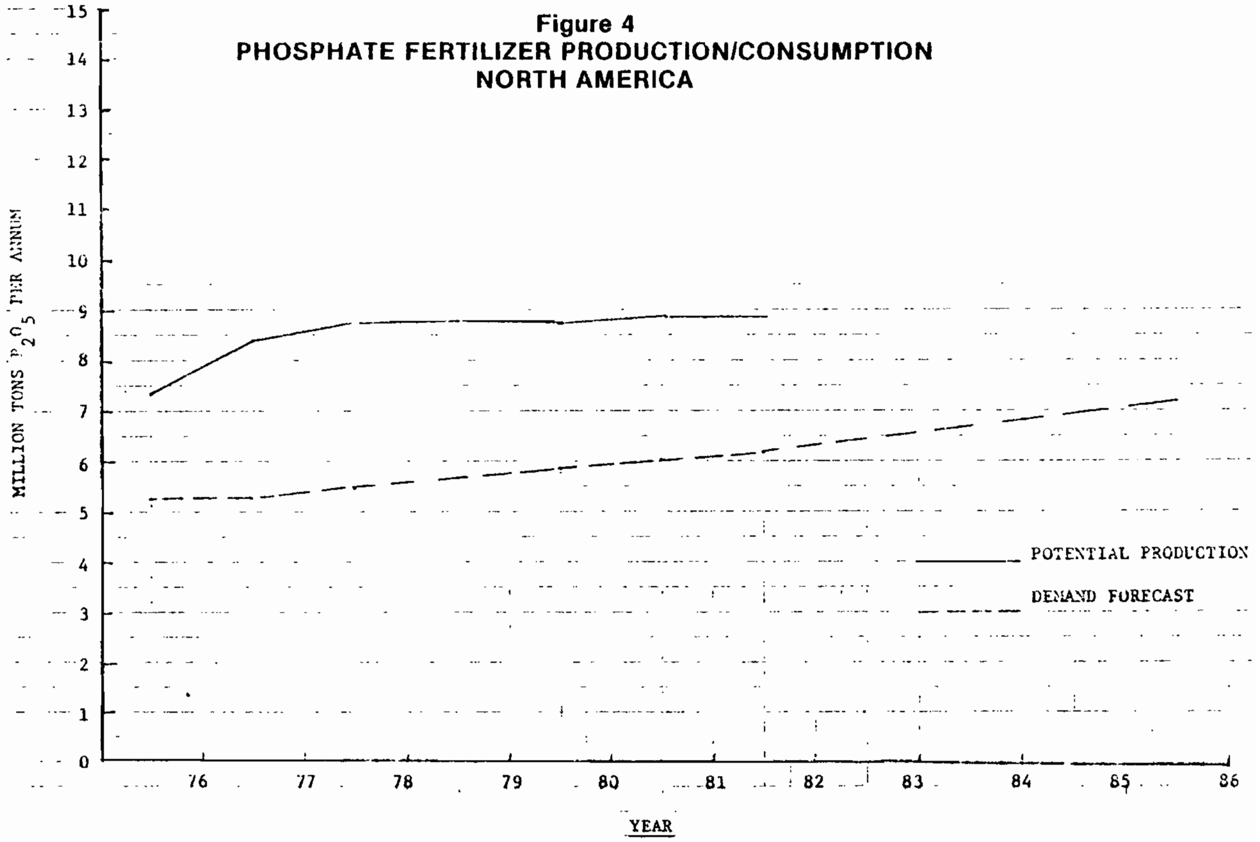


Figure 4
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
NORTH AMERICA

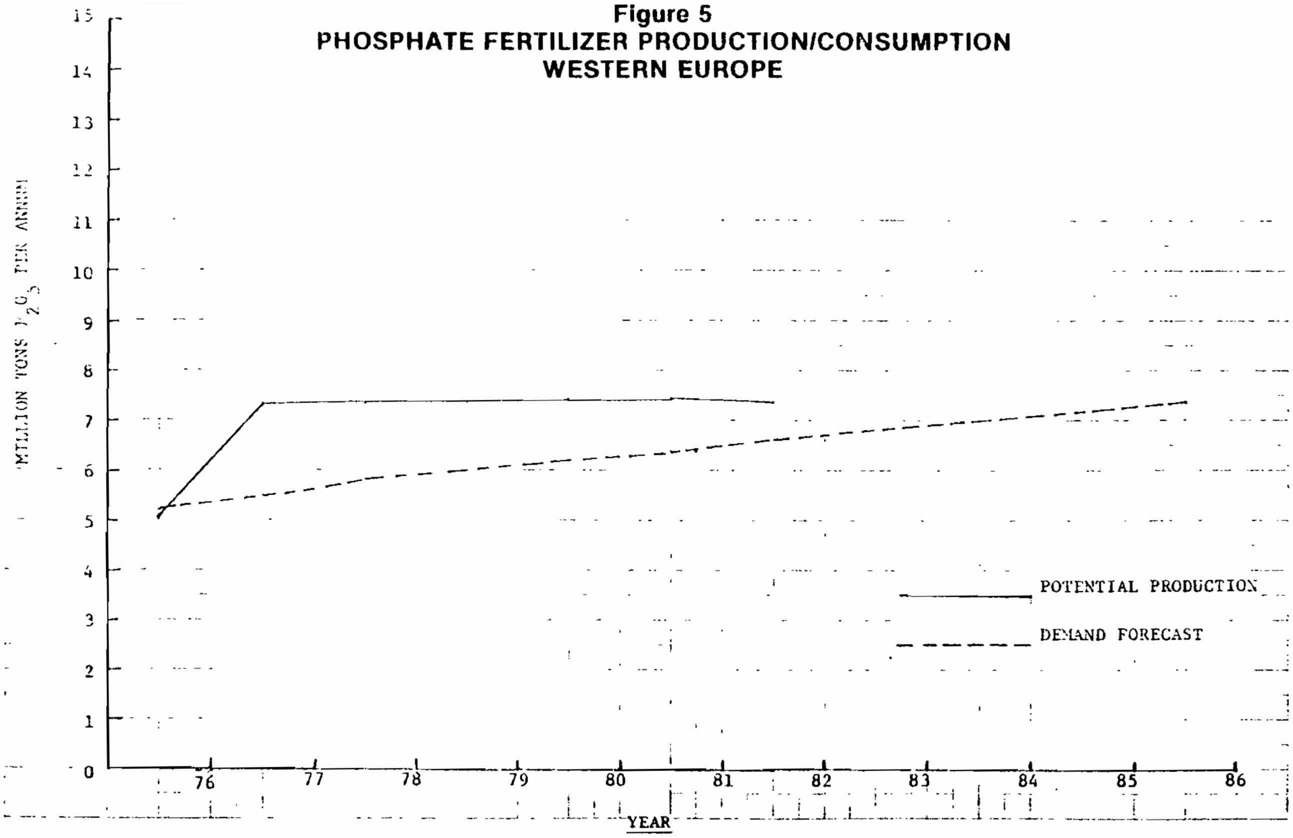


Figure 5
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
WESTERN EUROPE

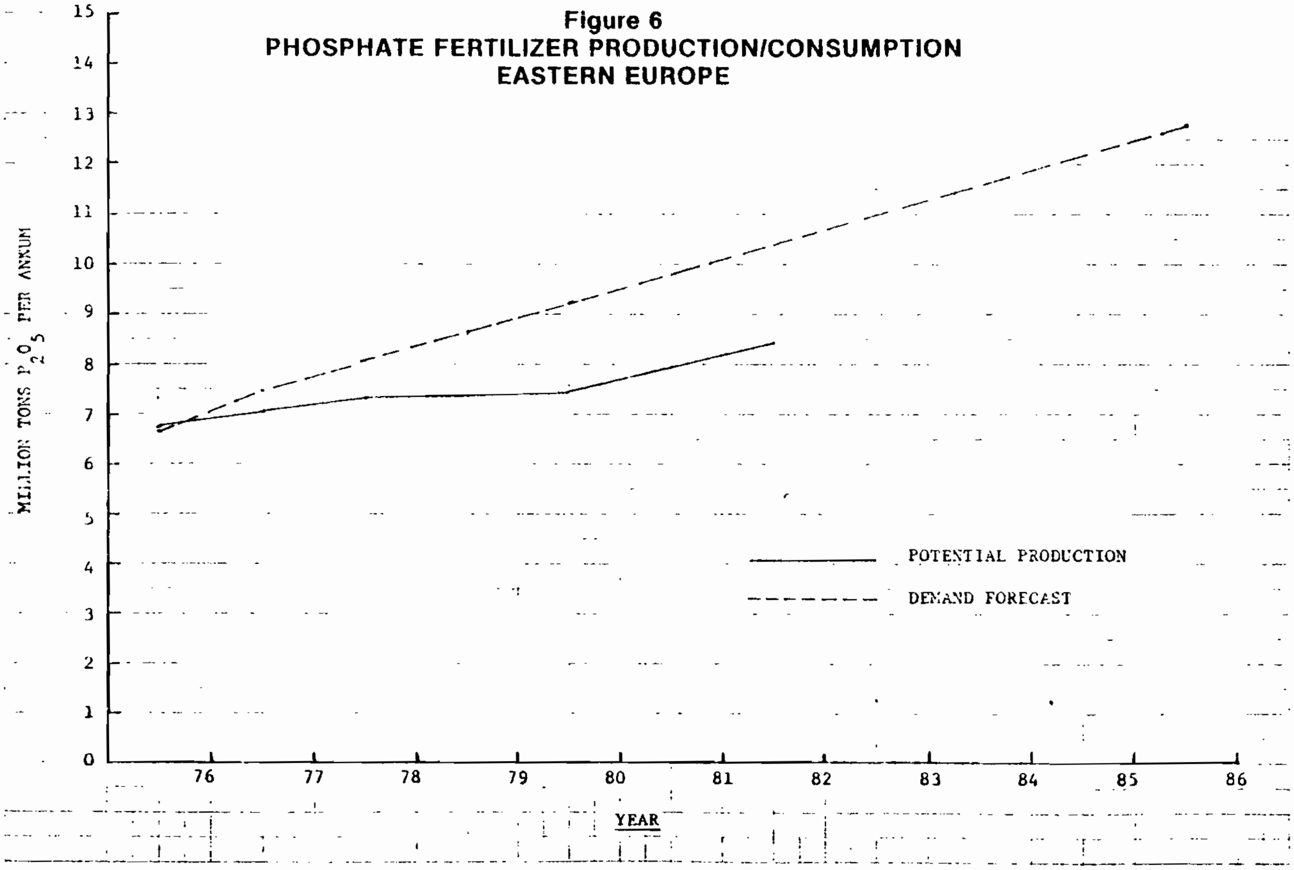


Figure 6
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
EASTERN EUROPE

Figure 7
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
AFRICA

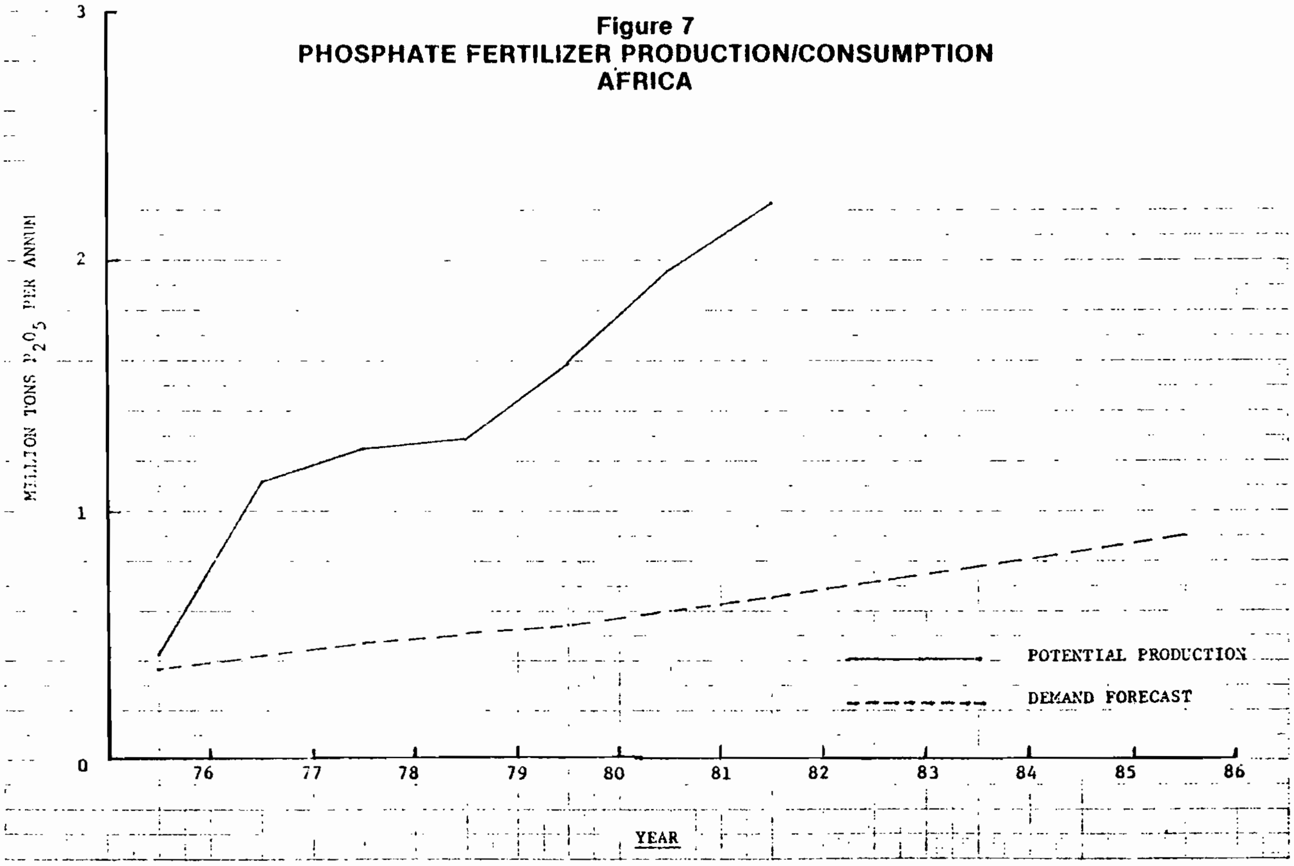
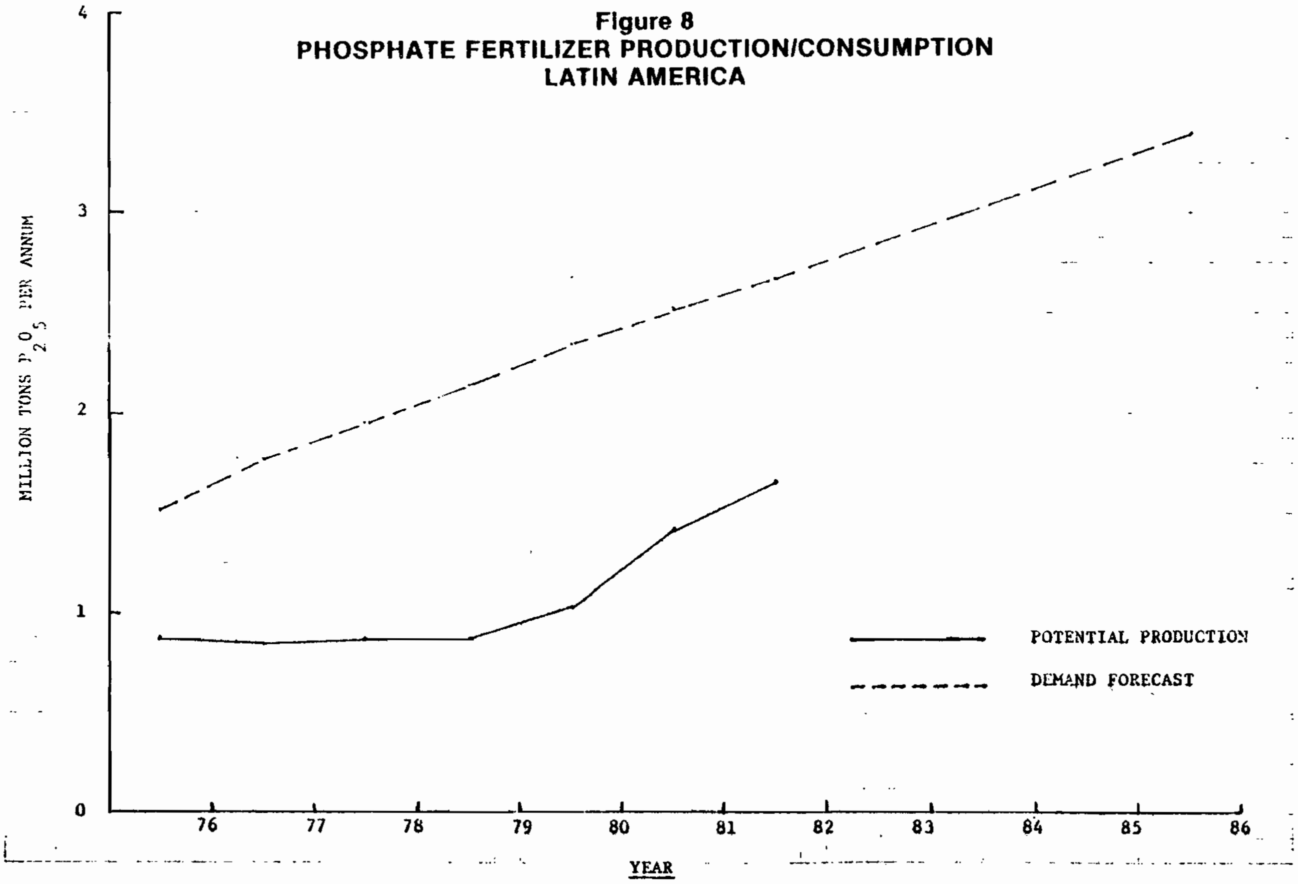


Figure 8
PHOSPHATE FERTILIZER PRODUCTION/CONSUMPTION
LATIN AMERICA



WILLIAM F. SHELDRICK— Speaker and Moderator: Well, acting as Speaker and Moderator, I would like to ask if there are any questions.

QUESTIONS: Your two million ton East Block deficit around about 1980; The Occidental Deal presumably would supply about 700,000 tons. Is there a specific deal that will supply the rest or will that just come from commercial channels?

MR. SHELDRICK: I don't think we have any more information on where this will come from. The Morocco Deal, I think, starts in 1980 so that won't make a very big impact before then. As you know, this is to supply up to five million tons of rock plus finished products; but I don't know how much. I would guess that this is an area of considerable sort of potential for exporting phosphates too because there is evidence that the Russians will stick to their target of use. It was one of the few areas that wasn't affected by the price hike that took place in 1973-'74, and it is part of the national plan to apply this fertilizer. I think they'll do this. Are there any further questions, gentlemen? Yes.

QUESTION: What do you think of the grades of phosphate rock in Morocco and also in North America, in Florida? Are they decreasing?

MR. SHELDRICK: Well, they are, of course, and I think people are realizing that the economics of beneficiating rock to very high degrees and then exporting it and processing it are just not perhaps the best. There is a trend, a very strong trend, I think, which was implicit in some of the slides towards the processing of low grade rocks in U.S. Now there is certainly in Morocco, I know, and I've been there not too long ago, there's a lot of very high grade rock left, rock that will certainly last for many, many years — almost 50 years or more. So there is high grade rock available. Florida, of course, isn't of the same quality, and I don't think ever has been. It requires a degree of beneficiation. I think what is changing is the appreciation that perhaps it is not most economic to purify something and then process it again. There is a lot of talk; I hope perhaps we might hear more about it this week to actually processing rock as mined to the direct acidulation of the ore body. I would think there will be a trend towards processing lower grade rock. There doesn't have to be; there's still plenty of high grade rock about. It isn't going to run out overnight. There's enough for 100 years at least, I would think from our assessment of the situation.

If there aren't any more questions, gentlemen, perhaps I can introduce our next speaker. Don Borst, of CF Industries, is going to talk to us about potash. Don is the executive vice president of CP Industries and also manager of CF's Food Division. He serves as president of Canadian Fertilizers Ltd.; and he's president of Agri-Trans Corporation; it's a cooperative large line, and he has a lot of other things that he does. He's obviously a very busy man. He's been with CF Industries for seven years, and before that he spent 13 years with W. R. Grace's Agricultural Chemicals Group. He's a chemical engineer, received his degree from the University of Tennessee and has worked in his career in research, process engineering, marketing, planning operations and general management. Potash is something we don't hear too much about, and I'm personally looking forward to hearing Don's presentation. Don. [Applause]

Potash Supply/Demand to 1980's

Donald V. Borst

Forecasting plant food supply and demand is especially difficult because of two distinguishing factors: year-to-year farmer discretion on potash usage, and a high level of government interference in the potash industry. For this reason, it pays to utilize all of the help one can get in potash forecasting, and I want to give credit at the outset to several major reference sources including the U.S. Bureau of Mines, the Tennessee Valley Authority, the Potash Institute, the United Nations Industrial Development Organization, the Food and Agriculture Organization, and several general information sources. The CF Industries' Market Planning Group typically references such sources in formulating plant food supply/demand outlooks.

I have divided my presentation into three parts: first a projection of potash supply and demand for the World, then a look at North America, and finally some consideration of major factors affecting the potash industry today.

World Potash Supply and Demand

World consumption of potash (Table 1) is expected to increase from an estimated 27.2 million short tons of K_2O in 1978 to 36.8 million tons by 1985. The average annual growth rate for this period is projected at about 4-1/2%. Please note that all references are to short tons of K_2O and fertilizer years ending June 30.

The Union of Soviet Socialist Republics is thought to be the largest consumer of potash, accounting for about 24% of World consumption. Russia is expected to outpace North America, Western Europe, and Eastern Europe and remain the area of greatest consumption.

Although the average growth rate in the rest of the World, including Africa, Asia, Japan, the Middle-East, Oceania, and Latin America is projected to exceed 6% per year, the total consumption in these areas in 1985 will only approach the consumption of Eastern Europe because of a low starting base.

The total effective World potash mining capacity is currently estimated to be 31.4 million tons of K_2O per year (Table 2). As used here, effective capacity means production capacity that could actually be brought to bear to supply market demand. It is not uncommon for

a potash mine to have a design, or rated, or nameplate capacity significantly in excess of the mines's actual capacity to produce.

At 10.1 million tons of K_2O, North America has over 32% of the effective World annual capacity. North American capacity is projected to increase by less than 5% by 1985 due to factors which I will discuss later.

Russia, however, is expected to increase its potash mining capacity by 67% to 16.0 million tons per year of K_2O by 1985. This will increase Russia's share of World capacity from 30% to 40% (Table 3) making that country the largest producer as well as consumer.

The World is expected to have ample potash supplies through the mid-1980's. Effective supply capacity is 15% greater than anticipated demand this year (Table 4). Based on an evaluation of expansion plans, supply is projected to exceed demand by 8% in 1985.

Here again, Russia is expected to play the dominant role in the export market with an anticipated surplus of 7.0 million tons per year of K_2O in 1985 or two and one-half times the North American surplus of effective capacity over domestic demand. The Russians can be expected to aggressively pursue export sales, and if they succeed in developing a U.S. market, the effective North American surplus will be exacerbated.

Russia, North America, and Western Europe will still be in a surplus position in 1985. The deficit in Eastern Europe and the rest of the World is forecast to widen with the biggest increases in Eastern Europe and Latin America. On the positive side, the farmers of the World can expect adequate supplies of potash for the foreseeable future, assuming they can pay for it.

North American Potash Supply and Demand

Focusing on our own market area, the consumption of potash in North America has continued to increase at very respectable rates. The total disappearance in fertilizer year 1976 amounted to 7.4 million tons of K_2O including agricultural and industrial consumption and exports (Table 5). The Potash Institute reported a 24.6% increase in agricultural consumption in 1977, but our market planners at CF Industries doubt that the increase was that high. Our estimates indicate at 17.6% increase to 6.0 million tons of K_2O. I suspect the difference between the two estimates is caused by increased inventory at local distribution points.

The single most outstanding aspect of the North American potash market is the major role of agricultural consumption in the United States, which accounted for 70% of total disappearance last year. Exports form North America, at 23% of total disappearance, are the second most important demand followed by Canadian agricultural and North American industrial demands which together amount to only 7%. As the U.S. agricultural market goes, so goes the potash industry.

With the restrictions on crop acreage in the U.S. it is anticipated that potash consumption will be down by 5% in 1978. This should be offset by increased exports. For the 1978 through 1985 period, total potash demand, including exports, is forecast to increase at an average of 3.5% per year.

When considering the supply of potash for North America, one must first distinguish between the announced capacities of the various potash mines and their actual or effective capacities. For example, if you surveyed the literature and summed up the announced capacities you might conclude that the North American industry should be able to produce up to 12.2 million tons of K_2O (Table 6). A better figure is 10.1 million tons. This is the result of economic depression in the Canadian industry, which has resulted in mines not being brought up to the originally intended capacity, and the declining reserves and ore quality facing many of the U.S. mines and reducing their output.

The repressive taxation of the potash mines in Saskatchewan will retard any expansion of privately owned mines in the province. The Potash Corporation of Saskatchewan has announced expansions at two of the three mines recently acquired by the Crown Corporation. These expansions are anticipated to account for 50% of the 1.4 million ton increase in annual effective K_2O capacity forecast to occur over the 1978-1985 period. The balance of this increase is projected to come from fine tuning of existing privately owned mines.

U.S. mining capacity is forecast to decline about 19% over the same period, but this will be more than offset by a 300% increase in potash imports. Several potash producing countries have identified the U.S. agricultural market as a logical destination for part of their production, and undoubtedly exchange balances with the U.S. are a prime consideration. The reliable nature of the U.S. agricultural market is very attractive to Russia, Israel, and European producing countries. Vessel shipments to eastcoast warehouses and to New Orleans for transfer to river barges is quite feasible. Product quality problems will be solved either by compaction of standard grade material at eastcoast and midwest river warehouses or by screening of imported, compacted material to remove fines resulting from handling degradation. CF Industries is seriously considering imported potash to provide a major share of future volume growth and as an alternative to some current year-to-year purchases from Saskatchewan producers.

The major development in the North American potash industry has been the acquisition of the Duval, Sylvite, and Alwinsal mines by the Potash Corporation of Saskatchewan (Table 7). This has given the Saskatchewan Government 25% of the design Canadian potash mining capacity. This means that the Potash Corporation now has 17% of the total North American capacity, and the announced expansion at the Cory and

Rocanville mines should give the province 23% of the North American capacity by 1985. The Potash Corporation is presently evaluating another Saskatchewan mine for a possible acquisition that would increase the province's share of Canadian capacity to about 36% this year and 41% in 1985, still somewhat below the announced goal of "at least 50%." A fourth mine would increase the province's share of total North American capacity to 24% this year and 31% in 1985.

A comparision of supply and demand forecasts for North America indicates a widening of the Canadian surplus and an increase in the U.S. deficit relative to domestic mining capacity (Table 8). By 1985, Canadian capacity will exceed domestic consumption by 7.9 million tons per year of K_2O, and total U.S. potash consumption is forecast to exceed effective U.S. mining capacity by 5.1 million tons of K_2O.

Net exports from North America are forecast to increase from 1.8 million tons last year to 2.7 million tons in 1985. This is predicated on a 75% increase in exports more than offsetting the anticipated major increase in imports.

The surplus of potential supply over demand will increase in 1978 to an equal to 20% of demand. Our forecast indicates that it will be 1985 before North American supply and demand approach a balance. Again looking on the bright side, this means adequate supplies of potash for the farmers in the U.S. and Canada.

Major Factors Facing the Potash Industry

I consider the five major factors facing the North American potash industry today to be as follows:

1. The impact of the Saskatchewan Government's potash taxation program.
2. The uncertain role of the Saskatchewan Government now that it has acquired one-fourth of the Canadian potash mining capacity placing 17% of the North American potash industry at the disposal of those who through taxation and prorationing, economically control an additional 51% of the industry.
3. The looming potential for major imports into the U.S. from Russia and to a lesser extent, Europe and the Middle East.
4. The continuing shift toward bulk blended fertilizers increasing the demand for granular and coarse grades of muriate and increasing the surplus of standard grade.
5. The worsening logistics of supplying increased volumes of potash to a market becoming more seasonal due to price uncertainty on the part of dealers and farmers.

The last three of these factors are fairly well understood by people in the industry and will either prevail or fade away based upon real economics. The current and potential impact of actions by the Saskatchewan Government, however, are less well understood and certainly more mysterious for the future.

Can you imagine a modern, world scale, efficient mining venture running at full capacity and generating pre tax earnings of $31 million per year — and losing a million dollars after tax? Table 9 presents the current economics of a 1969 vintage, conventional potash mine, in Saskatchewan, producing at full capacity 1.5 million tons per year of muriate with sufficient compaction capacity to produce 39% coarse grade and 61% granular grade and no standard grade with all production wholesaled to the U.S. and Eastern Canadian markets. It would be difficult to define a more desirable potash business.

Net sales to regional wholesalers would amount to $67 million (Canadian funds), and after operating costs, depreciation charges, and interest expense, pre tax profit would be about $31 million. Then comes the pain of having a potash mine in Saskatchewan: provincial taxes totaling over $21 million, and since much of the provincial tax burden is not deductible under Canadian tax regulations, there would be almost $11 million in federal income taxes. The net result of this beautiful mining venture is a loss of just over $1.0 million per year. It would be difficult to devise a more disappointing business climate than exists today in the Province of Saskatchewan under the present socialist administration.

An unfamiliar economist might conclude that such a situation would be corrected by upward pressure on prices. Unfortunately, the structure of the Saskatchewan reserve tax is based upon market price to dealers f.o.b. mine, capital investment, and mines capacity, *but* there is *no* relationship to production costs or profitability. The reserve tax is designed to ensure that the Saskatchewan Government will receive, through all forms of taxation, a constant share of any increases in sales revenue to a maximum of 65%. For the mine represented in our example the Province gets 61% of any incremental price increase, and the Canadian federal government gets 27% (Table 10).

A 30% price increase would be required to turn the $1.1 million loss into a $1.2 million net profit, a net of 2% on sales and only a 1% return on over $100 million of total capital employed. Anyone with marketing experience knows that a 30% price differential is not feasible for a commodity and especially not for plant food.

So a price increase to offset the onerous Saskatchewan tax is not very productive. In fact, it is negative in effect if the price increase is to cover increased costs (Table 11). Since the reserve tax makes no allowance for increased costs, a price increase to offset an increase in production costs actually results in an increase in after tax losses. Unless the Saskatchewan Government relents on its present potash tax programs, the future of the privately owned Saskatchewan potash mines is bleak indeed.

And what about the role of the Potash Corporation of Saskatchewan in the marketplace? The PCS has a distinct advantage over private companies. Being a Crown Corporation, the PCS does not pay federal taxes. This means that for an equivalent 1.5 million ton per year mining operation the PCS has a $10.7 million per year edge over a privately owned mine, and that equates to over $7.00 per ton of product, that can be taken as increased profit or expended for marketing advantage or any combination thereof.

For example, consideration is apparently being given to the establishment of regional warehouses to better compete with shipments direct from mine by other producers. Years ago, CF Industries tried to reduce the burden of seasonal peaking by the use of regional warehouses for potash, and the poor economics and product degradation resulting from stopping product in transit more than offset any logistical advantage. But since when does a government bureaucracy have to be burdened with economics, especially if it can rely on each mining operation, such as discussed here today, to pay taxes equal to over $21 for every man, woman, and child in the province?

Taxation not related to earnings is bound to have a severe negative effect on a business enterprise. Unfortunately, this is becoming a popular concept with many governments today. The administration here in Washington is attempting to apply similar concepts to the energy industry, and if they are successful, I believe the gas and oil industries will be stagnated like the Saskatchewan potash industry.

The really bad side of all of this is that for both energy and potash, the farmer and ultimately the consumer will have to pay the bill. [Applause]

Table 1

WORLD POTASH DEMAND

Million Short Tons K_2O

	1978	1980	1985
U.S.S.R.	6.5	7.2	9.0
North America	6.3	7.1	7.8
Western Europe	5.4	6.0	7.0
Eastern Europe	4.8	5.4	6.5
Other	4.2	5.0	6.5
Total World	27.2	30.7	36.8

Table 2

WORLD POTASH SUPPLY

Effective Mining Capacity
Million Short Tons K_2O

	1978	1980	1985
U.S.S.R.	9.6	12.0	16.0
North America	10.1	10.7	10.6
Western Europe	6.8	7.2	7.7
Eastern Europe	3.7	3.9	4.3
Other	1.2	1.2	1.2
Total World	31.4	35.0	39.8

Table 3

WORLD POTASH SUPPLY

Per Cent Share of Effective Mining Capacity

	1978	1980	1985
U.S.S.R.	30	34	40
North America	32	31	27
Western Europe	22	21	19
Eastern Europe	12	11	11
Other	4	3	3
Total World	100	100	100

Table 4

WORLD POTASH SURPLUS (DEFICIT) (1)

Million Short Tons K_2O

	1978	1980	1985
U.S.S.R.	3.1	4.8	7.0
North America	3.8	3.6	2.8
Western Europe	1.4	1.2	0.7
Eastern Europe	(1.1)	(1.5)	(2.2)
Other	(3.0)	(3.8)	(5.3)
Total World	4.2	4.3	3.0
% of Demand	15%	14%	8%

(1) Effective capacity less domestic demands.

Table 5

NORTH AMERICAN POTASH DEMAND

Million Short Tons K_2O

	Actual 1976	Estimated 1977	Forecast 1978	Forecast 1980	Forecast 1985
Agricultural					
U.S.	5.1	6.0	5.7	6.3	6.8
Canada	0.2	0.3	0.3	0.4	0.5
	5.3	6.3	6.0	6.7	7.3
Industrial	0.3	0.3	0.3	0.4	0.5
Export	1.8	2.0	2.4	3.0	3.5
Total	7.4	8.6	8.7	10.1	11.3

Table 6

NORTH AMERICAN POTASH SUPPLY

Million Short Tons K_2O

	1976	1977	1978	1980	1985
Design Capacity					
Canada	8.3	8.3	8.3	8.7	9.0
U.S.	3.5	3.7	3.9	3.9	3.0
Total	11.8	12.0	12.2	12.6	12.0
Effective Capacity					
Canada	6.8	7.0	7.3	7.8	8.4
U.S.	2.7	2.7	2.8	2.9	2.2
Total	9.5	9.7	10.1	10.7	10.6
Imports	0.1	0.2	0.3	0.4	0.8
Total Supply	9.6	9.9	10.4	11.1	11.4

Table 7

OWNERSHIP OF DESIGN NORTH AMERICAN POTASH CAPACITY

Million Short Tons K_2O

Fiscal Year	Total Capacity	Free Enterprize	Province of Saskatchewan	% Government Owned
1976	11.8	11.8	-	-
1977	12.0	11.3	0.7	6%
1978	12.2	10.1	2.1	17%
1979	12.2	10.1	2.1	17%
1980	12.6	10.2	2.4	19%
1985	12.0	9.2	2.8	23%

Table 8

NORTH AMERICAN POTASH SURPLUS (DEFICIT)

Million Short Tons K_2O

	Actual 1976	Estimated 1977	Forecast 1978	Forecast 1980	Forecast 1985
Domestic Balance (1)					
Canada	6.6	6.7	7.0	7.4	7.9
U.S.	(2.7)	(3.6)	(3.2)	(3.8)	(5.1)
Total	3.9	3.1	3.8	3.6	2.8
Less					
North American Net Exports	1.7	1.8	2.1	2.6	2.7
Surplus	2.2	1.3	1.7	1.0	0.1
% of Demand	30%	15%	20%	10%	1%

(1) Effective capacity less domestic demand.

Table 9

SASKATCHEWAN POTASH ECONOMICS

1.5 Million Short Ton Per Year Muriate Mine

	Canadian Dollars Million Per Year	Canadian Dollars $ Per Ton
Net Sales	67.0	44.67
Operating Costs	25.7	17.13
Depreciation & Finance	10.3	6.87
Pre Tax Profit	31.0	20.67
Provincial Taxes		
Prorationing Fee	1.8	1.20
Royalties	1.2	0.80

(CONTINUED ON NEXT PAGE)

Table 9 CONTINUED

Producing Tract Tax	0.2	0.13
Reserve Tax	15.2	10.14
Income Tax	3.0	2.00
Total Provincial	21.4	14.27
Federal Income Tax	10.7	7.13
Total Taxes	32.1	21.40
After Tax Profit (Loss)	(1.1)	(0.73)

Table 10

SASKATCHEWAN POTASH ECONOMICS

Effect of Price Increase at Constant Costs
Million Canadian Dollars

	Current Economics	Per Cent Price Increase		
		+10%	+20%	+30%
Net Sales	67.0	73.7	80.4	87.1
Pre Tax Profit	31.0	37.7	44.4	51.1
Taxes				
Provincial, Total	21.4	25.5	29.6	33.7
Federal Income	10.7	12.5	14.3	16.2
Total Taxes	32.1	38.0	43.9	49.9
After Tax Profit (Loss)	(1.1)	(0.3)	0.5	1.2

Table 11

SASKATCHEWAN POTASH ECONOMICS

Effect of Price Increase to Offset Cost Increase
Million Canadian Dollars

	Current Economics	Per Cent Price Increase +10%	+20%	+30%
Net Sales	67.0	73.7	80.4	87.1
Pre Tax Profit	31.0	31.0	31.0	31.0
Taxes				
Provincial, Total	21.4	25.5	29.6	33.7
Federal Income	10.7	12.5	14.3	16.2
Total Taxes	32.1	38.0	43.9	49.9
After Tax Profit (Loss)	(1.1)	(7.0)	(12.9)	(18.9)

MODERATOR SHELDRICK: Thank you very much, Don, for that very fine presentation, and in particular the agony of the potash producers in Canada. I don't suppose I ought to comment as a member of the World Bank; but I've heard this situation explained so many times, and it's very sad indeed, and, I think, that is exists. It's very interesting, of course, to project that will happen eventually to the potash industry because of this, particularly when production is expanding in the U.S.S.R. and elsewhere. I would like to perhaps just open the questions by asking what is going to happen elsewhere in Canada, in New Brunswick. Is there going to be any investment in this area and could this in fact upset what is happening in Saskatchewan?

MR. BORST: Well, I doubt that the potential in Eastern Canada is anywhere near great enough to offset the supply base and potential in Saskatchewan. I was reading in yesterday's Wall Street Journal where Quebec has now decided to move into the asbestos industry so I guess the desease is catching.

MODERATOR SHELDRICK: Thank you. Well, gentlemen, we're open for questions. Would anyone like to ask about potash?

QUESTION: In the end result in the potash situation it seems so obvious to us what the Canadian Government is doing. I wonder what their side of the coin is. They must have some reason for doing it or they'd come out looking stupid.

MR. BORST: I'm not sure whether that's a question or an observation. I think the industry has been wondering what their intention is for a long time. I will give you my own personal thought. If you have a government that supplies your electricity, your telephone, your insurance, your potash, etc., etc., etc., I think it is fairly clear what their intentions are. They intend to supply all goods and services to the people of the Province and to control it from the Provincial Capital.

MODERATOR SHELDRICK: Other questions, gentlemen? If not, perhaps we should consider whether we have time for this.

CHAIRMAN SMITH: Yes, Bill. It's about 11:45, and Dr. Waitzman has, I think, what you'll all agree is a very important subject, nitrogen, that affects us all. In fairness to him, and to all of us, if we can get into the restaurants I believe it would be better if Dr. Waitzman appears immediately after lunch. Let's plan on that. Let me add my thanks to the morning speakers who have been very informative and helpful. These last three talks have been just great. Let's meet at 1:30 promptly, please. Thank you all. [Applause]

Tuesday, October 25, 1977

Afternoon Session
Charles H. Davis, Moderator

MODERATOR DAVIS: We have an excellent program on granulation technology that will be presented by several international experts in this field. Several of the papers today relate to the use of pipe reactors to decrease investment costs, conserve energy and simplify operations. Before we get into the granulation session we need to back up and pick up one paper that was left over from our morning session. This paper is titled, "A Technical and Economic Review of Coal Based Ammonia Production" by D. A. Waitzman of TVA. Don is a graduate of Auburn University in chemical engineering finishing in 1948. He worked for various engineering companies before he joined TVA in 1962. Since that time he has worked as a project engineer on several fertilizer projects at the fertilizers centers in Muscle Shoals, Alabama, and at the present time he is project manager of TVA's ammonia from coal project. Don. [Applause]

A Technical And Economic Review Of Coal-Based Ammonia Production

D. A. Waitzman

Because of the natural gas shortage, there is concern about meeting U.S. fertilizer needs. Planning must take into account the possibility that natural gas will be either available only at very high cost or unavailable at any cost, so alternate fuels and feedstocks have to be considered. The problem is urgent. At least one-third of the food and fiber produced in this country is attributed to fertilizers with nitrogen being the nutrient of major importance. Practically all nitrogen fertilizer is made from ammonia, which is in turn made from natural gas. If natural gas is unavailable, and the ammonia production is lost, a substantial portion of the food and fiber produced in this country will be lost. Neither this country nor the world can tolerate such a situation.

The fertilizer industry uses only about 3 percent of the natural gas consumed in the U.S. However, the total picture indicates that natural gas reserves in the U.S. are said to be about 240 trillion cubic feet and total annual consumption to be about 22 trillion cubic feet. Even including gas resources due to increased production from known fields plus gas likely to be discovered in the future, most experts predict that our gas will be depleted during the next 30 years or so. Between now and then, we expect gas to become increasingly costly or unavailable to those on interstate (regulated) supplies.

During the winter of 1976-77, about 730,000 tons of ammonia production was lost because of natural gas curtailment. In 1975-76, about 350,000 tons was lost and before that, a significantly lesser amount. Ammonia production losses due to gas curtailment are therefore increasing rapidly so there is a pressing need to develop the technology and economics for using alternate feedstocks.

Naphtha or fuel oil could replace natural gas, but they are also scarce and are expensive. Coal represents the only viable alternative for the foreseeable future.

Coal has been used for years to produce ammonia. The Germans developed the technology before World War II, and the technology is still in use in Europe, Africa, and Asia. However, there is a need for the development and demonstration of U.S. technology using U.S. equipment, methods, and expertise.

During 1975 TVA and The Fertilizer Institute (TFI) identified the need to develop efficient U.S. technology for production of ammonia from U.S. coal as the number one priority need for the nation's fertilizer R&D. In August of 1975, TFI appealed to TVA's Board of Directors for TVA to undertake the development and demonstration of the production of ammonia from coal. About this time, other U.S. organizations also identified the solution to the ammonia feedstock problem as being the number one R&D need in the industry. TVA responded to this need and the Ammonia from Coal

Project was initiated.

The initial problem was to define a course of action. In view of the uncertainties involved as to the most appropriate gasification process to be used, initial plans were to construct pilot plants (0.9 metric ton of coal per hour capacities) which would test and demonstrate five of the leading processes as shown in Figure 1. Common coal handling and preparation facilities, gas desulfurization and purification, and an ammonia synthesis section would be installed to serve the multi-pilot-plant facilities. A cost estimate was prepared for this system, but because the cost appeared excessive and the time involved in obtaining useable results would be too long, this aproach was abandoned.

Further analysis revealed that the lowest cost and quickest way to meet the immediate needs of the U.S. fertilizer industry was to retrofit a coal gasification system onto TVA's small, but modern, ammonia plant at Muscle Shoals. The TVA ammonia plant is a 225-ton-per-day, natural gas, steam reforming plant, completed in 1972. The plant has two reciprocating compressors, each with 60-percent capacity; therefore, the plant can be turned down to 60 percent of capacity. The least-cost installation, therefore, would be a coal gasification facility that would produce 60 percent of the gas needed by the ammonia plant. In order that the greatest use be made of the existing plant, the gas should be introduced as near to the front end of the ammonia plant train as possible as shown in Figure 2. Thus, the existing shift, CO_2 removal, methanation, and synthesis sections would be utilized to minimize the amount and size of new equipment required. The technical problem would be to provide a gas that would match the composition, temperature, and pressure of the gas coming from the existing secondary reformer. With this arrangement, the plant could be operated with 60 percent of the synthesis gas from coal and 40 percent from natural gas or at 60-percent capacity with synthesis gas only.

A set of criteria was developed for selecting the gasification process. These criteria were (1) that the synthesis gas be composed of primarily hydrogen, CO, CO_2, and nitrogen in the same concentrations that exist in the present plant downstream of the secondary reformer, (2) that the gas be at the same temperature and pressure at this point, (3) that the gasification process not produce a large amount of methane which would require separation for either reforming or burning as fuel, (4) that the process accepts a variety of U.S. coals, (5) that the process not produce oils, tars, phenols, and other contaminants which would have to be disposed of in an economically and environmentally acceptable way, (6) that the process be developed at a commercial or near-commercial state of the art, (7) that the process be of U.S. development, and (8) that the process be economically competitive with other available coal-based processes. After a thorough review of all the processes that could be considered, it was concluded that the partial-oxidation process available from the Texaco Development Corporation, which had been commercialized with oil feedstock, best met the criteria, so it was selected for the TVA project. Design conditions are to gasify 168 tons per day of coal at a pressure of 490 psig to produce 135 tons per day of ammonia.

The TVA demonstration facility should provide a basis for retrofitting existing plants. There are about thirty 1000-ton-per-day natural gas-steam reforming ammonia plants operating in the U.S. In total, there are about 100 natural gas-steam reforming ammonia plants producing about 17 million tons of ammonia per year in the U.S.

It is recognized that differences from plant to plant will require special consideration. A case in point is high-pressure steam generation for steam turbines driving centrifugal compressors. TVA's compressors are electric-motor driven. The typical 1000-ton-per-day ammonia plant has high-pressure steam generation in the reformers and waste heat boilers. If this steam were not produced because the reformers were eliminated, the steam would have to be raised either by waste heat recovery or in coal, coal gas, or fuel oil-fired steam boilers. This requirement could be about 400,000 pounds of 1500-psig steam per hour for a 1000-ton-per-day ammonia plant. It is unlikely that this total amount could be produced as waste heat at the gasifier, and additional boiler capacity probably would have to be provided.

Waste heat recovery from the raw gases from the gasifier presents difficult problems as to slag deposition on tubes, erosion, and metallurgy. For this reason a waste heat boiler will not be installed initially in the TVA project. Provisions will be made for possible future installation.

The current status of TVA's Ammonia from Coal Project is as follows: Contracts have been awarded to Foster Wheeler Energy Corporation, Badger Plants, Inc., and Brown and Root Development, Inc., to prepare definitive engineering studies and cost estimates on the coal gasification and gas purification unit. These awards were made on the basis of competitive bidding after eight bids were received. The three contractors, in accepting the awards, have agreed that they will submit lump sum bids based on their studies and cost estimates for the engineering, procurement, and erection of the facility. A final contract will be awarded for this phase in January 1978. An award has been made for the air separation plant to Air Products and Chemicals, Inc., to provide the oxygen and nitrogen to the facility. Work by TVA forces is proceeding on the engineering, procurement, and erection for the coal handling and preparation, ash disposal, modifications to the existing ammonia plant, and services and utilities for the entire complex. The TVA facility will begin operation in late 1979.

In addition to the TVA Ammonia from Coal Project, there are two other coal gasification projects applicable to ammonia that are being conducted by the U.S. Energy Research and Development Administration (ERDA). One is a contract with W. R. Grace & Company, in conjunction with Ebasco Services, Inc., and the other is an agreement to negotiate a contract with Air Products and Chemicals, Inc. The Grace/Ebasco plant would use the Texaco process and gasify 1700 tons per day of coal at a pressure of 2500 psig. The gas would be scrubbed, purified, and sent to a new ammonia plant not funded by ERDA. A feasibility study will be made first and operation is scheduled for mid-1982 if a "go" decision is made. This is one of two contracts competing for funds available for one plant. The other contract is with Memphis Light, Gas, & Water Division, which does not involve ammonia. The Air Products Plant would use the Koppers-Totzek process and gasify 1210 tons per day of Texas lignite to produce H_2 and CO which are to be distributed through an existing pipeline to chemical industries in the gulf coast region. Operation is expected to begin in late 1981. The ERDA and the TVA projects complement each other in that the ERDA plants involve grassroots projects, and the TVA plant is a retrofit project. Also, the TVA project is on an accelerrated schedule that should provide useful information for the ERDA ammonia from coal projects scheduled to come on stream later.

In addition to the projects mentioned above, ERDA is engaged in numerous synthetic natural gas and low-Btu fuel gas projects. One of these involves the installation of Lurgi gasifiers on the Powerton Project in conjunction with Commonwealth Edison and the Electric Power Research Institute.

Aside from the TVA and ERDA efforts, there is a great deal of work being done around the world based on German coal technology and Shell and Texaco petroleum technology. At present, there are at least fourteen coal-based ammonia plants in operation: one Lurgi, ten Koppers-Totzek, and three Winkler. None of these plants are in the U.S. There are also larger numbers of Shell and Texaco petroleum-based partial-oxidation plants in operation producing ammonia, some of which are in the U.S. Of the current world ammonia capacity of about 77 million short tons N, 64 percent is based on natural gas, 13 percent on naphtha, 12 percent on coal or coke, with the remaining 11 percent equally divided among other feedstock sources.

In order to assure having as much background information as possible for the pursuit of the TVA project, and to obtain information to present to the U.S. fertilizer industry, members of TVA's Ammonia from Coal Project staff traveled to South Africa, India, and Germany during the summer of 1977 to visit operating plants and process developing firms who were concerned with producing ammonia from either coal or petroleum products. The group traveled to South Africa and visited the South African Coal, Oil, and Gas Corporation Limited (SASOL) plant in Sasolburg and African Explosives and Chemicals Industries Limited (AE&CI) in Modderfontein. The SASOL plant is large, complex, and relatively old. The SASOL staff were quite outspoken in their praise for the Lurgi process and considered it to have major advantages over other coal gasification processes. The plant consists of 13 Lurgi coal gasifiers that produce gas used in four different ways as shown diagrammatically in Figure 3: (1) to furnish town gas, (2) to feed the Synthol (developed from the old Kellogg Process) Fischer Tropsch unit to produce gasolines and light hydrocarbons in a fluidized bed unit, (3) to feed the Arge (based on old Ruhrchemic/Lurgi technology) Fischer Tropsch process to produce heavy oils and waxes in a fixed-bed unit, and (4) to produce ammonia in a 230 mtpd ammonia plant.

The coal contains 21 percent volatiles and 30 to 36 percent ash. The ash fusion temperature is between 2460° F. and 2730° F. Oxygen is produced with a purity of 98 percent. The gasifier operating pressure is about 400 psia. Gasification temperature is around 2190° F. The raw gas from the gasifier contains significant quantities of condensibles, such as ammonia, phenols, and tars which are recovered for fuel usage or sale. Water from biological treatment is used to transport the ash. The ash improves the waster color and precipitates fluorine from the water. Of the 13 gasifiers, SASOL runs 11 and maintains 2 on standby. Four larger gasifiers are currently under construction. The existing 13 gasifiers are about 12 feet in diameter and the 4 new gasifiers are about 13 feet in diameter. It was said that two of the new gasifiers would supply a 1100 stpd ammonia plant. The present gasifier availability was given at about 85 percent.

The AE&CI plant was designed to produce 1100 stpd total combined NH_3 plus methanol. The methanol plant is rated at 57 stpd and was completed late in 1974, but they are just now getting good operation. During the five days preceding the visit of the TVA team, 1025 stpd of NH_3 plus 75 stpd of methanol were produced. The plant has six Koppers-Totzek gasifiers. All six are normally used, but of necessary, full production can be maintained with five gasifiers only.

In early operations there was trouble with serious loss of the refractory in the gasifiers. The remedy for this was, initially, to operate at a lower temperature, with lower efficiency but, subsequently, modifications were made to the system. Despite the other difficulties encountered, raw gas composition has always been satisfactory.

The goal, containing 7 percent moisture, is dried and pulverized to 90 percent passing 175 mesh size. The gasifiers are two-headed and jacketed; each head is provided with two screw feeders. Oxygen and steam are admitted into the screw feeder where they are mixed with the coal, thus conveying it into the gasifier by entrainment. The gasifier reactions take place at 2900-3600° F.

and slightly above atmospheric pressure.

After gasification and water scrubbing, the raw gas is stored in a gas holder as shown in Figure 4. It then passes through two electrostatic precipitators to centrifugal compressors, which compress the gas to 450 psig and later to 750 psig. It is then sent to further processing in a Rectisol unit, a shift converter, a liquid nitrogen wash tower, and an ammonia synthesis unit.

In the compressor house, there is a 12-point CO monitor that monitors specific equipment points at which CO is most likely to be present; general atmospheric monitoring is considered to be inadequate.

The Fertilizer Corporation of India (FCI), Talcher, coal-based plant is designed to produce 1000 stpd ammonia and 1650 stpd urea. It will receive 3300 stpd coal and 15 million gallons of water per day, and use 55-MW of electric power. It is on an 830-acre site and is said to have cost about $184 million.

The coal-based ammonia plant at Ramgundam is to be essentially identical to the Talcher plant. The Talcher plant is 98-percent complete and Ramagundam is about two months behind Talcher. The previously announced plant to be built at Korba has been indefinitely postponed.

The Ramagundam and Talcher plants have three Koppers 4-headed gasifiers, each equivalent to about 330 stpd of ammonia, for a total gasification capacity equivalent to 1000 stpd of ammonia at each plant.

Design gasification temperature is 2900° F. at 16 inches of water pressure. Gas and entrained slag, after quenching to 1600-2000° F., will flow upward into a large waste heat boiler. Slag will flow out the bottom of the gasifier into a water quench seal and collecting pit located below the gasifier. Ash solidified and separated in the waste heat boiler will also fall through a duct into the collecting pit.

The waste heat boiler is a large cylindrical vessel containing a radiant section and a two-part convection section. The gases will be cooled in the radiant section at very low velocities to a temperature of 930-1100° F., which is well below the ash fusion temperature. For the most part, the ash particles will agglomerate and fall through the duct into the collecting pit. After the radiant section, there is a convection section with slanted tubes to allow the ash collected on them to fall off. This section is followed by a horizontal tubed section. The gas exit temperature will be 570° F.

The gas will pass to a cooler-washer where most of the remaining flyash will be removed and the gas cooled to 100° F. Further particulate removal will be accomplished in Tyssen separators and two primary and one secondary electrostatic precipotators.

The gas will then go to a gas holder after which turbine-driven raw gas compressors will deliver the gas at 460 psia to HCN removal, desulfurization, shift conversion, CO_2 removal, and nitrogen wash. From here, the gas will go to a standard ammonia synthesis unit.

The Talcher plant is in the final phase of construction and initial commissioning. One of the two air separation units had been run for several days and the other was started the day before the visit. The steam boilers were also in operation.

In Germany, visits were made to the process developing firms of Lurgi in Frankfurt, Krupp-Koppers in Essen, and Davy Powergas, which offers the Winkler process, in Cologne.

It was suggested at Lurgi that part of the condensibles, the "oil," could be hydro-treated over a catalyst to convert organic sulfur to H_2S, to reduce the CO content to five percent, and to reduce the HCN to methane and ammonia. The resulting purified naphtha could be used as fuel. It was also suggested that the other part of the condensibles, the "tars," might be used directly as a fuel under some conditions.

Lurgi stated that the most economical scheme would be to treat the condensibles separately by converting them to marketable byproducts and to use the purified synthesis gas for ammonia production. It was suggested that methane and CO could be separated in a cryogenic unit and sold for town gas or be fed by compression to a steam reformer.

It was pointed out that Lurgi has the lowest oxygen requirement of all commercial gasifiers. Other conditions being equal, the requirement ranges from 0.11 scf oxygen per scf of synthesis gas for active lignites to 0.21 scf/scf synthesis gas for anthracites. In addition, it was stated that Lurgi requires an oxygen purity of only 90 percent, which should reduce the cost of the air separation plant by about 10 percent.

At Davy Powergas (DPG), it was learned that DPG has the experience of having built 16 plants with a total of 36 Winkler generators using a wide variety of coals. Twelve of these 16 plants have been for the production of ammonia, and 3 plants are still in operation. All of these plants were operated at near atmospheric pressure. However, a DPG task force has been working on a pressure system for about 3 years. DPG is now ready to offer, with guarantees, a process operating at 45 psig.

The reasons for choosing 45 psig for ammonia synthesis applications are:

(1) It does not involve the use of novel equipment.
(2) The pressure is sufficient to allow final particulate removal in venturi scrubbers rather than electrostatic precipitators.
(3) The slight increase in methane content caused by operation at 45 psig can be counteracted by a slight increase in temperature. The modern Winkler generators with a radiation ring boiler near the top of the generator allow operation at higher temperatures as has been proved at a plant built by DPG in Turkey.
(4) The gas needed for a 1100 tpd NH_3 plant can be produced in 2 Winkler generators of a commer-

cially proven size if operated at 45 psig.

(5) Major savings in capital cost and compression costs can be obtained at this pressure level without increasing the nethane content of the synthesis gas. The ash leaves the gasifier mainly in the form of a flyash. This Winkler flyash is a combustible char containing about 6-12 percent of the carbon in feed depending on coal properties. Over 90 percent of this flyash is removed in a dry state and used as an auxiliary fuel for producing additional high-pressure steam which is needed in coal-based ammonia plants. The ash removal at the bottom of the generator and the remaining flyash removed in the wet scrubbing section, contain only about 2-3 percent of the carbon in the feed; thus 97-98 percent of the carbon values in the feed are utilized within the ammonia plant.

DPG is currently looking at higher pressures, at least 200 psig. This is the minimum pressure needed for combined cycle power generation processes.

A wide variety of coals has been gasified in the Winkler gasifier. However, lignites and subbituminous coals are preferred. The Winkler is a nonslagging gasifier operating at temperatures lower than the ash fusion temperature but still high enough to prevent formation of methane and condensibles. Coals with reactivity lower than that of lignites and subbituminous coals can also be gasified by operating the generator with a closer approach to the ash fusion temperature in the suspension zone. This is done by including a radiant ring boiler in the upper section of the gasifier.

DPG feels that the major advantages for the Winkler gasifier are its simplicity and high capacity per unit and that the nonslagging operation gives a high onstream efficiency. The large inventory of the fluidized bed provides a safety against oxygen breakthrough and tends to even out the variations in the quality of feedstock. Additionally the process is not sensitive to feed size distribution. The unit can operate successfully on run-of-mine coal fines —0.79 in + 0 in. The preferred range is —0.39 in + 0 in, with the natural distribution obtained during simple crushing operations. This is an advantage, especially, when gasifying low-grade high-ash coals since no pulverization of coal is required.

At Krupp-Koppers the Koppers-Totzek process was reviewed in detail. Koppers stated that the Shell-Koppers development program at the Harburg refinery of Deutsche Shell A.G., near Hamburg, involved the installation of a demonstration gasifier that has a coal feed rate of 165 st of coal per day at a pressure of 440 psia and is expected to reach mechanical completion in December 1977. Initial operation will begin shortly thereafter. Dry pulverized coal feed will be used. About 10 million SCFD of synthesis gas will be produced.

Visits were also made to the following firms:

(a) Fredrich Uhde, GmbH, Dortmund; the engineering offices and computer facilities.

(b) Braunkohlenwerke, A.G., Cologne; a coal gasification pilot unit under construction, based on the high-pressure (45 psia) Winkler process.

(c) Ruhrchemie, A.G., Oberhausen; a 7-ton-per-hour Texaco coal gasifier is under construction. The plant will produce a CO-H_2 synthesis gas to be used in the Oxo-process plant for the manufacture of aldehydes from olefins. The facility features direct wet-grinding of coal in a concentrated slurry with water and a waste heat boiler in conjunction with the Texaco gasifier.

At each point visited specific questions were asked about incidents, experiences, and histories of (1) air and stream pollution, (2) occupational health, particularly results of exposure to carcinogens or cancer-producing materials such as coal tars, and (3) safety problems.

Air pollution problems are being handled in varying degrees, depending on the emission regulations in effect at the particular location. Generally speaking, air pollution controls in the U.S. will have to be much more extensive than those seen during the trip. SASOL has, up until recently, released H_2S through a boiler stack, but they have now installed a Stretford sulfur recovery unit. The coals used in most places visited were low-sulfur coals. Carbon monoxide release to the atmosphere was allowed in some of the plants.

Water pollution in South Africa is rigidly controlled because water is scarce and plant water effluents go into the community water supply system. Close monitoring for heavy metals has been practiced but no corrective action has been needed.

Incidents with toxic fumes were reported. There have been fatalities from carbon monoxide and nitrogen asphyxiations. Incidents have also occurred with methanol fumes. Effective corrective action has been taken by installing suitable detection devices and making plant modifications. At no plant was there any report of cancer being caused by exposure to coal tar chemicals. At Ruhrchemie, where coal chemistry has been practiced since the early 1930's, it was stated that they were unaware of any problem. SASOL established a health program 23 years ago and monitored the workers for cancer, and there has not been a single cancer case. It was reported that the incidence of colds and flu was lower in their plant workers than in other persons in the area.

It is apparent then that the experience levels of the German coal-based processes and similar oil-based processes are entirely adequate for the design and construction of ammonia from coal plants. These firms are continuing to advance their process technology and are anxious to have their processes put into operation in the U.S.

Each coal gasification process studied has certain apparent advantages in given situations. The Lurgi process would have prime application where there would be a use or market for a multiplicity of products consisting of synthesis gas, methane, oils, tars, phenols, etc. Its best use is with those coals that have noncaking characteristics. The Lurgi process requires the lowest oxygen consumption.

The Koppers-Totzek process is said to be applicable for coals having varying ash melting behaviors and temperatures, reactivities and where coal tar condensibles are not desired. The Koppers-Totzek process produces high-pressure steam in a commercially proven waste heat boiler. The Winkler process performs well with certain coals but cannot be used with others. Winkler does not produce condensibles, but it does produce a char that must be burned or disposed of; this would not be a problem in NH_3 production because of high-steam requirements. The Texaco process is not advanced to commercial use with coal but offers the potential of operating at elevated pressure and is expected to accept a variety of coals without producing condensibles.

Development work is being carried out with both the Winkler and Koppers-Totzek processes on gasification at elevated pressure. Lurgi is developing a slagging type gasifier.

Very little capital or operating cost information was available during the TVA team's visit. The information obtained was either inapplicable to U.S. conditions or was out of date. TVA has, however, recently prepared a series of conceptual designs and cost estimates on 1000-short-ton-per-day grassroots ammonia plants. The estimated cost of a natural gas-steam reforming plant is about $75 million, and a coal partial-oxidation ammonia plant is about $140 million. The estimated ammonia sales price, f.o.b. plant, for 1000-ton-per-day plants is shown on Figure 5 for various feedstocks. The sales price includes the cost of raw materials and chemicals, operating labor and supervision, utilities, maintenance, simple depreciation at 15 years, insurance, plant and administrative overheads, a 50-50 debt-equity capital structure, interest at 10 percent on borrowed capital, marketing and a 14 percent after-tax return on owner's equity. Ammonia could be produced in a natural gas-steam reforming ammonia plant built in 1977 at a sales price of about $120/ton, using $2/MCF natural gas. The sales price for a coal-based plant would be about $150/ton, using $25/ton coal. It can be seen that if natural gas rises to $3/MCF, coal would be competitive at $25/ton. Naphtha, heavy oil, and electrolytic hydrogen are also shown on the curve and can be seen to be noncompetitive with coal at current costs of $13/bbl for fuel oil, $120/ton for naphtha, and 20 mills/kWh for electricity. In order to bring all of this into perspective, ammonia prices delivered to retail dealers in the Midwest are currently about $125-130/ton, about $100/ton on the Gulf Coast, and less for spot prices on small shipments. Coal costs at Muscle Shoals are currently between $25 and $30 per ton. The cost would be about $17-23 per ton for a coal-based plant located at the coal mine (high-sulfur, bituminous).

The conclusion reached at this point is that both the technical and economic aspects of coal-based ammonia production are unclear. It is apparent that no one gasification process will be applicable for all ammonia from coal applications in the U.S. In addition to the selection of the gasification process, there are numerous other technical alternatives that the ammonia producer must consider, depending on his particular circumstances. The economic picture will depend on future availability and costs of feedstocks. We expect that natural gas costs will continue to increase in the future. We also expect the cost of coal to increase. It would appear that coal costs will not increase as much as natural gas in the next 10 to 15 years, but there is no certainty of this. One main objective of the TVA project is to firmly establish the economics of producing ammonia from coal. Accomplishment of this objective will provide a useful yardstick for U.S. industry as producers consider alternatives for meeting the nation's nitrogen fertilizer demand in the future.

Note: Figure #1 thru Figure #5
continued on pages #39 thru #41

FIGURE 1
MULTIPROCESS PILOT PLANT

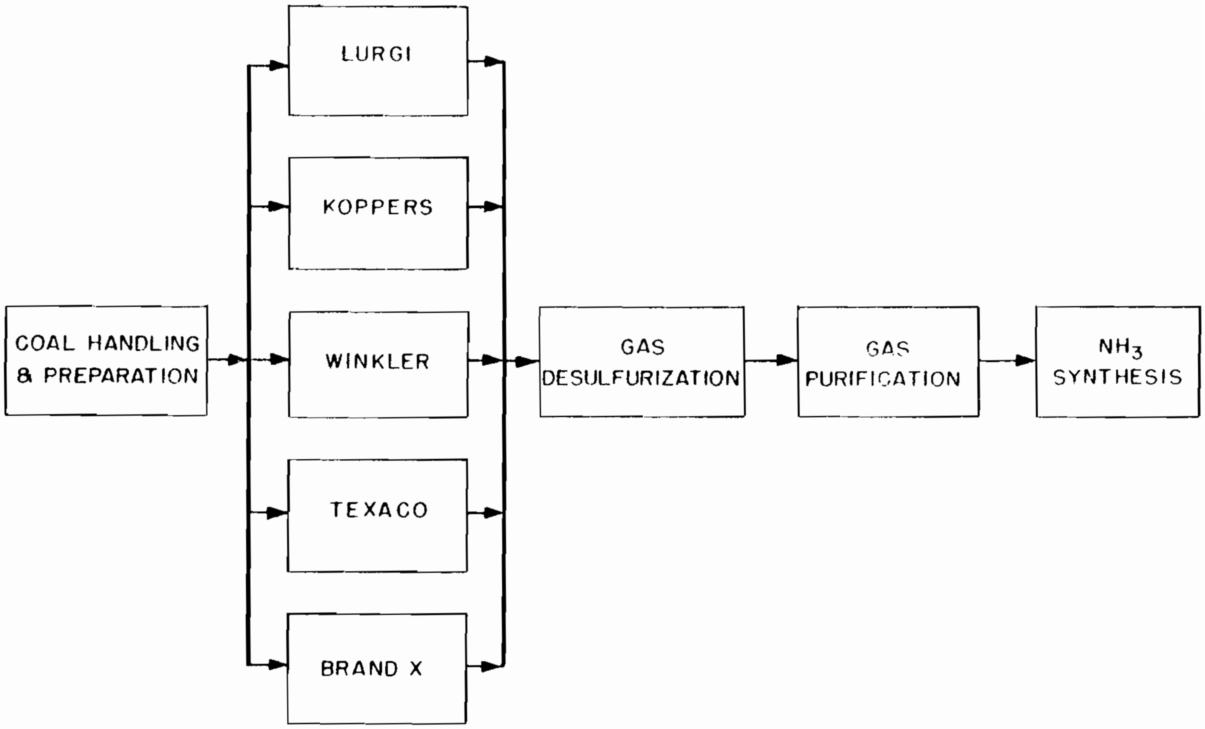


FIGURE 2
COAL GASIFICATION RETROFIT TO EXISTING NH_3 PLANT

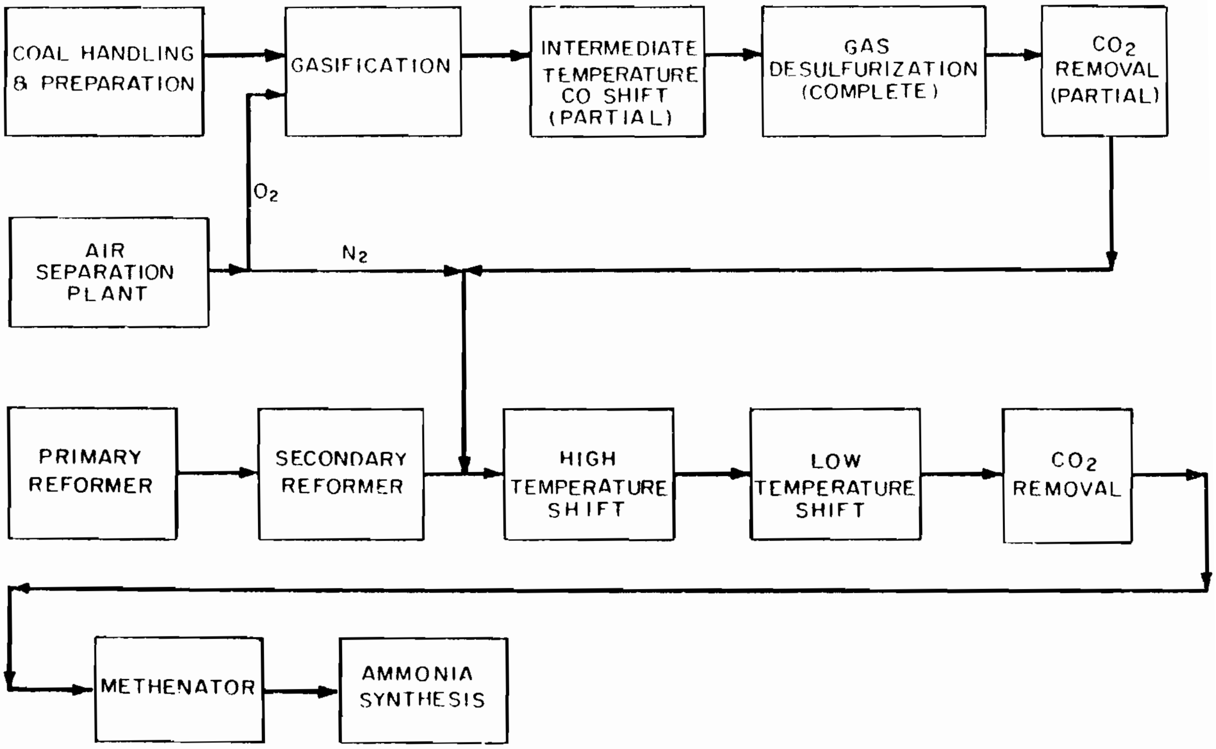


FIGURE 3
SASOL PLANT

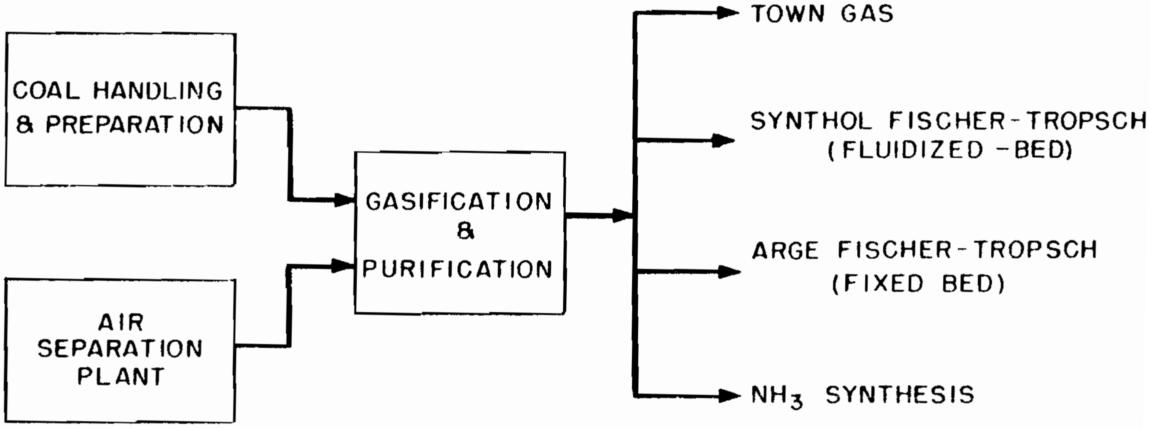
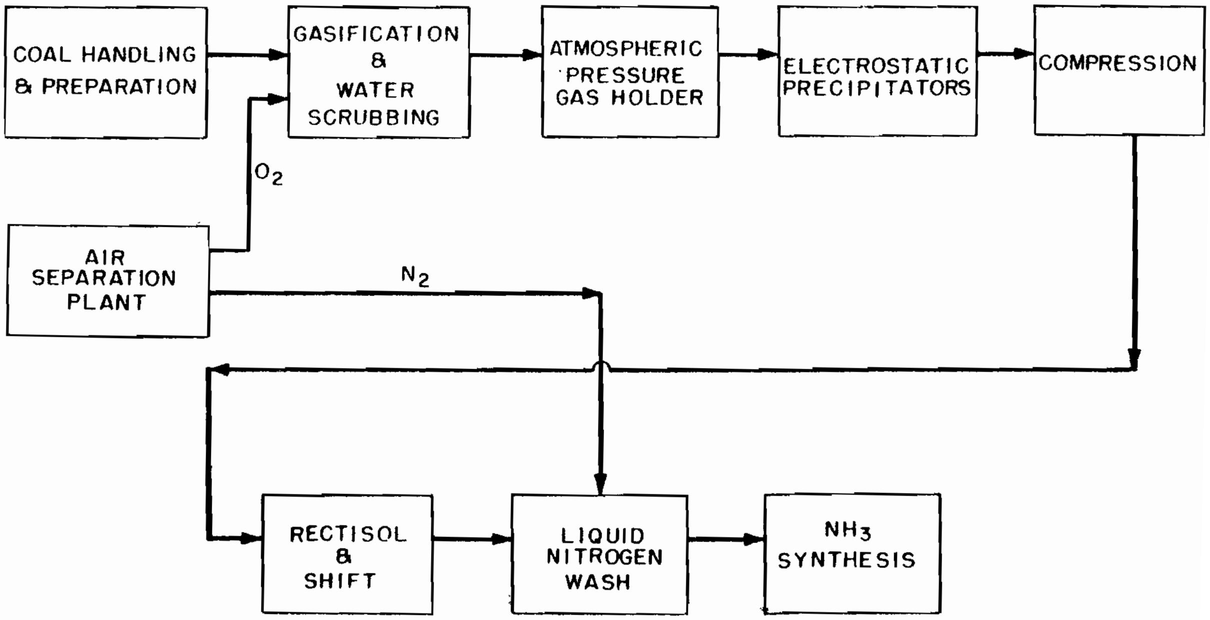


FIGURE 4
AE & CI PLANT



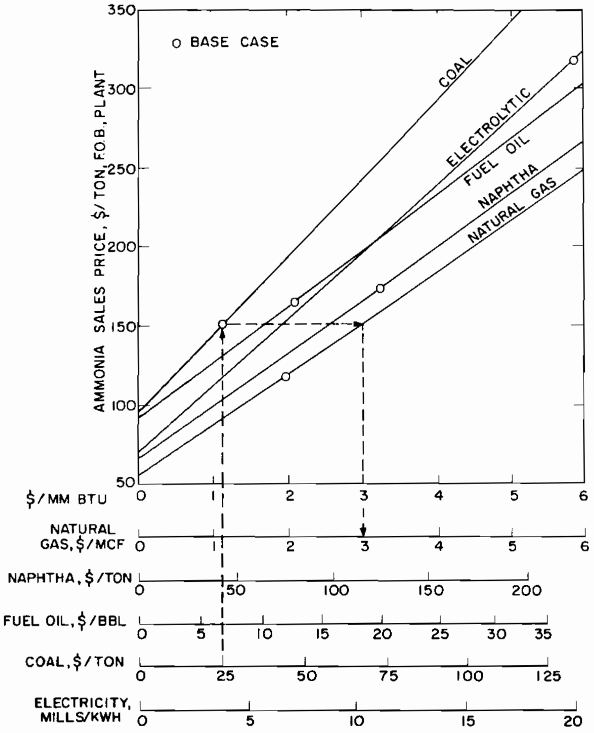


FIGURE 5
AMMONIA SALES PRICE VERSUS FEEDSTOCK COSTS

MODERATOR DAVIS: Do we have any questions for Mr. Waitzman? Yes Sir.

QUESTION: My name is Martin Hess. I'm with the Koppers Company. We are licensees for the Koppers Totzek process. I'd like to make one comment and then ask a question. The Koppers' Totzek process was piloted after World War II in Louisiana, Missouri by the Koppers Company of Pittsburgh in cooperation with what was then Heinrick Koppers Company of Essen. Koppers has had a license for that process for a number of years now, and we offer substantially a U.S. technology. We have made numerous studies, and the plants that we have designed incorporate American equipment and instrumentation to a very large extent. The question I'd like to ask is can you tell us something about the CO shift? Have you made any selection as to the type of catalyst and also has the sulfur remover process been selected?

MR. WAITZMAN: These three contracts I mentioned that Badger, Foster Wheeler and Brown & Root have, they are making these studies and cost estimates using what they consider to be the best arrangements relative to shifts, desulfurization and purification. It then becomes a part of their bid that they have determined the most economical arrangement, and on bidding this competitively this is the one that will be awarded. In the specifications that we wrote, because we did not think it practical to get this roller coaster effect of temperature, we did call for this intermediate temperature sulfur activated catalyst right at the striking of the gas fire and then go to a desulfurization and CO_2 removal sulfur recovered process to be selected by the contractors, and we're leaving that up to them.

MODERATOR DAVIS: I believe we'll have to move on now. I thank you, Don. [Applause]

Our next paper this afternoon is "Energy Conservation in Granulation Plants" by Frank Achorn and David Salladay. Frank will make the presentation. David is also present.

Frank's certainly well known to this group. He's served as a member of the Board of Directors of The Fertilizer Industry Round Table for 12 years. He has been working with fertilizer industry plants for more than 30 years. Frank is a chemical engineering graduate of Speed Scientific School at the University of Louisville. He presently is a senior scientist and also head of TVA's process and product improvement section directing technical assistance for over 300 plants that use TVA's products, process and technology. Frank has made numerous contributions to the advancement of fertilizer technology. Two of his more notable inventions include the pipe cross reactor which is rapidly gaining in popularity and about which you'll hear a great deal more this afternoon and also the TVA process for production of granular diammonium phosphate which is used by most U.S. producers of this product. Frank's an honorary member of the National Fertilizer Solutions Association. He's recognized in "Who's Who in America Men of Science" and "Who's Who in American Education." Additionally in appreciation for his outstanding contributions to the TVA program he has received the TVA meritory service award. Frank. [Applause]

Conservation of Energy in Ammoniation-Granulation Plants

Frank P. Achorn — David G. Salladay
Presented by Frank P. Achorn

Fertilizer producers in the ammoniation-granulation industry have always been interested in conserving energy. During the past year the Tennessee Valley Authority and the Energy Research and Development Administration, in cooperation with the fertilizer industry, have been developing new ways to conserve energy in these plants. Last winter many granulation plants did not have fuel available; at the same time, fuel costs almost tripled. Therefore, conservation or elimination of the fuel required for drying fertilizers became a critical need.

The ammoniation-granulation industry could be energy sufficient if the excess energy available from the production of sulfuric acid were used to produce concentrated phosphoric acid containing 54% P_2O_5. No fuel for drying would be required if this phosphoric acid were used to produce these fertilizers by the ammoniation-granulation process. A summary of the energy available from the sulfur consumed in making sulfuric acid and the amount of energy derived from fuel consumed by this segment of the fertilizer industry is tabulated below (1) (2).

Energy Data for Ammoniation-Granulation and Phosphate Industries
(estimated annual value 1976)

Tons P_2O_5 as wet-process phosphoric acid	6.1×10^6
Tons of sulfur to produce phosphoric acid	5.5×10^6
Heat from sulfur, Btu	2.89×10^{13}
Heat for phosphoric acid (54% P_2O_5), Btu	2.27×10^{13}
Balance of heat available from sulfur, Btu	0.62×10^{13}
Heat from fuel (for ammoniated-granulated products), Btu	0.61×10^{13}

This paper will suggest how the concentrated phosphoric acid containing 54% P_2O_5 can be used more efficiently so that the fuel requirements for drying fertilizers produced by ammoniation-granulation can be decreased or eliminated. This information should be of particular value to plants which have fuel costs as great as $3 per ton for drying products.

Ammonium Phosphate Plants

Most of the ammonium phosphate produced in the U.S. is produced as diammonium phosphate (DAP) of 18-46-0 grade. Almost 8 million tons of ammonium phosphate, primarily DAP was produced in the United States in 1976 (1). A recent survey of DAP producers shows that an average of about 235,000 Btu/ton of product as fuel is required to dry these products. Therefore, about 1.9×10^{12} Btu as fuel is required annually to dry ammonium phosphate.

The process used in manufacturing DAP is shown in figure 1. In this process filter grade phosphoric acid containing 30% P_2O_5 is fed to the scrubbers and usually concentrated acid containing 50 to 54% $P_2O_5$is fed to the preneutralizer. In most plants the quantities of these two acids are controlled to result in an acid containing 40% P_2O_5 being fed to the preneutralizer. This phosphoric acid is usually ammoniated to a NH_3:H_3PO_4 mole ratio of 1.45:1, a degree of ammoniation for high solubility of ammonium phosphate in solution. The slurry from the preneutralizer usually contains 18 to 25 percent moisture. The slurry is mixed with recycle and is ammoniated to DAP in a rotary granulator.

Ammonia is lost from the granulator and preneutralizer and exit gases from this equipment must be scrubbed with dilute acid containing 30% P_2O_5 to prevent the scrubber liquor from becoming too viscous. Slurry from the preneutralizer must be relatively high in moisture so that it can be pumped and distributed across the bed in the ammoniator-granulator. This results in a moisture content of 3 to 6 percent in the product leaving the granulator; the average temperature of this product is about 190°F. Under these conditions it is necessary to use from 94,000 to 402,000 Btu per ton of product for drying.

Part or all of this fuel could be saved if granular monoammonium phosphate (MAP) were produced instead of DAP. This is possible because less ammonia is lost in the production of MAP; therefore, lower quantities of dilute phosphoric acid are required to scrub the exit gases from the ammoniator-granulator. Also, more concentrated phosphoric acid can be used in the prereactor and granulator without excessive ammonia loss. Ammoniation of this more concentrated acid results in a higher product temperature in the granulator. This granulator product at 220 to 230°F. contains enough sensible heat so that it can be dried by cooling.

The recycle rate is usually 3 to 4 tons per ton of product when an acid containing 50 to 54% P_2O_2 is used. Under these conditions no fuel is required in the dryer and all of the excess scrubber liquor is consumed in the granulator.

Chemical and plant data indicate that there is sufficient steam generated in the manufacture of sulfuric acid, 4.9×10^3 lb of steam per ton on $P_2{}^\circ{}_5$ in the H_3PO_4, to concentrate the filter grade phosphoric acid containing 30% P_2O_5 to a concentration of 54% P_2O_5, 3.75×10^3 lb of steam per ton of P_2O_5 in the H_2PO_4, without the need for fuel (2). Therefore, if the acid containing 54% $P_2{}^\circ{}_5$ can be effectively used, no fuel should be required in the ammonium phosphate plant.

TVA has developed a process for the production of MAP and monoammonium phosphate sulfate (MAPS) from merchant grade phosphoric acid containing 50 to 54% P_2O_5 (3). This new process uses a pipe-cross reactor. It consists of a conventional ammonium phosphate plant with a new type pipe reactor used as a substitute for the preneutralizer. The pipe reactor is located inside the granulaor, as shown in figure 2. The reactor discharges hot melt directly into the granulator, eliminating the need to pump slurry from a preneutralizer to the granulator. Also, an essentially anhydrous melt is sprayed from the reactor which helps in controlling the water input to the process.

Additional concentrated acid is also added above the bed in the ammoniator-granulator and ammonia is added beneath this bed. The product is ammoniated to a much lower degree than DAP resulting in much higher material temperatures from the prereactor without excessive ammonia losses from the granulator. In the production of MAP and MAPS the moisture content of product leaving the granulator is about 2 percent, which is about half the moisture content of the granulator product during the production of DAP.

Test results for the production of MAPS are shown in table 1. In this test a 3-inch pipe-cross reactor was used to produce a 12-48-0-4S. The test shows that the reactor size of 3 inches was too small and about 30 percent of the phosphoric acid was ammoniated in the reactor. This resulted in a granulator product temperature of 236°F. which caused high ammonia losses from the granulator. Based on the results of this and other tests, the maximum reaction rate (heat flux) within the reactor should be limited to 500 x 10^3 Btu per hour per in^2 of reactor cross section when MAP is to be produced. When the heat flux exceeds this value the ammonia losses from the reactor increased dramatically. Other tests show that the minimum heat flux should be 250 x 10^2 Btu per hour per in^2. At lower fluxes there is not a good spray pattern from the reactor.

Recently a plant with a 6-inch pipe-cross reactor has produced over 1,000 tons of 12-48-0-4S at 25 tons per hour using a recycle rate of about 3:1. When acid containing 52% P_2O_5 was used no fuel was required to dry the product. Similar results were obtained in the production of a MAPS of 16-20-0-14S grade.

In other tests a 4-inch pipe-cross reactor was used to produce MAP of 11-44-0 grade. It was found in most tests, that when the phosphoric acid addition was split so that 50-75% of this acid was added to the pipe-cross reactor and the remainder to the ammoniator-granulator, the temperature of the product from the granulator was usually about 220°F. and there was no need for fuel to dry the product.

Some industry representatives have expressed concern that the reactor could plug when acids containing large quantities of sludge are used. Plant scale tests have been conducted in which acid containing an estimated 15 to 20 percent of settled solids was fed from the bottom of a storage tank to the reactor. Plugging of the reactor did not occur when 50 pounds of sulfuric acid per ton of product was fed to the reactor along with the phosphoric acid. Additional plant tests are required to confirm that the reactor will not plug and will function satisfactorily with freshly prepared sludge phosphoric acid. Plant tests for the MAP and MAPS show that when the pipe-cross reactor is used, the recycle rate will be about 3:1 to 4:1 and a good quality product can be produced without the need for fuel to dry the product.

Other tests show that MAP can be satisfactorily produced in the rotary ammoniator-granulator without the pipe-cross reactor. In plant tests granular MAP was produced by simply feeding phosphoric acid and ammonia to the granulator. Operating data are shown in table 2. Because of the large quantity of chemical heat added to the granulator, about 594,000 Btu per ton of product, there is a tendency to lose ammonia even with the low degree of ammoniation. This ammonia loss can be avoided by the addition of large quantities of water, 0.5 lb of water per lb of phosphoric acid, or scrubber liquor to the ammoniator-granulator. In this process the recycle rate is about 5 to 10 tons of recycle per ton of product. However, if care is taken to avoid the addition of excess scrubber liquor or water to the granulator the requirement of fuel for drying can be eliminated.

The purpose of the prereactors, either the pipe-cross or the preneutralizer, is to prereact some of the phosphoric acid outside of the ammoniator-granulator so that high recycle rates to the granulator can be avoided. There is sufficient plant data available to show that although the use of the pipe-cross reactor is advisable for the production of MAP, it is not necessary that it be used to avoid the need for fuel in the dryer. These data show that if 25 to 75 percent of the required phosphoric acid containing 45-54% P_2O_5, used in the manufacture of MAP were preneutralized in a standard tank-type preneutralizer and half were added to the granulator, probably drying of the product could be accomplished by the sensible heat in the granulator product. It is estimated that the recycle rate would be about 4 tons per ton of product. This process could be used by existing plants, such as the conventional DAP plants, that have preneutralizers (figure 1). It is suggested that the preneutralizer be operated so that the NH_3:H_3PO_4 mole ratio in the slurry from the preneutralizer will be about 0.60:1 and the pH about 2.0. Data from the curve in figure 3 show that the solubility of the ammonium phosphate at this degree of ammoniation is about the same as that obtained at the 1.45:1 mole ratio, used for the manufacture of DAP (4) (5), 268 lb of ammonium phosphate salts per 100 lb of water at 167°F.

Plant tests show that at this degree of ammoniation a slurry containing 8 to 10 percent moisture can be pumped and distributed satisfactorily in the granulator. The slurry temperature is 270°F. and there is practically no loss of ammonia from the preneutralizer. At this high slurry temperature and low pH, stainless steel preneutralizers may not be sufficiently corrosion resistant; a brick lined preneutralizer such as shown for the first stage in figure 1 may be more suitable. This type preneutralizer has been used for several years under these slurry conditions. Slurry from the preneutralizer and additional phosphoric acid are ammoniated and mixed with recycle in a conventional rotary ammoniator-granulator. When the pH from the granulator is controlled, between 3.5 and 4.5, the recycle rate should be about 4:1.

Since the authors are recommending the marketing of MAP instead of DAP, perhaps we should discuss the advantages to using MAP instead of DAP in the market place.

1. MAP has more versatility for use by the bulk blender since a larger number of grades can be produced from MAP as compared to using DAP.
2. MAP is compatible with triple superphosphate (TSP) whereas DAP reacts and causes caking when mixed with most commercially available TSP.
3. MAP can be used to produce suspension fer-

tilizers by the addition of only ammonia whereas when DAP is used to produce these suspensions, phosphoric acid must be mixed with it and acid storage must be available at the dealer level.

4. The dual marketing of anhydrous ammonia and MAP is probably more economically attractive than ammonia and DAP.

5. Most phosphate producers desire to ship mostly P_2O_5 and add ammonia to the product only to convert the P_2O_5 to a suitable form for shipping.

Granular Homogeneous NPK: Mixtures

About 10 million tons of granular NPK mixtures are produced annually in the United States in about 100 plants. The number of plants has not increased; but, the quantity produced by each plant seem to be increasing each year. One plant of this type has produced almost one million tons and another about 300,000 tons per year. The type of operation varies from those that use only phosphoric and sulfuric acids, ammonia, and potash to those that use a wide variety of materials such as TSP, powdered MAP, crystalline ammonium sulfate, normal superphosphate, acids, ammonia, and nitrogen solutions. A flow diagram of these plants is shown in figure 4. Some use a preneutralizer, but in most instances all of the ammoniation and granulation occurs in the TVA-type rotary ammoniator-granulator. Materials from the granulator are dried in a rotary dryer and cooled in a rotary cooler.

Usually some steam, water, and/or scrubber liquor is added to the granulator to promote granulation; usually about 350,000 to 500,000 Btu per ton of product as fuel in the dryer is required to dry the product. This drying causess dust which in turn must be returned to the granulator as scrubber liquor or as dust which requires extra liquid phase for granulation. Thus drying indirectly causes increased moisture to be introduced into the granulator to granulate dust caused by drying. Therefore, if the drying step could be eliminated, probaly less moisture would be added in the granulator.

In the first tests conducted in these plants, it was found that less fuel would be required for drying if more chemical heat were introduced. The obvious way to introduce this extra chemical heat is to neutralize larger quantities of phosphoric or sulfuric acid. However, plant operating experience showed that if more than 400 lb of acid per ton of product is used, overgranulation occurs and the plant can not be operated. Most plants still ammoniate the phosphoric acid to a degree of ammoniation equivalent to 7.2 lb. of ammonia per unit of P_2O_5. Data in figure 3 show that at this degree of ammoniation, the solubility is high, about 290 lb of salt per 100 lb of water at 167°F. Much larger quantities of phosphoric acid and ammonia could be used in the formula if the degree of ammoniation were lowered to 5.0 lb of NH_2 per unit of P_2O_5 because of lower solubility.

Data in figure 3 show that when the degree of ammoniation of the phosphoric acid is lowered from 7.2 lb NH_3 per unit P_2O_5 to 5.0, the solubility changes from about 237 to 114 lb of ammonium phosphate salts per 100 lb of water at 167°F. In one commercial plant which lowered the degree of ammoniation, the fuel consumption was decreased from an average of about 600,000 Btu to 200,000 Btu ton of product, about a 70 percent reduction in fuel cost. Two typical formulations which use the lower degree of ammoniation are shown in table 3. Some companies that produce the high phosphate grades such as a 6-24-24 report that at times they can cut their burners off to their dryer, provided at least 600 lb of phosphoric acid per ton of product is used.

In all plants that have adopted these new procedures, phosphoric acid that has a concentration in excess of 50 percent P_2O_5 is used. The same type results can be obtained by the introduction of chemical heat into the granulator by the addition of relatively large quantities of sulfuric acid to the formulation. This is an old practice in batch granulation plants. In many instances these plants did not have a dryer and depended mainly on chemical heat to dry the product. In the modern continuous ammoniation-granulation plants that have much higher production rates and are subjected to much stricter environmental emission standards, there are some problems involved in the addition of large quantities of sulfuric acid to the granulator. Many producers have reported the problems with ammonium chloride particulate loss which occurs when sulfuric acid, potash, and ammonia are added to the granulator (6). No further remarks are necessary on this subject except to emphasize the extreme difficulty in removing the ammonium chloride aerosol from the exit gas stream of the plant. Use of the TVA pipe-cross reactor helps to eliminate this problem.

A sketch of the latest design of the TVA pipe-cross reactor is shown in figure 5. All of the sulfuric acid used in the formulation is prereacted in the pipe-cross reactor; therefore, the reaction between sulfuric acid, potash, and ammonia to form an ammonium chloride aerosol can be avoided. Also, part of the phosphoric acid used in the formulation can be added to the reactor. With this reactor it is possible to add large quantities of sulfuric and phosphoric acid to the formulation so that all of the nitrogen required for the grade can be supplied by the usually low-priced anhydrous ammonia.

Table 4 shows formulations and operating results when two different sized pipe-cross reactors were used. In both tests a scrubber was used for the granulator and coolers and the scrubber water pH was kept between 5 and 6 by diverting part of the sulfuric acid used in the formulation. In both tests no fuel was used in the dryer; one of the plants has not used fuel in their dryer for about 3 years.

Particulate loss from the plant scrubbers was nil for the 8-24-24 grade product and 3.4 lb per hour per ton of product for the 12-12-12 grade. Fluorine and chlorine losses were nil for both grades. The ammonia loss during the manufacture of 8-24-24 was low, less than 1%, whereas the loss from the 12-12-12 grade was higher than desirable. The plant in which the 12-12-12 was produced did not have an efficient scrubber and this formulation has a much higher chemical heat of reaction which causes higher ammonia losses from the pipe-cross reactor. Recent plant data from a plant that has a good scrubber show this loss to be less than one percent when a 12-12-12 grade was produced.

Other plant tests show that all of the scrubber water can probably be added to the ammonia sparger. In one of these plants the pipe-cross reactor shown in figure 5 was used and scrubber water from the ammoniator-granulator scrubber was added through the extra sparger labeled scrubber water sparger. In the other plant the pipe-cross reactor has only one sparger and scrubber water is used instead of water which is premixed with liquid anhydrous ammonia. When this is done the scrubber water is first passed through a hydroclone, figure 6, and the thick underflow is delivered to the ammoniator-granulator, while the thin overflow is delivered to the pipe-cross reactor. Work with the pipe-cross reactor is continuing.

Plant data have shown that a substantial portion of the fuel used to dry granular fertilizers in ammoniation-granulation plants can probably be conserved and the following suggestions are given:

1. Produce MAP instead of DAP. If concentrated phosphoric acid containing 46 to 54% P_2O_5 is used in the manufacture of ammonium phosphates, probably no fuel will be required to dry the product. There is sufficient heat available from the manufacture of sulfuric acid to concentrate filter grade acid from 30% P_2O_5 to 54% P_2O_5. Also, there are many marketing advantages of MAP over DAP.

2. In the production of granular NPK mixtures in the ammoniation-granulation plants the degree of ammoniation of the phosphoric acid should be lowered from 7.2 to 5 lb of ammonia per unit of P_2O_2 to lower the solubility and thereby the liquid phase in the granulator. If this is done, larger quantities of acids and ammonia can be used in the formula which will supply most of the heat required to dry the mixtures.

3. In NPK granulation the use of the TVA pipe-cross reactor will eliminate the need for fuel to dry the product because the moisture addition in the granulator can be minimized and the amount of chemical heat as acids and ammonia can be maximized without affecting product quality or production rate.

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2. Blouin, G. M., Effects of Increased Energy Costs on Fertilizer Production Costs and Technology, TVA Bulletin Y-84.
3. Achorn, F. P., and Lewis, J. S. Jr., Granular Ammonium Phosphate Sulfate and Monoammonium Phosphate Using Common Pipe-Cross Type Reactor. U.S. Patent 3,954,942 May 4, 1976.
4. Lenfesty, F. A., and Brosheer, J. C. Ammonia-Phosphoric Acid-Water System at 25°C. *Chem. Eng. Data, 5* (2) 152-4 (Apr. 1960).
5. Brosheer, J. C. and Anderson, J. F. Jr., System Ammonia-Phosphoric Acid-Water at 75°, *J. Ame. Chem. Soc. 68* (5). 902-4 (May 1946).
6. Perkins, R. H., Dibble, D. L., Ecology of a Mixed Fertilizer Plant, pp. 99-100 Proc 22nd Annual Meeting Fertilizer Industry Round Table 1972 (Memphis, Tenn.).

Note: Tables #1 thru #4
and Figures #1 thru #6
continued on pages #46 thru #52

Table 1

Plant Test Data for Production of Granular Monoammonium Phosphate 12-48-0-4S in a 3-inch Pipe-Cross Reactor

Formulation, lb/ton of product		
Pipe-cross reactor		
Ammonia		147
Sulfuric acid (66°Bé.)		228
Phosphoric acid (54% P_2O_5)		600
Water		59
NH_3:H_3PO_4 mole ratio		0.95:1
Ammoniator-granulator		
Ammonia		146
Phosphoric acid (54% P_2O_5)		1265
NH_3:H_3PO_4 mole ratio		0.91:1
Duration of test, hours		32
Operating results		
Production rate, tons/hour		18
Recycle ratio, tons of recycle/ton of product		3.8:1[a]
Granulator, product average pH		4.0
Temperature, °F (average)		
Material from granulator		236
Dryer exit gas[b]		174
Product (estimated)		110
Chemical heat		
Released in pipe-cross reactor 10^6Btu/hr-in^2		0.86
Released in formulation 10^3Btu/ton product		686
Total wgt. acid in formulations, lb/ton of product		2093
Product chemical analysis, %	N	12.9
	P_2O_5	46.7
	H_2O[c]	1.2
Product screen analysis, % (Tyler Screen)	+6	0.8
	-6+8	48.3
	-8+12	50.6
	-12+14	0.3
	-14+16	0
	-16+20	0

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[a] Calculated by measuring volume of material on recycle belt

[b] Burner off during all these tests, dryer used as a cooler

[c] Estimated by doubling the results of the rapid analysis method

Table 2

Production of Granular Monoammonium Phosphate, 11-55-0[a]
No Prereactor

Total hours of operation	12
Average production rate, tons/hr.	8[b]
Formulation, lbs/ton of product	
Phosphoric acid (54%P_2O_5)[c]	2,098
Ammonia	280
Recycle ratio, tons of recycle/ton of product[d]	5-10:1
Granulator product	
pH	3.7
Temperature, °F[e]	220
Moisture, %	1.0
Screen analysis, %	62.3
- 6 + 10	35.0
- 10 + 6	2.4
- 16	0.3
Dryer product	
Chemical analysis, % of total	
N	11.4
Total P_2O_5	54.4
Available P_2O_5	54.4
Moisture	0.5
Screen analysis	
+ 6	34.0
- 6 + 10	60.2
- 10 + 16	5.0
- 16	0.8
Temperature, °F[f]	174
Cooler Product	
Temperature, °F[g]	92

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a. Normal grade average data for test.
b. Production gradually increased from 4 to 10 tons per hr.
c. Wet-process acid from Florida, 19%H_2O.
d. Estimated
e. A temperature above 220°F; thermometer read to only 220°F.
f. Average temperature with heater off.
g. Product to storage.

Table 3

Formulation and Operating Data for Ammoniation-Granulation Plants Using Low Degree of Ammoniation Phosphoric Acid (5 lb/unit of P_2O_5)

Grade	6-24-24	12-12-12
Formulation, lb/ton of product		
Ammonium sulfate (21%N)	145	801
Anhydrous ammonia	111	92
Triple superphosphate (46% P_2O_5)	348	-
Phosphoric acid (54% P_2O_5)	600	448
Sulfuric acid (66°Bé.)	-	98
Potash (60% K_2O)	800	400
Filler	56	187
Chemical heat in formulation Btu x 10^3	230,000	220,000
Liquid phase[a]	734	660
Operating data		
pH material from granulator	4.0	3.8
Temperature of material from granulator, °F	220	225
Production rate, tons/hr	30	22
Recycle ratio, tons of recycle/ton of product	1.5:1	2.5:1

[a] Calculated using standard liquid phase factors for each material used in formulation

Table 4

Plant Operating Data Using TVA Pipe-Cross Reactor For NPK Mixtures

Grade	12-12-12	8-24-24
Size pipe, inches	5	4
Formulation, lb/ton of product		
Pipe-cross		
NH_3 (82%)	227	122
H_2SO_4 (66°Bé.)	598	80
H_3PO_4 (54% P_2O_5)	227	808
Ammoniator-granulator		
H_3PO_4 (53% P_2O_5)	229	-
NH_3 (82%)	23	-
Ammonium sulfate (21-0-0)	175	240
MAP (10-52-0)	-	100
Filler	243	-
Potash (0-0-60)	400	804
NH_3:H_3PO_4 mole ratio: pipe	1.17:1	-
granulator	0.796:1	1.0:1
Total wgt of acid in formulation, lb/ton of product	1054	888
Operating results		
Production rate, tons/hr	19.5	30
Recycle ratio, tons of recycle/ton of product	2.85:1	-
pH		
Granulator prod. discharge average	4.8	4.4
Granulator scrubber liquor range	3.8-7.2	-
Average	5.7	3.2
Dryer cooler scrubber liquor average	5.9	-
Temperature °F (average)		
Reactor skin	246	-
Granulator product discharge	240	225
Granulator scrubber liquor	142	132.3
Product from dryer	207	-
Product to storage	154	-
Dryer - air in	-	146
air out	-	145
Scrubber liquor to pipe, gpm	6.4	3.4
Cooler scrubber liquor to gran, gpm	4.9	-
Water to bed, gpm	-	2.9
Back pressure, psig	-	50
Moisture, gran product discharge, % H_2O	0.9	-
Chemical heat		
Released in PCR, Btu/hr-in^2	0.592	0.664
Released in formulation Btu/ton product	645	281
Emissions		
Chlorine, lb/hr	Nil[1]	Nil[1]
Fluorine, lb/hr	Nil[1]	Nil[1]
Sulfate, lb/hr	16.6	Nil[1]
Particulate, lb/hr/ton of product	3.4	Nil[1]
Ammonia loss % total	7.9	0.9

[1] 0.1 lb/hr or less

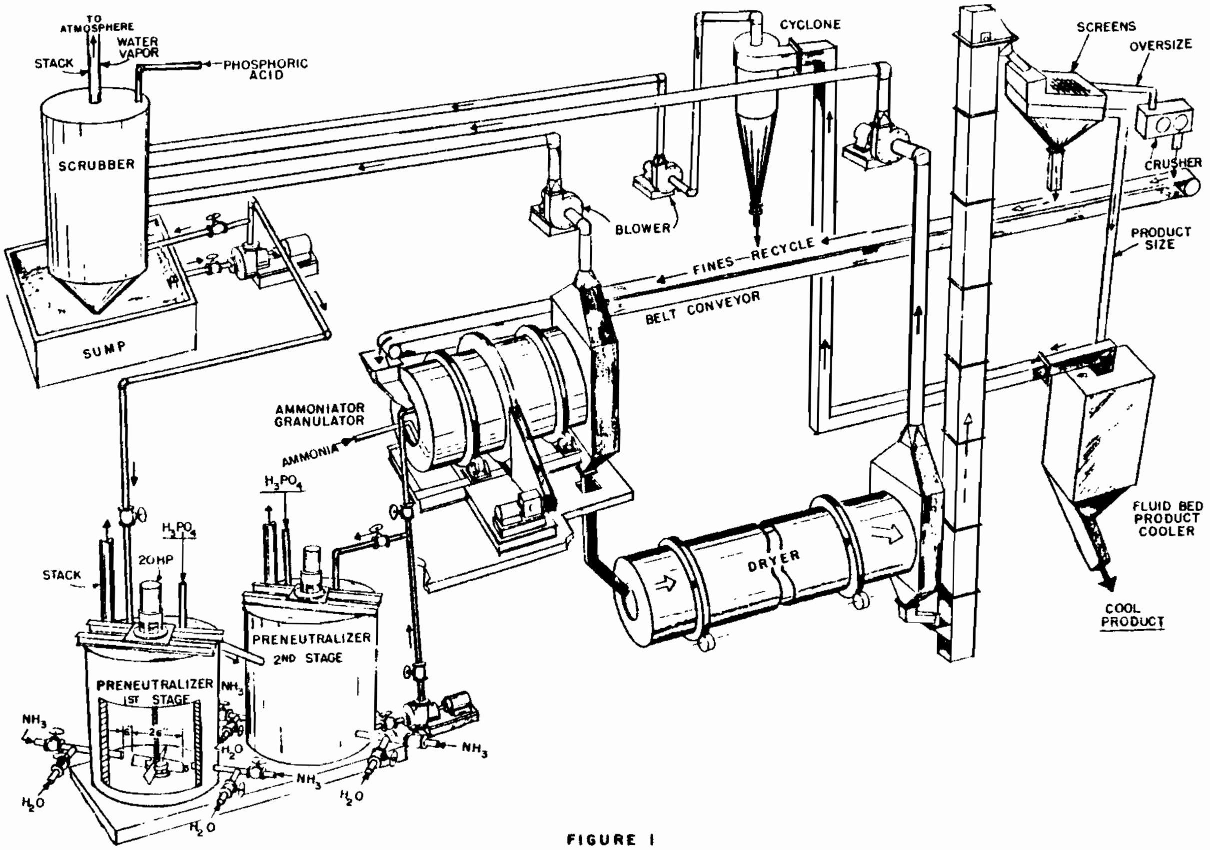
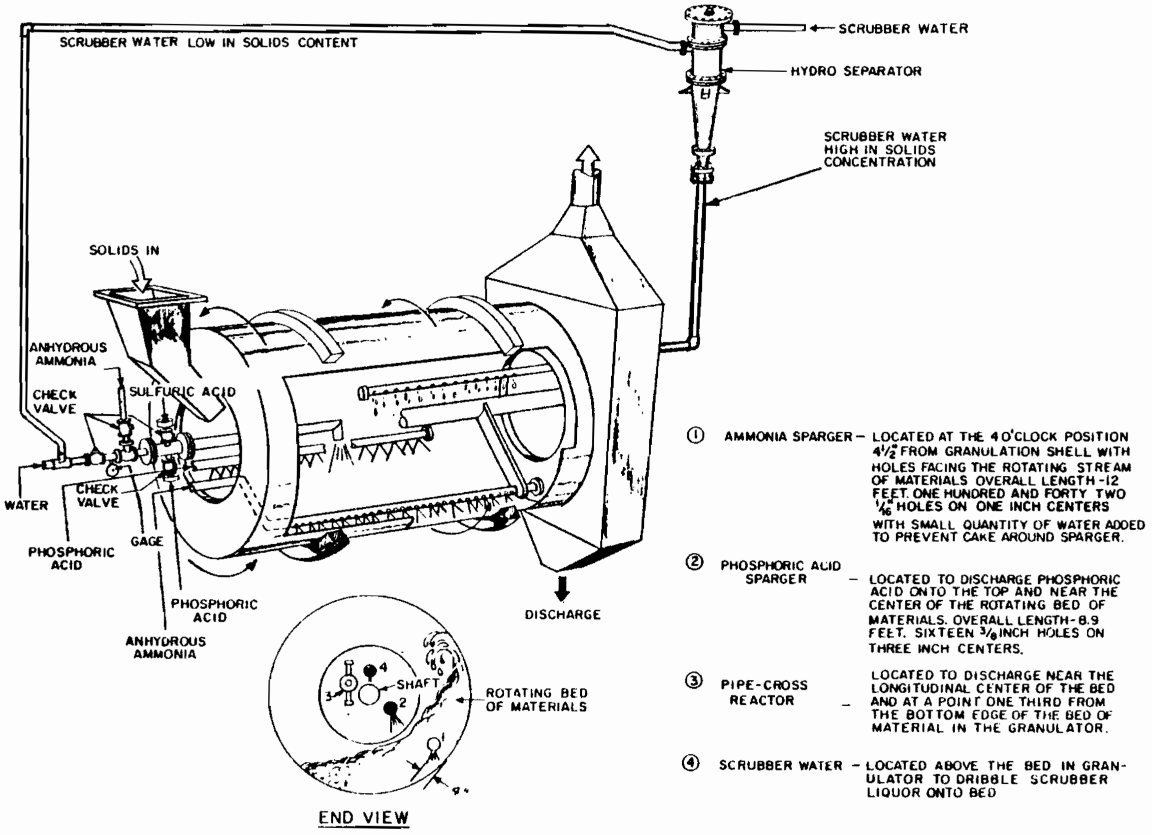


FIGURE I

CONVENTIONAL TVA PROCESS FOR PRODUCTION OF GRANULAR DIAMMONIUM PHOSPHATE



① AMMONIA SPARGER – LOCATED AT THE 4 O'CLOCK POSITION 4½" FROM GRANULATION SHELL WITH HOLES FACING THE ROTATING STREAM OF MATERIALS OVERALL LENGTH -12 FEET. ONE HUNDRED AND FORTY TWO 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 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 LIQUOR ONTO BED

FIGURE 2

TVA PIPE-CROSS REACTOR IN ROTARY AMMONIATOR-GRANULATOR

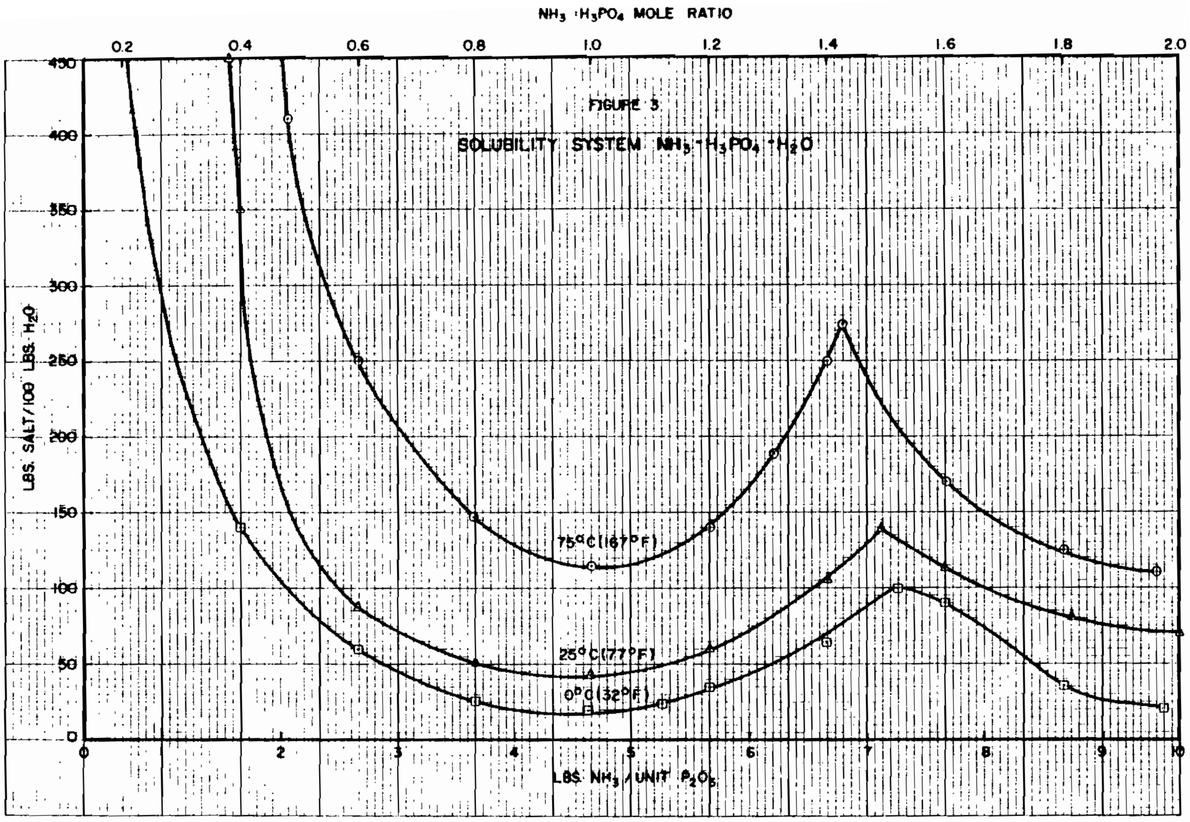


FIGURE 3

SOLUBILITY SYSTEM $NH_3-H_3PO_4-H_2O$

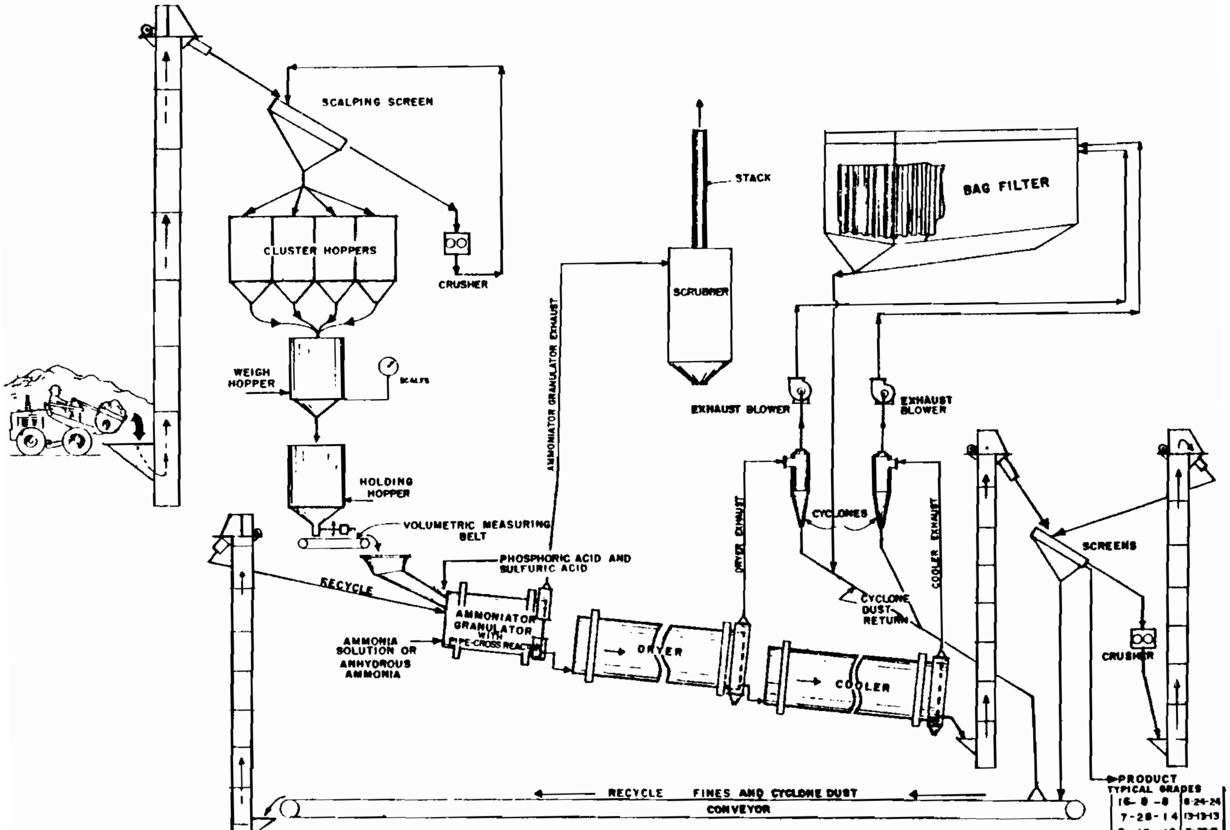


FIGURE 4
CONVENTIONAL AMMONIATON-GRANULATION PLANT FOR NPK MIXTURES

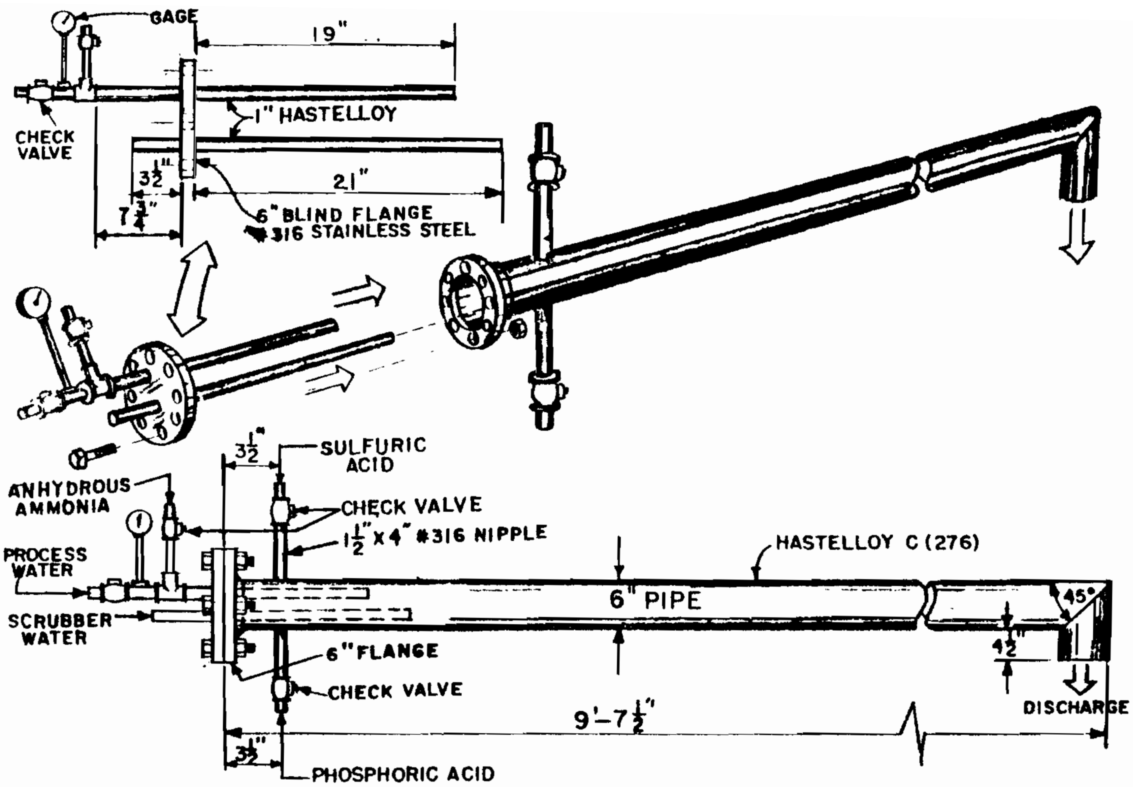


FIGURE 5
TVA PIPE-CROSS REACTOR

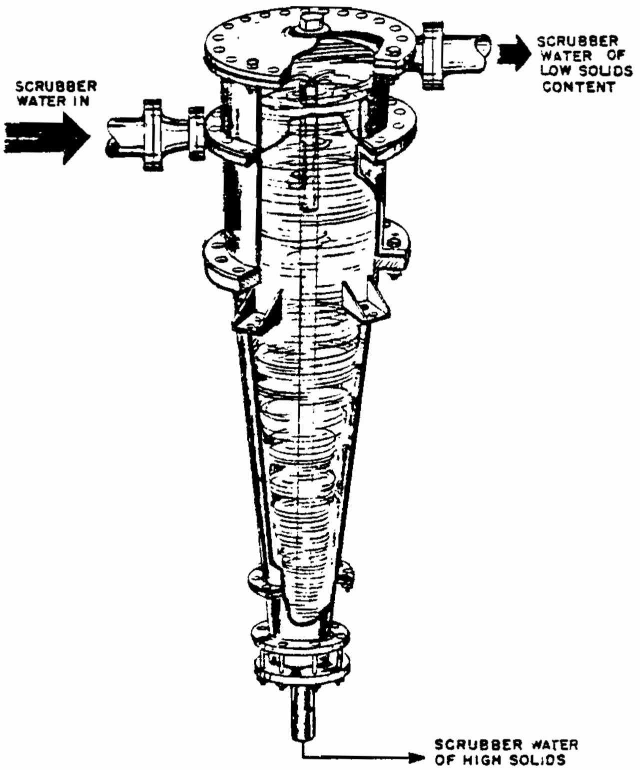


FIGURE 6
HYDRO CYCLONIC CLASSIFIER

MODERATOR DAVIS: Do we have a question for Frank?

Our next paper is "Experience with the Pipe Cross Reactor" by John L. Medbery of I.M.C. John is also well known to this group for his expertise in granulation technology having made numerous contributions in this area to our Round Table programs in the past. John has a degree in chemical engineering from the University of Minnesota. He has more than 23 years of granulation experience with I.M.C. beginning as plant manager back in 1954. He's worked his way up through a number of positions related to granulation operations in the company including production coordinator, zone production manager, manager of fertilizer technology and finally to his present position as director of operations production for the Rainbow Division. John. [Applause]

Experience With The Pipe-Cross Reactor In Making N.P.K. Fertilizer

John L. Medbery

Granular mixed fertilizers are manufactured and marketed by the Rainbow Division of International Minerals & Chemical Corporation. The division operates six plants in the southeastern states which feature 30 TPH nominal production rate granulation systems, all built in 1964/65. The granulation units are similar to each other. (Fig. 1) Each consists of an 8′ x 12′ ammoniator, an 8′ x 60′ dryer, and an 8′ x 60′ cooler. They all have two 4′ x 15′ two-surface Tyler hummer screens for product sizing. Double row cage mills are used for over-size crushing. Cyclonic collectors and wet scrubbers are used for controlling dust and other particulates from the dryer and cooler. A medium to high pressure drop scrubber is used at each plant to control pollutants originating in the ammoniator. The dryers are equipped with combustion chambers capable of burning both natural gas and fuel oils.

A variety of grades are produced by these plants. (Table I) The three located in the Coastal Plain make mainly 5-10-15, 3-9-18, and 0-10-20 grades. A large portion of this tonnage includes various secondary and minor nutrients. Two plants are located in the Carolina piedmont where 10-10-10 is the most popular grade. The sixth plant, located at Florence, Alabama, produces a wider range of grades, including a number in the 1-4-X ratio which are barged via the Tennessee-Mississippi-Missouri river systems to markets in Nebraska, Illinois and Indiana. The Florence plant also makes all of the grades popular in Alabama, Mississippi and Tennessee. The most popular single grade in this region is 13-13-13, however, 8-24-24 is gaining in popularity.

The pipe-cross reactor was developed by TVA, at first for producing an ammonium phosphate suspension base for use in fluid fertilizers[1,2], and later was adapted for use in a conventional N-P-K granulation plant[3]. The Missouri Farmers Association plant at Palmyra, Missouri installed a 3″ size pipe reactor and obtained successful operation in the production of many different grades[3]. Our review of pilot plant work at TVA and our observation of full scale operations at Palmyra convinced Rainbow Division management that this device would be beneficial in the production of many of the grades manufactured at Florence.

Photo 1 is described as follows:

The pipe-cross reactor was first used at Florence in September, 1976. These photos show the installation just prior to start-up.

A teflon-lined 4″-size cross was used for mixing the two acids. Phosphoric acid, 52-54% P_2O_5 wet process type, is fed in at the right side branch. Sulfuric acid of 78% concentration is fed in at the left. The acids mix together as they flow into the reactor pipe. Anhydrous ammonia liquid is mixed with water in a 1″ size tee and then fed through the length of the 4″ cross and released in the reactor pipe where the chemical reaction with the mixed acids takes place. The pressure gauge indicates the down-stream conditions by reading the back-pressure in the ammonia piping. Check valves are installed on the 1″ piping for all four fluids.

Photo 2 is a view of the reactor pipe taken from the inlet end of the ammoniator. The pipe is 4″ size schedule 40 Hastelloy-C-276. Seven feet of straight pipe are used, with five feet of it being inside the ammoniator.

Photo 3 shows the 90° elbow which is welded to the end of the 7 ft. long reactor pipe. The ell is also Hastelloy-C. The discharge is downward toward the bed of materials contained in the ammoniator.

Photo 4 was taken from outside the ammoniator. This gives some idea of the over-all dimensions and orientation of the reactor. The large pipe to the left is used to support the scraper bar needed to keep the inside of the shell clean. It also supports the arms used to position the under-bed spargers.

Figure 2 is an over-all Flow Schematic of the pipe reactor system. Phosphoric and sulfuric acids are pumped from storage tanks via magnetic flow meters to the process. When the pipe-cross is used, all of the sulfuric is fed to it, however, the phosphoric stream is usually split and a portion is sprayed on the surface of the bed.

The ammonia tank car shown here has been replaced by a permanent storage tank. Pumps are used to deliver liquid ammonia to armored rotometers which meter two streams, one to the pipe-cross, and one to the under-bed sparger. Evaporative coolers are used to keep the ammonia in the liquid phase to permit its metering.

Most of the time, the plant makes use of recovered scrubber water as process water; however, the ability exists to use regular city water or pond water from the run-off catch basin if desired. Two water meters are needed, one for the water added to the ammonia at the pipe-cross inlet, and the other for water mixed with ammonia sparged under the bed.

Dry materials fed to the ammoniator-granulator include the solid raw materials in the formulation, process recycle and a controlled amount of product.

Figure 3 is a schematic of the two-stage ammoniator scrubber. The 24″ natural draft stack that was originally installed is blocked-off. An 18″ side branch draws the air, water vapor, escaping ammonia vapor, etc. to a pre-scrubber which is essentially a wet cyclone. Water of adjusted pH is sprayed into the duct ahead of the pre-scrubber. Part of the ammonia escaping from the ammoniator is recovered here. The pressure drop in the pre-scrubber is usually 7″ H_2O.

The gases are next ducted to an Entoleter Centrifield scrubber, which is usually operated at a pressure drop of 30″ H_2O. This is an effective device for particulate removal. Both scrubbers are on the suction side of a blower which discharges the cleaned gases into a silencer-equipped vent stack.

Sulfuric acid is fed to the water tank for the pre-scrubber to maintain the pH in the 2-3 range. A portion of the pump discharge fluid is frequently used as process water at the pipe-cross. This promptly reintroduces to the formulation part of the ammonia lost from the reactor discharge or from the under-bed sparger.

Figure 4 shows the construction of the pipe-cross reactor. This differs from the photo shown earlier in that the 90° ell is shown here as flanged to the reactor pipe. I would prefer to have it flanged for ease of replacement and for rotating it somewhat, in slotted bolt holes, for better impingement of the discharging reactants on the ammoniator bed.

The ammonia-water mixture is sparged into the reactor pipe 6" beyond the cross. This allows ample time for the two acids to mix before they are neutralized by ammonia and also ensures that the violent reactions occur a safe distance inside the corrosion-resistant Hastelloy-C reactor pipe. The reactor pipe is shown here as 9 ft. in length. As stated earlier, the Florence reactor is only 7 ft. long. We feel the extra 2 ft. would be preferable, helping to ensure completed reactions before discharge. We have had some difficulty in achieving steady conditions at low production rates. This is probably caused by inadequate mixing inside the reactor pipe. TVA has developed a number of design parameters which are important when assembling a pipe-cross reactor system[3,4]. These are generally followed in our installation. They recommend a length to diameter ratio of between 21 and 24.

Figure 5 shows our method for obtaining constant volume recycle within the process. The quantities of fines and crushed oversize tend to vary from time to time, especially if the operator is having difficulty in holding steady-state conditions by use of liquids in the ammoniator. The rack and pinion gate permits a portion of the screened product to fill any valleys in the returning recycle rate curve. This is sometimes referred to as smoothing. The gate opens a side-feed chute to a screw conveyor used to bring the regular recycle streams back to the ammoniator. A portion of the screened product flows through the opened gate to fill the screw conveyor to a constant level. Only a small portion of the product stream is used in this way. If the demands of any formulation are for more recycle than can be supplied in this manner, product is weighed into the dry material batches, which are being fed to the process.

Figure 6 is a drawing of the cross which we fabricated from type 316 stainless steel. The plant originally used a Teflon-lined malleable iron cross, as shown in Photo 1. The teflon was accidentally cut and began leaking during a run. This stainless steel cross was quickly made by the plant people to continue production with a minimum delay. It has held up exceptionally well and is probably sufficiently corrosion-resistant for this purpose. About 35,000 tons have been made since its installation.

As stated earlier, in discussing the drawings, when the pipe-cross is in operation, most formulas call for ammonia and phosphoric acid to be fed to the ammoniator bed in addition to the quantities supplied through the pipe-cross reactor. The additional ammonia is sparged under the bed surface and the extra phosphoric acid is sprayed on the surface of the bed.

Formulas are written to show the pipe reactor feeds as separate from the chemicals fed directly to the ammoniator. This enables the formulator to check the mole ratios of the reactants and to calculate the chemical heat generated in the pipe-cross reactor. In practical operation, the chemicals are shifted somewhat between the pipe reactor and the ammoniator bed until the most desirable operating conditions are obtained. A certain amount of trial and error is necessary, in this respect, to discover the best running formula for each grade.

During the fall months of 1976, the Florence plant manufactured three grades using the pipe-cross reactor. These were all destined for midwestern markets and were barged to Omaha and Riverdale, Illinois. The products possessed excellent physical properties, particularly as they were uniformly sized, resisted abrasion and caking, and arrived at the final user practically dust-free.

Table II is a summarization of the formulas used to make these three products. The manufacturing rates and tonnages are given. The formulas were written to achieve a mole ratio of ammonia to phosphoric acid of 1.0 in both the pipe-cross and the ammoniator bed.

In June of 1977, test runs were made on three more products: 8-24-24, 11-44-0, and 12-48-0. As is customary, the trial and error procedure was followed to determine the optimum distribution of ammonia and phosphoric acid between the pipe-cross feeds and the bed spargers. The most desirable water feeds to the pipe reactor and to the under-bed ammonia sparger also had to be determined. Table III is a summarization of the formulas used to make these three products. As before, the formulated mole ratio in both the pipe-cross and the bed is held at 1.0.

Both TVA and Palmyra have varied the mole ratios, sometimes operating the pipe-cross at .6 or .7 and adjusting the overall mole ratio by adding extra ammonia in the bed[3]. Our plant has not been too successful in doing this, however. The Palmyra plant has a 16 ft. long ammoniator and ours is only 12 feet, with a retaining dam 2 feet from the discharge. Since the pipe-cross reactor discharges on the bed surface only 5 feet from the dam, little bed volume remains to allow chemical adjustment of mole ratio.

Figure 7 (courtesy of TVA) is the solubility curve for the saturated solutions of the ammonium phosphate compounds. Note that the point of least solubility is at the mole ratio of 1.0. This corresponds to a pH of 4.0. Operational control is maintained by catching frequent samples at the ammoniator discharge and taking a pH measurement on the water extract. The operator makes small adjustments to the ammonia feed to maintain this value between 3.8 and 4.2.

We measure the pipe-cross temperature on the surface of the reactor pipe at a point 18" downstream from the cross flange. This point is 12" downstream from the tip of the ammonia nozzle. The surface temperature usually reads 265°F., when the reactor is performing well and the system is in equilibrium. This temperature is taken when the desired water addition to ammonia is being made. We estimate a 30-40° differential between the measured surface temperature and the internal temperature. In otherwords, the reaction zone temperature is probably 300°F.

We were handicapped in our early pipe-cross operation by low air flow to the atmosphere through our ammoniator scrubber system. Measurements showed this to total only 5340 ACFM. This volume was not adequate to evacuate all of the water vapor released by the process. Consequently, our product moistures have been somewhat too high when we have attempted to operate the plant with the dryer burner completely off. This appears to be a marginal condition, and with some formulas we have gone for several hours with only the pilot flame of 140,000 BTU as a source of dryer heat.

This past September 6, we began producing a 14,000 ton order of 8-32-8. The ammoniator stack air flow had been increased to 8,500 CFM. Members of the TVA Process and Product Improvement Section were present on September 8 & 9 and assisted in the collection of samples and data. Table IV gives the manufacturing formulas and operating parameters.

Formula A-29-1 was used before September 8 and it produced an excessive amount of oversize. This resulted in the product consisting of too many granules with jagged edges and irregular shapes. After changing to formula A-29-3, the product was more spherical in shape and the loading on the cage mill was reduced.

The pipe-cross system is considerably less expensive than a tank type preneutralizer system. The cost of our installation, not including ammonia and phosphoric acid storage tanks, was about $50,000. This includes the recycle control screw conveyors and the pH-control prescrubber unit. It does not include the regular ammoniator scrubber which was provided for control of particulate emissions when conventional formulations are used.

We have very little visible emission from our plant stacks when the pipe-cross reactor is used. Stack samples indicate almost no ammonium chloride, ammonium fluoride or ammonium sulfate is present. Opacity caused by water vapor is low, probably because of the condensing effect of our wet scrubbers.

Our operators have had little difficulty in learning to operate the pipe-cross system. In fact, several of the shift foremen have indicated they prefer operating the pipe-cross to some of the conventional formulations.

Conclusions

The pipe-cross reactor enables the plant to use significantly less expensive raw materials in formulations. This contributes to improved profit margins. Most large companies apply internal transfer prices to materials exchanged between their P_2O_5 complexes and their mixed fertilizer manufacturing divisions. For this reason, formulation savings must be calculated by each company using their own cost tables.

The fuel savings are variable too, depending on how efficient each plant is in the use of drying fuel before installing a pipe-cross reactor. Our fuel usage on September 8, when formula A-29-3 was being used was only 348,000 BTU per hour, equivalent to 14,000 BTU/ton. This is a drying cost of 3 to 4 cents per ton.

The TVA-developed pipe-cross granulation concept is a major advancement in the production of multinutrient fertilizers.

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1. Meline, R.S., Lee, R.G., and Scott, W.C., TVA "Use of a Pipe Reactor in Production of Liquid Fertilizers with a Very High Polyphosphate Content", *Fertilizer Solutions*, March-April, 1972, pp. 32-45.
2. Achorn, F. P. and Kimbrough, H. L., TVA, "Latest Developments in Commercial Use of the Pipe Reactor Process", *Fertilizer Solutions*, July-August, 1974, pp. 8-21.
3. Achorn, F. P. and Salladay, D. G., TVA, "Production of Monoammonium Phosphate in a Pipe-Cross Reactor", *Proceedings of the 25th Annual Meeting, Fertilizer Industry Round Table, 1975*, pp. 196-199.
4. Achorn F. P. and Salladay, D. G., TVA, "TVA's New Pipe Cross Reactor Process for Granular Ammonium Phosphates", presented at American Chemical Society, San Francisco, Aug. 29 - Sept. 3, 1976.

Note: Tables #1 thru #4
Photos #1 thru #4
Figures #1 thru #7
continued on pages #56 thru #64

TABLE I

REGION	PLANTS	MAJOR GRADES
COASTAL PLAIN	AMERICUS, GA	5-10-15
	AUGUSTA, GA	3-9-18
	HARTSVILLE, SC	0-10-20
PIEDMONT	SPARTANBURG, SC	10-10-10
	WINSTON-SALEM, NC	1-2-2 Ratios
NORTH ALABAMA	FLORENCE, AL	1-4-X Ratios
		8-24-24
		13-13-13

TABLE II

SUMMARIZATION OF FORMULAS USED IN FALL, 1976 OPERATION OF THE PIPE-CROSS REACTOR

	6-24-24	8-32-8	8-35-10
PIPE CROSS REACTOR			
SULFURIC ACID	148	128	72
PHOSPHORIC ACID	800	700	600
AMMONIA	140	123	94
AMMONIATOR			
PHOSPHORIC ACID	112	140	100
AMMONIA	14	27	12
SULFATE OF AMMONIA	---	80	97
MONOAMMONIUM PHOSPHATE	---	240	550
TRIPLE SUPERPHOSPHATE	---	160	121
MURIATE OF POTASH	742	140	274
SUL-PO-MAG	185	365	185
MINOR ELEMENT MIXTURE	---	15	---
ZINC OXIDE	42	80	40
EVAPORATION	(183)	(199)	(145)
PRODUCTION RATES,			
TPH, MAXIMUM	30	30	24
, MINIMUM	18	20	18
TOTAL TONS MFR'D.	7294	6452	1931

TABLE III

SUMMARIZATION OF FORMULAS USED IN PIPE CROSS REACTOR TESTS AT FLORENCE, AL

JUNE 23-24, 1977

GRADE	8-24-24	11-44-0	12-48-0
DATE OF TEST	6/24/77	6/23/77	6/23/77
FORMULATION, LBS/TON OF PRODUCT			
PIPE-CROSS REACTOR			
AMMONIA	121	180	297
SULFURIC ACID, 78%	80	65	247
PHOSPHORIC ACID	792	1304	1864
WATER	64	128	190
$NH_3 : H_3PO_4$ MOLE RATIO	1.0	1.0	1.0
AMMONIATOR-GRANULATOR			
AMMONIA	12	0	0
AMMONIUM SULFATE	242	200	0
MONOAMMONIUM PHOSPHATE*	21	400	0
PHOSPHORIC ACID	96	0	0
POTASSIUM CHLORIDE	804	0	0
WATER	46	90	100
FILLER	0	84	0
$NH_3 : H_3PO_4$ MOLE RATIO	1.0	N/A	N/A
CHEMICAL HEAT			
RELEASED IN PIPE-CROSS, BTU/SQ.IN./HR.	598,000	514,260	547,590
RELEASED IN FORMULATION, BTU/TON	305,720	409,160	697,080
PIPE REACTOR TEMPERATURE, °F. (SURFACE)**	265	262	255
PRODUCT DATA			
PERIOD OF OPERATION - HRS.	12.1	4.0	5.5
MFG. RATES, TPH	30 & 25	16.0	10.0
AVERAGE,TPH	27.27	16.0	10.0
TONS PRODUCED	329	65	55

*10-52-0, NON-GRANULAR.

**ADD 30-40° FOR INTERIOR TEMPERATURE.

TABLE IV

FORMULAS AND OPERATING DATA
SEPTEMBER 1977, PRODUCTION OF 8-32-8

PRODUCTION RATE: 25 TPH

DATES FORMULA USED	9-7-77	9-8-77
FORMULA NO.	A-29-1	A-29-3
PIPE-CROSS REACTOR, LBS/TON		
SULFURIC ACID	80	80
PHOSPHORIC ACID	750	750
AMMONIA	115	115
AMMONIATOR, LBS/TON		
PHOSPHORIC ACID	150	50
AMMONIA	18	6
SULFATE OF AMMONIA	112	112
MONOAMMONIUM PHOSPHATE	350	450
MURIATE OF POTASH	140	140
SUL-PO-MAG	365	365
MINOR ELEMENTS	105	105
$NH_3 : H_3PO_4$ M.R. (PIPE)	1.0	1.0
$NH_3 : H_3PO_4$ M.R. (BED)	.96	.96
TOTAL ACID, LBS/TON	980	880
TOTAL CHEMICAL HEAT, BTU/TON	308,000	278,900
HEAT FLUX, BTU/SQ.IN/HR.	522,000	522,000
GRANULATION	FAIR	GOOD
RECYCLE RATIO	Not Meas.	.74

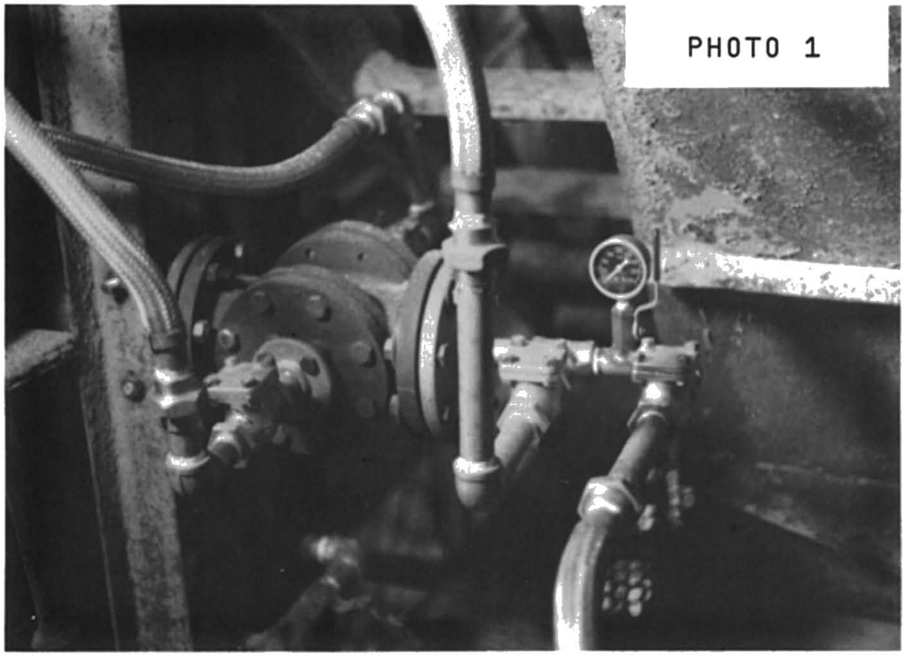


PHOTO 1

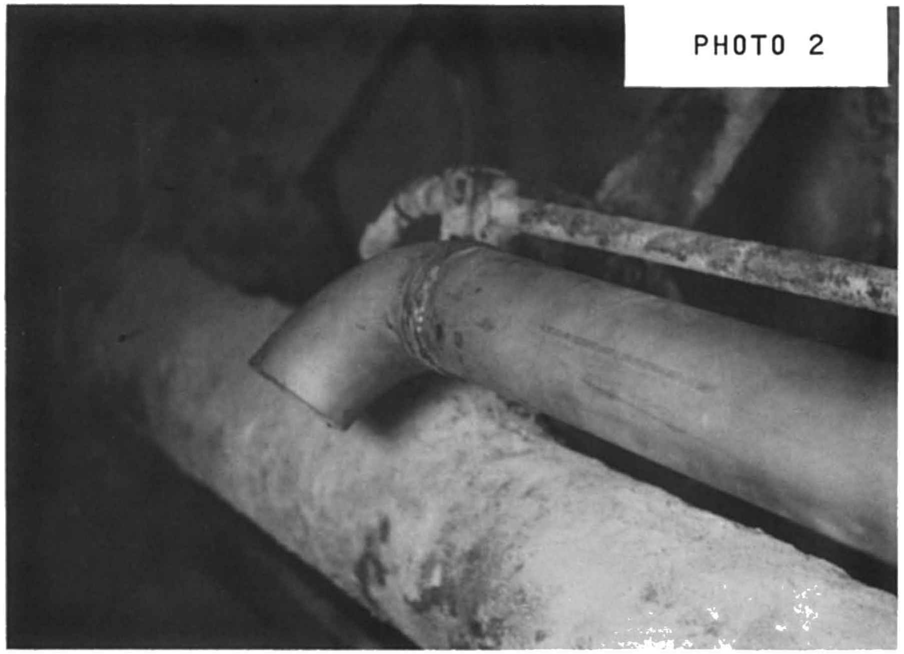


PHOTO 2

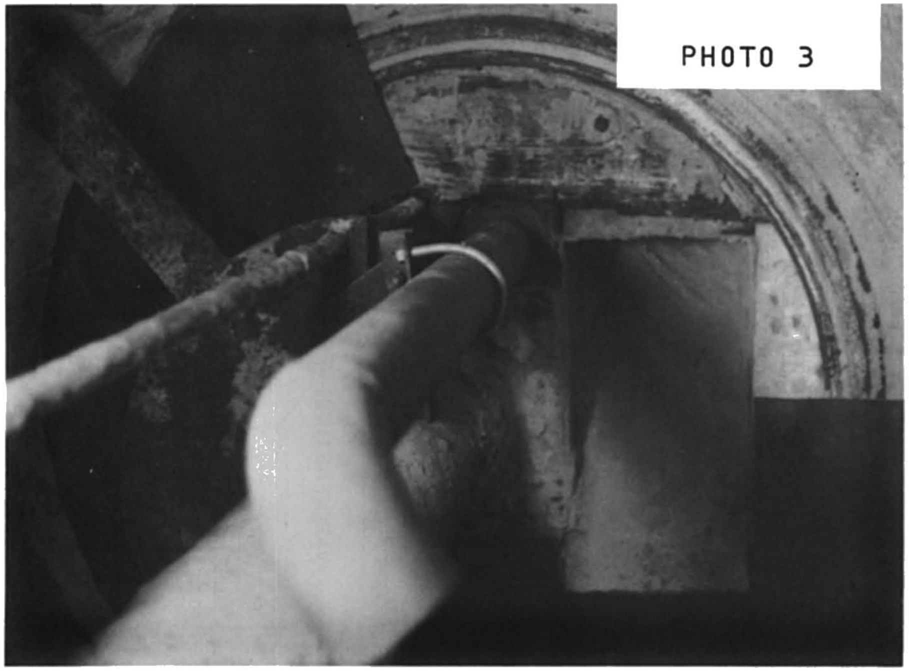


PHOTO 3


PHOTO 4

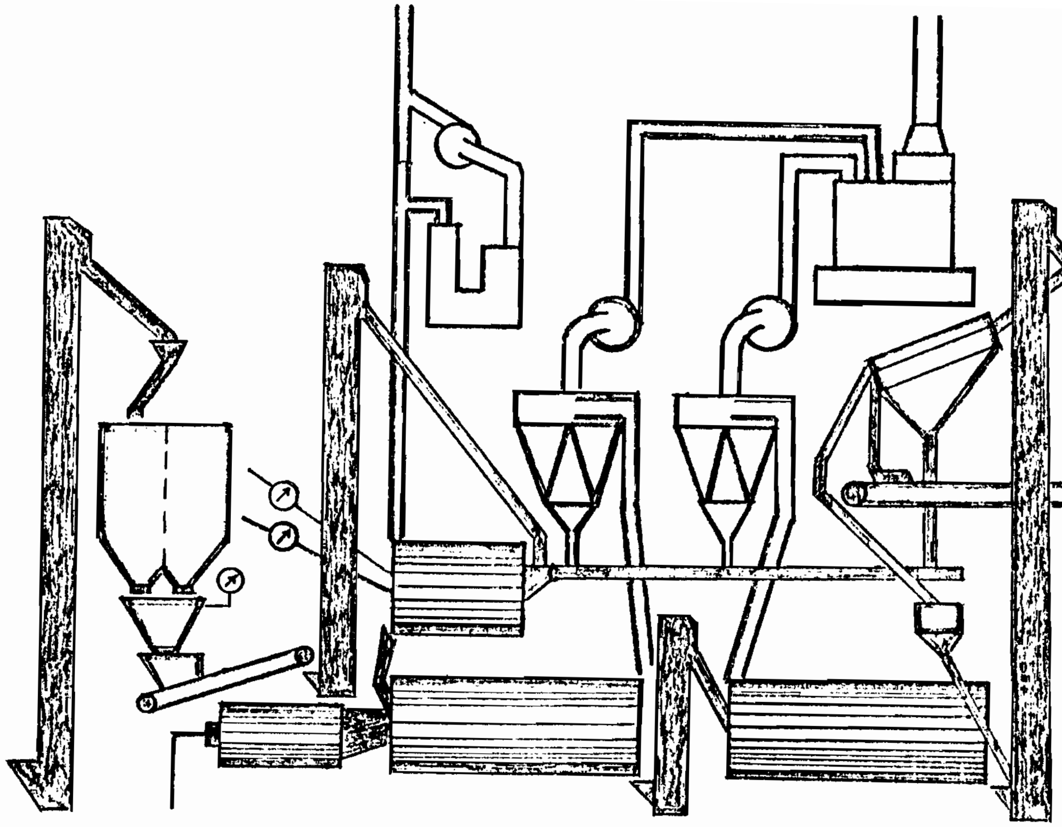


FIG. 1

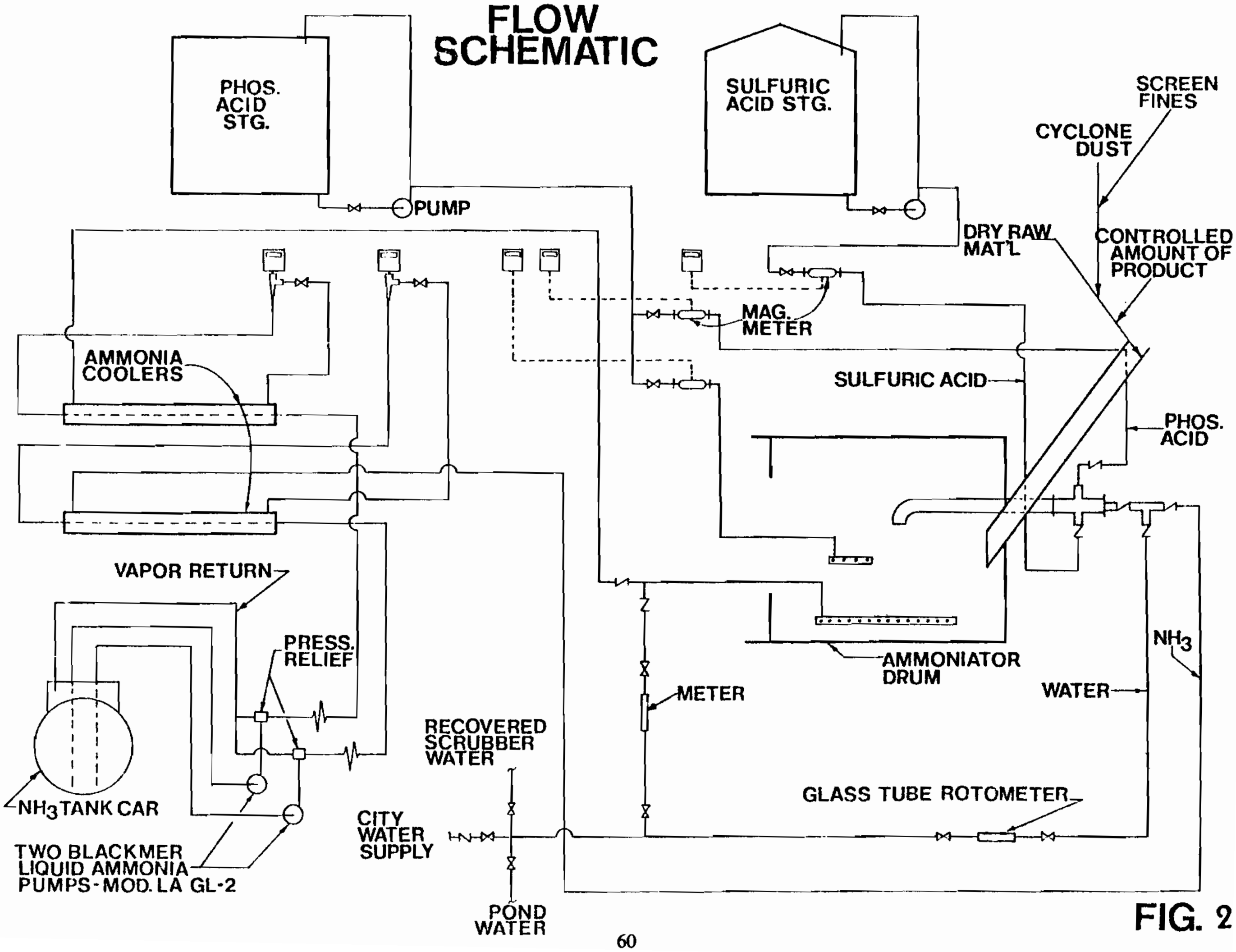

FLOW SCHEMATIC
PHOS. ACID STG.
SULFURIC ACID STG.
PUMP
SCREEN FINES
CYCLONE DUST
DRY RAW MAT'L
CONTROLLED AMOUNT OF PRODUCT
MAG. METER
AMMONIA COOLERS
SULFURIC ACID
PHOS. ACID
VAPOR RETURN
PRESS. RELIEF
AMMONIATOR DRUM
NH3
WATER
METER
NH3 TANK CAR
TWO BLACKMER LIQUID AMMONIA PUMPS-MOD. LA GL-2
RECOVERED SCRUBBER WATER
CITY WATER SUPPLY
GLASS TUBE ROTOMETER
POND WATER

FIG. 2

SCHEMATIC
TWO STAGE AMMONIATOR SCRUBBER

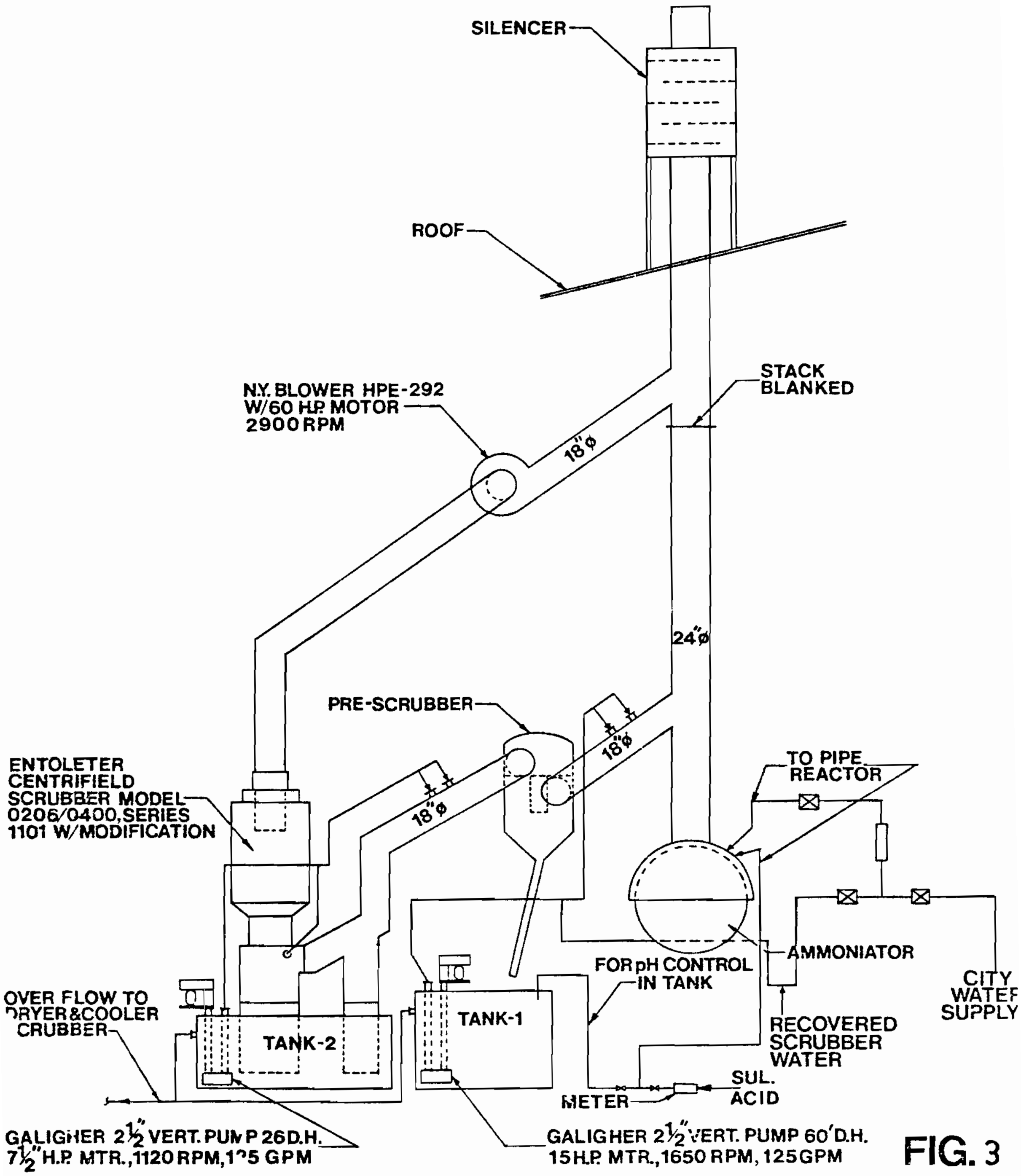
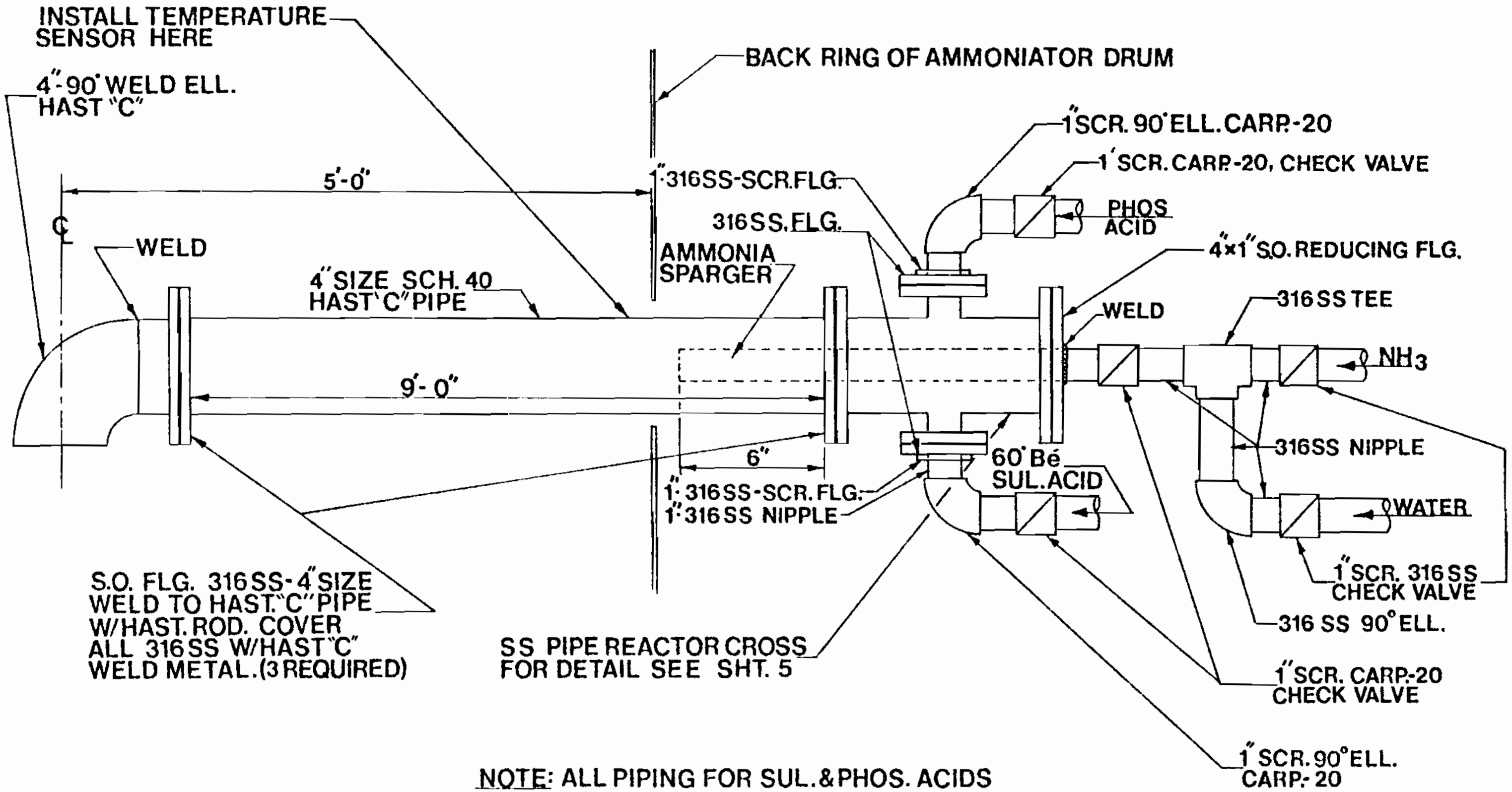


FIG. 3

PIPING DETAIL
OF
PIPE CROSS REACTOR

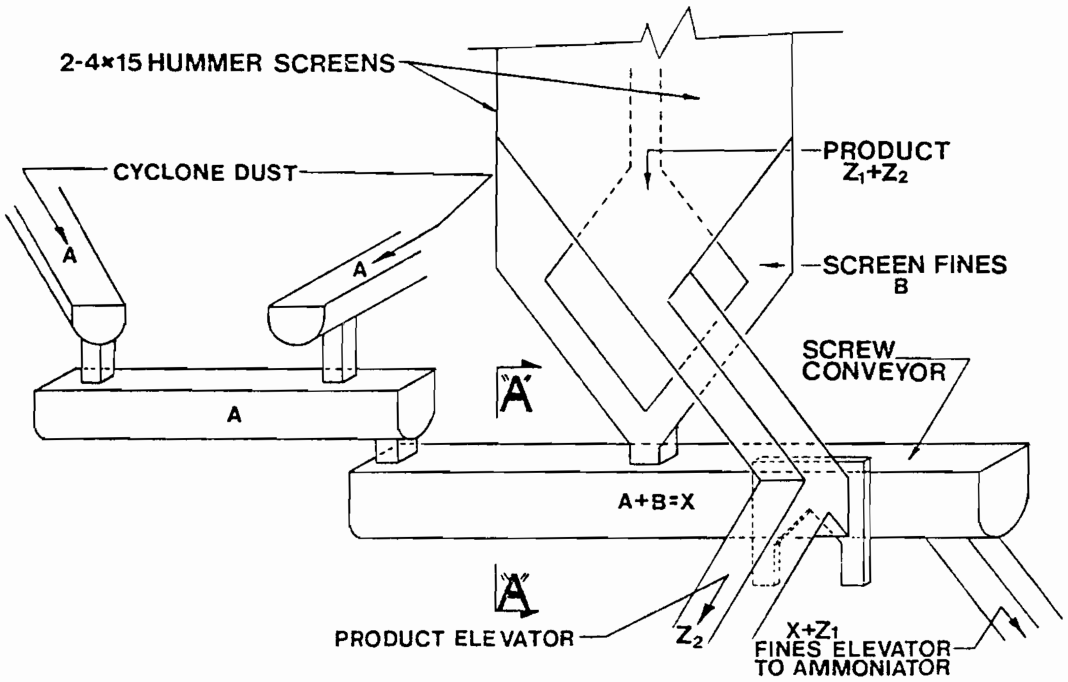


NOTE: ALL PIPING FOR SUL. & PHOS. ACIDS TO BE 316 SS.

FIG. 4

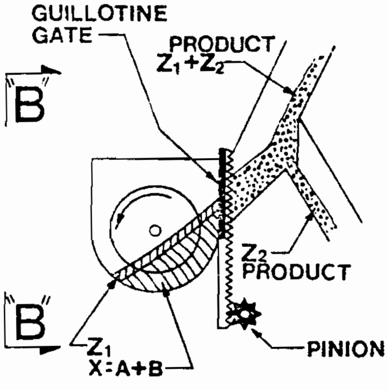
REV 3 30 77

CONSTANT VOLUME RECYCLE FEEDER FINES +PRODUCT



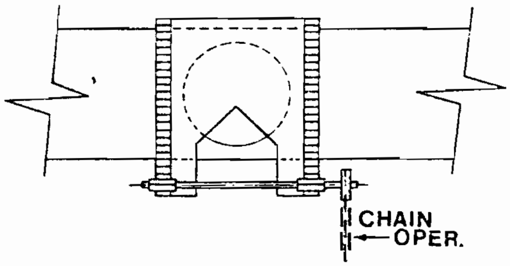
CONSTANT FEED TO AMMONIATOR CONSISTS OF THESE FOUR FLOWS:

1. DRY R/M ························ CONSTANT
2. SCREEN FINES ············ VARYING
3. CYCLONE DUST ·········· VARYING
4. PRODUCT RECYCLE ···· CONTROLLABLE W/GATE



SECTION A-A

A : CYCLONE DUST (VARIES)
B : SCREEN FINES (VARIES)
X : VARIABLE
Z_1 : ADJUSTABLE
$X+Z_1$ = CONSTANT

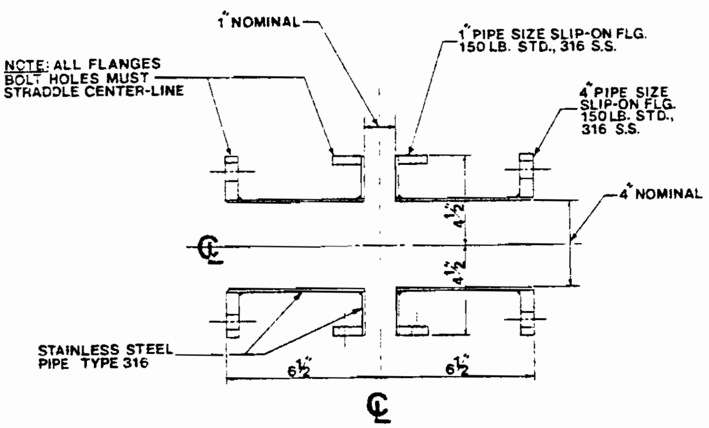


SECTION B-B

GATE CONFIGURATION MAY VARY

FIG.5

REV 3-30-77



DETAIL OF·SS·PIPE REACTOR CROSS FIG. 6

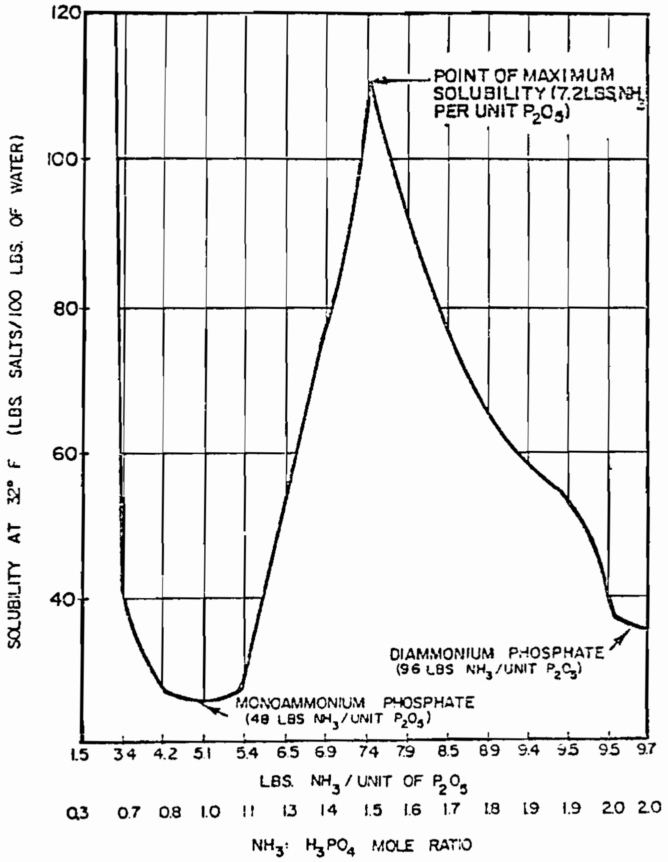


FIG. 7
SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTIONS
(COURTESY T. V. A.)

MODERATOR DAVIS: Thank you John.

Do we have any questions.

QUESTION: Could you go over metering arrangement?

JOHN MEDBERRY: Go over the metering arrangement again? O.K. We have two meters for phosphoric acid; we have one meter for sulfuric. We have two meters for ammonia. Now all of the sulfuric is fed to the pipe cross and part of the phosphoric is fed to the pipe cross and part of it is sprayed on the surface of the bed so we have to have two meters. Likewise we divide the ammonia flow, part into the pipe reactor and part under the bed sparger. So we have a total here of two meters for phosphoric, one for sulfuric, two for ammonia and then we also meter our water streams. We have two water streams and we have two meters for water. Now we're also adding some recovered scrubber water to the process which we don't meter. It is just dribbled on the bed and we can adjust that flow in order to achieve whatever granulation we feel necessary. Any other questions? O.K. Thank you. [Applause]

MODERATOR DAVIS: The next paper is also on plant experience with the pipe cross reactor, this by Missouri Farmers Association at Palmyra, Missouri. The paper was written by Ken Baggett, the plant manager, and will be presented today by Don Brunner, the production manager. Ken is also present and would be able to help with our discussion. Like our previous speakers Don has also made a lot of valuable contributions on the subject of granulation to our Round Table programs. He has about 30 years of experience in fertilizer plant granulation technology, and he has also worked with bulk blending plants and with phosphoric acid production. Don has worked his way up through various increasing levels of job responsibility including shift supervisor, process manager and plant manager. He's always been quick to pick up on new innovations. It was in his plant at Palmyra where the very first test work was conducted with the pipe cross reactor. Since that time Don has continued the successful developmental work on this system, and he's freely shared information with industry personnel as well as with those of us from TVA. Don [Applause]

MFA's Experience with The TVA Pipe-Cross Reactor

Presented by Donald J. Brunner

Written by Kenneth J. Baggett, Sr.

In the spring of 1974 we were using some of TVA's sodium nitrate at the Palmyra, Missouri plant. One requirement was higher than normal heat and liquid phase formulation. However, the reaction of sodium nitrate, sulphuric acid, and ammonia caused ammoniator fires and the need for a new type pre-reactor was indicated.

At that time, in a meeting with Frank Achorn and Joe Lewis, it was concluded a modified "T reactor" could do the job. We had just installed a pre-neutralizer tank for the new formulations, but we had not trained the operators. Consequently, we had all the meters, valves and pipe needed already installed. We even had a

3" stainless "T reactor" which had been used at our Springfield plant. The first TVA Pipe-Cross Reactor was quickly designed, assembled and installed. [1]

Then the problems began. We enjoyed many minor changes in equipment and control procedure. We did not give up. The principal was sound and we felt very near success. Also, Achorn got so excited when he saw how close to success this idea was — he wouldn't let us rest.

As you remember, Frank mentioned this new innovation of pre-reaction in his presentation to the round Table in 1974 and again in 1975. [2]

Although the TVA Pipe-Cross Reactor will see more changes and adaptations and may work somewhat differently in other plants, we sincerely feel it is here to stay in the fertilizer manufacturing field and may some day find use in other chemical processes. [3]

The Energy Research and Development Administration (ERDA), TVA, and MFA have cooperated in this fossil fuel savings device which also has proven to be as an aid in fertilizer production by improving process control and formulation and thereby producing a better final product.

Our plant is a TVA ammoniator, granulation system with an 8 x 16 ammoniator, a 9 x 60 dryer, and a 7 x 60 cooler. Elevators and conveyors are designed for 100 ton per hour. Classification screens are adequately sized. Cyclones collect dust before the wet scrubbers. The ammoniator scrubber is a Doyle, Impingment Type, and the dryer-cooler scrubber is Venturi wet scrubber. Both scrubbers re-circulate until the liquor is used in either the Pipe-Cross or ammoniator. Production rates vary from 24 to 32 tons per hour with a 2 or 3 to 1 recycle rate.

This summer we improved our scrubber, air handling and metering. We are testing the use of oil on our final product to help control dust.

Our plant has now used the original 316 stainless Pipe-Cross, a 3" hastelloy C, then two 5" hastalloy C and presently we are using a 6" hastelloy C pipe. The 6" pipe gives us just a little more flexibility and is easier to procure. This larger diameter has increased capacity and improved the reaction. It appears the temperature runs lower and is easier to control.

As you can see, the Pipe-Cross Reactor is a relatively simple piece of equipment. Critical measurements are the reaction area and the length of insertion of the 1" ammonia pipe. It should be long enough to extend at least 9" beyond the acid mixing area.

We tried to add scrubber water in the ammonia sparger in the Pipe-Cross Reactor but it plugged, so we added a separate sparger along side the ammonia sparger extending about 2" longer. There has been no plugging since this addition.

The Pipe-Cross Reactor process has been patented by TVA.

Hastelloy C-276 pipes have lasted 50,000 to 70,000 tons. The cost of a new Pipe-Cross is less than 10% of our fuel savings alone. The most critical corrosion area is the bottom of the pipe covering more than 1/3 the diameter. For the first foot and a half or two feet beyond the end of the 1" ammonia bar, the entire inside of this pipe corrodes. this is the area the pH is lowest at the highest temperature.

The seam of the pipe and the construction welds show more corrosion, also, the high-velocity area of the elbow. A teflon lined elbow failed after several days. We believe it failed rapidly once the hot slurry penetrated the teflon lining, first by abrasion, then corrosion.

We use sulphuric acid in all grades for ammoniation. Consequently, our pipe stays clean — possibly too clean.

In formulating with the Pipe-Cross Reactor we vary the amount of each liquid, either through the Pipe-Cross or the sparger bars to control heat, liquid phase, agglomeration, and ammonia loss.

More than 6,000 pounds of water goes out of our two stacks, as steam, each hour or over 200 pounds per ton of product. Our operators regularly run a pH of the ammoniator discharge to insure the proper mole ratio is maintained. The pH required will range between 2 and 5.5.

On low nitrogen grades we run a total mole ratio of .89 because it reduces the dust load. High nitrogen grades are run at a mole ratio of 1.17. High nitrogen grades over-granulate at .89.

We hold ammoniation of phosphoric acid to 5 pounds of NH_2 per unit of P_2O_5 (see graph). This assures the liquid phase will not become excessive when we use large amounts of phosphoric. Reaction to MAP is much faster than to DAP, giving better control and quicker action. Both MAP and DAP have been successfully produced using the Pipe-Cross.

Total formulation heat will range from 350,000 BTU per ton of 6-24-24 to 750,000 BTU per ton of 12-12-12. We hold the heat within the Pipe-Cross to less than 300°F. in order to control ammonia losses.

In early work, we had a few "blow-outs" on start-up, some quite violent blowing out of the end of the Pipe-Cross with enough force to blow material out of the ammoniator. This had only happened in start-up. We determined the cause of this was hydrogen gas created either by sulphuric acid in contact with metal or the action of sulphuric acid and phosphoric acid reacting in the mixing area of the Pipe-Cross. We figure that when we introduced the ammonia, the temperature and pressure ignited the hydrogen gas, causing a mild explosion out the open end of the pipe. We have eliminated this happening by using a start-up and shut-down procedure, mainly being sure water was introduced first before the ammonia.

We have a continuing program with TVA on stack emmission studies at our plant.

The first study, October 1976, revealed ammonia loss from the ammoniator scrubber, a low efficiency cyclones and only about one-tenth or less of the florine in the phosphoric acid was released as ammonium floride. The latter observation should be of interest to DAP producers.

As a result of the first study, we installed a thermocouple in the Pipe-Cross Reactor, metered water to the Pipe-Cross Reactor, separated the water of the two scrubbers so the ammoniator scrubber was fed back to the Pipe-Cross, added sulphuric to the ammoniator scrubber water and lowered the mole ratio of the slurry from the Pipe-Cross to .65.

The second study, February 1977, indicated very convincingly that, if we are to control ammonia losses, water must be added to the ammonia in both the Pipe-Cross and the sparger bar. The quantity of water will vary with the amount of ammmonia, the heat of the Pipe-Cross, and the heat in the ammoniator.

Following studies continue to confirm we do not have significant chlorine or florine losses. We did have difficulty on one grade with ammonium by-sulphate losses but recent tests show these losses can be eliminated by proper control of degrees of ammoniation of sulphuric acid.

Our manufacturing section is within 600′ of a 79,000 KVA and a 169,000 KVA electrical substation and we have been very conscious of floride and chloride from our plant shorting out the insulators.

Shown (on screen) are two high liquid phase formulas, one of 12-12-12 and one of 6-24-24. These are formulas we have used for a large amount of production. We show separately the flows to the ammonia sparger and to the Pipe-Cross. Many variations of these flows can be used.

We always put all of the sulphuric acid into the Pipe-Cross in order to keep from driving off ammonia chloride from the ammoniator bed.

These flows are all based upon a .65 mole ratio in the Pipe-Cross, then we go up to 1.17 in the ammoniator for 12-12-12 and to a .89 mole ratio for 6-24-24.

Let's assume we want to use five units of P_2O_5 as triple superphosphate in 6-24-24. This would lower the liquid phase of the formula. In order to compensate, we would use more phosphoric acid in the ammoniator sparger. We normally do not use TSP in 12-12-12 formulation because it forces us to use more sulphuric.

The determination of flows to the Pipe-Cross and ammoniator are based upon solubility and temperature and the reaction in the ammoniator bed.

The Pipe-Cross can also be operated at a mole ratio of 1.00 or 1.20. Then your ammonia loss from the Pipe-Cross may be somewhat greater. It is our opinion, at the Palmyra Plant, that granulation is best with the Pipe-Cross at a mole ratio of 1.00 rather than at .65. We believe the reason for this is the solubility of the melt coming from the Pipe-Cross.

Depending upon the availability of various raw materials, many different formulations can be used with the Pipe-Cross. If either or both the BTUs and liquid phase become low enough, the Pipe-Cross would be optional. As an example, we manufacture a 5-22-24 grade with or without the Pipe-Cross. Using TVAs empirical factors for liquid phase this formula has a liquid phase of 990 with 284,000 BTU per ton. For comparison, 12-12-12 has a liquid phase of 1,333 with 762,750 BTU and 6-24-24 has 1,126 with 354,000 BTU.

A part of the original equipment at our plant included a 35 million BTU burner which was used to dry product. However, I doubt this burner was ever used at more than 50% open. For the last 2-1/2 years with the Pipe-Cross Reactor in use, the burner has not been turned on. Other than the chemical heat of reaction in the Pipe-Cross Reactor and the spargers in the ammoniator, no heat has been used for these 2-1/2 years. Current costs of 1/2 natural gas and 1/2 propane would otherwise have our fuel bill above $100,000 this winter, or almost $2.00 per ton of final product. Thus, we feel we have achieved the objective of this joint project between MFA, TVA, and ERDA.

The use of fossil fuels have been eliminated at our plant. We feel the use of the Pipe-Cross Reactor can, at least, conserve fuel in other fertilizer plants.

Product sizing of final product at our plant will vary some and is very good, but not yet perfect. The particles are hard and contain 1-1/2 to 2% moisture. There is some dust because of the monoammonium phosphate crystals created.

Bagged storage of this product has been no problem. Some slight bay set takes place, but the 30′ high piles are easily knocked down with a probe extending from a front end loader bucket.

The Pipe-Cross Reactor is easier to operate than a sparger bar only arrangement, and much easier than prenutralizing tanks.

Safety alone would be justification enough for a Pipe-Cross Reactor. We feel it is safer to operate than either of the above processes.

Although we have given up the idea of using sodium nitrate, we now can use more or less water, more phosphoric and sulphuric than before and consequently a much wider range of dry raw materials.

In cooperation with TVA, visitors have been, and are, welcome to visit our plant and view the Pipe-Cross Reactor. Arrangements can be made through Frank Achorn, or contact Ken or Don at the Palmyra Plant.

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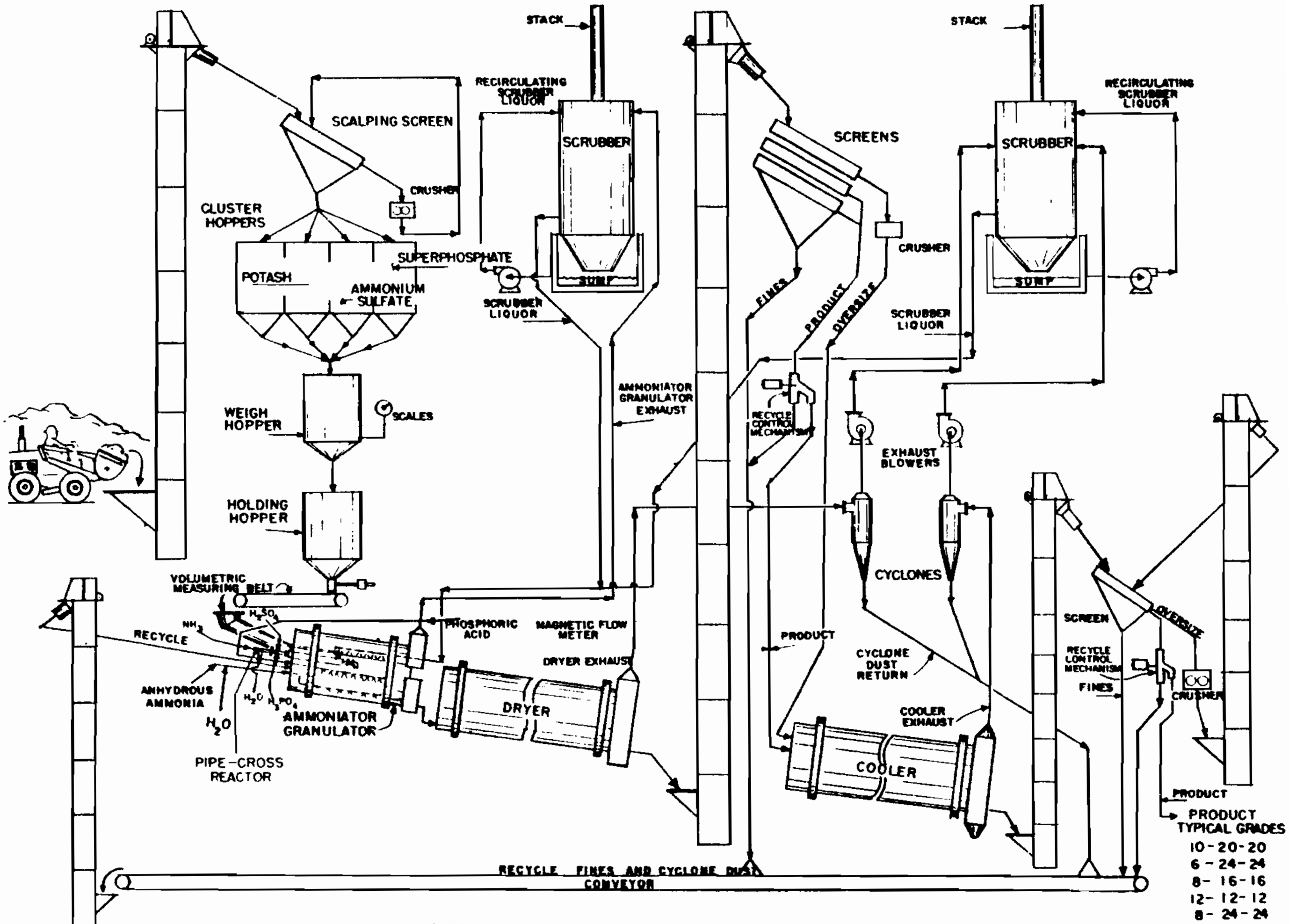
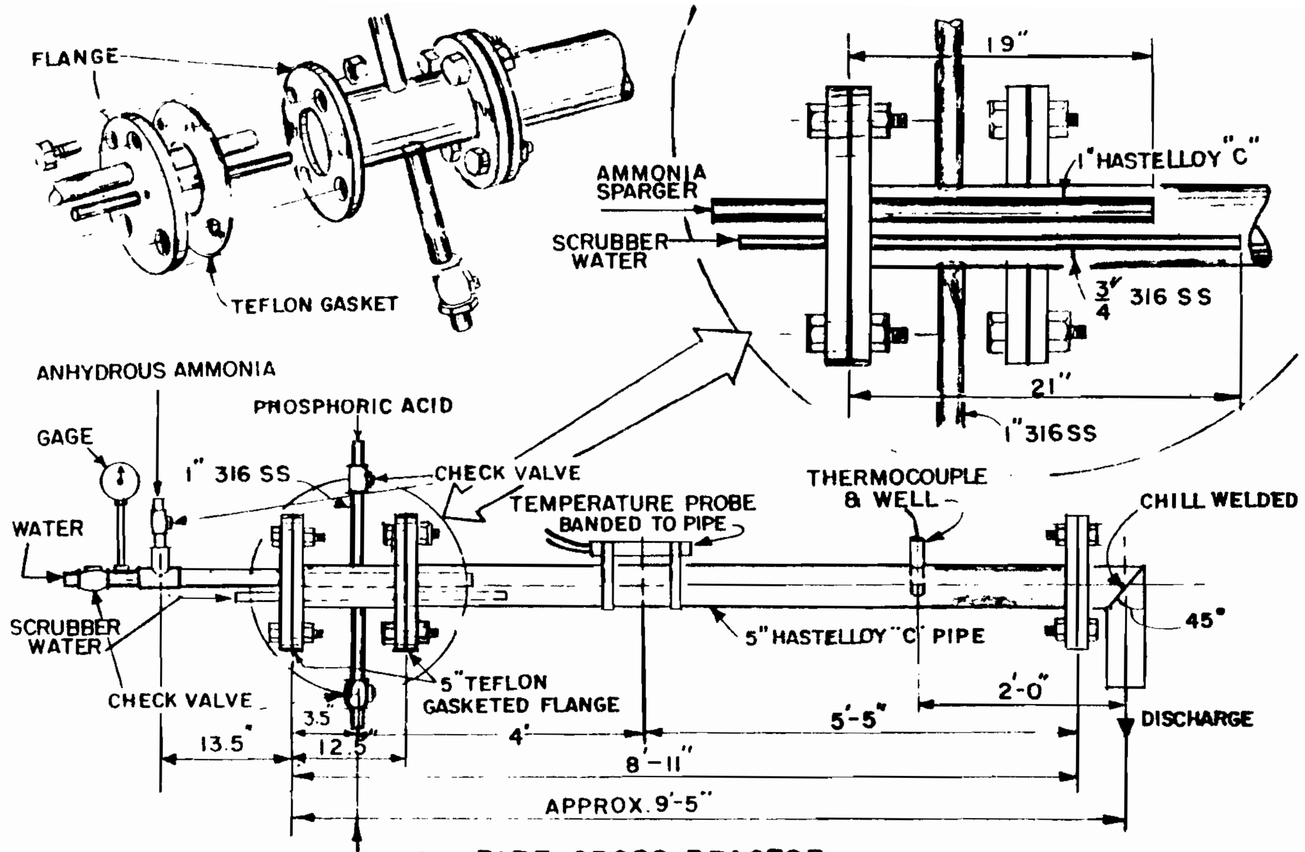
2. Achorn, Frank and Salladay, David, TVA, Page 196, 1975 Achorn, Frank and Balay, Hubert, TVA, Page 57, 1974 Fertilizer Industry Round Table Proceedings
3. TVA 11th Technology Demonstration, 1976, Page 44, "Production of Granular Fertilizer with TVA Pipe-Cross Reactor and Drum Granulator"



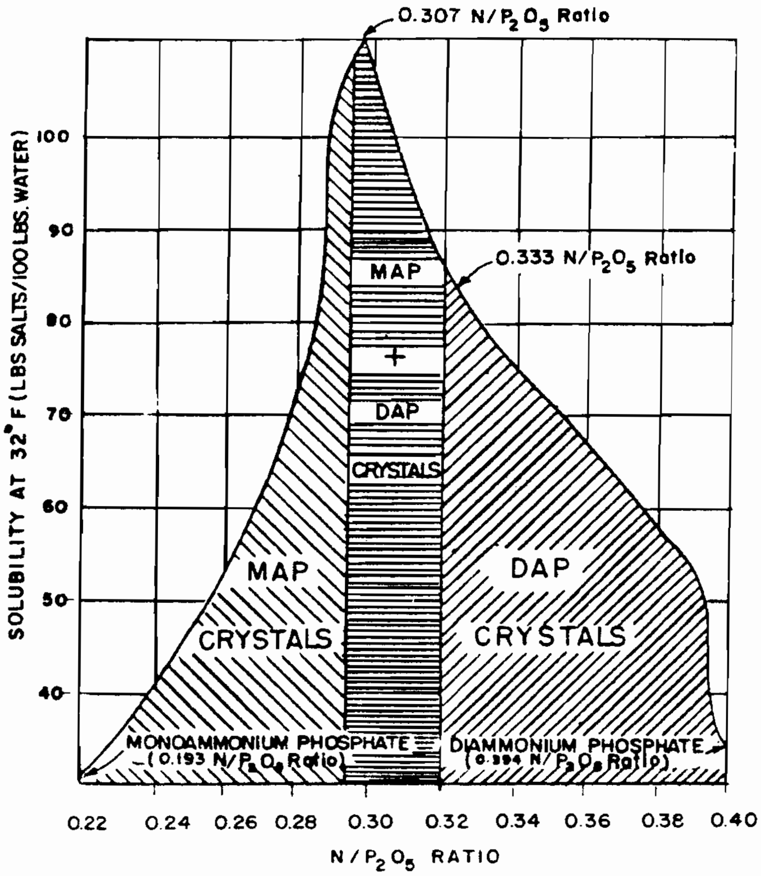
AMMONIATION-GRANULATION PLANT WITH PIPE-CROSS REACTOR

Slide 1



PIPE-CROSS REACTOR

Slide 2



SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTION

Slide 3

START-UP PROCEDURES

- Start ammonia into sparger bar
- Start feeder belt, vibrator, timer & charts
- When dry charge of raw materials starts through the ammoniator, open fresh water valve to Pipe-Cross Reactor
- Start sulphuric acid into PCR
- Start phosphoric acid into PCR
- Start up fresh water pump
- Check material in ammoniator - be sure it is not wet
- Start phosphoric acid into sparger bar

Slide 4

SHUT-DOWN PROCEDURES

- Shut off water valves
- Shut off phosphoric acid into sparger
- Shut off ammonia into PCR
- Shut off fresh water pump into PCR
- Shut off phosphoric acid & sulphuric acid into PCR
- Shut off main fresh water valve
- Turn down ammonia into sparger until the bed of material is dry
- Shut off ammonia into sparger

Slide 5

Emission Test Results...Ammoniator-Granulator Scrubber...Production of Granular Monoammonium Phosphate Sulfate MFA's 5" Pipe-Cross Reactor...Feb 1977

			Stack Loss Rate - Lbs/Hr[3]				
Grade	Scrubber Liquor pH	Gas Flow ACFM	Fert. Part.	Free NH_3	NH_4Cl	NH_4F	$(NH_4)_2SO_4$
6-24-24	1.1-6.3	10334	3.6	70	89	.75	–
12-12-12	2-4.1	9539	7.8	134	0.12	2.9	29

[3] Samples were collected for about a two-hour period & reflect average conditions

Slide 6

TVA Pipe-Cross Reactor Formulations & Data

	12-12-12	6-24-24
Formula Number	B 1270	B 628
Formulation		
Pipe-Cross Reactor		
Ammonia	268	95
Sulphuric Acid (66°Be)	731	139
Phosphoric Acid (54% P_2O_5)	456	500
Ammoniator Scrubber water	Yes	Yes
Ammoniator		
Ammonia	25	55
Phosphoric Acid (54% P_2O_5)	—	412
Potash Standard Grade (60% K_2O)	400	800
Filler	232	163
Dryer-Cooler Scrubber water	Yes	Yes

Slide 7

TVA Pipe-Cross Reactor Formulations & Data

	12-12-12	6-24-24
Formula Number	B 1270	B 628
Operating Results		
Production Rate Tons/Hr	18.96	29.12
Recycle Ratio Recycle/Ton Product	3/1	2/1
Ammoniator Product pH (average)	4.25	3
Temperature °F (average)		
Material from Ammoniator	240	240
Pipe-Cross Reactor	280	280
Material from Dryer	200	200
Dryer Exit Gas	220	220
Product to Storage	120	120
Chemical Heat		
Released in Pipe-Cross Reactor 10^6 BTU/in^2 hr	707,296	232,420
Released in Formulation 10^3 BTU/ton	762.7	354.0
Total Weight Acid lbs/ton Product	1187	1051

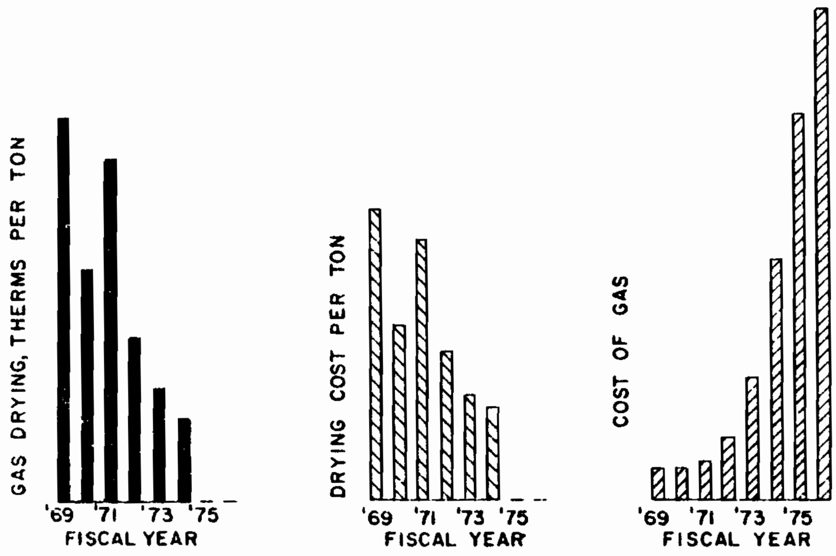
Slide 8

TVA Pipe-Cross Reactor Formulations & Data

		12-12-12	6-24-24
Formula Number		B 1270	B 628
Product Chemical Analysis %	N	12.12	6.65
	P_2O_5	12.06	23.48
	K_2O	12.48	24.13
	H_2O	1.8	1.6
Product Screen Analysis %	+6	4	7
	-6+8	20	25
	-8+12	49	48
	-12+14	21	15
	-14+16	5	5
	-16+20	1	0
	-20	0	0

Slide 9

NATURAL GAS CONSUMPTION FOR FERTILIZER DRYING



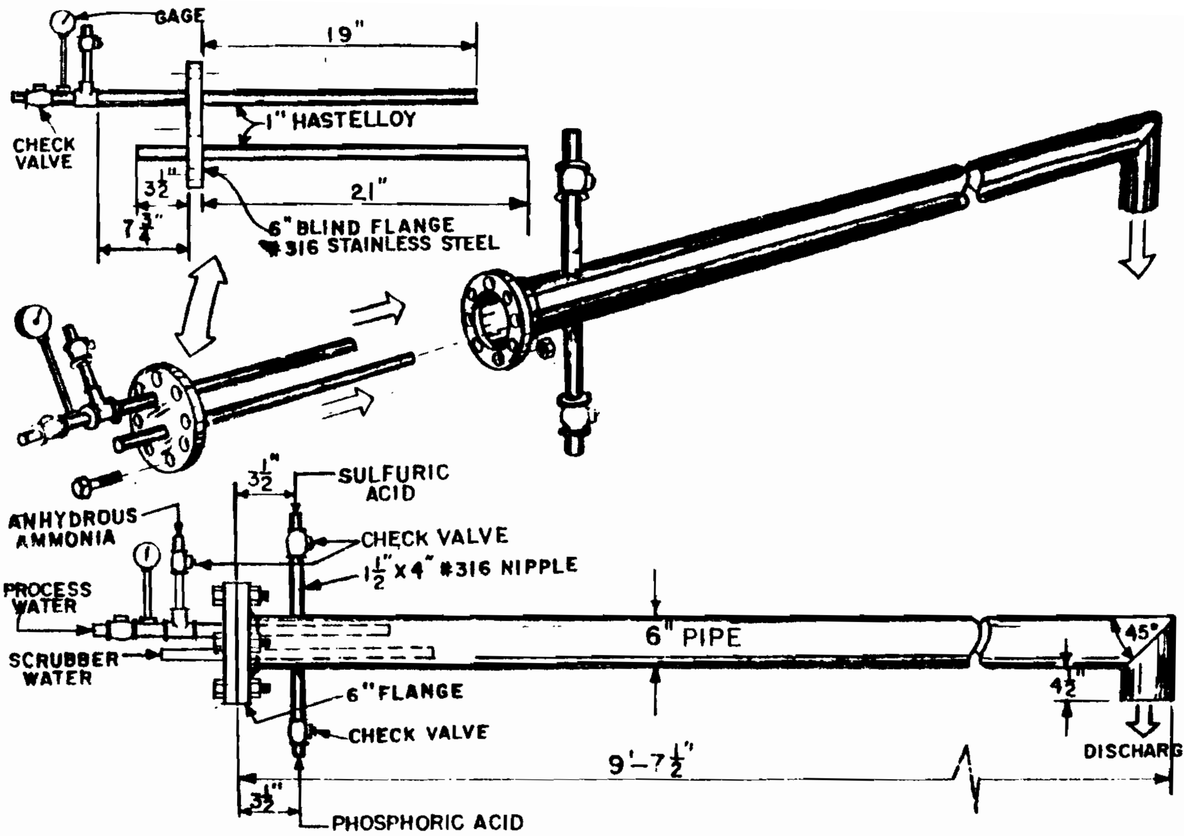
METHOD OF OPERATION

'72,'73,'74
USE OF SOME SUPERPHOSPHORIC ACID AND CHANGED OPERATIONS FROM A 1.4 MOLE RATIO TO 1.0

'74
BEGAN USE OF TVA PIPE-CROSS REACTOR

'75,'76
FULL USE OF PCR-- NO HEAT USED IN FERTILIZER PRODUCTION OTHER THAN THE HEAT OF REACTION OF THE CHEMICALS THEMSELVES.

Slide 10



PIPE-CROSS REACTOR
6 INCH DIAMETER HASTELLOY "C" REACTOR TUBE

Slide 11

MODERATOR DAVIS: Thank you, Don. Do we have any questions for Don? I believe there will be copies of Don's paper in the back of this room at the close of this session this afternoon.

DON BRUNNER: I might just add this. There will be some repetition. We've had three and we're going to have another one. But I look at it that if you've seen some of the things that have happened in two or three plants in a row, this ought to confirm some things if there is any doubt. [Applause]

MODERATOR DAVIS: The next paper is the fourth and last in a series that we're going to have this afternoon involving pipe reactors and granulation. The title of it is "The Manufacture of Granular Ammonium Phosphates Using a Pipe Cross Reactor Process." It's prepared by R. S. Fittel and L. A. Hollingworth and presented by Graham Torney of Consolidated Fertilizers Ltd. of Brisbane, Australia. Graham has over thirty years of experience with the Fertilizer Industry including production work with sulfuric acid, phosphoric acid and granulation units. In recent years he has moved more into development work, and at the present time is development manager of C.F.L. Graham visited with us at TVA several times in the last few years, and we at the fertilizer center have always profitted from these exchanges. We've learned to respect Graham's knowledge of granulation, and we've also found out that Graham is not hesitant to take a new idea and quickly develop it into something practical. This is extended by the innovative work of C.F.L. and production of granular DAP that you will hear more about in his presentation. Graham is presently nearing the end of a six month tour with his wife covering Europe and the U.S.A. as part of his company's long service leave. He has three daughters each of which has participated in a student exchange scheme in the U.S.A. Graham is an active Rotarian, and he enjoys bushwhacking, camping and photography. We deeply appreciate his rearranging his schedule so that he could be with us this afternoon. Graham. [Applause]

Manufacture of Granular Ammonium Phosphates Using A Pipe Reactor Process

Prepared by R. S. Fittell & L. A. Hollingworth

Presented by J. Graham Torney

Summary

This paper discusses the development and operation of a pipe reactor which is used as a preneutralizer

for the manufacture of Di-Ammonium Phosphate in an otherwise conventional T.V.A. Ammoniator-Granulator process. The subsequent use of the process for Mono-Ammonium Phosphate and Ammonium Sulphate production is briefly described.

Introduction

Consolidated Fertilizers Limited was formed in 1971 by the merging of the major nitrogen producing companies in the eastern States of Australia. Two production plants were available for DAP manufacture — a 50 000 t.p.a. Nissan Spray Tower and Compaction system, and a 250 000 t.p.a. granulation plant featuring a MAP tower linked to a conventional T.V.A. ammoniator-granulator process. After the merger the larger plant was mothballed. However in 1974, it was confirmed that demand would exceed the capacity of the smaller plant, so that the larger plant would need to be brought back on line in 1975.

The opportunity was taken to look at possible modifications to the reaction section at the front end of the plant for the following reasons:

(1) There had been some problems in feeding the powdered MAP consistently to the granulation drum and granulating it satisfactorily.

(2) The annual demand was much less than 250 000 t.p.a. so a lower production rate than the original design rate was required.

(3) Recent overseas developments in ammonium phosphate technology looked promising.

The pipe reactor was attractive because of its simplicity and low capital cost, but because of doubts about operating this system at the high N/P ratios required for DAP production, an extensive series of pilot plant tests was performed. The results gave good correlation with theoretical heat and mass balances and confirmed that the reactor was suitable for operation at N/P mole ratios around 1.4.

Design Features

(i) *General*

The process design was carried out for a production rate of 15 tonnes per hour DAP, and the resulting flowsheet is shown in Figure (1). The process is essentially the same as the T.V.A. ammoniator-granulator process but with the pre-neutralizer and slurry distributor replaced by the pipe reactor system.

Phosphoric acid is mixed with scrubber liquor of N/P mole ratio 1.3 - 1.5 and 35-45% moisture and fed to the pipe reactor where ammoniation to N/P mole ratio 1.4-1.5 takes place. The slurry discharging from the reactor is distributed on to the granulator recycle bed where further ammoniation is effected. Flashed steam and ammonia slip from the reactor and granulator bed are exhausted to the granulator scrubber. The product is then dried and screened with crushed oversize, fines and some product size being recycled to the granulator. Recycle ratios of 3-4:1 are normally achieved.

(ii) *Reactor Design*

The configuration and dimensions of the pipe reactor are shown in Figure 2(a) and Figure 2(b) gives the detail of the reaction tee. Some features of the design are now described:

(1) The reactor tee, pipe and spray sections were constructed of Type 316L Stainless Steel.

(2) The ammonia inlet pipe was designed to extend into the reactor pipe well above the slurry inlet pipe.

(3) Two bends were incorporated to promote mixing in the reactor. The pipe length was based on the dimensions of the pipe reactor used by T.V.A. for MAP melt production combined with experience gained from the pilot plant reactor.

(4) Provision was made for the injection of steam into the ammonia and slurry lines for preheating the reactor, prevention of back flow on start-up and purging of blockages on the run. An automatic steam-purge system was also provided for purging the reactor on shutdown.

(5) A recirculation system was provided so that flows of the reactor feeds could be stabilised and then introduced simultaneously to the reactor.

(6) Provision was made on the reactor spray pipe for altering the number and size of nozzles.

(iii) *Granulator*

The granulator is a rubber-lined drum 28 feet long and 11 feet in diameter with an 18" high weir at the discharge end; slope approx. 2° and rotating at 9 RPM. The arrangement of the sparger and reactor spray inside the drum is shown in Figure 3.

(iv) *Scrubber Design*

The pilot plant tests indicated that reactor slip would be about 15% of the ammonia fed to the reactor. Slip from the granulator bed was expected to be about 10% of the total ammonia feed and from the dryer about 4%. It was anticipated that the existing scrubbers on the plant (cyclonic type) would not be capable of handling these levels of slip. A Venturi scrubber was therefore installed on each of the exhaust streams (granulator and dryer).

Process Control

In describing the method of operating this plant it can be considered as five separately controlled, but inter-related areas; These areas are —

(i) the exhaust gas scrubbers
(ii) the pipe reactor
(iii) the granulation drum
(iv) the dryer
(v) the product sizing system

The drying and product sizing systems are quite conventional and will not be discussed in this paper.

A schematic layout of the control system for the exhaust gas scrubbers is shown in Figure 4(a) and Figure 4(b) indicates the system for the pipe reactor.

(i) *Exhaust Gas Scrubbers*

The functions of the control system for this area are —

(a) to provide a liquor of suitable composition and fluidity to absorb ammonia and dust carryover from the exhaust gases.
(b) to provide a suitable reactor feed slurry.

The operation of this section centers around the scrubber liquor tank. This tank acts as a buffer so that variations in the scrubber system are damped out before being carried through to the tee reactor. The measured N/P mole ratio* of the scrubber liquor is controlled at 1.3 to 1.5 by adjustment of the phosphoric acid flow-rate to the tank. The moisture content of the liquor is controlled by adjusting the water flowrate to the tank. The level in the tank is controlled manually by adjusting the scrubber liquor flow out of the tank.

(ii) *Pipe Reactor*

The slurry flowrate to the reactor is set to correspond to the required plant production rate. A small reactor feed mixing tank is installed where the scrubber liquor is mixed with phosphoric acid before being fed to the reactor. The level of liquor on this tank is controlled by adjusting the phosphoric acid flow.

The ammonia flowrate is then adjusted to maintain the slurry at a measured N/P mole ratio* of 1.35-1.5.

(iii) *Granulator*

The recycle rate is set and the flow of reactants to the tee is adjusted to give good granulation conditions. This is usually corresponds to a recycle ratio of 3:1 to 4:1. The ammonia flow-rate to the granulator is then adjusted so that the granulator product has a measured N/P mole ratio* of 1.93-1.97, pH 7.6-7.8.

To maintain the product analysis at 19.2%N and 20.2%P, it is sometimes necessary to add additional sulphuric acid to compensate for fluctuations in the H_2SO_4 content of the phosphoric acid. This acid is added to the reactor feed mixing tank.

Operating Experience

Operation of the plant commenced in October 1975 when DAP was produced at 15 tonnes/hr. A set of typical operating conditions is given in Table 1.

(i) *Product Specifications*

Most of the DAP manufactured on this plant uses wet process phosphoric acid made in a Nissan plant from Nauru rock phosphate. Typically this acid is 20.6%P (47% P_2O_5) with 8.5% H_2SO_4. A full analysis of the acid is given in Table 1.

Because of the high level of sulphuric acid in the Nauru acid, no additional sulphuric acid is usually added during DAP manufacture. The product specification achieved is 19.2%N, 20.2%P, 1.5%H_2O. Foaming problems are often experienced with Nauru acid and antiformant is added to the scrubber system to avoid this.

(ii) *Commissioning Experience*

Initially some problems were experienced in achieving satisfactory granulation. These were overcome by —

(1) Changing the scrubber control system. The initial design was based on an overflow system from the scrubber liquor tank to the reactor feed mixing tank which resulted in wide variations in the flowrate and composition of the reactor feed slurry.

When the system was changed to the one mentioned previously, steady granulation conditions were achieved.

(2) Improving the distribution of the reactor product on to the recycle bed. Initially, allowance for 21 nozzles was made and nozzles of different diameters or plugs could be screwed into the spray pipe. Because blockage of the smaller nozzles occurred, it was found that the best distribution was obtained with three 2″ diameter nozzles. Following further trails, these nozzles have since been discarded and a slot 5/8″ wide and 3′-6″ long is now used. This has resulted in a significant improvement in reactor product distribution on the bed and the ability to achieve satisfactory granulation.

Use of a 90° pipe bend as the means of slurry distribution on the bed has been tried briefly, but is not considered to be as effective as the slot.

Three types of reaction tee with slightly different types of mixing chambers were designed and built. On testing these reactors, very little difference was noted, so it was concluded that these design details are not critical.

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* Plant measurements of N/P mole ratio are carried out by a double titration method, which gives a value somewhere between (N/P) ammonium phosphate and (N/P) Total.

(iii) *Pipe Reactor Blockages*

One major problem yet to be solved is the build-up of deposits in the reactor pipe (an annular build-up) and at the nozzles or slot. A photograph of typical build-up in this pipe is shown in Figure (5). This results in blockage of the pipe after 40 to 120 hours operation, when shutdown for cleaning is necessary. The deposit has been identified as predominantly Magnesium Ammonium Phosphate (Mg $NH_4PO_4.H_2O$) and is insoluble in water and only slightly soluble in acids. Steam cleaning is ineffective and the deposit has to be removed by mechanical means.

A literature search was carried out and the results suggested that the crystal growth of the deposit could be modified to produce a softer deposit by altering the relative levels of Fe, Al, Mg and F in the phosphoric acid. This was backed up by plant evidence which showed that build-up was significantly reduced when Gardinier Acid was used. (Gardinier acid has similar levels of Mg but different Fe, Al and F levels. See Table 1). Addition of Al to the Nauru acid was therefore tried but to date has been unsuccessful in reducing the frequency of blockages.

A teflon-lined pipe has also been tried but it has been ineffective in preventing blockages.

(iv) *Experience with Gardinier Acid*

About 6000 tonnes of DAP analysis 18.2%N, 20.2%P has been manufactured from Gardinier Acid. A set of typical operating conditions has been included in Table 1. About 4.5% Sulphuric acid was added to achieve the product specification. As mentioned previously, very little scale build-up occurred in the pipe reactor but the product tended to overgranulate more than Naura DAP and more build-up occured on the sparger and its supports.

Other Products

(i) *MAP*

The existing DAP manufacturing equipment has been used to manufacture about 3000 tonnes of MAP of product specification 11.5%N, 21.5%P. The scrubber liquor used had an N/P mole ratio of 0.5 and moisture content 60% and, after being mixed with phosphoric acid, was ammoniated to an N/P mole ratio of 0.7 in the reactor. Final ammoniation to N/P mole ratio 1.0-1.1 was effected in the granulator. A production rate of 25 tonnes/hr was achieved at a recycle ratio of 3:1.

(ii) *Ammonium Sulphate*

A modified reactor was designed and installed to allow ammonium sulphate to be produced (See Figure 2[c]). The design was based on premixing liquid anhydrous ammonia and scrubber liquor and then reacting this with sulphuric acid to give an NH_3/H_2SO_4 mole ratio of 1.1 Ammoniation was then completed in the granulator. During operation it was found that improved granulation was obtained by ammoniating to an NH_3/H_2SO_4 mole ratio of 1.5 to 1.6 in the reactor.

The original ammonium sulphate reactor was constructed of a combination of Hastelloy C276 for the reaction Tee and the first half of the pipe, and 316L Stainless Steel for the remainder of the pipe. However severe corrision occurred to both materials. Teflon-lined mild steel pipe was installed in the reactor pipe from the reactor Tee (of Hastelloy C276) to the granulator entry, and the pipe of 316L stainless steel was retained inside the granulator. This reactor has operated satisfactorily for ammonium sulphate production with only a small amount of corrosion occurring in the section of pipe inside the granulator.

Over 12 000 tonnes of ammonium sulphate have been produced in the plant to date. The ammonium sulphate produced is of excellent physical quality and has a chemical analysis of 20.5%N, 0.2%H_2O and 0.3% free acid. To assist granulation and to provide a non-caking product, an additive is mixed with the reactor feed.

Conclusion

The pipe reactor has been used successfully for DAP, MAP and Ammonium Sulphate production. Because of its simplicity, it is relatively inexpensive to construct and is flexible during operation. The reactor blockage encountered during DAP production is the major remaining problem with the system. Downtime resulting from blockage is high although with current loading on the plant it does not result in a significant increase in total downtime. Efforts to solve the problem are continuing. Production rates of up to 25 tonnes/hr have recently been achieved during DAP and MAP production on this plant.

Note: Tables, Figures and Slides
continued on page 74 thru 80

Table 1 TYPICAL OPERATING CONDITIONS

		DAP (Nauru Acid)	DAP (Gardinier Acid)
Product Analysis % N		19.2	18.2
% P		20.2	20.2
Production Rate	(TPH)	18	21
Reactor Temperature	(°C)	139	135
Total Ammonia Slip (% of Total NH_3 feed)		21	18
Water Evaporation from Reactor and granulator (kg/tonne product)		310	270
Granulator Disch. moisture	(%)	3.1	2.8
Granulation temperature	(°C)	91	102
Recycle rate	(TPH)	60	60
Ammonia feed rate to reactor	(TPH)	3.65	3.90
to granulator	(TPH)	0.75	0.91
Phosphoric Acid Feed to Scrubbers	(TPH)	7.4	5.4
Total Feed	(TPH)	18.1	18.7
Sulphuric acid feed rate	(TPH)	-	0.96
Dryer Fuel Oil usage (kg/tonne product)		22	24
N Efficiency	(%)	96-98	96-98
P Efficiency	(%)	98	98
Phosphoric acid analysis :-			
% P		20.6	23.1
% H_2O		23.9	18.0
% Fe_2O_3		0.25	1.57
% Al_2O_3		0.06	1.60
% Mg O		0.55	0.78
% H_2SO_4		8.5	3.45
% F		0.2	0.95

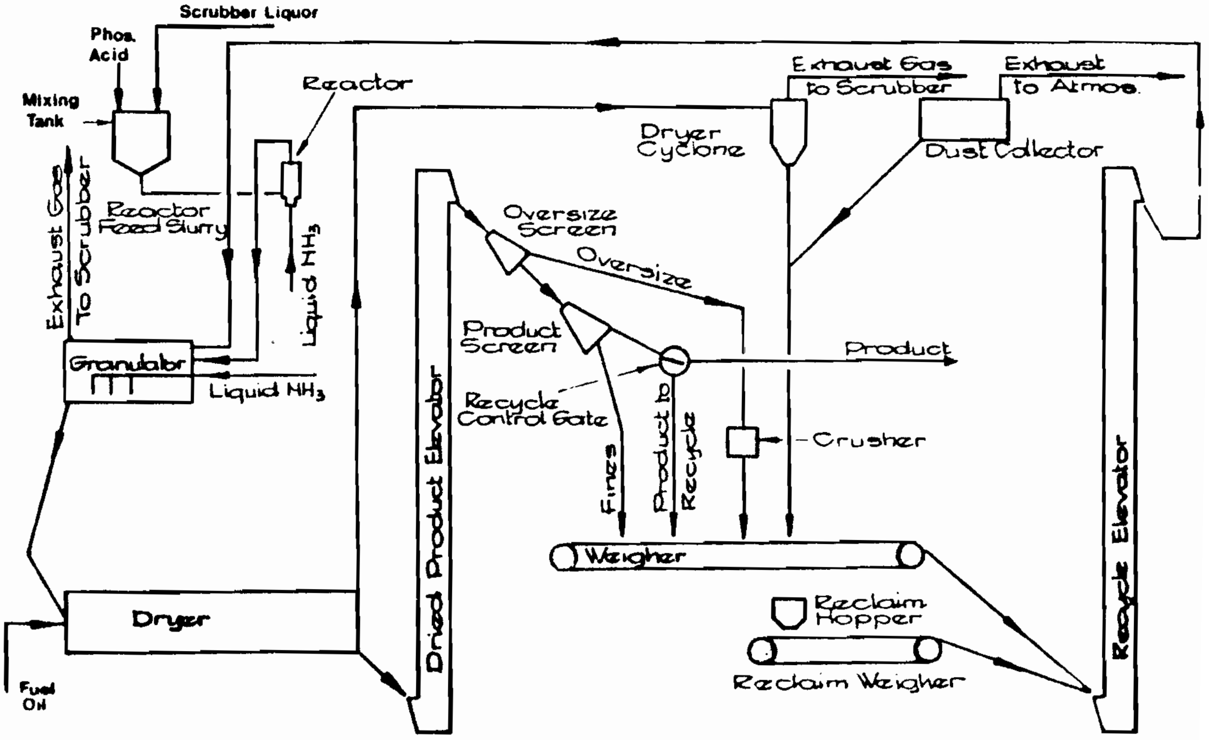


Figure 1 PROCESS FLOWSHEET

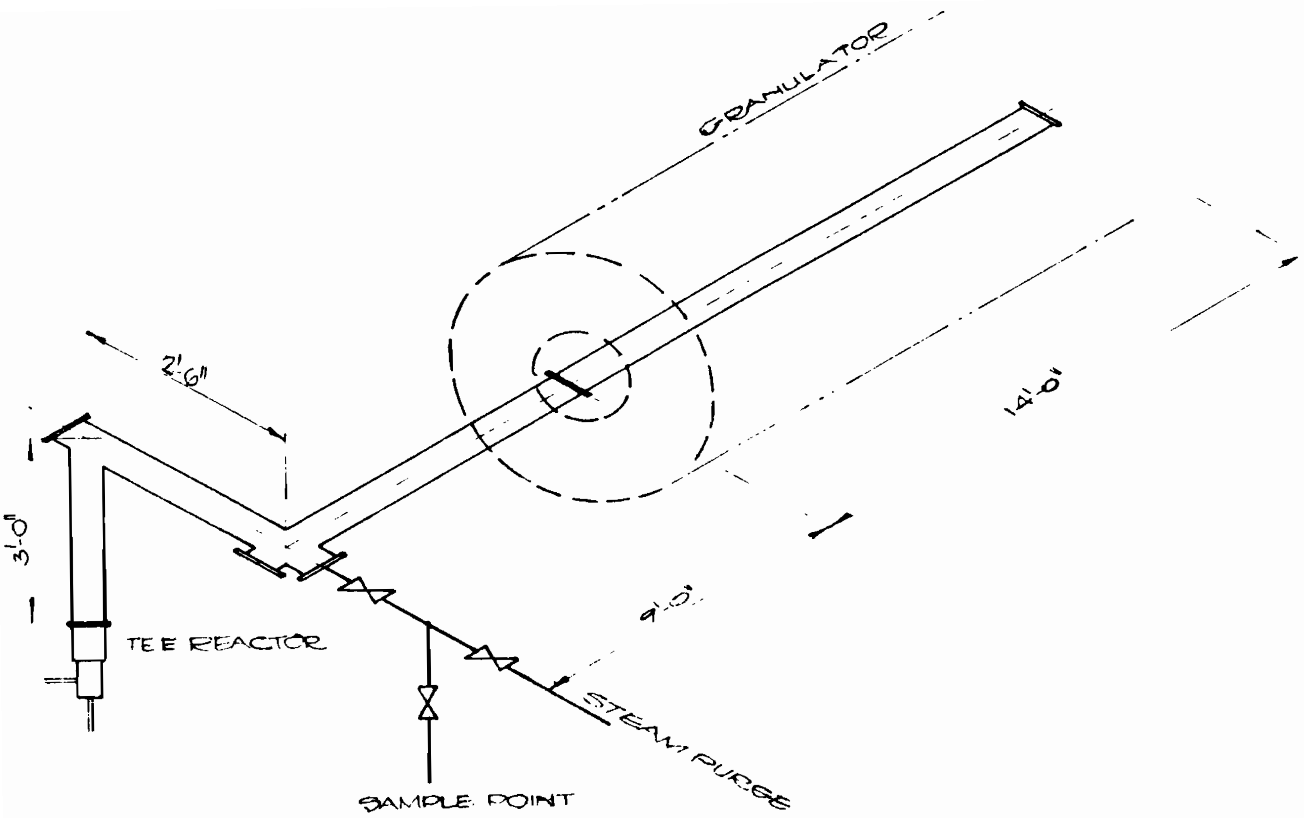


Figure 2a CONFIGURATION OF PIPE REACTOR

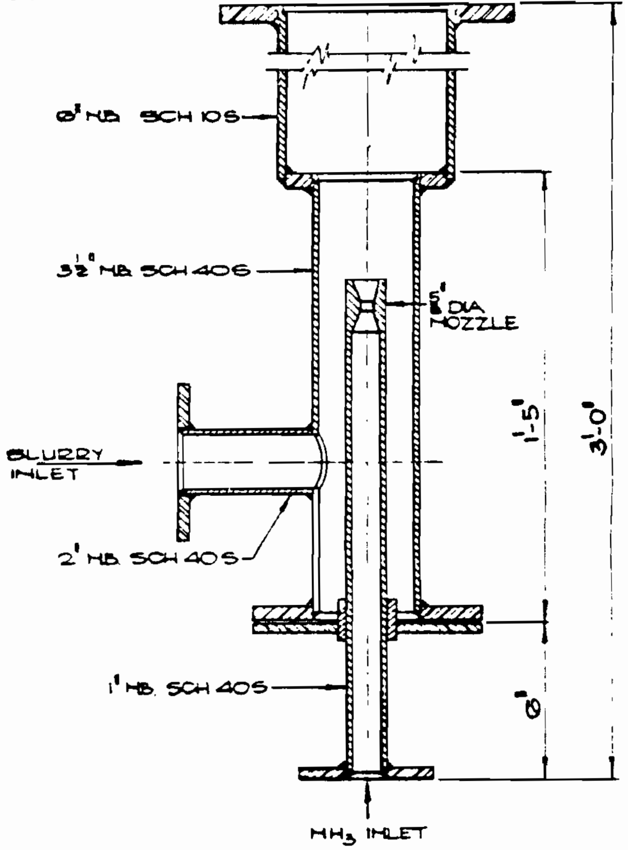


Figure 2b DETAIL OF REACTION TEE

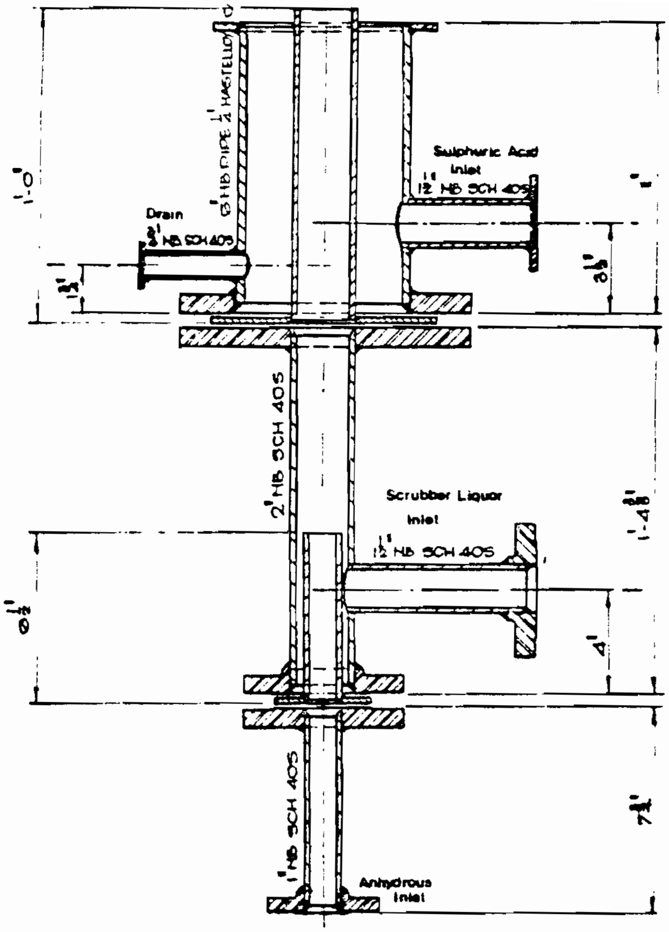


Figure 2c MODIFIED REACTION TEE

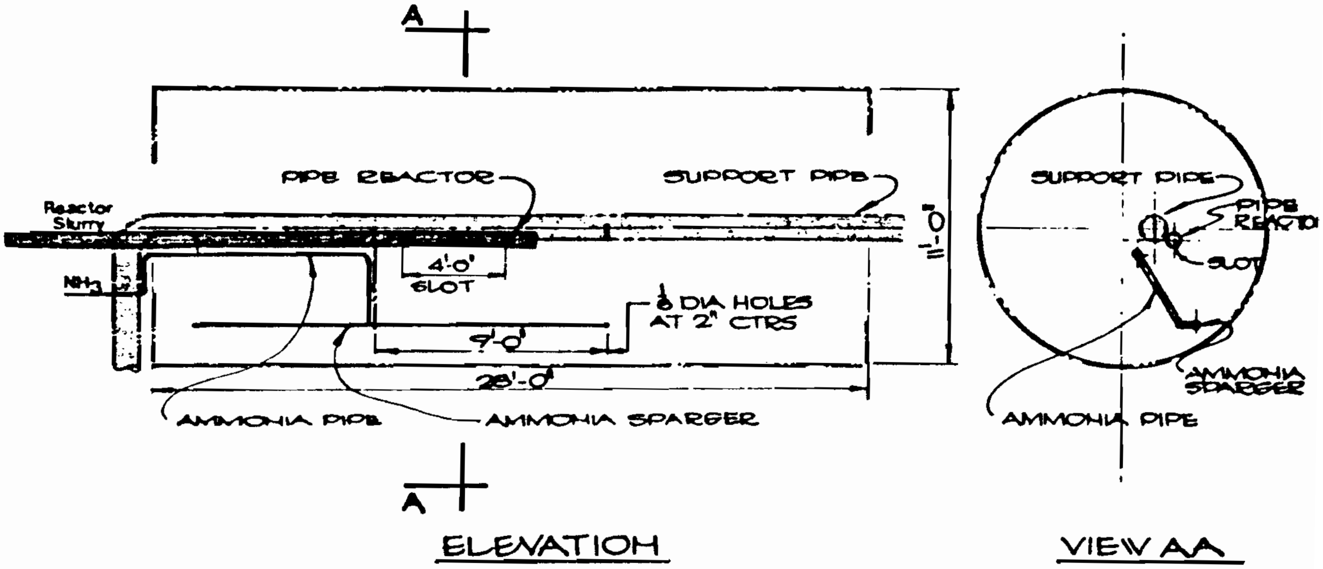


Figure 3 SPARGER & REACTOR LAYOUT INSIDE DRUM

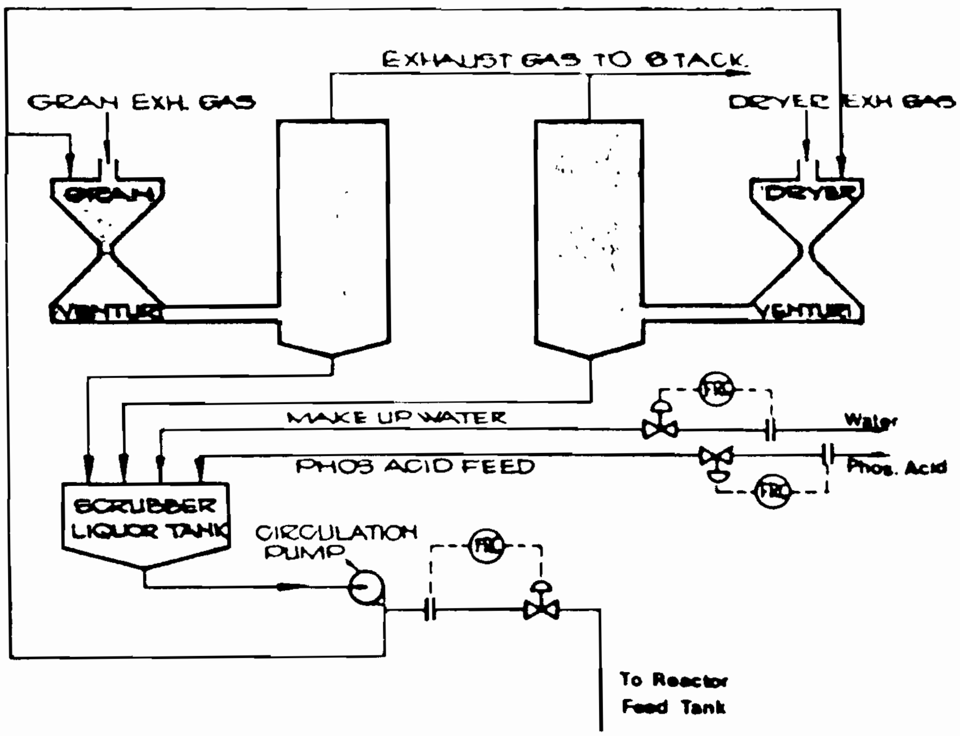


Figure 4a SCRUBBER AREA CONTROL SYSTEM

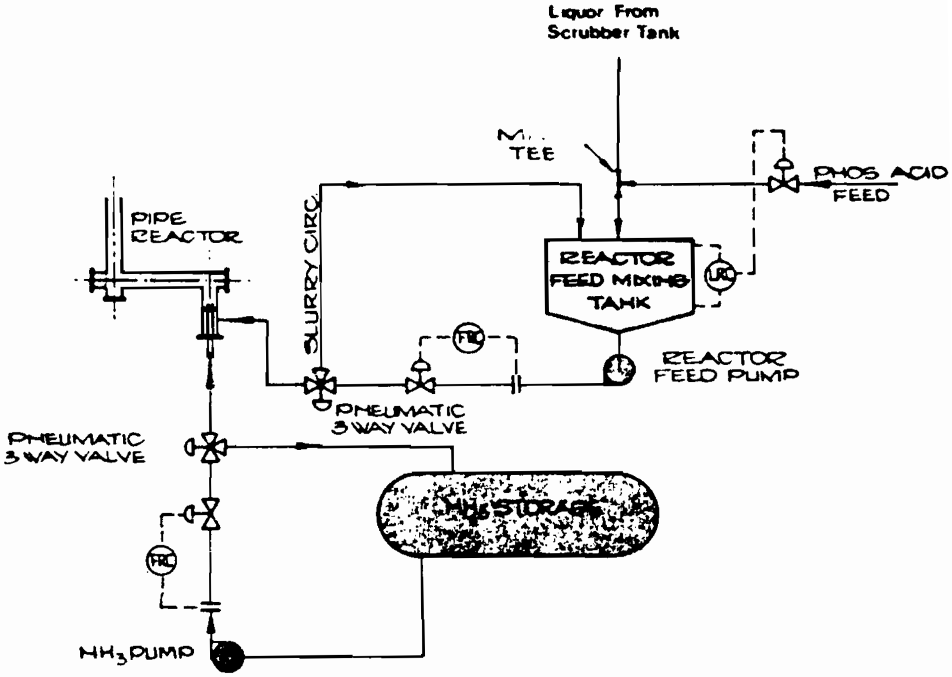


Figure 4b PIPE REACTOR CONTROL SYSTEM

Table 1 TYPICAL OPERATING CONDITIONS

A. MATERIAL FLOWRATES

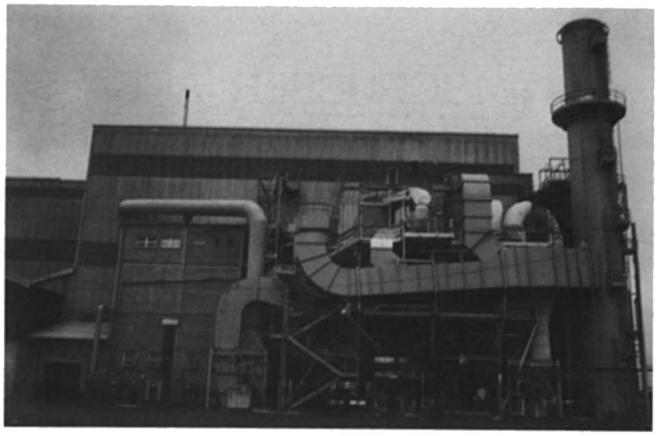
		DAP FROM NAURU ACID	DAP FROM GARDINIER ACID
PRODUCT ANALYSIS:			
N	(%)	19.2	18.2
P	(%)	20.2	20.2
P_2O_5	(%)	(46.3)	(46.3)
PRODUCTION RATE	(TONNES/HOUR)	18	21
AMMONIA FEED RATES	(TONNES/HOUR)		
TO REACTOR		3.65	3.9
TO GRANULATOR		0.75	0.9
PHOSPHORIC ACID RATES	(TONNES/HOUR)		
TO SCRUBBERS		7.4	5.4
TOTAL FEED		18.1	18.7
SULPHURIC ACID FEED	(TONNES/HOUR)	-	0.96
DRYER FUEL OIL USAGE (KG/TONNE PRODUCT)		22	24
N EFFICIENCY	(%)	96-98	96-98
P EFFICIENCY	(%)	98	98

B. PLANT DATA

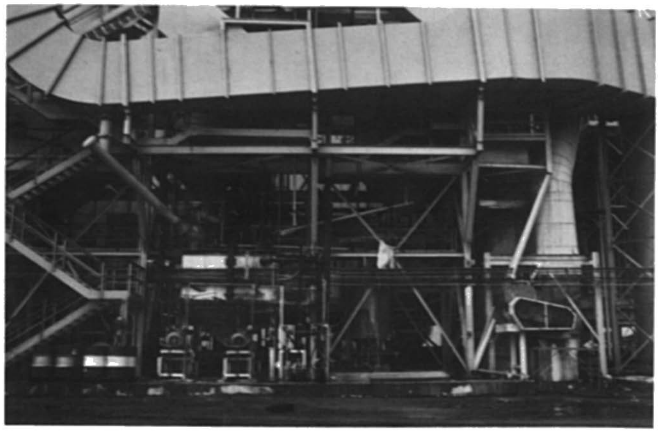
		DAP FROM NAURU ACID	DAP FROM GARDINIER ACID
PRODUCTION RATE	(TONNES/HOUR)	18	21
REACTOR TEMPERATURE	(°C.)	139	135
	(°F.)	(282)	(275)
TOTAL AMMONIA SLIP FROM REACTOR AND GRANULATOR. (% OF TOTAL NH_3 FEED)		21	18
WATER EVAPORATION FROM REACTOR AND GRANULATOR (KG/TONNE PRODUCT)		310	270
GRANULATOR DISCHARGE MOISTURE	(%)	3.1	2.6
RECYCLE RATE	(TONNES/HOUR)	60	60
GRANULATION TEMPERATURE	(°C.)	91	102
	(°F.)	(196)	(216)

C. PHOSPHORIC ACID ANALYSES

		DAP FROM NAURU ACID	DAP FROM GARDINIER ACID
PRODUCT ANALYSIS:			
N	%	19.2	18.2
P	%	20.2	20.2
(P_2O_5)	%	(46.3)	(46.3)
ACID ANALYSIS:			
P	%	20.6	23.1
(P_2O_5)	%	(47.2)	(52.9)
H_2O	%	23.9	18.0
Fe_2O_3	%	0.25	1.57
Al_2O_3	%	0.06	1.60
MgO	%	0.55	0.78
H_2SO_4	%	8.5	3.45
F	%	0.2	0.95

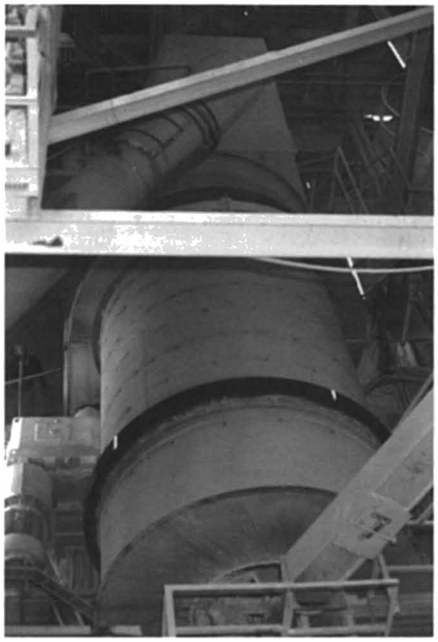


Slide 1
GENERAL VIEW OF PLANT AND SCRUBBERS



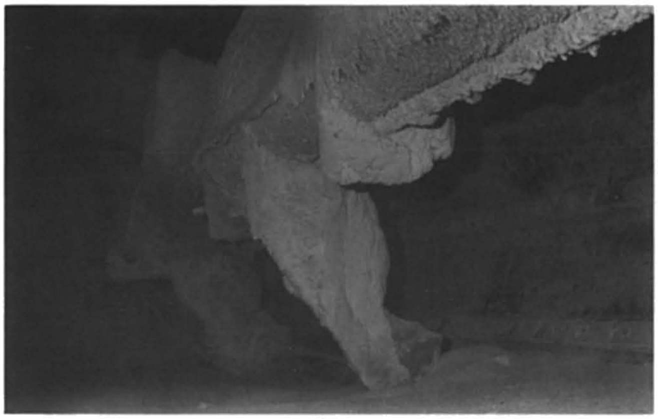
Slide 2
SCRUBBER RECIRCULATION SYSTEM

Slide 3
GRANULATION VENTURI SCRUBBER

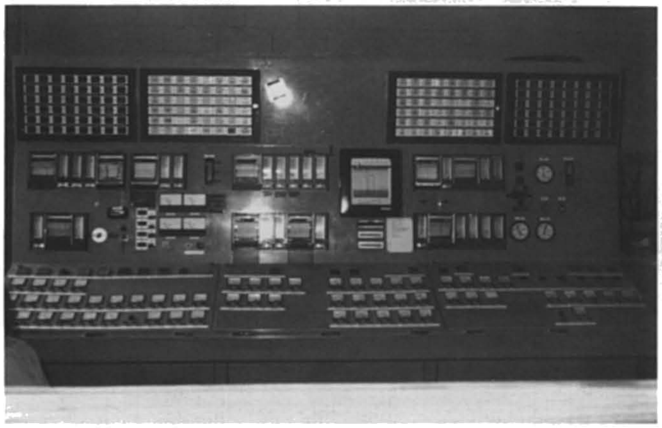


Slide 6
GRANULATOR AS VIEWED FROM ABOVE

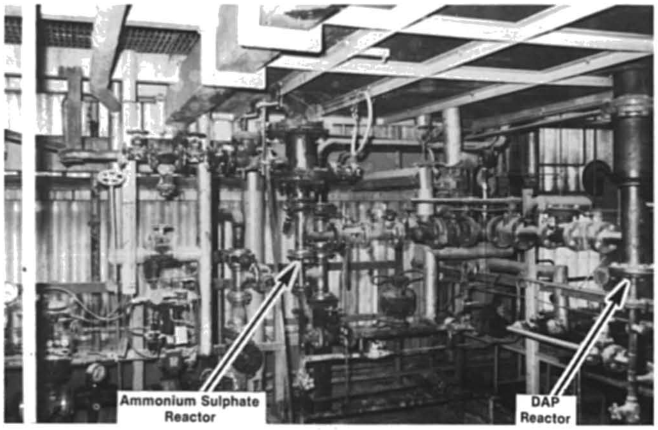
Slide 4
REACTOR SLURRY TANK AND PUMPS



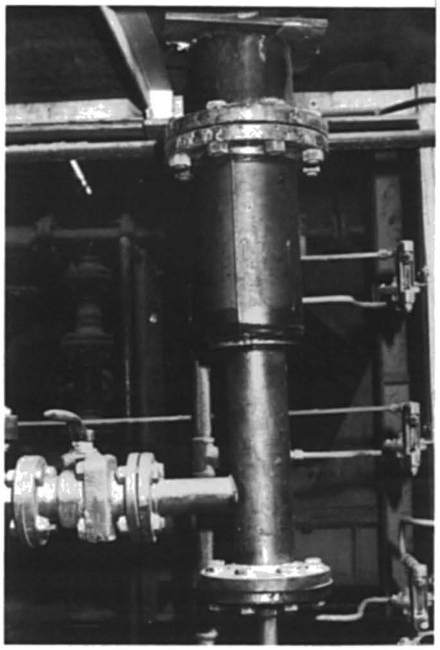
Slide 7
SPARGER ARRANGEMENT AND
BED OF AMMONIUM SULPHATE



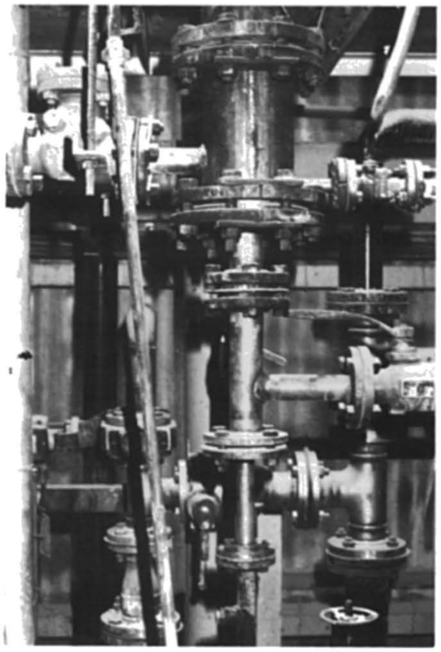
Slide 5
CONTROL PANEL



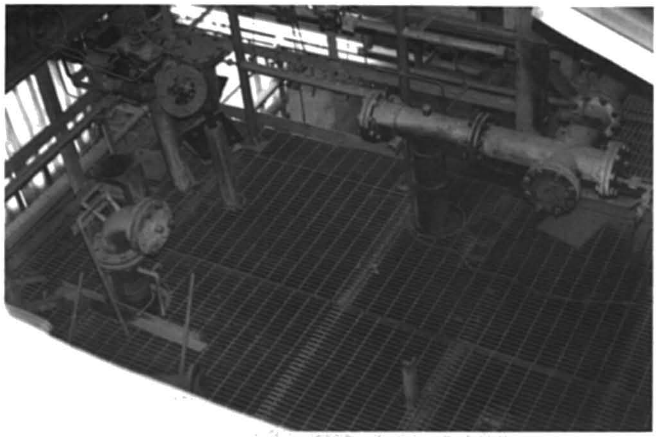
Slide 8
REACTION PLATFORM SHOWING
REACTION TEES AND CONTROL EQUIPMENT



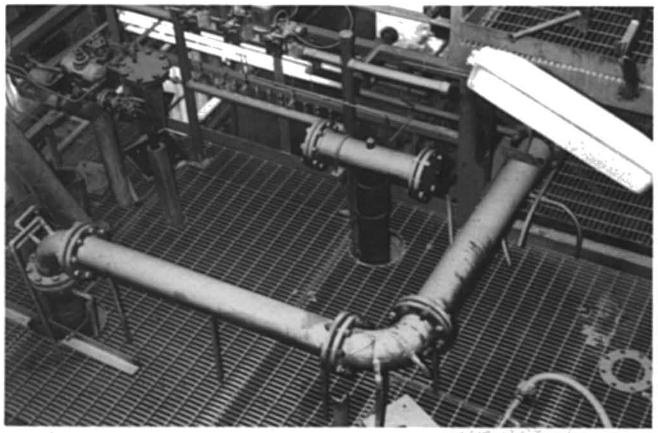
Slide 9
D.A.P. REACTOR



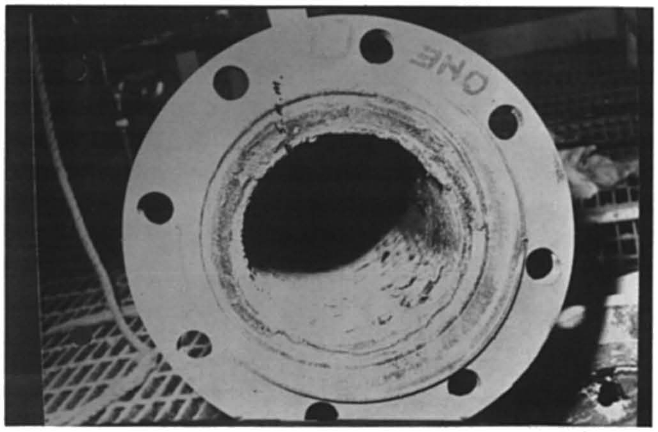
Slide 10
AMMONIUM SULPHATE REACTOR



Slide 11
CONFIGURATION OF PIPE REACTOR
FOR D.A.P. PRODUCTION



Slide 12
CONFIGURATION OF PIPE REACTOR
FOR AMMONIUM SULPHATE PRODUCTION



Slide 13
TYPICAL BUILD-UP IN TEFLON-LINED
PIPE REACTOR (NAURU D.A.P.)

MODERATOR DAVIS: Do we have questions for Graham Torney. [Lots of Applause]

QUESTION: Isn't 28 feet critical? Other people are saying 9 feet; you say 28.

MR. GRAHAM TORNEY: I believe that TVA's original meltwork had pipes of about 20. They also said that you had to stick the tee up vertically. We were dropping so many eggs into one basket here that we weren't prepared to make a mistake. We believe there's a degree of witchcraft in this that we put the tee vertically, we put two bins in it, and we made it well in access of the length they had. Yet, nevertheless we are sure that the reaction is not complete until downstream of the second bin. We know this because we take samples out of the tee reactor during running; and if you do mass balances, you know that the material coming out of that reactor is of higher N to P ratio than we are sampling.

Secondly, we have done temperature traces both with instruments and with infrared photography along the pipe, and we know that the reaction is continuing to well past that second bin.

Lastly, as far as having a long pipe is concerned 316L stainless isn't very expensive for a few feet of pipe, and I love the idea of getting the reactor way away from the drum where you can do some decent engineering in setting it up instead of standing close to that dusty old drum. So I don't believe it's critical, but I believe it needs to be greater than 28 feet.

QUESTION: What are your drying requirements for DAP?

MR. GRAHAM TORNEY: Our drying requirements for DAP are certainly no better than we would have expected at this point in time than with a preneutralizer. There is no reason to expect them to be. In fact, in our particular plant we have a problem with our dryer, and I suspect that we are getting very poor heat utilization; but that's associated with the dryer and with the size of it. I think you could only say that on DAP at this point in time if you want to make straight DAP without sulfuric acid in it then you cannot expect to make very great energy savings. Now the temperature out of the drum is controlled by how high you're prepared to push on DAP, and 80 to 100°C. is about as safe as you can go without losing ammonia. Similarly our moisture level is at 2½ to 3%. If you put in a long enough cooler then you'll need that down probably to 1½ to 2%. I don't know what you're required to dry DAP to. We need to get it down to about 1% in our conditions.

MODERATOR DAVIS: Thank you very much, Graham. That's a very fine paper. I believe you'll be here during the remainder of the meeting; and if you have questions about DAP or ammonium sulfate, why perhaps you can catch Graham in the halls. [Applause]

Our next paper is the "Production of Inverse Ratio Fertilizers." The authors of this-paper are M.E. Arias, the director of production for Fertisa, S.A., San Jose, Costa Rica; E. Gia Rerro, plant superintendent, Guanomex, Minatitlan Plant and Adolfo Sisto, operations manager of Quanomex, Mexico City. Mr. Sisto will present the paper. Adolfo is a member of our Board of Directors for The Fertilizer Industry Round Table and like our other speakers this morning he also has had numerous years of experience in production of granular fertilizers. Adolfo Sisto. [Applause]

Production of Inverse Ratio Fertilizers

Written by M. E. Arias & Gia Rerro

Presented by A. Sisto

The so-called "inverse ratio" granular fertilizers, that is, those with contents of nitrogen higher than phosphorus, account for 20% of all granular materials consumed in Mexico during the year of 1976. The production of granular fertilizers, however, does not reach very high tonnage levels, since still most fertilizers are applied as straight meterials or as bulk mixtures. The inverse ratio grades produced in Central America have been for export to Mexico.

In this paper an attempt is made to convey our operating experience and some of the problems encountered in the manufacture of these grades and two of them, 20-10-10 and 13-9-18, produced in different plants and countries and by different processes, have been selected for this purpose.

20—10—10

ACAJUTLA, El Salvador, C.A.
FERTICA de El Salvador, S.A.
T.V.A. process.
PUNTARENAS, Costa Rica, C.A.
FERTICA de Costa Rica, S.A.
P.E.C. process.

18—9—18

MINATITLAN, Ver. Mexico.
GUANOS Y FERTILIZANTES DE MEXICO, S.A.
P.E.C. process.

Due to local conditions and availability of raw materials, the ingredients used at each location are different. It should also be borne in mind that in Mexico, non-water soluble P_2O_5 fertilizers are not very well accepted.

Two kinds of conditions may be distinguished in granulation: those which once selected are not subject to change during the running of the formula, which we will call BASIC CONTROLS, and those which can be changed at any time during the operation in order to maintain granulation at a satisfactory or, if possible, optimum level, which we will refer to as OPERATION CONTROLS.

Of the basic controls, the most important is the selection of the formulation to be used, as it will determine the liquid phase and the heat of reaction.

The operation controls vary with the process and among those available at a T.V.A. plant are the addition of stream or water, variations of amount and temperature of recycle and variations of temperature of the dryer. At the P.E.C. plants, we have such controls as the distribution of the ammonia in the reactors for pH control, the circulation of water or steam in their jackets, the temperature of the dryer, the pressure of the atomizing air and the amount of recycle.

Manufacture of 20-10-10 by the T.V.A. Process (Acajutla).

1) *BASIC CONTROL.*

Three different formulations were used in order to obtain the best operating conditions and output:

Percent, dry basis.

	Form.1	Form.2	Form.3
N solution, 317 (15-0-45)	6.0	7.6	4.9
Ammonium sulfate	33.4	41.7	36.7
Urea	13.9	7.3	14.2
DAP, (18-48-0)	18.8	21.7	20.0
NSP, (0-20-0)	7.3	---	4.1
Potassium chloride	16.9	16.8	16.9
Sulfuric acid	3.7	4.9	3.2

Analysis of the raw materials used. (Percent)

NITROGEN SOLUTION	
Total N	31.7
Ammonia	14.8
Urea	41.8
Water	43.3

AMMONIUM SULFATE	
Total N	21.2
Moisture	0.1

UREA	
Total N	45.6
Moisture	0.3

DAP	
Amoniacal N	17.9
Total P_2O_5	46.0
Insol. P_2O_5	0.1
Moisture	1.1

NSP	
Total P_2O_5	20.4
Insol. P_2O_5	0.6
Moisture	2.7

KCl	
K_2O	60.0
Moisture	1.0

Sulfuric acid	
Concentration	98

2) *OPERATION CONTROL.*

The manufacture was started using formulation No. 1. From the beginning the material overgranulated and caused sticking and obstructions in every duct, elevator and hopper, and in the ammoniator and in the dryer discharges.

The temperature in the dryer was adjusted to 140°F. and the recycle increased to no avail. Only by increasing the recycle ratio to a point where the plant hourly production dropped to 10 MT/hr (barely ½ of the rated capacity), was it possible to maintain 165°F. in the dryer and obtain reasonable operating conditions. Of course, operating at this capacity was not profitable.

The problems were the result of a too high liquid phase for the heat of reaction (58 800 Btu).

Formulation No. 2 has a higher heat of reaction, 74 800 Btu, as well as a higher liquid phase. It produced fines in excess, making granulation difficult, even adding water to the ammoniator-granulator.

The *formulation* which performed the best was *No. 3.* It has the lowest liquid phase and heat of reaction (49 200 Btu). The dryer temperature was maintained at 170°C. Although granulation was not perfect it did not produce a versized material in excess and production reached 18 MT/hr.

Manufacture of 20-10-10 by the P.E.C. process. (Puntarenas)

1) *Description of the process.*

The plant includes two sections:

a) Wet or reaction sections:

It has a number of reactors in series, each one with individual agitation. The raw materials are added at different points in the chain of reactors and the result is a slurry with the same ratio of nutrients as the finished product and enough water to allow it to run to the slurry tank; from there it is pumped to the granulators.

b) Dry section:

This section performs the granulation, drying and classification of the product, and its main feature are two "spherodizers" where granulation takes place by spraying the slurry on a rolling bed of fine particles, where the granules increase in size due to the formation of additional layers.

2) *Basic Control.*

The correct dosage of the ingredients is very important as it affects the melting point and the pH of the slurry and in consequence its running characteristics. The quality of the raw materials is also important since inpurities influence the composition of the slurry as well as its abrasive and corrosive characterisitics. The presence of potasssium chloride in the formula, helps granulation.

Two different formulations were used:

Percent, dry basis.

	Form. 1	Form. 2
Ammonia	2.8	2.5
Phosphate rock	16.2	13.8
Nitric acid	18.8	17.7
DAP, (18-46-0)	9.8	11.2
Potassium chloride	16.4	16.4
Ammonium Nitrate	33.3	31.9
Ammonium Sulphate	-	4.0
Diatomite	2.0	2.0
Moisture	0.5	0.5

Analysis of the raw materials:

a) PHOSPHATE ROCK:

Total P_2O_5	33.2%
Moisture	1.0 "

b) DAP (18-46-0):

Ammonia Nitrogen	18.5%
Total P_2O_5	46.7 "
Moisture	1.0 "

c) NITRIC ACID:

Nitric Nitrogen	12.0 "
Water	46.0 "

d) AMMONIA:

Ammonia Nitrogen	82.0 "
Moisture	0.2 "

e) MURIATE OF POTASH:

K_2O	60.0 "
Moisture	0.1 "

f) AMMONIUM NITRATE:

Nitric Nitrogen	14.0 "
Ammonia Nitrogen	14.0 "
Water	20.0 "

g) AMMONIUM SULPHATE:

Total Nitrogen	21.0 "
Moisture	0.1 "

MT/hr.	Form .1	Form .2
FINAL SLURRY		
Temperature, °C.	97	98
pH	5.2	5.2
Water content, percent	18	17
SPHERODIZERS.		
Inlet air temp., sphero A, °C.	165	179
Inlet air temp., sphero B. °C.	152	180
Outlet air temp., sphero A, °C.	78	79
Outlet air temp., sphero B, °C.	77	78
RATE OF PRODUCTION, MT/hr	9.5	12.3
Mesh Analysis Exit Percent +6.	4.4	7.5
Mesh Analysis Exit Percent —6+10	50.8	19.8
Mesh Analysis Exit Percent —10	44.8	76.2

3) *OPERATION CONTROL.*

The main variables to control are:

- temperature and ph of the slurry. They affect its viscosity and the former also affects the drying of the slurry. They must be carefully controlled in order to avoid decomposition of the material.
- water content of the slurry, as it affects granulation and production rate.
- pressure of the spraying are and of the slurry, which affects the size of the product.
- rate of recirculation (amount of fines).

Production of 20-10-10 was started using formulation No. 1, at a rate of production of 12.3 MT/hr.

The material in the "sphero" showed a strong tendency to stick to the walls and a high proportion of oversized material was produced. This condition resulted from the low melting point of the slurry, which limited the temperature of the spraying air to 163/167°C. and its high water content (18%), and it became necessary to lower the rate of production.

At 9.2 TM/hr the operation became manageable but pH had to be watched carefully and adjusted very frequently; frequent cleaning of the whole of the dry section was necessary to keep it unobstructed and to maintain a high spraying air pressure to avoid overgranulation. A tendency to overformulation of the 3 nutrients was also noticed; we think it can be explained by losses of mass as CO_2, due to the high amount of phosphate rock used.

In an attempt to increase the rate of production, formulation No. 2 was used, with good results. It includes the addition of ammonium sulphate and made it possible to raise the granulators' incoming air temperature to 190°C. The addition of ammonium sulphate was made in reactor No. 12.

At a rate of 13.25 MT/hr, the tendency to stock and to overgranulate persisted, but reasonable operation was maintained at 12.3 MT/hr.

Manufacture of 18-9-18 by the P.E.C. Process (Minatitlan)

This plant is of similar design to the Puntarenas plant and its rated capacity us 29 MT/hr of 15-15-15.

1) *BASIC CONTROL*

RAW MATERIALS

Percent, dry basis.

Ammonia	3.75
Ammonium Nitrate	38.58
Phosphate rock	8.04
Nitric acid	7.05
Phosphoric acid	8.90
Potassium chloride	29.92

Balance, coating and H_3PO_4 impurities.

2) *Analysis of Raw Materials:* (wet basis)

a) PHOSPHATE ROCK

P_2O_5 33.50 %

b) NITRIC ACID

52 % concentration.

c) FOSFORIC ACID

P_2O_5 40 %

d) AMMONIA

Nitrogen 82.35 %

e) AMMONIUM NITRATE

Concentration.	90.0	%
Nitrogen	35	"

f) MURIATE OF POTASH

K_2O	60	%
Moisture	1	"

3) *OPERATION CONTROL*

a) *Wet section.*

With this formulation, two different chemical processes, plus the addition and mixing of two of the ingredients, occur in the wet section.

A) Phosphonitric process: nitric attack of the phosphate rock, and regression with phosphoric acid of the calcium nitrate produced, followed by ammoniation,

B) Neutralization of phosphoric acid with ammonia,
C) Addition of ammonium nitrate liquor,
D) Addition of potassium chloride.

The nitric attack of the rock takes place in reactors 1, 2 & 3 and ammonia is added to reactors 4 to 13 until a pH of 7 is reached. The addition of ammonium nitrate liquor is made in reactor No. 7 and that of potassium chloride in reactor No. 13; this leaves two extra reactors to obtain an homogenous slurry.

pH and temperature of reactors.

#	t°C	pH	#	t°C	pH	#	t°C	pH
1	45		6	112	2.5	11	114	7.0
2	66		7	112	3.5	12	110	7.0
3	70		8	119	5.5	13	104	7.0
4	104		9	119	6.2	14	95	7.0
5	111		10	115	6.8	15	94	7.0

Most of the troubles with this formulation occur in the wet section in the form of thickening of the slurry in reactors 6, 7 and 8, where the pH is in its critical range.

As minimum solubility and maximum viscosity of this slurry are obtained at a pH of 3.5/4.5, it is necessary to avoid extending this range to more than one reactor.

b) *Dry section.*

The high ammonium nitrate content of the slurry imposes limitations in this section and the temperature in the granulator and the water content of the slurry must be kept as low as possible: 200°C. and 10% are the limits. Even so, there is a tendency to overgranulation. A ratio of recycle of 1.5 to 1 gives a reasonable granulation at rates of 20/20.2 MT/hr.

FINAL SLURRY ANALYSIS, Percent.

NH_4NO_3	46.64	KCl	29.45
$(NH_4)_2SO_4$	1.03	SiO_2	0.30
$(NH_4)_2HPO_4$	4.52	$AlPO_4$	0.19
$NH_4H_2PO_4$	2.63	$FePO_4$	0.18
$CaHPO_4$	9.29	Inerts	0.77
		H_2O	5.00

OPERATION CONDITIONS

FINAL SLURRY	
Temperature	94 °C
pH	7
Water content	5 %
SPHERODIZER	
Inlet air temperature	170/200 °C
Outlet "	87-92 °C
Product disch. "	82-87 °C
Spraying air pressure	2.2/3.0 kg/cm^2.
Fines recycle ratio	1.5 to 1
PRODUCTION	20.8 MT/hr.

FINISHED PRODUCT ANALYSIS (percent)

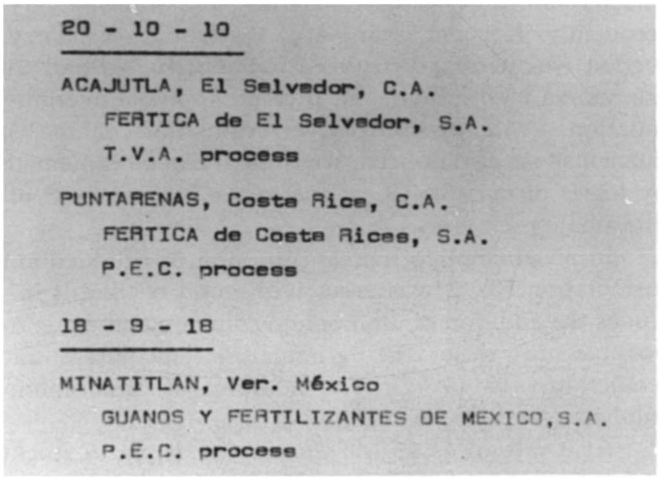
	20-10-10		18-9-18
	T.V.A.	P.E.C.	P.E.C.
Total N	20.0	20.5	17.9
Nitric N	--	10.1	8.1
Ammoniacal N	13.4	10.4	9.8
Urea N	6.6	--	--
Total P_2O_5	10.9	10.3	9.2
Water Sol. P_2O_5	8.	2.5	4.5
Citrate sol. P_2O_5	2.8	7.6	4.7
K_2O	10.6	10.1	18.3
$S\ (SO_4^{=})$	45.6	--	--
Coating		2.3	1.9
Moisture	1.3	0.8	0.8
pH	7		6.7

Mesh Analysis.

20 - 10 - 10		18 - 9 - 18	
P.E.C. Puntarenas		P.E.C Minatitlán.	
+ 5	0.2	+ 6	2.8
- 5 + 10	50.	- 6 + 8	9.1
- 10 + 14	39.6	- 8 + 12	40.2
- 14 + 18	9	- 12 + 20	42.3
- 18	1.2	- 20	5.6

Conclusion:

Inverse ratio granular fertilizers are grades that are difficult to manufacture, but with a proper formulation a material of good quality can be produced at profitable operating ratios in both T.V.A. and the P.E.C. plants.



20 - 10 - 10

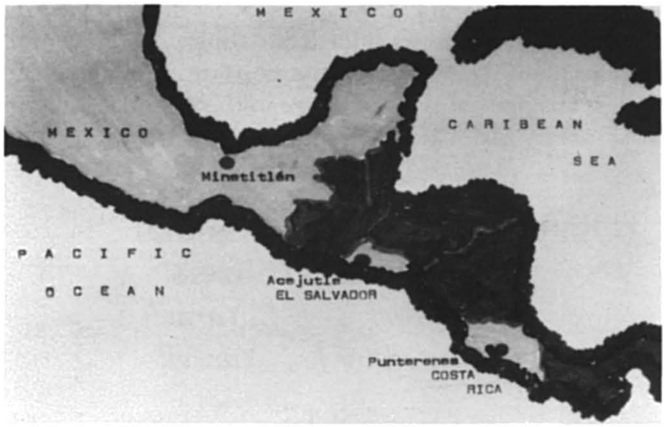
ACAJUTLA, El Salvador, C.A.
FERTICA de El Salvador, S.A.
T.V.A. process

PUNTARENAS, Costa Rica, C.A.
FERTICA de Costa Ricas, S.A.
P.E.C. process

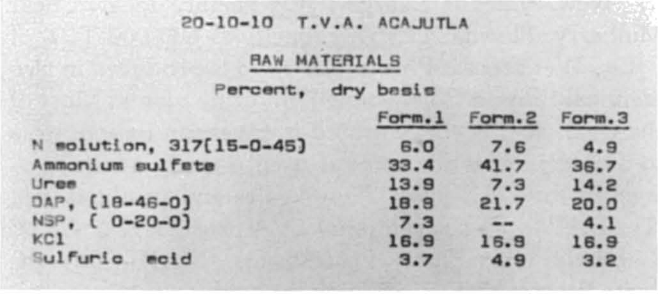
18 - 9 - 18

MINATITLAN, Ver. México
GUANOS Y FERTILIZANTES DE MEXICO, S.A.
P.E.C. process

Slide 1



Slide 2

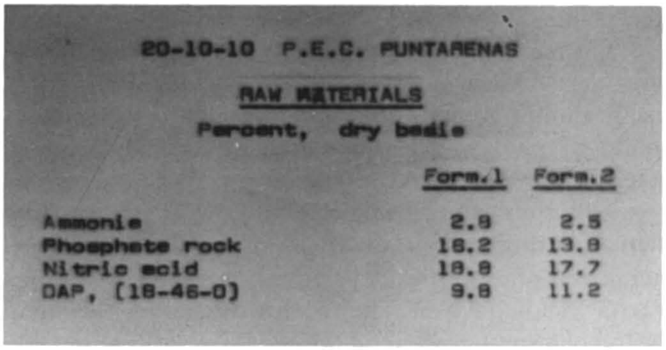

20-10-10 T.V.A. ACAJUTLA

RAW MATERIALS

Percent, dry basis

	Form.1	Form.2	Form.3
N solution, 317(15-0-45)	6.0	7.6	4.9
Ammonium sulfate	33.4	41.7	36.7
Urea	13.9	7.3	14.2
DAP, (18-46-0)	18.9	21.7	20.0
NSP, (0-20-0)	7.3	--	4.1
KCl	16.9	16.9	16.9
Sulfuric acid	3.7	4.9	3.2

Slide 3

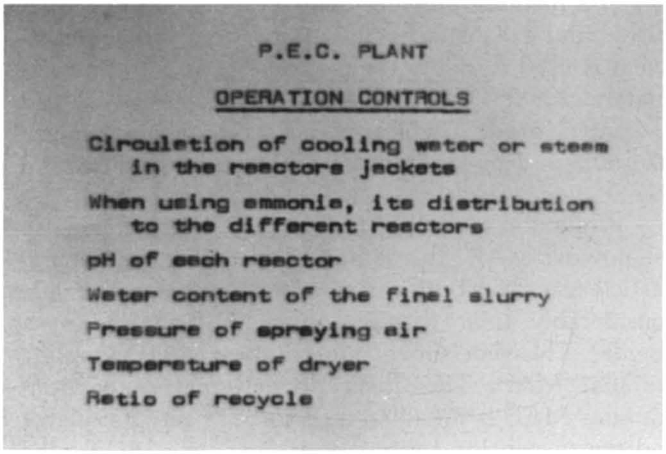

20-10-10 P.E.C. PUNTARENAS

RAW MATERIALS

Percent, dry basis

	Form.1	Form.2
Ammonia	2.8	2.5
Phosphate rock	16.2	13.8
Nitric acid	18.8	17.7
DAP, (18-46-0)	9.8	11.2

Slide 4


P.E.C. PLANT

OPERATION CONTROLS

Circulation of cooling water or steam in the reactors jackets

When using ammonia, its distribution to the different reactors

pH of each reactor

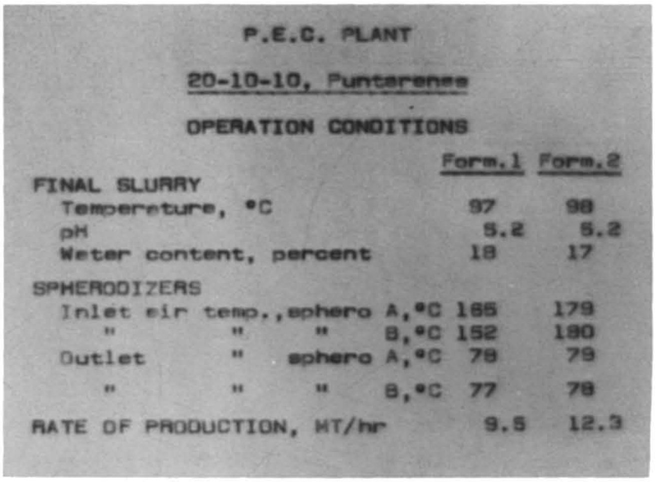
Water content of the final slurry

Pressure of spraying air

Temperature of dryer

Ratio of recycle

Slide 5

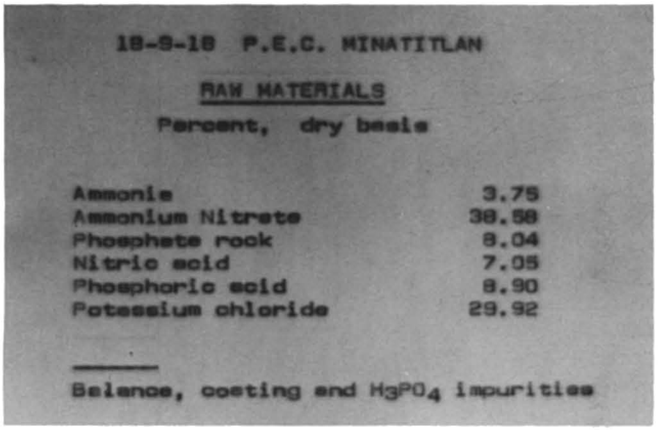

P.E.C. PLANT

20-10-10, Punterenas

OPERATION CONDITIONS

	Form.1	Form.2
FINAL SLURRY		
Temperature, °C	97	98
pH	5.2	5.2
Water content, percent	18	17
SPHERODIZERS		
Inlet air temp., sphero A, °C	165	179
" " " B, °C	152	180
Outlet " sphero A, °C	78	79
" " " B, °C	77	78
RATE OF PRODUCTION, MT/hr	9.5	12.3

Slide 6


18-9-18 P.E.C. MINATITLAN

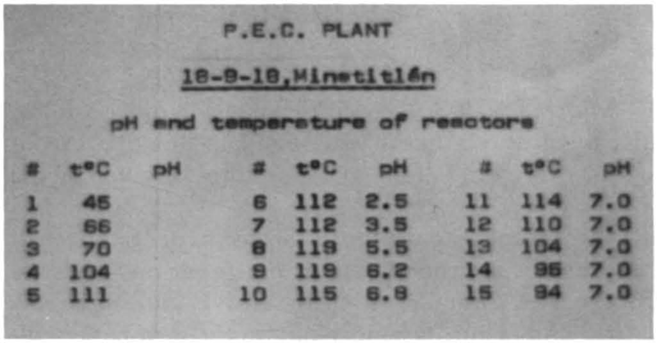
RAW MATERIALS

Percent, dry basis

Ammonia	3.75
Ammonium Nitrate	38.58
Phosphate rock	8.04
Nitric acid	7.05
Phosphoric acid	8.90
Potassium chloride	29.92

Balance, coating and H_3PO_4 impurities

Slide 7

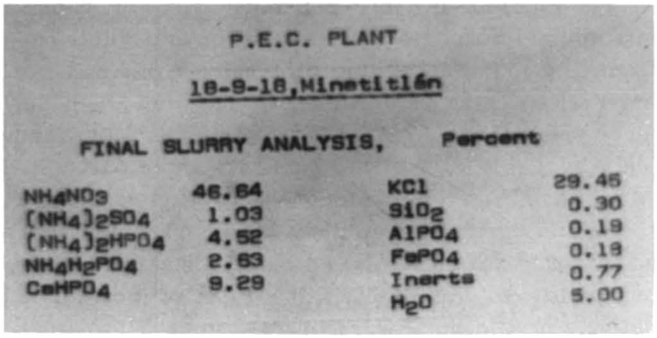

P.E.C. PLANT

18-9-18, Minatitlán

pH and temperature of reactors

#	t°C	pH	#	t°C	pH	#	t°C	pH
1	45		6	112	2.5	11	114	7.0
2	66		7	112	3.5	12	110	7.0
3	70		8	119	5.5	13	104	7.0
4	104		9	119	6.2	14	96	7.0
5	111		10	115	6.8	15	94	7.0

Slide 8

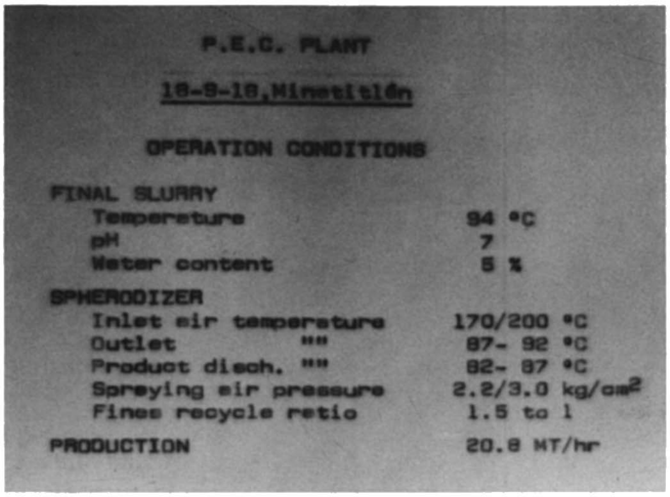

P.E.C. PLANT

18-9-18, Minatitlán

FINAL SLURRY ANALYSIS, Percent

NH_4NO_3	46.64	KCl	29.45
$(NH_4)_2SO_4$	1.03	SiO_2	0.30
$(NH_4)_2HPO_4$	4.52	$AlPO_4$	0.19
$NH_4H_2PO_4$	2.63	$FePO_4$	0.18
$CaHPO_4$	9.29	Inerts	0.77
		H_2O	5.00

Slide 9



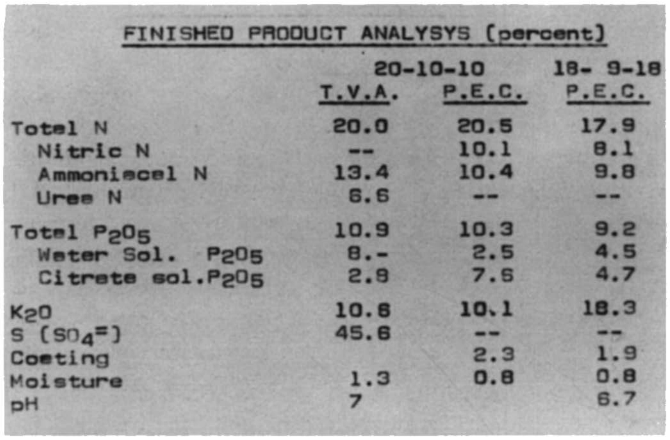
P.E.C. PLANT

18-9-18,Minatitlán

OPERATION CONDITIONS

FINAL SLURRY	
Temperature	94 °C
pH	7
Water content	5 %
SPHERODIZER	
Inlet air temperature	170/200 °C
Outlet ""	87- 92 °C
Product disch. ""	82- 87 °C
Spraying air pressure	2.2/3.0 kg/cm^2
Fines recycle ratio	1.5 to 1
PRODUCTION	20.8 MT/hr

Slide 10



FINISHED PRODUCT ANALYSYS (percent)

	20-10-10		18- 9-18
	T.V.A.	P.E.C.	P.E.C.
Total N	20.0	20.5	17.9
Nitric N	--	10.1	8.1
Ammoniacal N	13.4	10.4	9.8
Urea N	6.6	--	--
Total P_2O_5	10.9	10.3	9.2
Water Sol. P_2O_5	8.-	2.5	4.5
Citrate sol.P_2O_5	2.9	7.6	4.7
K_2O	10.6	10.1	18.3
S ($SO_4^=$)	45.6	--	--
Coating		2.3	1.9
Moisture	1.3	0.8	0.8
pH	7		6.7

Slide 11

MODERATOR DAVIS: Thank you, Adolfo. Adolfo has asked that if you have questions he'd want you to write them to him, and his address is given on the back of your programs.

We are going to postpone the last paper of our program for this afternoon, that is the paper on "Physical Properties of Granular Urea Based NP and NPK Fertilizers" until Thursday morning. So the next paper will be our final paper of the session this afternoon.

The subject of this paper is "Use of Monoammonium Phosphate in Granulation and Fluid Fertilizers" by J. J. Yarnell and John Surber of I.M.C. at New Wales Chemicals in Mulberry, Florida. The paper will be presented by Mr. Yarnell. Mr. Surber is here and will be available to help with questions and discussions. I.M.C. have been the leaders in the development of the process and operating conditions for nongranular MAP and for the use of the MAP in other fertilizer production operations. As you know, this type of product is relatively new in the U.S. fertilizer system. Mr. Yarnell received his degree in chemical engineering from University of South Florida in 1973. He has worked in plant production of granular triple superphosphate and on pilot plant recovery of uranium prior to joining New Wales. His present job duties are in the granulation and MAP areas. Mr. Yarnell. [Applause]

Use of MAP In Granular And Fluid Fertilizers

John Surber — J. J. Yarnell

Presented by J. J. Yarnell

New Wales Chemicals, Inc., is a wholly owned subsidiary of International Minerals and Chemicals Corporation.

New Wales is a large P_2O_5 Facility located near Mulberry, Florida. Design capacity is 600,000 TPY of P_2O_5. Wet process Phosphoric Acid is produced in two identical Prayon Convertible Dihydrate plants. Most of the weak acid is concentrated in Swenson Evaporators to 54% P_2O_5, while some is used directly at the 30% level in the DAP plant. New Wales end products are: (1) DAP — by conventional TVA process, (2) GTSP — by the Dorr Slurry Process, (3) MAP — by the Swift Process and (4) Merchant acid.

Sulfuric Acid requirements, which are in excess of 6,000 TPD, are met by three Monsanto Double Absorption plants.

The merchant acid production to a large degree dictates our MAP production. since our DAP and GTSP plants cannot accept a feed acid too high in suspended solids, the sludge acid from merchant acid clarification is used to produce MAP.

This slide is a schematic of the Swift process for manufacturing non-granular MAP. Anhydrous ammonia and phosphoric acid sludge are reacted in a pipe reactor yielding MAP. The reactor discharges through the top of a spray tower and the MAP free-falls about 90 ft. It is then mechanically raked up and conveyed to storage. Air is exhausted at the top of the tower, scrubbed in a medium pressure drop Venturi Scrubber, demisted and exhausted to the atmosphere. Scrubber effluent is used to dilute the feed sludge acid to approximately 43% P_2O_5. Sulfuric Acid is occasionally added to control grade. Typically the product will analyze 10.1-50.5-0. This is a copy of our product specification sheet.

While non-granular MAP is quite often referred to as "powder MAP" this is not correct. It has a general particle size distribution similar to beach sand. While considerably finer than granular MAP, it is not a powder. This slide shows non-granular MAP alongside granular MAP. The finely divided mature of non-granular MAP is an advantage to both the granulator and the suspension formulation. First, let's discuss the use of non-granular MAP in suspension fertilizers.

Suspension fertilizers hold many advantages, and we believe they will continue to increase their share of the fertilizer market. Suspensions permit higher analyses than clear liquids. Since a suspension contains undissolved solid materials, it is no problem to apply in cold weather. Suspensions can be stored year-around and applied through flood jet nozzles. The product is completely homogeneous and there is little particle segregation. This is particularly important when you consider secondary and trace element addition to your formulation.

Non-granular MAP is an ideal material to use in suspension formulations. We recommend the addition of 2.44 lbs. NH_3 per unit of P_2O_5 from MAP. This is recommended because our trials have shown that a 9-30-0 is the highest analysis safely formulated directly. A 10-30-0 is possible, but NH_3 losses are high and if rapid cooling is not available, large DAP crystals form which may plug spray nozzles. If a 9-30-0 is not acceptable and a 10-30-0 is desired, we recommend the last percent N be added from 30% N solution. Modify the formulation by adding 67 lbs. of N solution.

The formulation procedure is to gel the clay in the water and then add the nitrogen solution, MAP and finally the Ammonia. Some formulators add the N solution to the water first, but our research shows the clay gels better when added first.

Normal formulations, using granular MAP, require 1.5% - 2% clay. Our formulations only call for 1% clay. This is due to the finely divided nature of non-granular MAP. A solid is kept in suspension by controlling two physical properties— solid particle size and solution viscosity. The function of the clay is to increase the solution viscosity. The high shear mixing affected by the equipment used, such as the Bard & Bard or Fergusen Fert-O-Batcher, reduces the particle size.

Non-granular MAP is already a fine material when shipped. Thus, the suspension formulator receives a double cost reduction. Less horsepower is required and less clay is required to create an acceptable suspension. Much of our field experience and laboratory research indicates that usually no clay is required. However, this is an area that is being researched further.

It appears that, for once, the impurities present in wet process phosphoric acid are a benefit. While our research is still under way, the iron and aluminum content of the MAP effects its suspendability. There seems to be a correlation between the ratio of I&A to gypsum present in MAP to its suspendability. A high ratio results in a MAP that suspends without clay; a suspension from a MAP with a low ratio requires 1% clay. Scottish Agricultural Industries, Ltd. reports[1] that the impurity ratios and concentrations are important to the size, shape and properties of MAP/DAP crystals. Akiyama and Ando[2] reported that a gel-like substance, (Al, Fe) $NH_4HF_2PD_4$, is formed during the ammoniation of wet process acid. We intend to further investigate the effects of impurities on the suspendability of MAP.

A major problem facing the suspension formulator is "How do I know when I have a 9-30-0 base"? While there are several control methods possible. We recommend pH. A 9-30-0 suspension has a pH of 6.9. This slide is a plot of pH vs #NH_3/Unit P_2O_5. A 9-30-0 contains 6.0 #NH_3/Unit P_2O_5. If a 10-30-0 base is made, the expected pH is 7.1. While viscosity or temperature rise are sometimes used they are dependent upon external factors and are not as reproducible as pH.

While the nutrient ratios of suspensions utilizing MAP are lower than those made from 10-34-0 poly phosphates solutions, they have a distinct cost advantage per unit of P_2O_5. We believe that this advantage coupled with the rapid growth of the fluid suspension market, offers a real opportunity for utilizing solids formed by taking advantage of impurities in Florida Rock.

Now let's turn our attention to the use of non-granular MAP in granulation plants.

MAP was originally thought to be a product ideally suited as an intermediate material for granulation in developing countries and as such would not find extended use in the domestic market. Since non-granular MAP is easily handled and readily shipped in covered hopper cars, a North American market has developed. Many granulation plants now use non-granular MAP to economic advantage in a variety of NPK grades. The product generally has been found to be best used in formulations where supplemental heat, either from steam or chemical reaction, is available.

Moisture is necessary to permit ammoniation of MAP. Previously published work[3,4] indicates that about 4%-7% H_2O is the optimum. Our work shows this is on the low side. There is also some question as to how high an N/P ratio can be achieved. We feel that with the proper moisture present, MAP can be ammoniated to an N/P mol ratio of 1.95-2.00.

Our direct experience has, thus far, been only with bench scale equipment. However, there are plants operating adding MAP to DAP and/or NPK plants. Our Korean affiliate reports adding MAP to the recycle stream of a DAP plant and achieved a mol ratio of 1.95-2.00. As much as 75% of the acid P_2O_5 input has been replaced with MAP. Swift[4] reports ammoniating MAP to a 1.95 mol ratio in a similar manner.

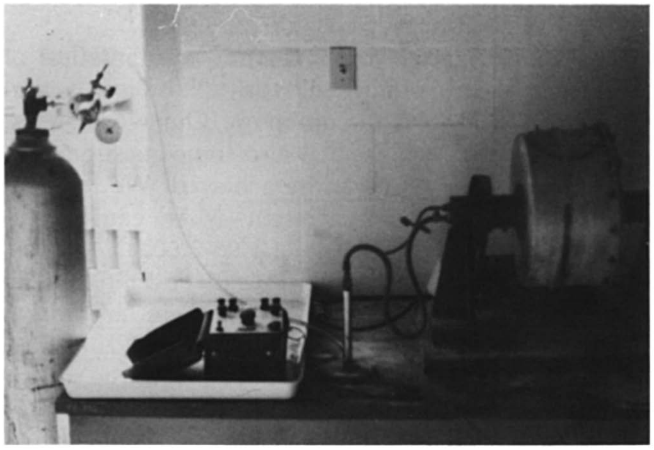
This slide show a formulation with no MAP added to a DAP plant. Notice that a 6:1 recycle is used. This slide shows a formulation with MAP added; note the recycle is 2.1:1. This is probably due to a similar phenomenon that occurs when ROP Triple Super Phosphate fines are added to a Granular Triple Super Phosphate plant[5]

In granulation, fine grains of recycle material are "cemented" to the surface of granulation nuclei by reaction slurry and the chemical bonding that occurs during ammoniation in the bed. The most important aspect to consider is the condition of the recycle bed. The slurry must be partially absorbed by the granulation nuclei. This results in a stronger bond being formed between two particles in the granulator.

Non-granular MAP is an ideal recycle conditioner for a DAP/NPK plant. Indeed, one Brazilian company has installed a non-granular MAP facility just to provide MAP as a recycle conditioner at their DAP/NPK plant; one Florida company is also planning to do this. The finely divided, porous nature of MAP provides excellent granulation nuclei. It is far more absorptive than the DAP formed in the TVA type process. The recycle ratio may be drastically reduced with the introduction of MAP. This leads to longer equipment life, lower operating expenses and increased production capability.

As expected, if non-granular MAP is added to the recycle of a NPK/DAP plant, the production capability increases. Kearns[4] reports a production increase from 8 TPH to 18 TPH.

Our bench scale tests have been with equipment identical to that used by Hardesty, et al.[6], in their study of the ammoniation of super phosphates. The drum is 316 S.S. and is 14 inches in diameter by 7¼" long. The NH_3 sparger is located under the bed and has six 1/32" Ø openings. A thermocouple is attached to the sparger to monitor bed temperature. Anhydrous ammonia is metered through a rotameter. This meter was calibrated by feeding NH_3 into 0.05 N H_2SO_4 and back-titrating.



Ammonation Equipment

Different ammoniation rates were tested at different moisture levels. The slide being shown shows the maximum NH_3 absorbed versus moisture. It was found that at 18% free moisture, the entire weight of the MAP was solubilized. Once so solubilized, the MAP can then be ammoniated to the same degree as an equivalent phosphoric acid. The 18% moisture needed to achieve maximum MAP ammoniation is easily handled in a system with a 2.1:1 recycle ratio. Assume the recycle has 1% H_2O. The granulator would operate at 6.5% moisture. This is quite acceptable. Of course, recycle depends upon the NPK grade being made.

The bed temperature was monitored during our tests. These are the results showing bed temperature vs final N/P mol ratio. The temperature at 18% moisture was 185°F. It is believed that all of these temperatures are lower than would be experienced in a full scale unit. This is because our equipment was small and the radiant heat losses were quite high. Dr. Shu Lin Peng[3] reports operating at about 170°F. in the ammoniator and 145°F. in a pan-granulator. He used non-granular MAP to produce NPK, particularily 9-36-12. 6-36-12, 8-24-12. Dr. Peng reported that formulations granulated better when Sulfuric Acid is added to generate sufficient reaction heat to raise the granulation temperature above 175°F. Kearns[4] reports that 185°F.—195°F. is the desirable temperature range for proper granulation.

Above this temperature the material becomes too plastic and over-granulation occurs.

The ammonia efficiency data collected during our bench scale testing is erratic, and therefore, we hesitate to report it. The data does show that ammonia efficiencies, with less than 8% free moisture, are very low. We experienced ammonia recoveries on the order of 90% + with most of the samples that had more than 8% moisture.

A brief word is in order on the economics of using MAP as an intermediate in DAP manufacture. Sweeney[7] developed the economics of providing DAP to a Northern European port location by several methods:

1. Producing phosphoric acid on site from North African Rock.
2. Shipping phosphoric acid from North Africa.
3. Shipping MAP from North Africa.
4. Producing DAP in North Africa and shipping to Europe.

The DAP costs were the highest for the case of shipping the rock to Europe and then producing DAP; and lowest when MAP was shipped and then used to produce DAP. The latter was about $5/ton DAP cheaper. When all shipping costs are subtracted, using MAP as an intermediate is still the cheapest way to produce DAP.

At this time, we would like to thank the Round Table for the opportunity to present this paper. Particular thanks goes to Mr. Dan McCoy, who assisted in performing the test work that has culminated in this presentation.

REFERENCES

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2. Akiyuma, Takashi and Ando, Jumpei, "Constituents and Properties of Ammoniated Slurry from Wet Process Phosphoric Acid", Bull, Chem, Soc. Japan 45, pp. 2915-20 (Sept., 1972)
3. Peng, S. L., "Granulation of compound Fertilizers by Ammoniation of Blends Containing Non-Granular Mono-ammonium Phosphate", presented at 166th National Meeting of ACS, Div. of Fert. and soil chemistry, Chicago, Ill. (Aug., 1973)
4. Kearns, T. C., "Plant Production of 18-46-0 using Non-Granular Mono-Ammonium Phosphate". paper presented 166th National Meeting of ACS, etc.
5. Yarnell, J. J., "Triple Super Phosphate Manufacture — No Longer Mud Chemistry" *Phosphorus & Potassium 80*, pp. 33-38 (Nov. Dec., 1975)
6. Hardesty, RAPP, Kumagai, "Physical Factors Influencing Ammonia Absorption by Super Phosphates", paper presented to 124th Meeting of ACS, Chicago, Ill. (1953)
7. Sweeney, G. C., "The Role of Intermediate Fertilizer Products", paper presented to ACS meeting, August 31, 1976, San Francisco, California.

10-50-0 (MONOAMMONIUM PHOSPHATE POWDER)

chemical specifications*

	RANGE	TYPICAL	GUARANTEE
Available Nitrogen	10.0–10.5	10.2%	10.0% min.
Total P_2O_5	52.0–53.5	52.6%	—
Available P_2O_5	52.0–53.5	52.5%	50.0% min.
Water Soluble P_2O_5 (as a % of available P_2O_5)	84–88	85.0%	—
Water Soluble Nitrogen (as a % of available N)	88–91	90.0%	—
Moisture	1.0– 2.0	1.5%	—
pH	4.2– 5.0	4.7%	—

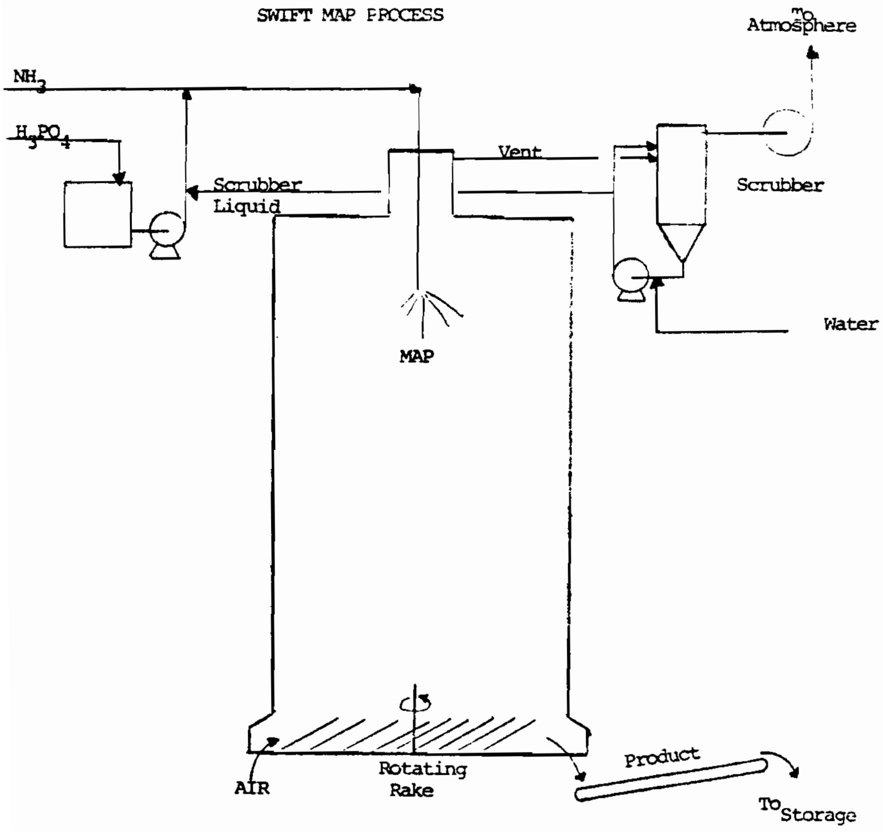
physical specifications (typical)

Bulk density, 55-59 lbs/cu ft

Angle of repose, 30-34°

screen size (Tyler standard) % cumulative weight retained	RANGE	TYPICAL
+ 20	3–10	6%
+100	70–90	80%
+200	96–99	97%

***Nitrogen and P_2O_5 specifications on bone dry basis.**

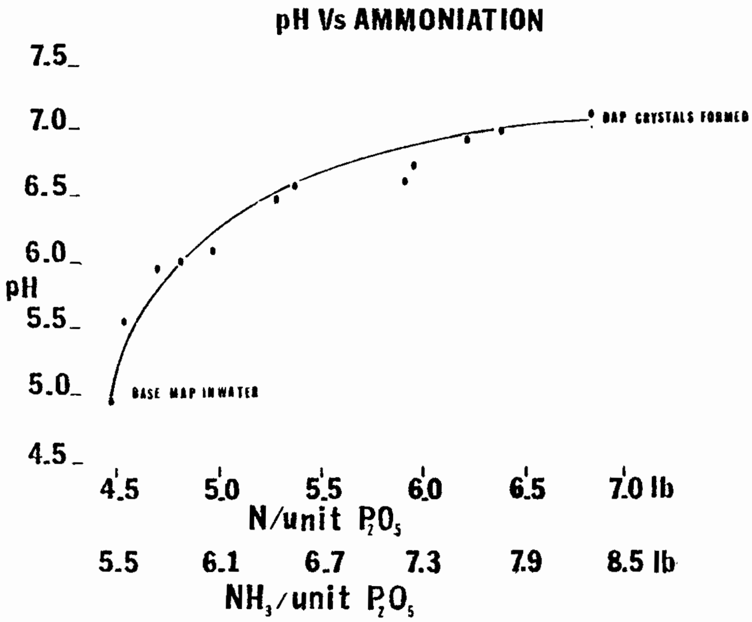


10-30-0 FROM MAP

WATER	640 LBS.
10-50-0	1200 LBS.
CLAY	20 LBS.
NH3	73 LBS.
30-0-0	67 LBS.
	2000 LBS.

9-30-0
SUSPENSION FORMULA

WATER	707 LBS.
10-50-0	1200 LBS.
CLAY	20 LBS.
NH3	73 LBS.
	2000 LBS.



FORMULA W/O MAP

GRADE 18.5 - 46.25 - 0

INGREDIENT	KILO/TON
PHOSPHORIC ACID 54%	857
NH3	225
H2SO4 60° BE	40
	1122
LESS H2O	122
NET DRY BASIS	1000

HEAT OF REACTION (APPROX.) 224,000 KG CAL/TON

AT 6:1 RECYCLE RATIO = 31,920 KG CAL./TON THROUGHPUT

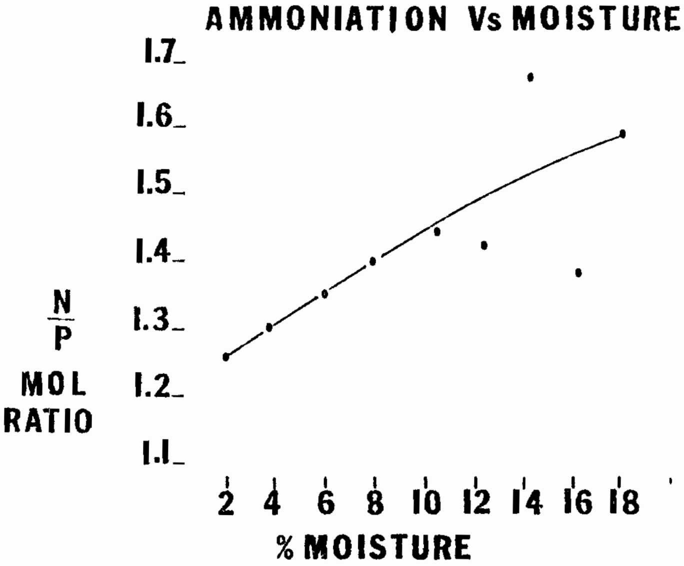
FORMULA WITH MAP

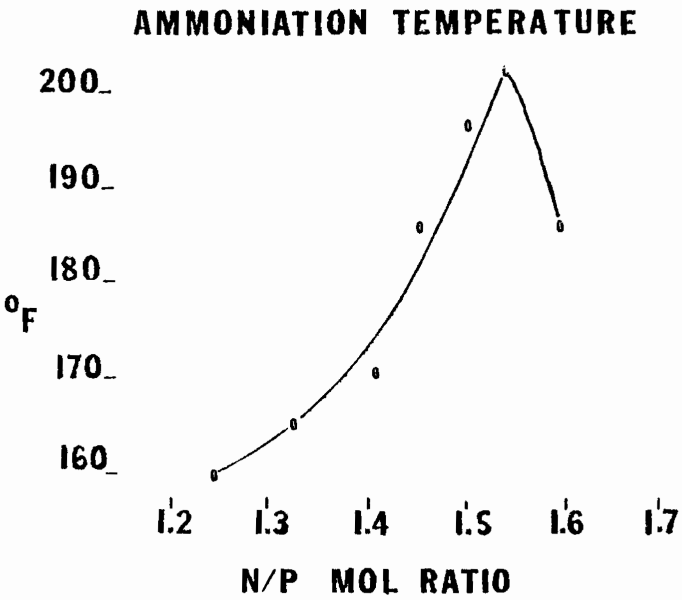
INGREDIENT	KILO/TON
PHOSPHORIC ACID 54%	214
NH3	142
MAP 11-55-0	628
H2SO4 60°BE	40
	1024
LESS H2O	24
NET DRY BASIS	1000

HEAT OF REACTION

H3PO4 + 2NH3 -- (NH4)2 HPO4	57,400 KG/CAL.
NH4H2PO4 + NH3 -- (NH4)2HPO4	58,240 KG/CAL.
	115,640 KG/CAL./TON

AT 2.1:1 RECYCLE RATIO 31,640 KG CAL./TON THROUGHPUT





MODERATOR DAVIS: Do we have questions for Mr. Yarnell?

QUESTION: I would like to ask what ammoniation rate, expressed as mole ratio you are using in your conventional granulation plants.

MR. YARNELL: In the preneutralizer?

ANSWER: Yes, in the TVA type granulation plants.

MR. YARNELL: 1.45

QUESTION: To what degree do you ammoniate the MAP in a granulation plant when you take it in as an intermediate?

MR. YARNELL: Our Korean affiliates can get up to 1.95. It ammoniates as well as an equivalent phos acid.

MODERATOR DAVIS: O.K. I'd like to express our appreciation to our speakers and authors here today. I think the quality of their papers and presentations show that they spend a lot of time working on these. Let's give them one final hand. [Applause]

Wednesday, October 26, 1977

Morning Session
David W. Brochstein, Moderator

MODERATOR BROCHSTEIN: It is indeed a pleasure and a privilege for me to act as your moderator for the forthcoming seven presentations. We have a most interesting group of subjects concerning granulation and granulation dust control. Specifically the subjects to be covered are:

Granulation Plant Dust Control Systems
Additives to Control Dust in
  Granulation Plants
Preventing In-Plant Granulation Dust Problems
Use of Scrubber Effluent in Granulation Plants
Storage and Granulation of Powdered MAP
Granulation of Ammonium Sulphate in
  Rotary Granulator
Availability and Selection of
  Trace Element Materials

Our first speaker this morning is Miles Wilson who will discuss Granulation Plant Dust Control Systems.

Miles is a Mechanical Engineer and a graduate of Lafayette College, and has had extensive machine design and materials handling experience. Since 1972 a Senior Project Engineer, he had been involved in the design and installation of pollution control systems for USS Agri-Chemicls. Miles may we please have your presentation. [Applause]

Fertilizer Granulation Plant "Dust Collection Systems"

Miles M. Wilson, Jr.

Today I am going to discuss with you, the representatives of The Fertilizer Industry, a subject which I am sure has become most apparent and in some cases very costly and of a great concern to your respective companies. The subject is "NPK Fertilizer Granulation Plant-Dust Collection Systems". The areas to be discussed will include not only In-Plant Dust Control but also Cooler and Dryer Granulation Process Dust Control.

To begin with, I would like to give you a little background as to how and why I got involved in this area of pollution control and what it entailed for me and our company relative to this involvement.

I was transferred to the Agri-Chemical Division of U.S. Steel in 1972 from the mechanical design engineering group for U.S. Steel's Headquarters in Pittsburgh. On my first visit to a fertilizer manufacturing plant in Chicago Heights, Illinois, it became apparent to me that the dust collection needs for this type operation were altogether different than those of the typical Steel Plant of which I was familiar. It was then that I felt a need and desire to not only learn what was required and had been done in the past but also to endeavor to make needed design improvements as well as equipment modifications. It was at this point that specific design parameters were established for all future dust collection systems to be installed at any of our manufacturing as well as marketing facilities. I acquired a copy of the "Industrial Ventilation Handbook", published annually by the American Conference of Govermental Industrial Hygienists.

This book is considered the "Bible" by most in the area of Industrial Ventilation, and it is recommended that anyone who does not have a copy of this handbook obtain one by writing the Committee on Industrial Ventilation, P.O. Box 453, Lansing, Michigan 48902. This handbook details general principles, hood design, specific operations, design procedures, fans, testing, etc. and will familiarize the layman with ventilation systems design.

Using the principles outlined in the Ventilation Handbook, I next determined the ventilation problems peculiar to the Fertilizer Industry. I noted that the recommended air and NPK dust design velocity of 3500 FPM was inadequate and too slow to effectively move the hydroscopic NPK fertilizer. By increasing fan speeds on existing fans, I found that 4500 FPM proved to be more effective from a process standpoint in keeping the ductwork open and pick-uppoints noticeably cleaner. The increased velocity does not appear to increase wear from abrasion but it will increase energy consumption to some degree. This energy consumption, however, is more than offset by the decrease in downtime for maintenance.

From this point with a design velocity of 4500 FPM, 4000 FPM minimum to 5000 FPM maximum, hoods for various types of pick-up points could be sized and rates set for duct sizing could be established. For example, it was found that a vibrating screen requires at least 50 CFM/SF of screen area, an elevator inlet tractor hopper requires at least 75 CFM/SF of hopper area and an elevator at the top requires at least 100 CFM/SF of elevator casing to list a few cases in point.

Thus, using these criteria and after one decides where additional ventilation is required, one can proceed to design the ductwork sizes and the total network required. I am sure you are aware at this point that I am discussing the design parameters and procedures for an In-Plant Dust Collection System, as a Cooler-Dryer Dust Collection System does not entail duct pick-up points but only process handling duct sizing for adequate ventilation. That is to say that the In-Plant Dust Collection System would comprehend pick-up points at all raw materials feed points as well as final product material handling points while the Cooler-Dryer Dust System would handle dust ventilation for the fertilizer granulation process itself.

Now, to continue with the design for the In-Plant Dust Collection System, you size your network of ducts using the static pressure balance method described in the Ventilation Handbook. Once you know the total volume in CFM required to adequately control the specific pick-up point, you can size your dust collector and fan. With respect to this area of collector and fan design, (in the four (4) in-plant systems I have installed), the pulse-type collector with polypropylene or dacron filtering media has outperformed the mechanical shaker type collector, not only from bag life longevity but also from a maintenance standpoint. Since an In-Plant Dust System is a continuous operation, it is a good application for a pulse collector as long as the age old bugaboo of air to cloth ratio is not overlooked. In the past many, including USS Agri-Chemicls, were sold on the concept of an 8 to 1 air to cloth ratio. This has proven to be too costly in the long run and in fact has resulted in complete failure in many applications. Thus, a design parameter of 6.0 to 1.0 min. and 7.5 to 1 max. has been set for this application. All of our installations presently are operating between 6.5 and 7.0 to 1 air to cloth ratio. Also, with respect to pulse collector specifications, the following are a few of the items I insist on as standard for purchased collectors:

1) Bag Cages of Stainless Steel with Stainless Steel Clamps.
2) 10 Gauge minimum thickness all welded construction.
3) Coat inside walls with a high build epoxy tar.

These specialty items have extended the operational life of the collectors and have also reduced maintenance from the standpoint of metal corrosion.

The fans that are in use in these In-Plant Dust Collection Systems have been sized utilizing the fan static pressure calculated and total air volume requirements based on the static pressure balance method. In general, all fans are Heavy Duty Industrial Radial-Blade type with rim type wheels, clean-out doors, drain plugs and outlet dampers. Backward inclined fans have not been used to date because of their high speeds and the greater probability of noise pollution arising from an unbalanced condition. BI Fans are, however, more efficient with respect to energy savings and could be considered as an equivalent substitute for the heavy duty Industrial type fan.

In general, this relates the design and application of In-Plant Dust Collection Systems as installed in USS Agri-Chemicals' Plants except to state some of the auxiliary type devices installed to assist not only maintenance personnel but also the operating personnel who must keep the system balanced. As an aid to balancing and rebalancing Dust Collection Systems, slide gate valves with Stainless Steel Slide Plates are installed at each pick-up point so that design air flows as well as corrective air flows from elimination or addition of future pick-up points can be adjusted accordingly. Sample port type couplings are installed eight (8) pipe diameters upstream or two (2) pipe diameters downstream from the nearest obstruction which includes slide gates, elbows, etc. so that a velometer or pitot tube can be used to obtain static pressure, velocity and volume readings. Clean-out doors are located at least ten (10) feet apart and near elbows to aid in the cleaning of the ductwork when fertilizer becomes caked and forms blockages.* Now, to contemplate the design and installation of an NPK Fertilizer Granulation Plant Cooler/Dryer Dust Collection System, our experience has been primarily with the installation of continuous automatic mechanical shaker type collectors. We have four (4) of our eleven (11) manufacturing plants still utilizing wet scrubbers as the primary means of process pollution control; however, these have proven to be more costly from the standpoint of energy consumption and also pose the threat of water pollution. Also wet scrubbers don't permit material recovery as do the mechanical shaker collector at the rate of approx. 500 lbs. per hour on a 30 TPH plant.

Thus, eventually all of our plants will probably be converted to mechanical collector type plants in the near future.

As far as design parameters go for the sizing of all ductwork for a Cooler/Dryer Dust Collection System, the same design velocity of 4500 FPM (4000 FPM min. to 5000 FPM max.) is utilized in a static pressure balance method. This type design, however, is a process flow design and is calculated in series as air flows are drawn through the cooler, opposite to material flow, from the cooler through a cyclone via an in-line industrial fan with adjustable outlet damper, from the cyclone fan circumferentially into the combustion chamber, through the dryer in the same direction as material flow, from the dryer either through a dryer cyclone or directly to the shaker collector with the collector fan on the discharge side of the collector.

Ductwork can be either FRP or steel construction. If the less expensive steel is used, a minimum of 10 gauge construction up to 20 inch diameter and 3/16″ rolled plate over 20 inch diameter should be utilized. All ducts should be coated externally with either an epoxy tar or an insulating material such as urethane or mineral wool wrapped with wire and coated with tar.

The continuous-automatic mechanical shaker type collector should be designed with a gross air to cloth ratio of 1.5 to 1 max. and a net air to cloth ratio of 2.0 to 1 max. with one [1] compartment off-line. The collector should be an all welded 10 Gauge construction unit to withstand at least 20 inches water gage based on static pressure design. The interior of both bag house and hopper should be coated with a high temperature epoxy paint and the exterior should be insulated. Our experience has been that one [1] inch thick mineral wool blankets fastened to the walls, wrapped with chicken wire and coated with epoxy tar gives the best appearance and is safer than the sprayed urethane used for many years in the past.

Experience has also shown that with a well balanced system and a multiple compartment continuous automatic shaker collector a lightweight filament acrylic type bag with a reinforced strap and separate cuff will last up to two [2] seasons before replacement is necessary. Longer periods should be possible if preventive maintenance on a weekly basis is insured to correct bags that are loose, broken, torn or have fallen down. Installation of stainless steel hanger hooks will also decrease the wear on bags as they will not corrode and will not bend or break when tension from heavy fertilizer laden bags results from moisture in the system.

The collector fan as designed for a Fugitive In-Plant Dust System would also be designed for a Cooler/Dryer Dust Collection System except for the fact that higher static pressures and higher temperatures are involved which could preclude going to a heavier duty base angle construction. A heavy duty outlet damper is a necessity in this operation for cold starts as well as air flow changes from different product mixtures being manufactured and varying atmospheric conditions.

Specific auxiliary equipment has been utilized at several of our fertilizer plants in conjunction with the Cooler/Dryer Dust Collection System. Three [3] of these devices deserve mentions as they have definitely assisted our operating personnel to properly operate and control the entire production unit. The first device installed to control and monitor the moisture and temperature within the collector is an air heater complete with air volume fan, filter assembly and turndown burner for use with propane or natural gas. This unit comes prepiped and assembled and is directly connected to the inlet duct to the collector. Butterfly dampers in front and upstream of this unit enable the operator to isolate the system and control the temperature of the air entering the collector. Its primary function is to preheat the bag collector as well as maintain the temperature in the collector above the dew point so that moisture cannot build up the bags during process shut-down periods, i.e. over a weekend.

The second device used is an air-monitoring probe which is installed in the collector exit duct ahead of the collector fan. This device gives a continuous reading in the control room as to total static pressure and total volume in the system as well as velocity in the duct being monitored. This enables the operator to adjust outlet dampers and prevent any over-loading or failure within the system.

The third device being utilized by operating as well as maintenance personnel is a compressed air vacuum cleaner which can be attached inside a compartment and via 80 PSI compressed air through a venturi directed into the collector hopper be used to vacuum a compartment. With appropriate attachments complete compartments can be cleared of all fertilizer build-up on floor and bags in a short period. Also if you can isolate a compartment with an inlet damper and/or isolation switches on the automatic timer, you can continue to process fertilizer in the other compartments.

These and other devices have proven themselves in our facilities; however, the primary factor in any operation or production facility is the people and their ability to maintain the equipment made available. This point is probably the most important issue we face in our fertilizer plants today. We can design and install any process equipment, but if our operators and maintenance personnel are not properly motivated and instructed to operate properly and to preventively maintain the equipment, we have wasted our investment dollar.

Thus, in closing, I would like to stress that all of you here today who are directly or indirectly concerned with Dust Collection and Pollution Control consider for whom you are providing this equipment. If you do not train, maintain and follow-up with preventive maintenance programs and seminars, your efforts to design and install an effective system, as well as your capital investment, will eventually be a total loss and *return your plant to dust.*

Thank you for your attention. Should you have any questions I will try to answer them now or individually at your convenience. I have some handouts in the back of the room of the manufacturers who make these devices. If anyone is interested or wishes to talk to me later about any of this type of equipment please feel free to do so. Thank you very much. [Applause]

MODERATOR BROCHSTEIN: Thank you, Mike. We will entertain any questions you may have.

QUESTION BY FRANK NIELSSON, New Wales: I don't have a question. I just want to add something to what you are talking about, your in-plant dust. Because you talk a lot about plant maintenance, cleaning and what not.

I have yet to see an in-plant dust system that stays unplugged. But this summer, in May, I was over at Windmill's Plant in Holland and there I saw something that all of us should have thought about years ago. They have a granulation unit, they make 20-10-10 with about 15 units ammonium nitrate. The big thing they do at each pickup point over belts, over elevators, over everything, they have a separate 4" line that comes in and blows steam heated air into this pickup point and this goes along with the air that has picked up the dust and these people don't have any plug ups. If they don't have it with a 20-10-10 dust you won't have it with triple or DAP, but this is the first in-plant dust system that I have seen that does not plug up at the corners.

I think that our trouble always has been even with triple in the the 90% humidity, like in Florida, you pick up some moisture and at the corners it starts plugging up and the next thing you know you have to clean. However these people here have put in at each pickup point an extra 4" line that blows in hot air to keep the things above dew point and they have an in-plant dust system that works and you may want to try it on one of your pick up points and see if it gets you out of this clean up. Thank you.

MODERATOR BROCHSTEIN: Any further questions? Thank you Miles. [Applause]

MODERATOR BROCHSTEIN: Our next speaker this morning is John Frick. John is currently with the Sun Company and is Product Manager of Agricultural Oil, White Oil and Plasticizers. He has been with the Sun Company some ten years and on this particular assignment for two years.

His background includes a B.S. in Chemistry from Kent State University, where he also did graduate work towards his M.S. In addition graduate work on an M.B.A. was done at Gannon College and Wright State University.

He is a member of the A.C.S., S.A.E., A.S.C.E. and various other professional organizations. John comes well equipped to discuss Additives for Dust Control. John please. [Applause]

Petroleum Based DCA's To Control Fugitive Dust

John O. Frick

Controlling fertilizer dust has always been a problem and with increasing OSHA, EPA, and even FDA demands, the problem will not disappear. We at Sun have been working to help solve this problem for a number of years. The effort has paid off with the development of a family of dust control agents (DCA'S). In our particular case, DCA means a highly refined hydrocarbon distillate. Applied by spraying, it forms a thin oily film on fertilizer granules to hold in dust particles and grab elements and other micronutrients.

When reviewing the need for controlling dust a few years ago, we were made aware of three types of additives to control fertilizer dust, and they were:

1. Fuel oil
2. Lignin
3. Fully refined petroleum bases

The advantages of fuel oils seem obvious, but disadvantages greatly outweighed these strictly economic considerations. I won't go into all the disadvantages of fuel oils at this time except to say the most important ones are low flash point (auto-ingnition), high volatility (fumes), odor, and penetration of the granule.

In the case of Lignin, while we found it to be economical, we also found problems in product uniformity caused by inconsistent Lignin particle size which caused filter plugging in various systems.

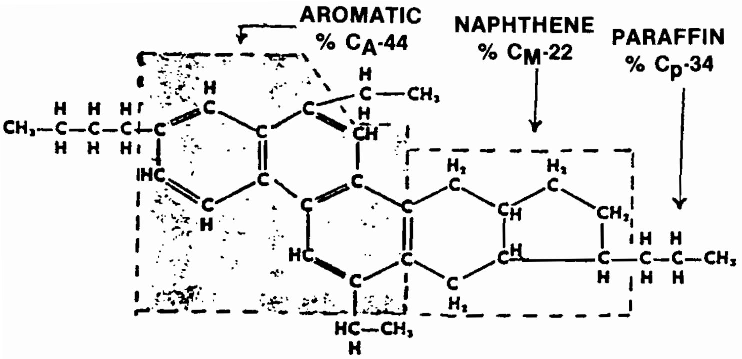
After rejecting both fuel oils and Lignin, our base oils were tested to toxicity and effects in both fertilizer particles, and the equipment used in their manufacture. It is at this point that I feel it is important to discuss basic petroleum chemistry, for although DCA'S may have amiriad of additives to improve various specifications as they affect the final product, they all begin as a highly refined petroleum distillate.

There are only three principle hydrocarbon structures that make up the bases for DCA'S and they are:

1. Paraffinic
2. Naphthenic
3. Aromatic

Each of these is made up primarily of ring structures. The typical oil molecule contains unsaturated rings (aromatics), saturated rings (naphthenes) and side chains (Frame 1).

(CONTINUED ON NEXT PAGE)



In an aromatic oil there is a preponderance of aromatic ring stuctures. In a naphthenic base oil, the predominant ring structures are the saturated rings containing no double bonds. In paraffinic oils the predominant ring structure is again the saturated naphthenic ring, but in the paraffinic oil there are fewer number of rings per molecule and a larger number of hydrocarbon chains dangling off of the ring structures than are found in the naphthenic type oil. Paraffinic here is somewhat of a misnomer when applied to a refined oil, since the only paraffins as such in an oil are wax.

It is difficult to define the exact composition of any base oil. In fact, only a very few molecules in the base oil fraction of petroleum have been isolated and identified, although a great deal of effort has been expended along this line by the American Petroleum Institute as well as many others.

However, it is possible to make postulations about the composition of oils from correlations obtained from physical properties of pure compounds of high molecular weight. I will not at this time go into any detailed discussion, only to say that the following table represents the molecular method.

ASTM OIL CLASSIFICATION

MAXIMUM PERCENTAGE

OIL TYPE	ASPHALTENES	POLAR COMPOUNDS	SATURATES	DESIGNATION
101	0.3	25	20	HighlyAromatic
102	0.5	12	20.1-35	Aromatic
103	0.7	6	35.1-65	Naphthenic
104	0.1	1	65 (Min.)	Paraffinic

Also the need for understanding what structures make up a petroleum base oil is relatively self explanatory. For if a person knows the unsaturates level he can make some pretty good estimates of how these oils will behave in a chemical plant. We must also remember that we are talking about oils with like viscosities when we compare their molecular composition and the resulting physical specification.

Having taken a cursory view of the definitions and classifications of petroleum base used in DCA, we should proceed to their acceptance by specification to the use as DCA'S.

As a start, I should perhaps relate the ASTM classification to economics. As can be seen, the higher the degree of saturation in the base oil portion of the DCA, the higher the cost. The reason for this again is obvious; namely, that for each increase of percentage in the amount of saturation, an additional step or severity in refining is required. Currently there are three major methods of making a more saturated oil. They are acid treating, hydrotreating, and extraction.

ASTM

TYPE	SATURATES %	COST/TON*
101	20	42¢
102	20 - 35	42¢
103	35.1-65	60¢
104	65 Min.	70¢-$1.15

*Based on average of slightly more than 1 gallon/ton

But, although the initial cost may be higher, the benefits will usually be worth it. A few rules of thumb may be used to determine the value of the degree of saturation of the DCA being considered.

They are:

% of Unsaturation

1. Directly proportional to degree of reactivity with product. Chemical reactivity with C = C.
2. Directly proportional to degree of reactivity with equipment. Namely, sensivity to rubber parts, e.g., conveyor belts.
3. Directly proportional to color. The more aromatic the darker the oil.
4. Inversely proportional to cost. Additional refining step required to reduce unsaturates.
5. Inversely proportional to OSHA, EPA, and FDA standards. For almost all standards are based on tests that measure unsaturate reactions.

Now that we have somewhat of a working knowledge of the carbon types, the next logical step is to take a look at the four most important specifications in selecting a DCA with a petroleum base, other than carbon type analysis. They are:

FLASH: This is the temperature at which the product could produce auto-ignition. A vital specification which not only relates to processing temperature, but also storage temperature of finished product.

VOLATILITY: This is the percent of oil lost to the atmosphere at a given temperature and time. This specification relates directly to oil misting and plays an important part in auto-ignition.

DISTILLATION RANGE: This specification relates not only to violatility losses, but also is a good indicator as to homogeneous nature of base oil. The smaller the range, the more homogenous and stable the DCA.

ANILINE POINT: This specification relates again to the degree of saturation of a given hydrocarbon DCA. The important fact here is normally the lower the aniline point, the higher the reactivity with rubber parts of the processing scheme, and also the higher the aniline point, the higher the biodegradability of the DCA.

The advantages of the petroleum based DCA are many and depending on the fertilizer being made at the granulation plant they each have their degree of importance. The selection of a good DCA should be approached from a value analysis point of view, where each of the specifications must be given a value and an economic balance reached.

The next logical question would be where and when should a DCA of this type be applied? The answer is obvious — the sooner the better. DCA can be sprayed onto the fertilizer at several strategic points within the manufacturing plant.

One of the best places is in the rotating cooling drum where the fresh hot fertilizer goes immediately after it has been made. Maximum dispersion of DCA over the fertilizer granules is obtained here. Also it is at this point where the base oil specifications are the most critical.

Another good spray-on point is in a secondary rotating drum and prior to entry of the fertilizer onto the conveyor system. DCA can also be sprayed on at conveyors, screws, chutes or bucket elevators, as the fertilizer is moved to various subsequent operations such as mixing (blending of various types of fertilizers and addition of micronutrients), storage, bulk loading, or bagging. It is obvious then that the sooner the fertilizer is treated with DCA during its movement through the manufacturing plant, the better.

Although controlling fugitive dust in the plant is the primary function of DCA, there are other benefits achieved from these types of DCA's. They are:

1. The improved storage life — protects against hygroscopic or water absorbing action.
2. Helps resist conpacting or clumping — preventing reworking and helps uniform field application.
3. Provides sticking qualities that aid in pick-up of trace elements and other micronutrients which may be added to the fertilizer blend. This action improves uniformity.
4. Economical — a varied choice of specifications to choose from.
5. Meets EPA pesticide registration division and certain FDA prerequisites.
6. Safe to handle. Most are well below required legal standards.
7. Has no crop phytotoxicity at recommended treatment levels.

The final question asked in this study was "What equipment is needed for this type of DCA"? Below is a very broad outline of what is required. The degree of sophistication again is a personal and economic choice. The base requirements would be:

1. Storage Tank — 6M Gallon Minimum
2. Pumps
3. Lines
4. Metered Nozzles
5. Quick Opening Valves
6. Pressure Switch to Control Size of Spray

I hope that this brief paper has answered some questions which might have arisen, but I think it is plain to see that there are many possible DCA'S of this type on the future marketplace and the ones used in any particular fertilizer plant will not only depend on the type of fertilizer being produced, of the base economics of the DCA, but rather on the other benefits attributed to the particular DCA — such as compliance with EPA, FDA, OSHA, and even with the toxic substances act.

I thank you for this opportunity. [Applause]

MODERATOR BROCHSTEIN: Thank you John. Any suggestions?

GEORGE HOFFMEISTER— TVA: Have you done anything to relate the wax content of oils to their effectiveness as dust control agents?

JOHN FRICK: You are talking about pure wax or again the paraffinic hydrocarbon structure. Now, there is a vast difference?

GEORGE HOFFMEISTER: Well I don't know that much about oils actually, but I have heard that high wax content oils are more effective.

JOHN FRICK: Well yes. Again high wax — if the comment was made from a person with a petroleum background — yes absolutely. They are more effective with a higher paraffinic content or wax content, if you will, because of the nature of the biodegradability of the product and the nature of the coating effect that is natural with a paraffinic structure. The refined wax, as such, we have found that it serves a purpose but it didn't really do the job that we were looking for in a dust control agent. Then this again is a separate identity from a waxy oil. I hope that answers your question.

MODERATOR BROCHSTEIN: Any further questions? Yes please —

BOB PENDERGRAST— USS Agri-Chemicals: Your point of application. The first one was in the cooler. Now from the cooler we go to the screens and somewhere up to half of what goes to the screens will return as recycle to the granulation process. Now I believe that everybody in this room has had experience with trying to granulate the water-proof potash that came out of Canada in the early days of those mines where they overtreated it with an anti-caking agent. What has been your experience where you have returned oil sprayed product as recycle to the granulator?

JOHN FRICK: That is an excellent question, and to be quite honest with you, my man that would know that is not here. I am not taking the Fifth Amendment on this, but rather than give you an answer which is only hearsay from a marketing point of view, I would be glad to have our people get back with you and answer that.

QUESTION: How much of that do you put on it?

JOHN FRICK: Okay, our recommendation, really depending on what you are doing, but we have never recommended more than 1%, which translates to about 2½ to 3 gallons per ton. The general application is about a gallon and a half per ton.

Thank you. [Applause]

MODERATOR BROCHSTEIN: Our next speaker is Allen Jackson. He will discuss Preventing In-Plant Granulation Dust Problems.

Allen has a Mechanical Engineering Degree from Georgia Tech and is currently President of J & H Equipment, Inc. He has been directly involved with the design, manufacture and installation of various types of machinery and systems for the fertilizer industry for the past twenty years.

Allen is well known to this group and I am sure his discussion will be both interesting and informative. Allen. [Applause]

Preventing In-Plant Dust "By Process"

Allen S. Jackson

In plant dust is a nuisance.

Controlling dust can be expensive. It can be very expensive, if add on equipment is used to suppress the problem.

Generally it is not necessary to spend large amounts of money on symptomatic dust control when adherence to a few basic rules will clean up a plant and make additional equipment unnecessary.

In order to have free floating dust blown into the air, four conditions must exist.

Slide 1

1. Obviously you must have floating dust in the process.
2. You must have an opening for the dust to escape.
3. You must have the motive power to put the dust in the air.
4. You must have air leakage into the system.

If any of these four conditions are not met you will not have blowing dust. If all four conditions are met you have guaranteed that you will have a dusty area.

Slide 2

Try to correct the situation with an add-on device, such as a bag collector, and you may suppress the symptom for a while but the original problem still exists and you now have a new device to maintain. Dusting problems are much more effectively controlled through process refinements than add on devices.

For illustration we will use several of the most common process faults found in granulation plants and their corrections.

Slide 3

In the screen-mill loop the breaker generates the floating dust while crushing the oversize. The material falling down the oversize chute pulls any air leaking in from the screen down with it and supplies the motive power to blow the dust at the bottom of the elevator. If an opening exists at the elevator inlet, dust will blow out.

Any dust not emitted at the elevator base will be passed to the screen area. The falling material over the screen will supply sufficient power to blow dust from any opening in the screen area. Any servicing on an operating screen would be difficult. This process arrangement certainly will be dusty.

The cure while not free is simple, effective, and permanent without additional maintenance burden.

Slide 4

First choice would be to feed the crushed oversize back through the cooler to allow the cooler to strip the floating dust. Both motive power and floating dust are eliminated.

Slide 5

If the plant layout prevents economical return of the crushed oversize to the inlet of the cooler turning the chute with the crushed material directly into the cooler discharge offers an acceptable alternative.

Either way, the floating dust will be removed from the screening loup.

Another dust emitting design that shows up about as frequently as the one just illustrated is in the use of an elevator feeding the ammoniator.

Slide 6

Raw materials are fed into the open elevator intake. Here we have two conditions for dusting, an opening and some floating dust in the raw materials.

This elevator however, assuming that it has adequate capacity and proper discharge design, will not blow at the bottom as it has no motive power. It will in fact if the discharge chute is reasonably long, pull air into the intake and discharge it into the ammoniator. Cyclone dust can be added to the elevator if its introduction does not supply the motive power to move air and the elevator still will not blow.

Slide 7

If a chute is used to return the fines from the screen to this elevator, or cyclone dust is dropped down a long chute or the elevator cups overfilled and spilling as they rise or if the elevator discharge is not effective, the air dragged by the falling material will furnish enough motive power to cause a totally unsatisfactory condition.

The motive power to blow the dust must be eliminated. How you do it obviously depends on the layout of the plant. Basically the streams to process must be separated. The fines, usually the worst offender in generating the motive power, by virture of the quantity involved, requires its own discrete route for return to the system.

Slide 8

First choice would be a chute or adequate screw conveyor direct to the ammoniator. A chute to a closed elevator or a belt direct to the ammoniator might be used. Once motive power is eliminated the elevator will operate clean.

Slide 9

A condition occasionally exists where separate streams, for example, feed, fines return and cyclone dust, are fed into an open ammoniator hopper. All the requirements exist for a dusty condition, the open hopper required for belt feed, the floating dust from the raw material and cyclone return, and the motive power of the falling fines down a chute.

Slide 10

The solution again is to eliminate at least one of the requirements for dusting. Separate the three feeds until they are in the ammoniator.

There is then no motive power after the separation to blow the floating dust out of the ammoniator chute.

The fourth most prominent source of floating dust would be simple leaks in the air handling systen on the pressure side of the fans or on the perimeters of high speed equipment. The dust that escapes at these points can be the very light dust that tends to float a long period of time. The problem spots are very obvious but getting people to take time to plug the leaks to give themselves a cleaner operating environment is not always easy.

The raw material feed side of a granulation plant offers fewer means to clean up dust within its own system yet it does not have to be excessively dusty.

Slide 11

For an elevator to have excessive blow it must have the same four conditions, dust, opening, motive power and an air entrance. Inside the elevator leg material falling from overfilled cups or a chute with an opening at the top bringing material to the elevator will draw large amounts of air with the material into the elevator that must escape somewhere.

Improper discharge wheither caused by improper speed or design or by build-up on the discharge lip can cause a large amount of material to fall down the elevator leg generating the motive power to blow at the inlet. Tailings falling down a recycle chute can move large amounts of air.

This brings a question. Do you really have to screen raw material very fine for a good product? Try a larger raw material screen opening or no screen at all if your feeding equipment will tolerate the lumps. Note the reduced dust and see if you can find any change in product quality.

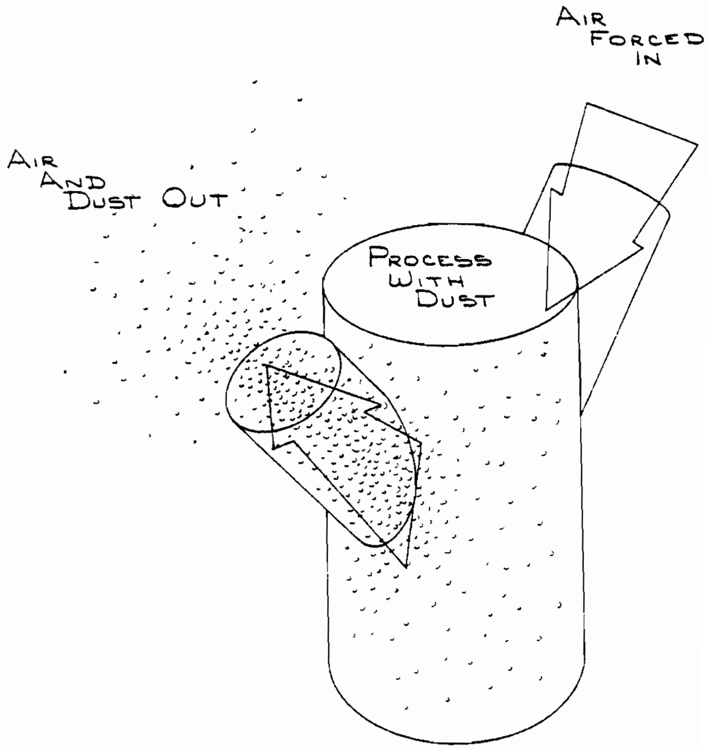
On a batch fed elevator opening the elevator inlet for any reason that permits far more material to enter the elevator than the elevator will lift with moderately filled cups simply floods the boot, overfills the cups so they spill as they go to the top and furnish the motive power for blowing. It costs power and wear with the cups digging in the boot and is certainly a nonproductive modification to an elevator.

30 tons of material an hour filling a system that is closed is only a displacement of about 20 cubit feet of air per minute. Air that you may see blowing from a dusty elevator inlet may be 1000 to 2000 cubit feet per minute. To have a blowing elevator you must have air entering into the system somewhere. Is the screen open? Is the top on the elevator? Are any inspection ports open? The elevator intake is only the place the symptoms show up, it may not be the cause, for the air to blow out it first must get in the system. A little care in closing the "clean" openings will sometimes do wonders for the dusty openings.

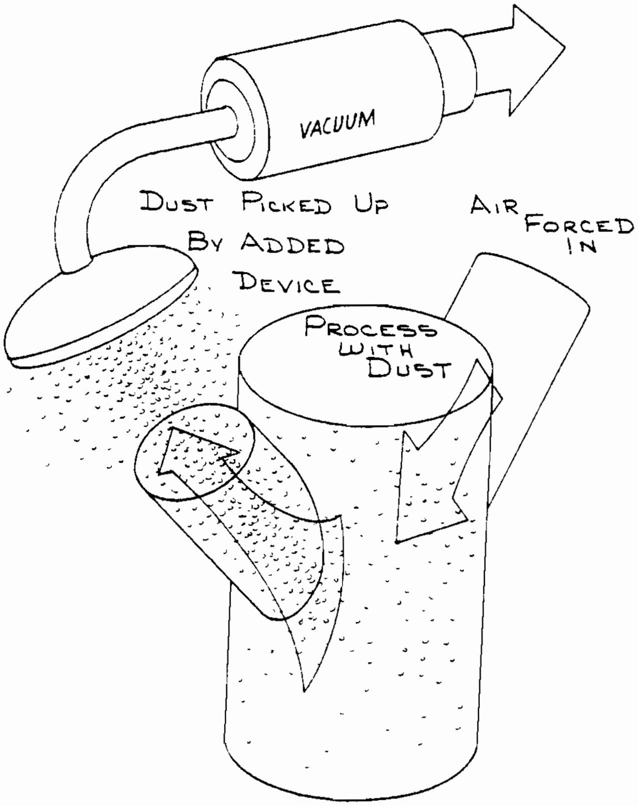
Dothan Photo

I am not trying to say that in every dusty situation internal process clean up is only practical method, or even possible in a few cases the most desirable method. But every dusty situation that can economically be cleaned up by refinement of design or operation willmake a permanent correction, with minimum of cost. A minimum of maintenance and will certainly have the best record of successful operation.

Any approach to clean up totally by add-on devices without correcting problem areas most certainly will have high initial cost, high maintenance cost and a very questionably probability of successful results. [Applause]



Slide 1



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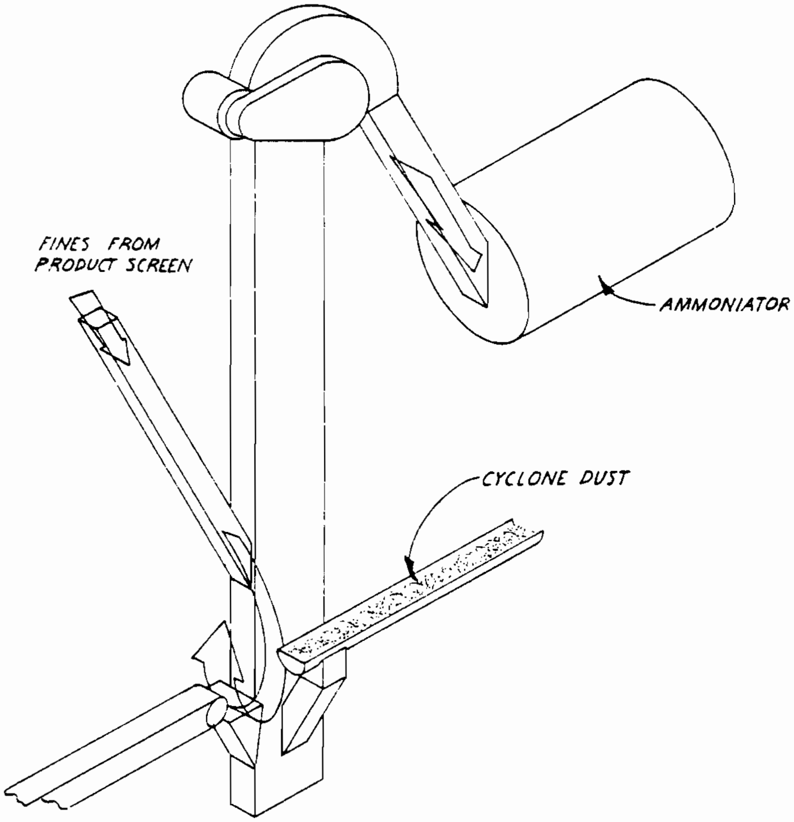

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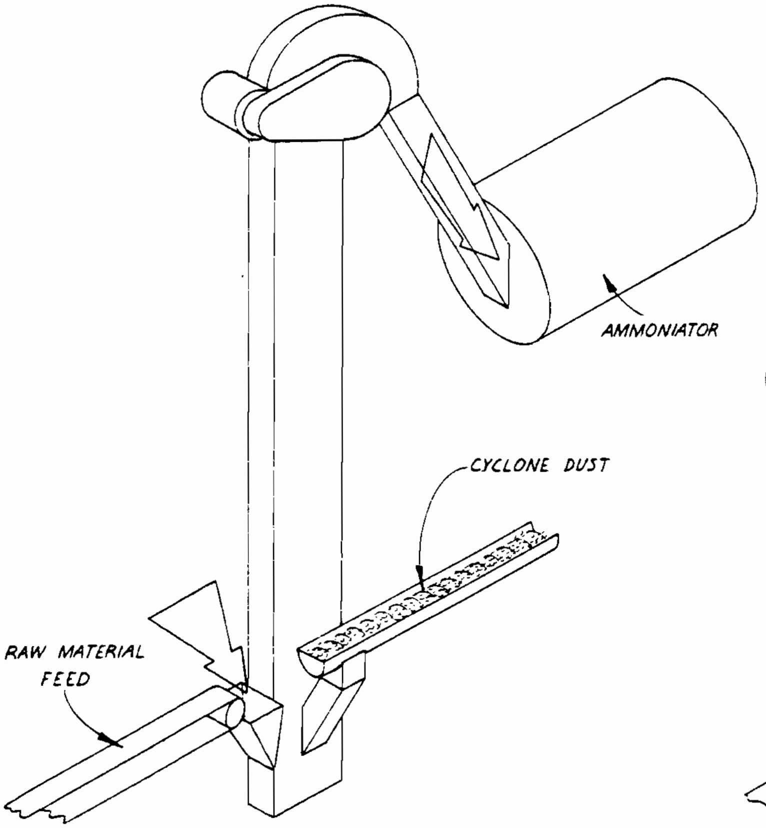

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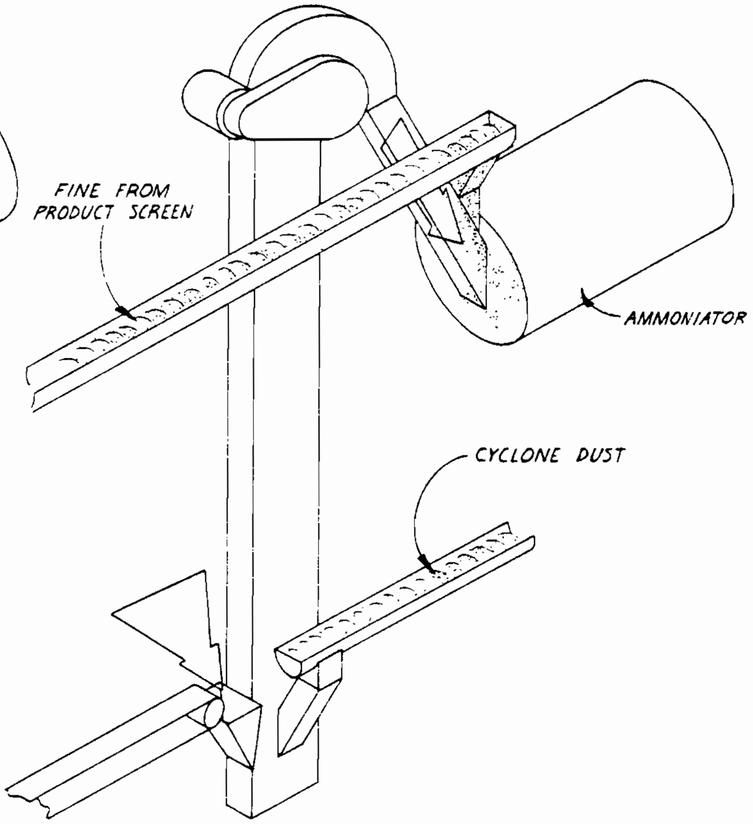

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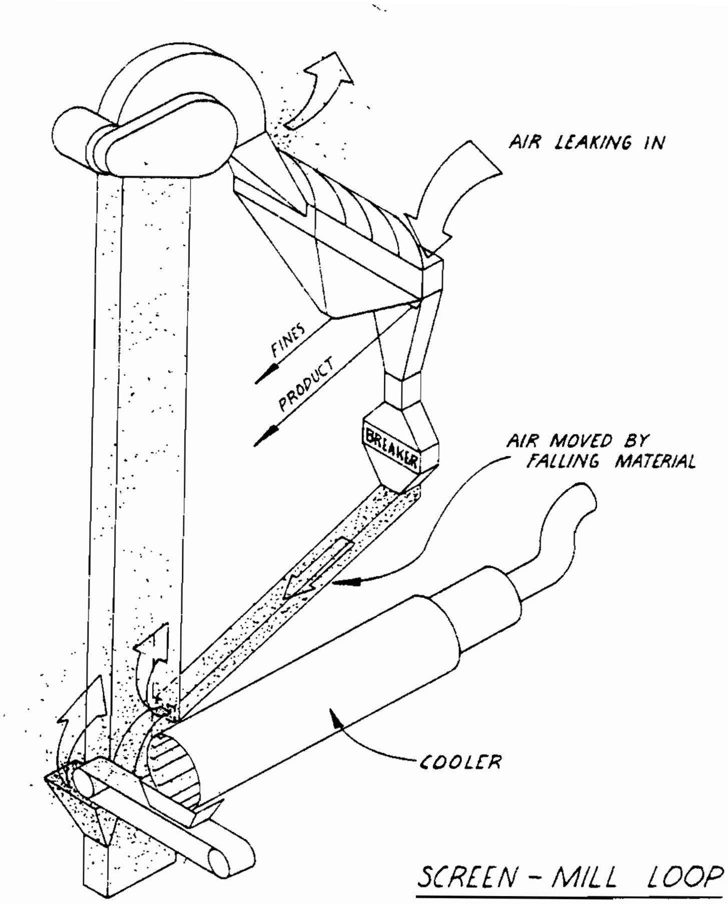

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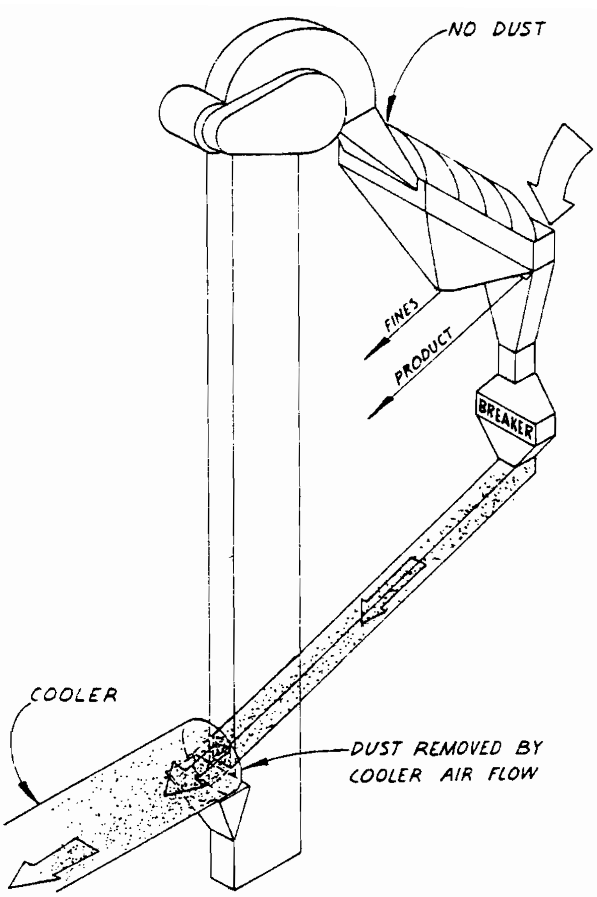

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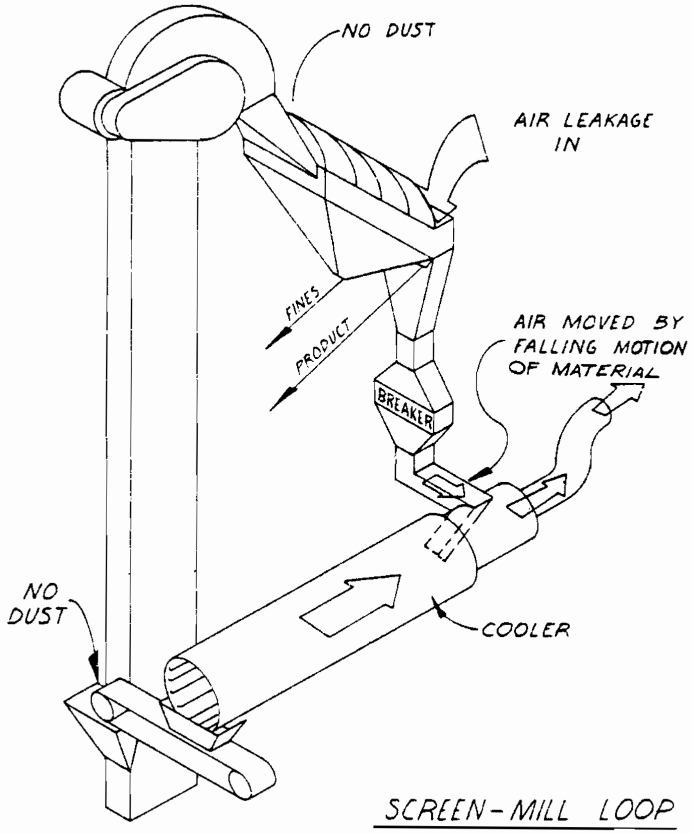

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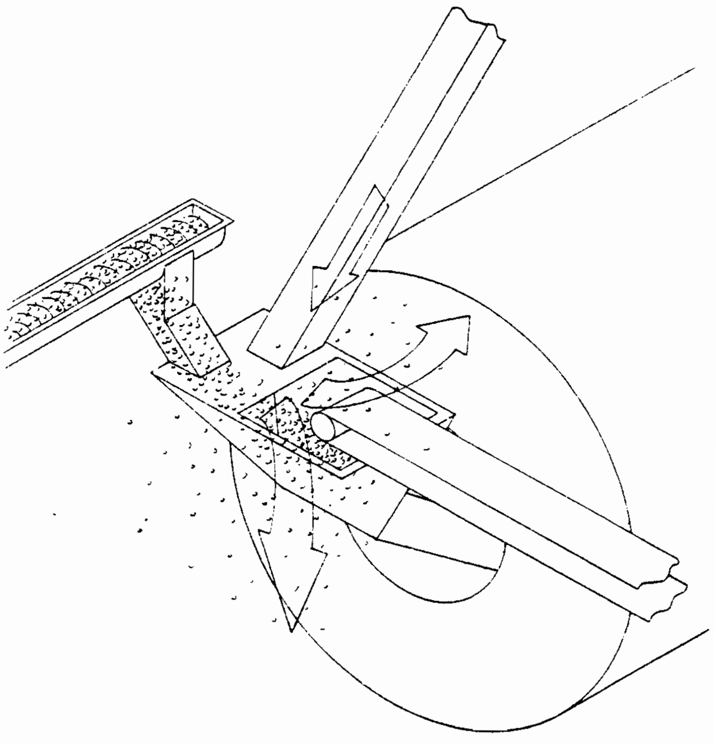

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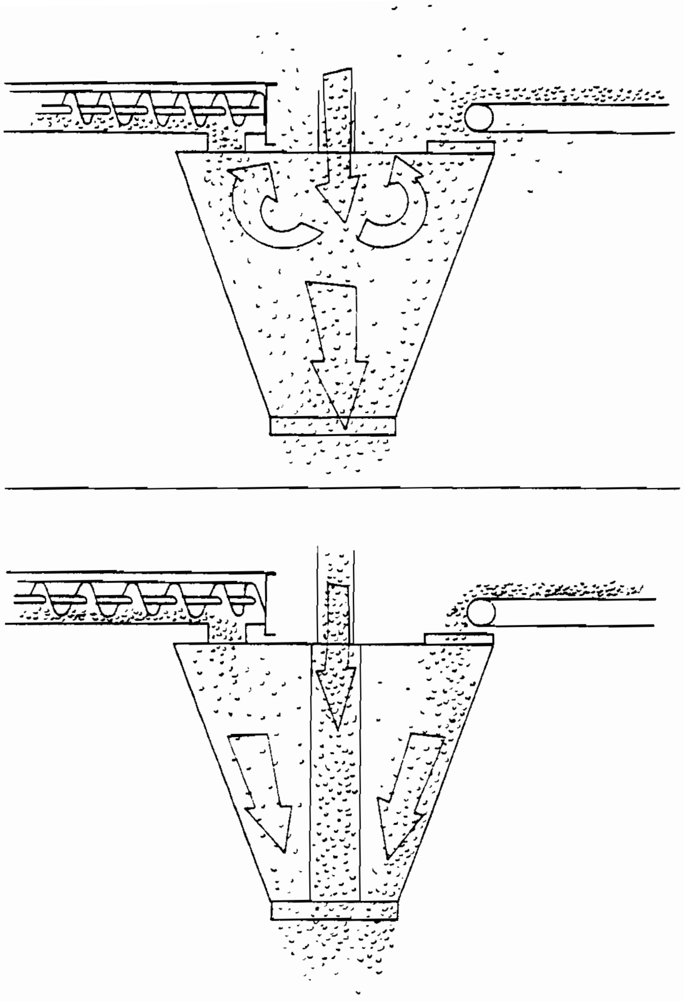

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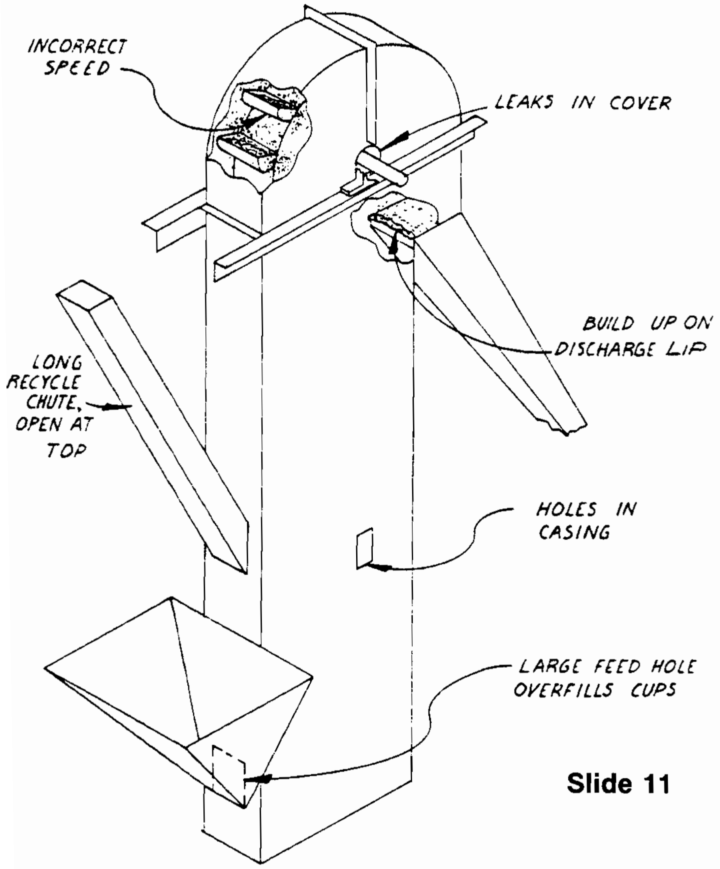


Slide 11

MODERATOR BROCHSTEIN: Thank you Allen. Any questions for Allen?

Continuing our discussion on pollution control of granulation units Glenn Feagin will discuss the Use of Scrubber Effluent in Granulation Plants.

Glenn is a Chemical Engineer and graduate of Georgia Tech and has been with International Materials and Chemical Corporation since 1949. First as a Production Trainee, then Plant Manager, Zone Production Manager and presently Manager of Fertilizer Technology with the Rainbow Division. As part of his job responsibility he works with various Rainbow Plants and other managers of the production staff in process improvements and compliance with government regulations.

He would like to describe to you some of the work that has been done at the IMC Plants in reusing and reducing plant effluents. Glenn please. [Applause]

Use of Scrubber Effluent In Granulation Plants

Glenn A. Feagin

There are three good reasons to be concerned with effluent recovery:

1) To save money.
2) To improve scrubber efficiency.
3) To meet water discharge standards.

While the primary theme of this discussion will be the recovery and use of effluent from a granulation unit, I would also like to touch on recovery and recycling of effluent from the other units at our plants.

The Rainbow Division of IMC presently operates six granulation units in the southeastern part of the United States. These units have a designed capacity of 30 tons per hour and a yearly capacity of over 100,000 tons.

At four of these units, we also manufacture single or as most of us refer to it, Run-of-Pile Superphosphate. Three of the superphosphate units are of the Sturtevant box den-type. The other unit is a J & H Equipment Company 40-ton per hour belt-type continuous den.

Some of our first recovery systems consisted of large holding ponds. The effluent was impounded. Hopefully, evaporation and soil seepage would take care of the problem.

After the ponds were built, it was found that the solids settled readily and that the water could be recycled to the scrubber system or used in other operations.

This method has several disadvantages:

1) A large area is required.
2) Periodic cleaning is required.
3) Plant food content cannot be recovered.
4) Soil seepage can cause problems.

We soon realized that we would not be able to operate indefinitely with only a recovery pond. We also realized that effluent recovery must be a part of the total water recycle system.

We ran some tests on our granulation system and found that we were discharging from 150 to 185 pounds of solids per hour from the dryer/cooler cyclones into our wet scrubber. For a 20-hour operating day this means we were losing 2000 to 3700 pounds of fertilizer . . . even more if an operator ran with a clogged cyclone.

Additional tests showed that as much as one-third of this material was being dissolved in the scrubber water. Could we recover and use this water? In theory, this was simple; run a take-off line from the scrubber water system to the ammoniator. We did. On low analysis grades where considerable water is required, it worked! But it wasn't as simple as that. The amount of water required varied. At times, none was needed. When the line was not in use, solids precipitated and clogged the line. We had used flexible PVC pipe. It was cheap, easy to run, and had good corrosion resistance. It had one flaw. It couldn't take the pump pressure when the valve at the ammoniator was closed.

A three-way valve and a return line solved these problems. Operators liked to use scrubber water. Its temperature was normally 100°F. and it definitely helped granulation on grades such as 5-10-15, 6-12-12, or 0-10-20. However, we manufacture a number of grades which do not require water for granulation. In total, this simple change was beneficial, but it was not the final solution to the problem.

In 1970, Messrs. R. D. Young, H. G. Graham, Jr., R. S. Meline and J. R. Gaham of TVA presented a paper on "Effluent Control Practices in Granulation Plants".[1] In this report they described the use of a wet collection system to remove solids from a scrubber. This recovered additional fertilizer and also reduced total effluent discharge.

Calculations (see Figure 1) showed that if we could concentrate the scrubber effluent to 20% solids and use 2 GPM of the material, we could keep our dryer/cooler scrubber water clean.

In 1972/73, we designed and installed a test unit (Slide #1). We constructed a hydroclone separation unit next to our dryer/cooler scrubber basin and used a Moyno pump to move the thickened slurry to the ammoniator. This was less than successful. We found that we could concentrate the scrubber effluent, but pumping the think slurry to the ammoniator wasn't practical. Pump rotor life was short and each time we shut down the unit, even for short periods, solids settled and clogged the lines.

As you know during this period, the Federal water discharge standards were drastically tightened. We realized we had to eliminate water discharge at our plants or install an expensive treating, testing and reporting system.

We took a close look at our plants and found that we had water being discharged from:

1) Sulfuric acid dilution units.
2) Hydrofluosilicic acid production.
3) Ammoniator exit gas scrubbers.
4) Dryer/Cooler exit gas scrubber.

At one plant our water bill had risen to over $5,000.00 per month. The largest volume of water was being used to cool sulfuric acid after it had been diluted from 66° to 60° Be. We were using it on a once-through basis. It was clean water and could legally be dumped. We did use some of it as make-up water at the granulation unit.

We were not really getting proper cooling and our production rates were too low. So we decided to construct a cooling unit that would allow us to do the job right. We used 2 in. diameter Karbate cooling tubes 10 ft. long in 12 banks of 6 each (Slide #2). A cooling tower was added (Slide #3). We can now dilute 20 tons per hour of 66° Be to 60° Be with a discharge temperature of less than 105° F. Power and water requirements are:

1) Water Pump — 20 H.P.
2) Cooling Tower Fan — 10 H.P.
3) Acid Pumps — 15 H.P.
4) Water Circulation — 800 GPM

These changes allowed us to eliminate discharge from this operation. We do have to pump water to our recycle pond when we drain the basin for repiars. Fresh water use was cut drastically! Now we use only enough to replace evaporation losses.

We use a three-stage absorption unit to recover the fluorine released while producing superphosphate. We recover it as 23% Hydrofluosilicic acid (Slide #4). Most of the fluorine is collected in the first stage. The other two steps are used for final clean up. We filter the HFS before it goes to storage to remove entrained solids — mainly silica and phosphate rock. filter press and equipment cleaning were the sources of discharge from this unit. The effluent was acid and could not be discharged without treatment.

We changed our filtering process so that we could remove the cake as a dry solid (Slide #5). We then constructed a sump pit and collected all wash water and acid leaks (Slide #6). This was added back to the first stage scrubber as part of the make-up liquid. This method has worked very well. We do have to clean the sump pit occassionally.

When we built our granulation units in 1965, we designed and installed a low energy box-type wet scrubber for final cleaning of the dryer/cooler exit gases. It was actually two scrubbers built together . . . one for the dryer and one for the cooler (Slide #7). Ammoniator exit gases were discharged to the atmosphere without treatment.

Over the years we had made many changes to this system. The design work for most of these changes was done by Mr. James B. Madsen of our Production Staff.

By 1974, we had installed, or were in the process of installing, scrubbers on our ammoniator stacks. We felt that we needed to and could improve the operation of our box scrubber. But to do so we needed cleaner water. There was no way we could discharge additional amounts of effluent. We must use a closed system. We had to make a solids recovery system work. So back to the drawing board!

Since pumping the thickened slurry had been the problem in our test unit, we decided to eliminate this step. We put the hydroclone unit above the ammoniator so that the slurry could drain into the ammoniator by gravity (Figure #2). Again, we were trying to remove 2 GPM of a 20% solids slurry.

The hydroclones selected were Bauer Nylon "Centri-Cleaner" Liquid Cyclones Model No. 600-3. With a 40 psi pressure drop, this model will give a 4-fold thickening at an inlet flow of 20 GPM and a slurry take-off of 1 GPM.

The maximum solids we felt we could keep in suspension in the scrubber water was 5%. These units would give us our needed 20% solids slurry. For a 2 GPM slurry removal, we would need to use 2 units in parallel (Slide #8).

In actual operation we are using 1 to 2½ GPM of slurry from each unit. Actual solid content runs 10 to 20% (Slide #9).

The cones for the hydroclone are easily changed and inexpensive. We keep several cones on-hand with various tip openings and adjust the flow rate to the ammoniator by changing cones. No valves are used.

We located a pump tank with a 2½ inch Galigher vertical sump pump as close to the hydroclone unit as possible. Equipped with a 15 H.P. motor, this pump easily maintains 50 psi and 40 GPM at the hydroclone unit (Slide #10).

The pump tank is divided into 3 sections — an inlet section, a pump section and an overflow section (Slide # 11). The inlet section is equipped with a screen to remove scale. We used 2 layers of 16 mesh stainless steel Tyler screen cloth. This screen is essential to the successful operation of the system (Slide #12). The maximum hydroclone opening we use is 3/8 inch; normal opening is 3/16 inch. Even a small piece of scale can cause trouble.

Overflow from the hydroclone is returned to the inlet section of the pump tank. Even if the water supply from the wet scrubber fails, the pump will not run dry (Slide #13).

Overflow lines were installed on both the hydroclone slurry tank and the pump basin to reduce the possibility of overflow and spills (Slide 14 & 15).

This gave us an almost fool-proof system. To put it in use, start the Galigher pump. to shut it down, stop the pump.

We wanted the inlet water to contain as high a percent solids as possible, so we divided our box scrubber basin into two sections — an inlet or dirty section and an exit or clean section. Each section has its own pump. Water for the solids removal system is taken from the first stage pump.

Operating conditions for this pump are:

Total Capacity	630 GPM
Dryer Venturi Sprays	175 GPM
Cooler Duct System	175 GPM
Solids Recovery System	90 GPM
Solids Agitation System	200 GPM

In 1974 and 1975, we installed one of these units at each of our plants and have them operating today.

Has all of this been worthwhile? Let's look at the economics first. At today's prices, our products have an average value of $100.00 per ton. We operate these units over 4000 hours per year. With a loss of 180 pounds per hour, this is 360 tons of fertilizer worth $36,000.00

By using scrubber water alone, we probably recovered 25% of this material — worth $9,000.00.

Our solids recovery system has not been 100% efficient. Our main problem has been getting 5% solids in the feed water. Using the thickened slurry, we are recovering about 50% of the material going to the scrubber. An improvement of $9,000.00 per year over using water alone.

These units cost us about $7,000.00 each to install. Maintenance cost has been minor. Power requirements are about 30 H.P. We feel we paid for them in the first year. As a bonus, we have the potential for even greater savings.

Scrubber operation has been improved. Our box scrubber may not look fancy, but it works (Slide #16). By cleaning up our water, we were able to install a packed bed scrubbing section (Slide #17) and a mist eliminator section (Slide #18).

Tests made at our Hartsville, S.C. plant in March, 1977, showed that we were discharging 0.57 pounds per hour of particulates from the ammoniator scrubber and 5.78 pounds per hour from the dryer/cooler scrubber. A total of 6.35 pounds per hour. Under existing laws, we are allowed to discharge 40.1 pounds per hour at our production rate of 30.4 tons per hour. So our actual is only 15.8% of allowable!

By using our recycle ponds as a balance wheel, we are operating our plants with no water discharge (Figure #3).

There is one problem with a closed system. When manufacturing O-X-X grades, that is grades without any nitrogen contents, you release acid gases. In a very short time, the pH of your scrubber system may be as low as 1.2. Then you must either add fresh water or neutralize the acid.

I hope this presentation has given you a general idea of our efforts on effluent usage. If there are any questions, I will be glad to try to answer them. Thank you. [Applause]

REFERENCES

1. "Effluent Control Practices in Granulation Plants" by R. D. Young, H. G. Graham, Jr., R. S. Meline, and J. R. Gaham. Tennessee Valley authority, Muscle Shoals, Alabama. Prepared for presentation at Technical Conference of International Superphosphate and Compound Manufacturer's Association, Limited at Sandefjord, Norway, September 8-11, 1970.

CALCULATIONS FOR SOLID REMOVAL

Figure 1

- 180 POUNDS PER HOUR TO BE REMOVED
- EQUIVALENT TO 3 POUNDS PER MINUTE
- REMOVE AS A 20% SOLIDS SLURRY
- MUST REMOVE 15 POUNDS PER MINUTE OF SOLID-LIQUID MIXTURE
- EQUIVALENT TO 2 GALLONS PER MINUTE

FLOW DIAGRAM FOR SOLIDS RECOVERY SYSTEM

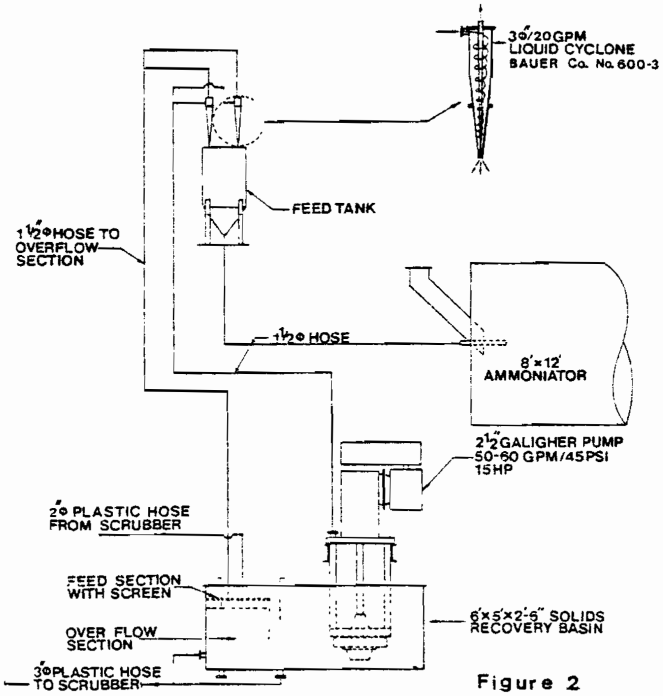


Figure 2

SCRUBBER WATER RECYCLE SYSTEM

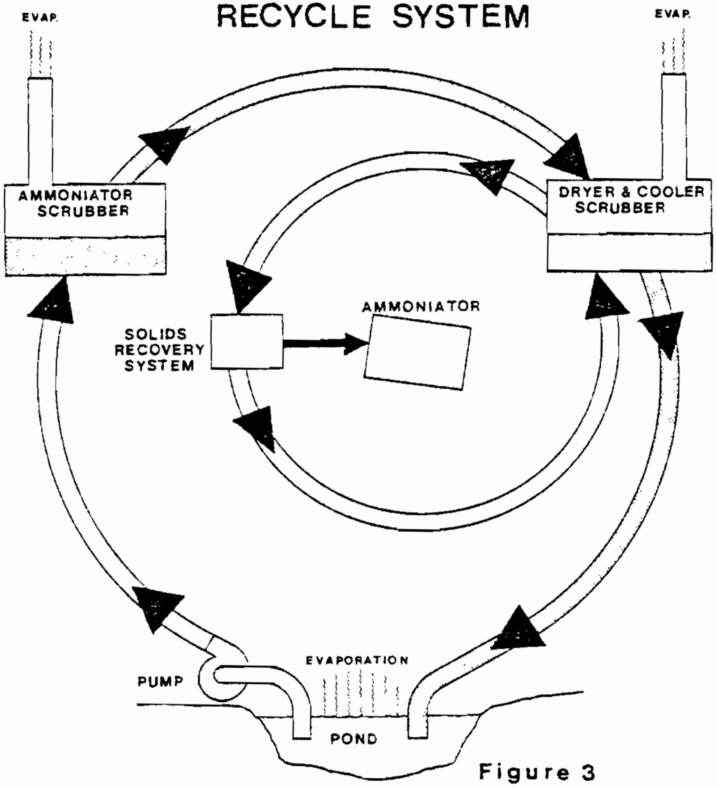
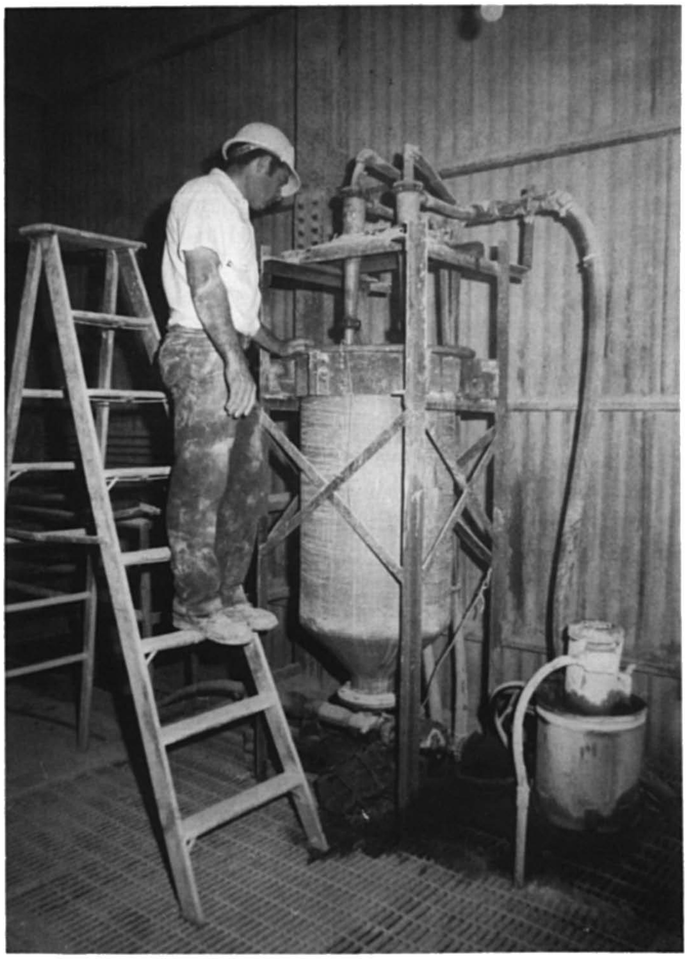


Figure 3



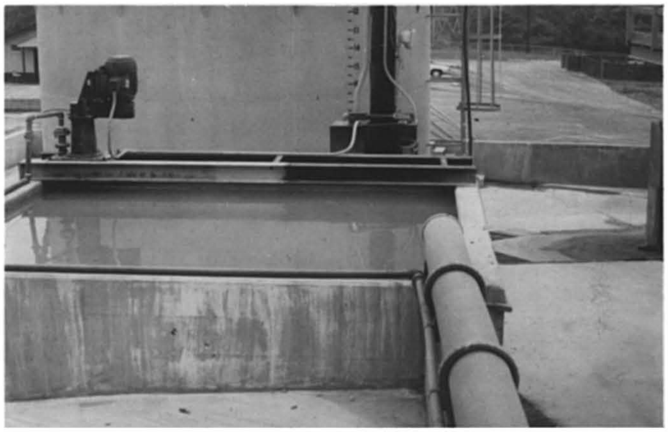
Slide 1

Slide 2

Slide 3

Slide 4

Slide 5



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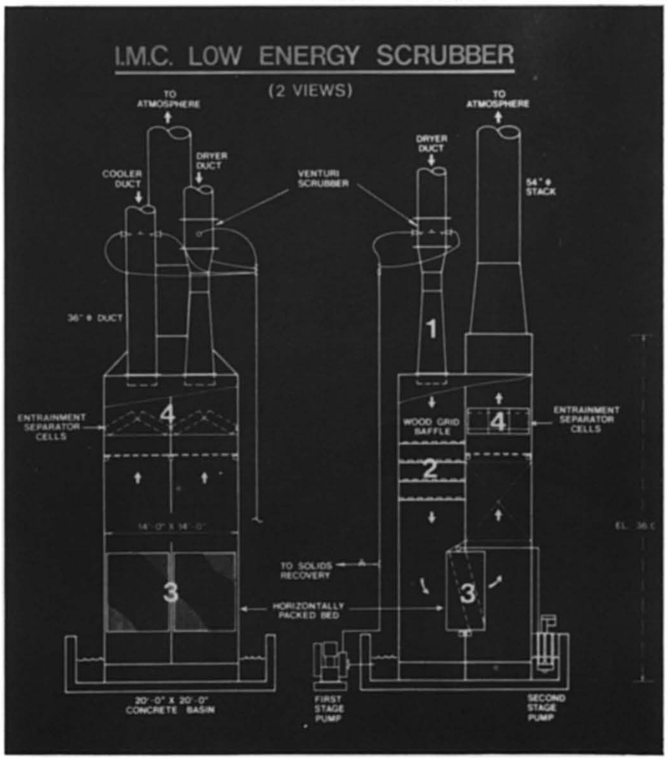

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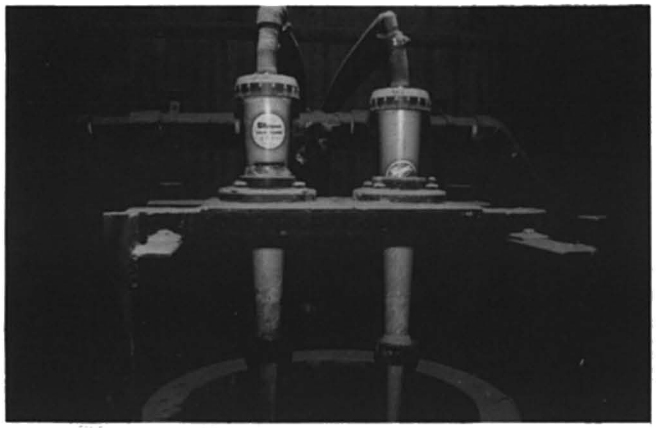

Slide 8

Slide 11

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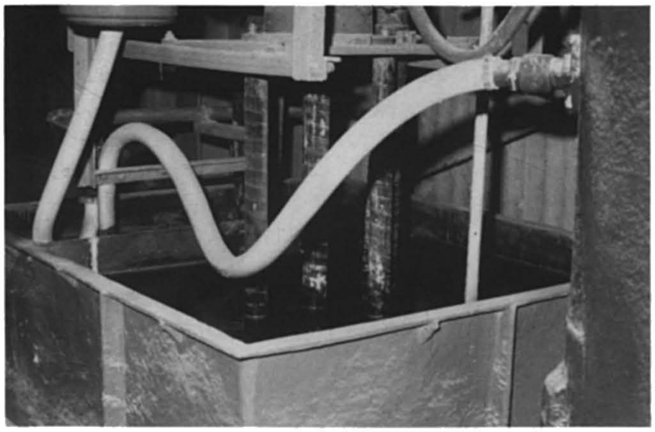
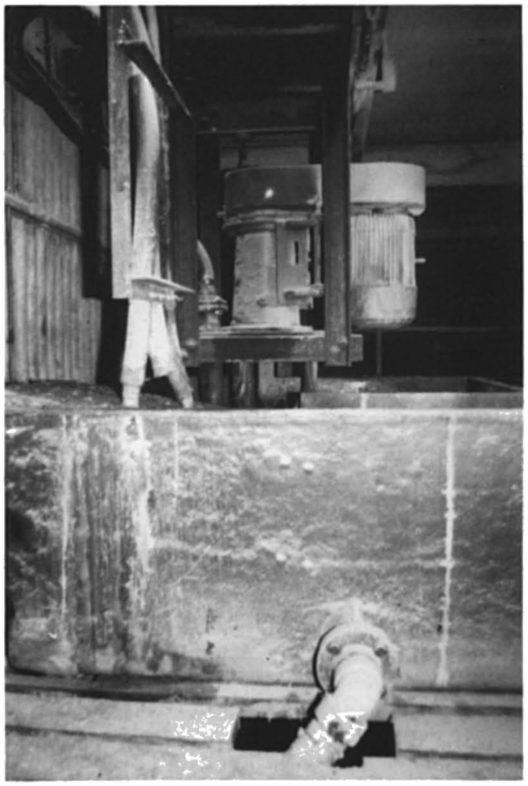
Slide 12

Slide 10

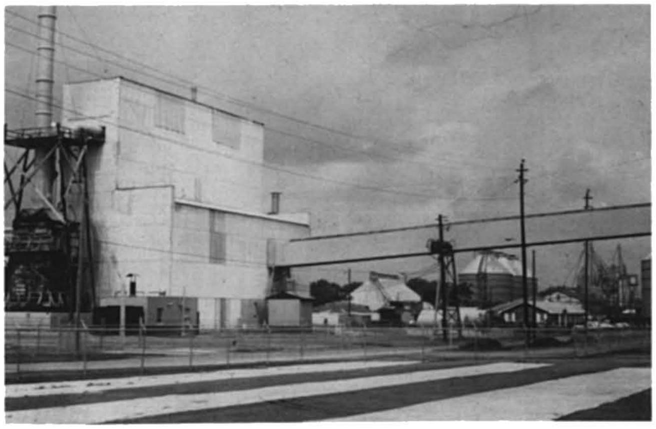
Slide 13



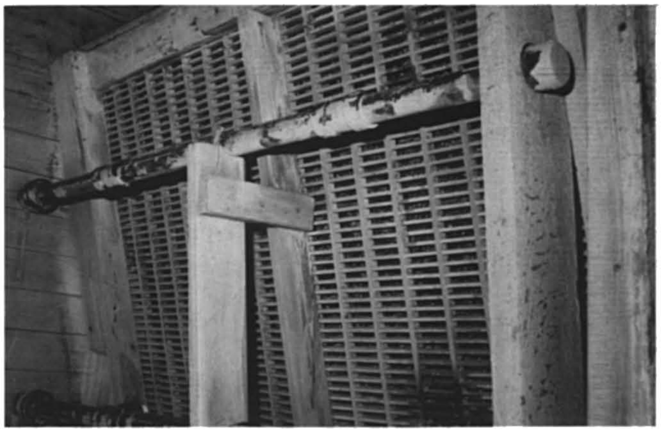
Slide 14



Slide 15



Slide 16



Slide 17

Slide 18

MODERATOR BROCHSTEIN: Thank you Glen. Are there any questions? [Applause]

Our next paper will be presented by Allan Brownlie and concerns the Storage and Granulation of Powdered MAP.

Allan is a Director with the Scottish Agricultural Industries Ltd., better known as A.C.I. He has been a Director for the past eight years and deals primarily with engineering research and technical matters. Allan has both a B.S. and a Ph. Degree from Glasgow University with graduate work being performed at Cambridge. He has been involved with fertilizer manufacture for the past twenty-five years. He is a Fellow in the Royal Institute of Chemistry and an Associate of the Royal Technical College and a member of the Fertilizer Society of England. Allan may we have your presentation please. [Applause]

ALLAN BROWNLIE: Mr. Chairman thank you very much for your introduction.

Storage and Granulation of Powdered MAP

I. A. Brownlie

Introduction

The original paper of which this is an extract was written to inform Fertilizer Society Members of SAI research on MAP. MAP manufacture dated back to 1917 now accounts for several million tonnes of world P_2O_5 production per annum.

One of SAI's predecessor companies was in the business of manufacturing superphosphate from the middle of the nineteenth century and when SAI went into phosphoric acid manufacture in the 1950's it was necessary to find a form of ammonium phosphate which would replace superphosphate in our customer's factories. The requirements for the process were low cost and able to provide a product that would granulate, store and transport well.

I am going to miss out the part of the paper which describes briefly progress from 1954 to 1961 through various stages of using crystalline, slurry, mini-granular and powder MAP until we came to the discovery of what we now refer to as the 'PhoSAI' form of monammonium phosphate. The process and the product were patented in 1961 and we highlighted at the time what we thought were important points about the process and the product namely :—

1—Good granulation.
2—Low cost process.
3—Good storage and handling.
4—Using easily like superphosphate.
5—Compatible with other materials.
6—Can be made from wet process phosphoric acid.
7—Made from different rocks.

The process as you probably already know depends on a back titration using the solubility curve of MAP and Figure 1 shows the simple flow-sheet of the process.

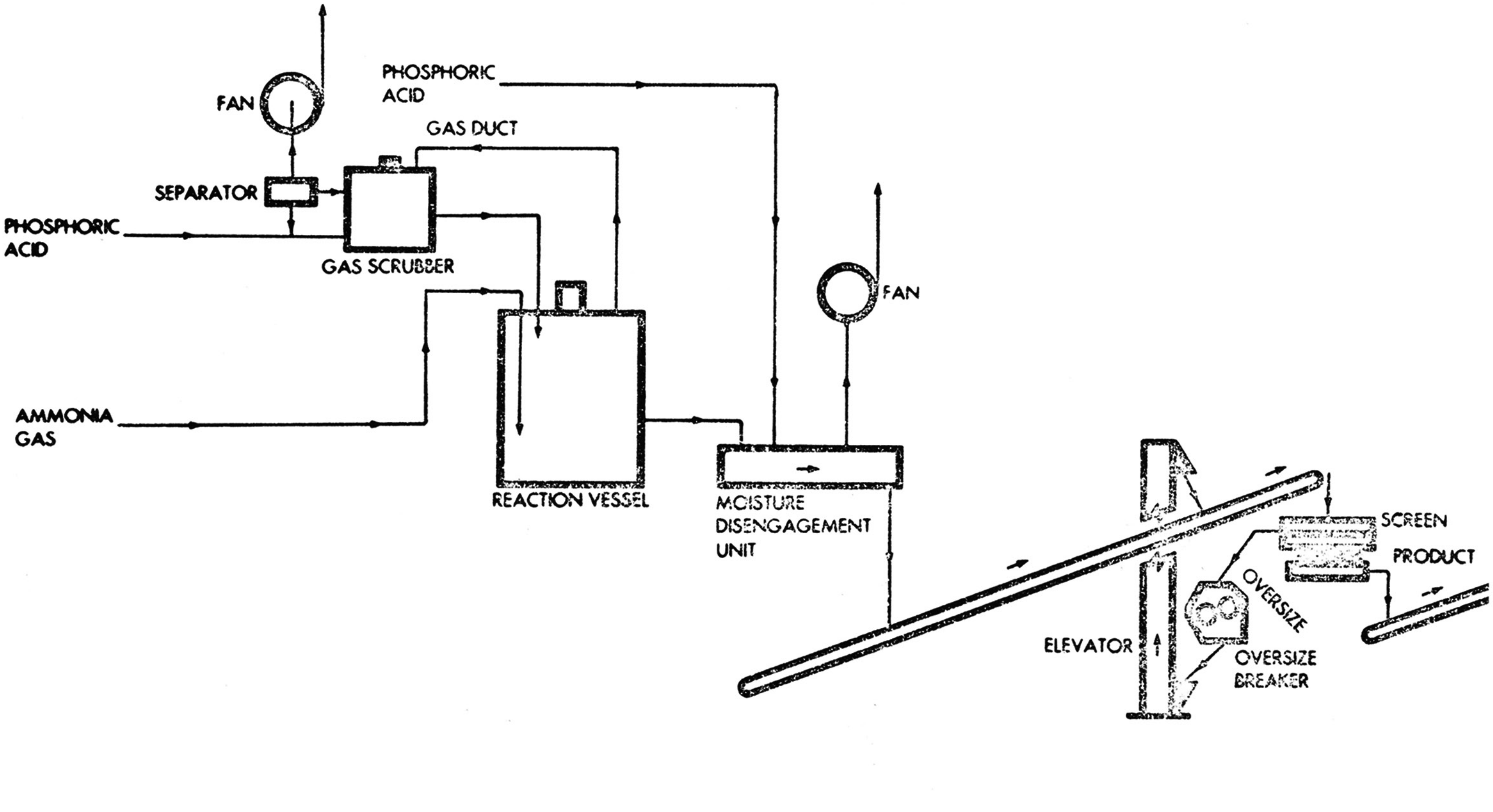


Figure 1

Since 1961 information on our process technology has been published in various places and it is not the intention of the paper to repeat this but to tell you more about our recent research. As the years went by we had experience of producing MAP from various rocks such as Morocco, Florida, Nauru, Senegal, Togo, Gafsa, Kola and Jordan and since proportions and levels of impurities present in the acids made from these rocks varied widely I thought it desirable to determine the importance of impurities with reference to MAP quality with a view to extending this to the effect of these impurities on granulation of the MAP in NPK compound production. Some people thought that our process had some advantages in product quality without necessarily being able to say why. Here was another reason for improving our knowledge of MAP. I am therefore describing in the following parts of the lecture the laboratory and pilot plant research leading eventually to full scale manufacture on a modified plant. All experimental material used was made in SAI's own facilities. Scanning electron micrographs (S.E.M.) were used extensively in the research work and these give dramatic visual evidence of the crystals to be found in the SAI form of MAP.

As we gained more experience in the manufacture of 'PhoSAI' and had the opportunity to use acid derived from different rock sources we found that although the properties of the product were constant the MAP crystal size varied according to acid source and between say Togo, Gafsa and Khouribga based products there was a large variation in crystal size.

The ultimate fate of the impurities in 'PhoSAI' is to be distributed on the surface of the crystals and in the intercrystalline spaces. Scanning electron micrograph in Figure 2 shows MAP crystals covered by a layer of amorphous material. Also if 'PhoSAI' is carefully leached with water the soluble MAP can be dissolved out leaving a relic structure of amorphous insoluble material.

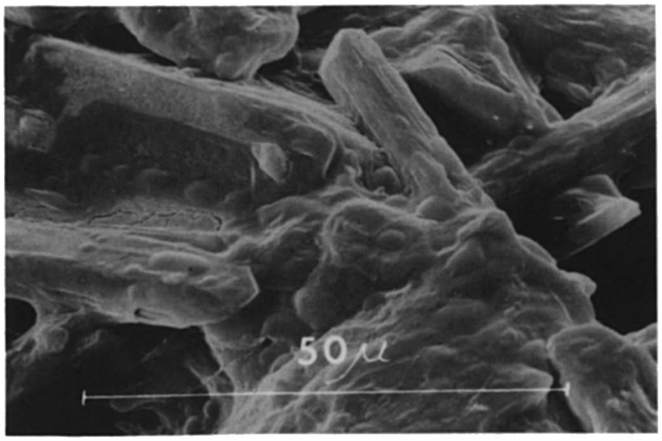


Figure 2
S.E.M. OF 'PhoSAI'
SHOWING MAP CRYSTALS EMBEDDED IN MATRIX OF AMORPHOUS INSOLUBLES

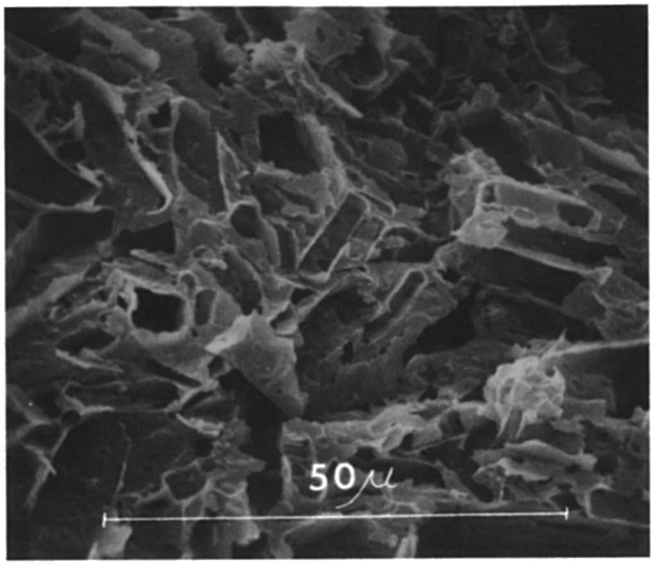


Figure 3
S.E.M. OF RELIC STRUCTURE FOR LEACHED TOGO 'PhoSAI' MAP

Figure 3 is a scanning electron micrograph of relic structure derived from aggregated crystals. You will notice how you can see the rectangular boxes from which the MAP has been leached. This relic was derived from aggregated crystals but the same thing can be seen for individual crystals.

The results I have outlined so far have shown that in 'PhoSAI' the impurities have a major effect, they control the crystallisation stage and they ultimately coat the crystal surfaces. This does not apply if we make MAP using different process conditions. We have found that if we use different conditions then even starting with the same raw material we can obtain a product which is very different from 'PhoSAI' in appearance and properties. This emerged during a series of experiments in which samples of 'PhoSAI' made from various acids were moistened to 15%, heated to 170°C. under pressure and then crystallized by cooling very rapidly to atmospheric pressure and ambient temperature. This material was in the form of very small spheres mostly less than 3mm in diameter and for want of a better name we will refer to this material as high temperature MAP or HT MAP.

In Figure 4 we see a comparison of SEMs of Togo 'PhoSAI' and Togo HT product (big crystals missing). Clearly the two types of material look very different. Similarly Gafsa 'PhoSAI' and HT MAP look very different from each other and indeed we found that there was always a very big difference between the appearance of HT MAP and the parent 'PhoSAI'. It also emerged that although variation in acid analysis yielded 'PhoSAI' of different crystal sizes the HT products all looked very similar. We took this to indicate that although the impurities control the crystallisation stage in the 'phoSAI' process they do not exercise a similar control in the HT process. Another difference between 'PhoSAI' and HT MAP is that if the HT material is leached no coherent relic structure remains. The insolubles merely collapse into a heap of individual particles.

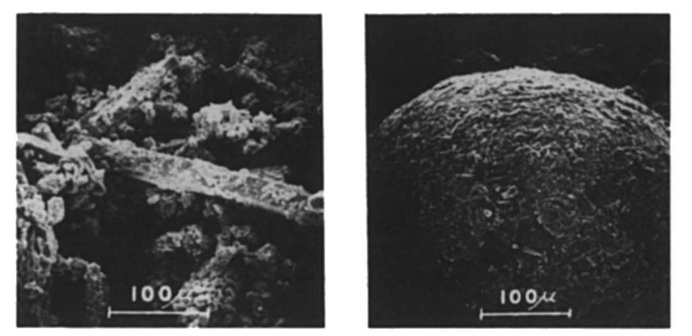


Figure 4

It is also worth noting that none of these particles has the form of membranes which might have been coating the surface of MAP crystals and they are very different from 'PhoSAI' relic material.

Let us now have a look at some comparative properties of 'PhoSAI' and HT MAP derived from 'PhoSAI'. Figure 5 shows the results of laboratory accelerated caking tests on samples of 'PhoSAI' and corresponding HT MAP.

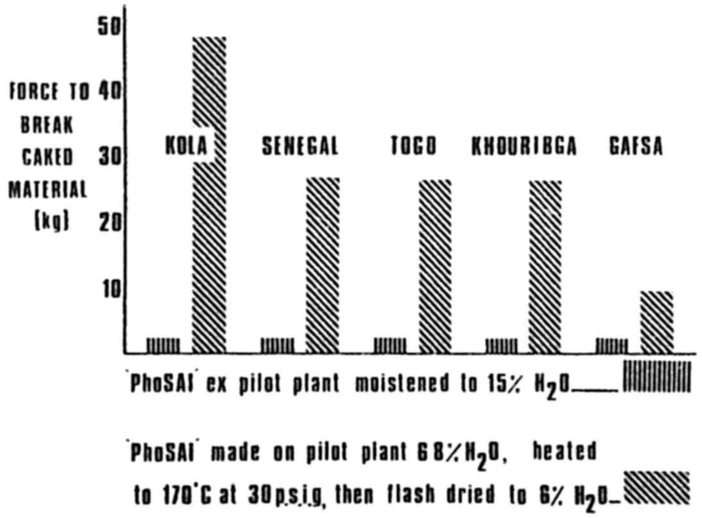


Figure 5

You will note that in every case the HT material produces very much higher results than the parent 'PhoSAI'. Futhermore you will see from Figure 6 that variation of moisture content over the range 1-8% does not markedly affect the results for 'PhoSAI', the results are all low (NB three different acids). On the other hand Figure 7 shows that over the same moisture range the caking results for HT MAP increase with increasing moisture content.

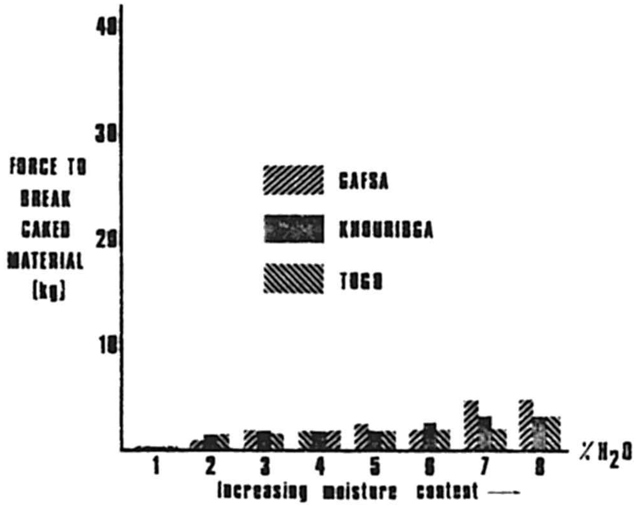


Figure 6

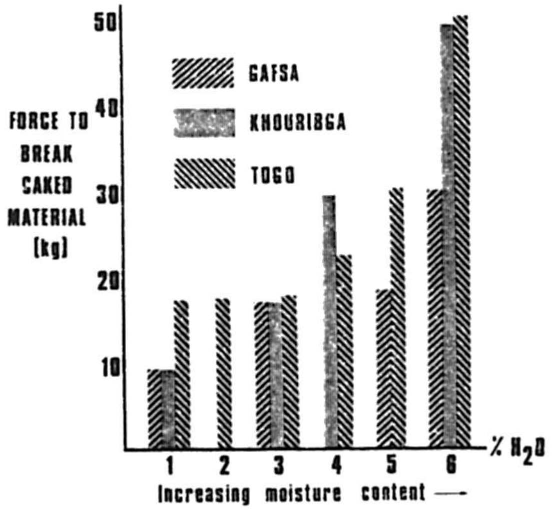


Figure 7

In the same way as it has been a generally accepted belief that presence of impurities improves caking properties it has, I think been generally accepted that impurities improve granulation properties. However, we have obtained results which suggest again that the mere presence of impurities is not enough. Impurities do not automatically confer good granulation properties — the process of manufacture appears to be a very important factor. We obtained these results by using a very simple laboratory granulation technique. We used a 12:12:18 formulation containing MAP, potassium chloride and ammonium sulphate. This formulation was chosen because plant experience has shown it to be one of the more difficult formulations to granulate. Under the conditions of our granulation test neither the potassium chloride nor the ammonium sulphate readily bind together by themselves so the test provides a measure of the binding ability of the MAP constituent.

Figure 8 shows the results of granulation tests on 'PhoSAI' and equivalent HT MAP. You will see that in each case the mixture containing 'PhoSAI' granulated very well whereas virtually no granulation occurred in the mixture containing the HT material. We suspected that the poor granulation results obtained with the HT MAP might be due to its physical form. We thought that this material being in the form of small prills might have a slow rate of dissolution and thus the dispersion of the MAP solid and MAP solution throughout the other ingredients would be slow. However, grinding the HT material to less than 100 mesh did not significantly improve the granulation results. Indeed it is worth noting that in these tests the granulation ability of HT MAP was little better than that of potassium chloride or ammonium sulphate.

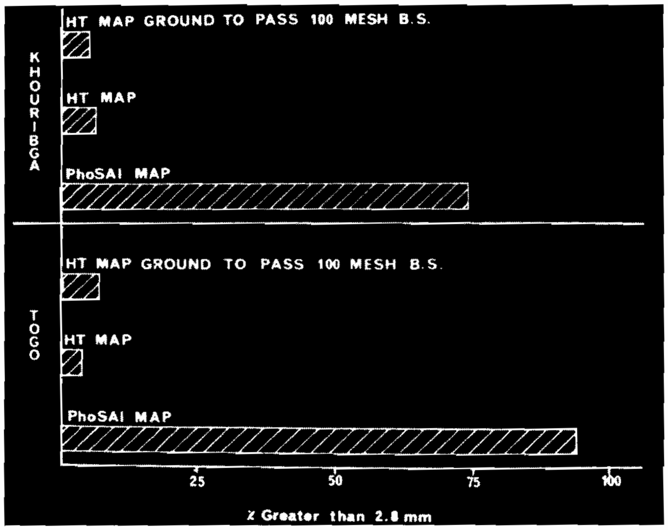


Figure 8

You will recall that we have already shown that in 'PhoSAI' the impurities are distributed on the surface of the MAP crystals (Figure 2). We know from other work that if the MAP is dissolved away and the insoluble membranes are collected they will stick together so this leads us to suggest that if the insoluble membranes stick together when removed from the MAP crystals they may also be capable of sticking together while on the surface of the crystals and thus serving as an inter-crystalline adhesive. On this basis we can postulate a credible mechanism, for the way in which the impurities aid the granulation of 'PhoSAI'. We envisage that the addition of granulation water not only adds liquid phase but also converts the layers of impurities on the surface of the crystals to a sticky state so that as the 'PhoSAI' is dispersed throughout the other ingredients the sticky surface layers enable the crystals to bind together and to the other ingredients. We imagine each 'PhoSAI' crystal behaving like a three dimensional piece of fly paper. Now if we pursue this line of thought a little further we obtain a credible answer to the question of why HT MAP does not granulate so well. According to the suggested mechanism the impurities should be on the surface of the crystals and they should have an appropriate form — this is sticky when wet. There are reasons to believe that neither of these criteria would apply to HT MAP. I explained earlier that we know that in HT MAP the crystals are not coated by membranes of impurities and it is possible that the temperature involved in the HT process may yield impurity complexes having form and composition different from those normally present in 'PhoSAI'.

It was found that depending on the impurity content of the phosphoric acid used to prepare the N:P 1.35 slurry, acidulation yielded at one extreme a very fluid MAP slurry containing large MAP crystals whereas at the other extreme the slurry would be viscous or solid and composed of very small MAP crystals.

However, we found that the high viscosities of N:P 1 slurries could be avoided if the acidulation step was carried out in two stages — initially the MAP/DAP slurry at N:P 1.35 was mixed with a proportion of the phosphoric acid and after a suitable time delay the remainder of the acid was added. This two stage acidulation resulted in marked increase in MAP crystals size compared to single addition of acid to slurry and we tested the technique successfully on a number of MAP/DAP slurries derived from various wet process acids.

In view of these promising results we decided to modify the 'PhoSAI' pilot plant to study further the effect of two stage acidulation Figure 9. The modification consisted of a small secondary vessel together with provision for distributing the phosphoric acid between the secondary vessel and the moisture disengagement unit.

N:P 1.35 slurry overflowed from the primary reaction vessel to the secondary vessel. A proportion of the total phosphoric acid feed was fed to the secondary vessel and the slurry then overflowed to the moisture disengagement unit when the remaining phosphoric acid was added to give an N:P ratio of 1. To allow for comparison with the unmodified process, provision for bypassing the secondary vessel was provided.

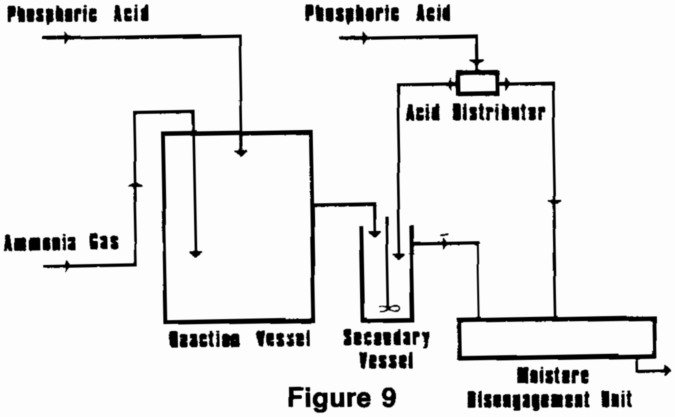


Figure 9

Runs were then carried out using Khouribga, Gafsa and Kola acids. It should be remembered that 'PhoSAI' from Khouribga and Gafsa acids typically consist of small MAP crystals whereas 'PhoSAI' from Kola acid typically consists of large MAP crystals. The promising results obtained in the laboratory were confirmed by the pilot plant work.

Figure 10 shows scanning electron micrographs of the product from Gafsa acid.

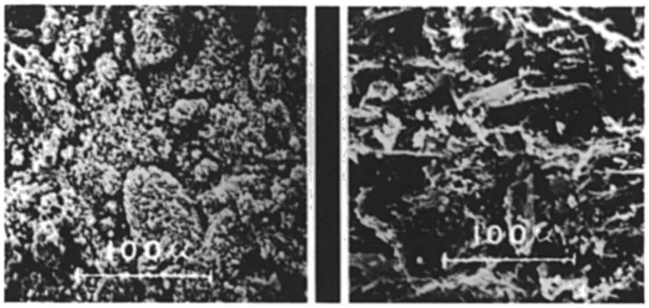


Figure 10

Scanning electron micrographs give more detail of individual crystals and agglomerates. On the left hand side we see the crystals obtained ,when bypassing the secondary vessel and on the right hand side we see the larger crystals obtained when the N:P 1.35 slurry and a proportion of the phosphoric acid were premixed in the secondary vessel. The same effect was obtained from Kola, Khouribga, Jordan and Senegal acids.

It was decided to install a small secondary vessel into the full scale plant for 'PhoSAI' production at the company's Aberdeen works. A large number of experimental runs have been carried out and the next two Figures show an example of the effect obtained on the full scale.

Figure 11 shows MAP crystals obtained from Khouribga acid when bypassing the secondary vessel.

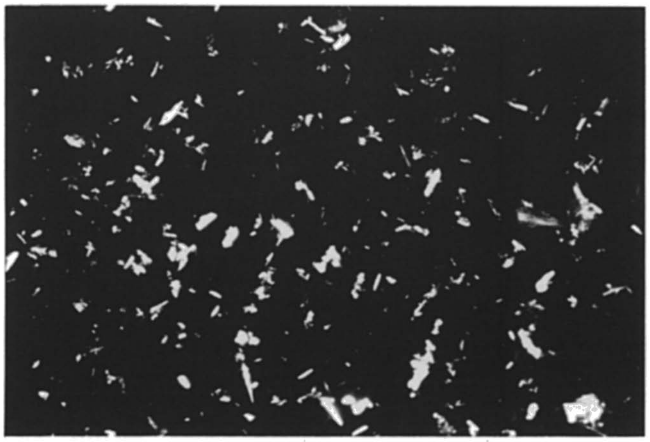


Figure 11

Figure 12 shows the marked increase in crystal size when the secondary vessel was used so that the N:P ratio in this vessel was 1.18.

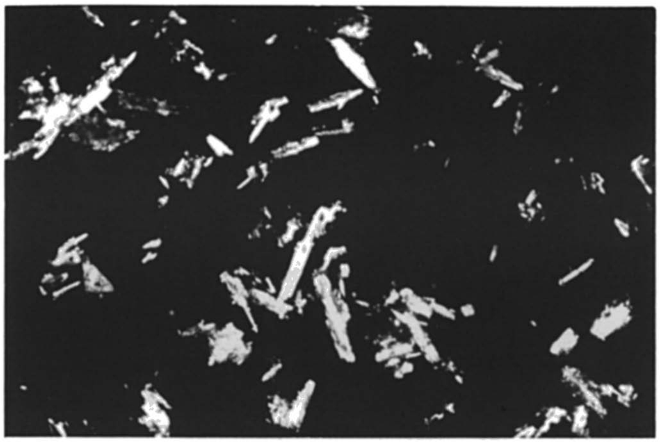


Figure 12

I have tried to describe the progress of our work from the laboratory studies, which gave us a greater understanding of the chemistry of the process, through pilot plant work which showed that the main findings could be easily and cheaply adapted to the full scale and I would like to finish by saying that in the full scale trials carried out so far the promising results of the earlier stages of the work in the laboratory and pilot plant have been clearly confirmed.

ALLEN BROWNLIE: I think probably that I have run out of time Mr. Chairman.

I am very sorry if I have taken longer than I should. Thank you very much.

MODERATOR BROCHSTEIN: That is all right. Are there any questions? Thank you very much Allan. [Applause]

MODERATOR BROCHSTEIN: Our next paper has to do with developments in the granulation of ammonium sulphate and will be presented by Pete Edwin Cox III.

Pete is currently President of Commonwealth Laboratories, Inc. and a partner in Edwin Cox Associates. He has a B.S. Degree in Chemistry from V.M.I. and a Masters in Chemical Engineering from the University of Virginia.

His memberships in professional societies, clubs, and governmental agencies are too numerous to mention.

It is my pleasure to present Pete Cox. [Applause]

PETE COX: Thank you sir.

Granulation of Ammonium Sulphate In Rotary Granulator

Edwin Cox III

This paper reports research on the granulation of ammonium sulphate begun in 1961 and completed two years thereafter. It has continued in part, but the inventions described herein are at least 16 years old. The concepts are older.

Normally a product such as ammonium sulphate would not justify space on the Round Table's program, particularly, when only a few years ago markets for it did not exist. 21-0-0 described its price as well as its analysis. Now, however, with increased costs and efforts at conservation of all materials and plant foods, it may be of interest to some of you.

BACKGROUND: In production of super phosphate fertilizerrs for alfalfa it was found that the run of pile did not give the severe caking problems in storage that the corresponding grade, without the addition of boron, did. Specific grades of interest was 0-10-20, 0-14-14, 0-18-36, 2-12-12 and 3-18-18. It was also noticed that caking decreased when sodium borate tetrahydrate ($Na_2B_4O_7.4H_2O$) was substituted for the borax of commerce, which is $Na_2B_4O_7.10H_2O$.

Past work at the time had revealed that reciprocal salt pairs contributed to caking. The subject had been treated very thoroughly by a founder of the Round Table — Dr. Sauchelli — and by others. The work of ICI with potassium nitrates and the work of Costolow at Phillips with trivalent metal irons had been published.

Work had been done with sulphonic acid derivatives, similar or identical to the products used in coating additives for ammonium nitrate, to improve storage characteristics. Bicalcic phosphate from Germany had been used years earlier to "soften" KCL.

For a plant under construction in the 1960s it was desired to be able to produce a limited amount of 21-0-0 to meet a small market. The size of the market did not justify capital investment in a crystalizer. Freight prohibited the movement of ammonium sulphate to the markets — it would have to be made at the production facility being built.

With this background the experiments I shall describe were undertaken.

EXPERIMENT: Batch laboratory granulation was conducted using a 5-gallon cylindrical can with its ends removed, except for a small edge to retain the magma. Rotation was obtained by placing this on a ball mill. Speed of rotation was varied by addition of pulleys to the drive mechanism and to the drive rollers (of the ball mill).

A slurry of the material to be granulated was made up stoichiometrically and added as a batch to the granulating can. 21-0-0 crystals were crushed and added as fines. Granulation occurred. The product was recovered damp and discharged onto a heated tray. Drying was accomplished by gentle agitation of the tray to insure that significant slumping of the wet granules did not occur.

Difficulties in granulating ammonium sulphate were expected because the product is a highly crystaline one which rapidly forms from the melt.

Research in catalysis had shown that a concentration of one part per million of an impurity added to a crystal 1-centimeter in diameter is sufficient to completely cover the surface of that crystal and to thus alter its surface chemical characteristics.

Knowing this, and knowing that crystalization is a surface chemical phenomenon, it was then obvious that a concentration of approximately one part per million of any active agent would deter crystal growth above one centimeter, and also that a slightly higher concentration would be needed to maintain crystals of a smaller size because the surface area to mass ratio would increase with decreasing particle size.

At the same time, it was known that not all faces of a crystal have the same activity (just as all faces of a diamond do not reflect light the same) and so the theoretical concentration of one part per million for the 1-centimeter diameter crystals would probably be all that was required for a much smaller particle size, indeed to yield granules which would meet a specification of —8+16.

The element Yttrium was selected as the crystal modifier to be used. Yttrium has a relatively large atomic radius which means that it will not replace in a crystal metal atoms such as calcium or potassium. Instead, it will form independent mineral species on the surface of a host crystal.

At the same time, Yttriums electronic properties were expected to contribute to an alteration of electronic properties of the host crystal. Again, since crystallization is a surface chemical phenomenal, it was expected that this would result in alteration of the crystal habit of the ammonium sulphate.

In the experiment it was assumed that by the use of a slurry complete solution would be obtained and the components (ammonium and sulphate ions) would be in solution.

Yttrium was obtained as its oxide and reacted with sulphuric acid to form the corresponding soluble sulphate. A diulte solution of this Yttrium sulphate was then made, which permitted addition to the slurry in varying concentrations during the experiment.

Granulation was accomplished at one-third critical speed. Moisture unfortunately could not be controlled because batch granulators do not permit exact measurement of the moisture. Fines were obtained by simply crushing commercially available ammonium sulphate crystals.

Drying was accomplished at relatively low (less than 90°F.) temperature so that ammonium would not be driven off.

RESULTS: It was found that a 6:1 recycle was obtained for ammonium sulphate in some cases. Granules of acceptable hardness were obtained although they were friable. The granulation product was non-caking in comparison to the crystalline ammonium sulphate.

The experiment showed that ammonium sulphate could be successfully granulated with an acceptable recycle rate without the addition of the foreign materials other than the Yttrium. Cost is estimated at $1 per ton for the reagent Yttrium. No cost calculations have been made for the material handling consideration of the Yttrium sulphate, since it can be added to the acid.

OTHER WORK: This work was then applied to modification of other sulphates, particularly calcium sulphate. Of interest was prevention of precipitation of calcium sulphate from phosphoric acid or the promotion of this settling. It was found that in concentrations of $10{-}^{7}$ (1/10th ppm) to 10 ppm that calcium sulphate precipitation was retarded. It was thought that the Yttrium set down on the dislocations on the surface of the calcium sulphate crystals and prevented crystal growth. The result was turbid acid which was not characterized by the well known layer of calcium sulphate.

An effort was made to apply this work to scale prevention problems. This work was not satisfactorily executed, however, because of our inability in the laboratory to duplicate the physical reactions on the surface of an evaporator.

The work was carried on in depression of salting out temperatures of some liquid fertilizers.

This work is simple and is presented solely to put it in the public domain, with the suggestion that many granulation problems can be solved by the simple addition of a reagent designed for a specific purpose.

In the case of Yttrium, crop effects are unknown although they are expected to be slight (if any) because of the trace amounts applied.

EPA and Water Control agencies have no regulations on Yttrium at this time.

There is a problem of FDA and USDA approval and in the future of toxic substances legislation.

This same technology is applicable to flotation work.

Thank you. [Applause]

MODERATOR BROCHSTEIN: Thank you Pete.

MODERATOR BROCHSTEIN: Our next speaker is Merle Switzer of Comico American. He is Manager of Marketing Administration.

He is a native of South Dakota and a graduate of South Dakota State University with a Degree in Soils. He has completed course work towards a Ph.D in Agricultural Economics.

Prior to joining Comico American, Merle served seven years as a Field Representative and Section Leader with TVA's Agricultural Development Division.

Merle will speak to us on Availability and Selection of Trace Element Materials. Merle please. [Applause]

Micronutrients In The Northwest

M. E. Switzer

There are at present 16 elements known to be essential for the growth and reproduction of higher plants. These elements are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, sulfur, calcium, megnesium, iron, boron, manganese, copper, zinc, molybdenum, and chlorine. Four additional elements— sodium, cobalt, vanadium, and silicon— may be essential to higher plants but proof has not been universally accepted.[1]

The carbon, hydrogen and oxygen contained in plants are obtained from carbon dioxide and water. These elements are not considered to be mineral nutrients and with the exception of the control man exerts over water and to a lesser extent, CO2, there is little that can be done to alter the supply to plants.

Three of the elements— nitrogen, phosphorus and potassium— are used in large amounts and are classified as major nutrients. They are outside the scope of this discussion.

Three of the ten remaining elements— calcium, magnesium and sulfur— are used in intermediate amounts by plants and are classified as secondary elements. Since calcium can be supplied through the application of agricultural lime rather than by a manufactured fertilizer, it will not be discussed.

The seven remaining essential elements are the so-called micro-nutrients because they are used in small amounts. One of the seven, chlorine, has only recently been classified as being essential. Most of the chlorine deficiences have been obtained in the greenhouse with only a few response in the field. Chlorine will not be discussed due to insufficient field response data. It might be well to remember, however, that chlorine in excess amounts has a detremental effect on tobacco and to less extent on potatoes.

Our discussion will center on magnesium, sulfur, zinc, iron, manganese, boron, copper and molybdenum.

One or more micronutrient deficiencies have been reported in forty-two states. Many states now provide diagnostic services and recommend certain micronutrients for specific crop and soil conditions.

USDA consumption data for zinc, magnesium, iron and copper in the U.S. in 1975/76 was zinc 17,000 tons; Mg 12,000 tons; iron 1,800 tons; and Cu 600 tons. Over the past ten years, consumption is characterized by zero and/or negative growth rates (Figure 1).[2]

COPPER

Very little copper is used in the western and north central states. Copper deficiency is very rare on mineral soils but does occur on peat and much soils. (Figure 2)

IRON

The western states are the highest consuming region. While iron deficiencies may occur anywhere in the U.S., they occur more often in the western states. (Figure 3)

MANGANESE

Manganese deficiency is most frequent in the humid region of the midwest, south, and Atlantic coastal plain. Consumption in the western states is very low. The north central states consume about as much as the remaining U.S. (Figure 4)

ZINC

Zinc deficiencies are common across the U.S. Consumption in the western states and the west north central states is about double that in the remaining U.S. (Figure 5)

The 10-year data is characterized by (1) low volume and (2) zero and/or negative growth. The concept of the low volume seems acceptable because micronutrients, while essential, are required in small amounts. The idea of zero or negative growth is not so acceptable. Some possible explanations are: (1) some consumption is not being reported; (2) more effecient sources are being used; (3) farming practices are resulting in a greater release of indigenous micronutrients and (4) consumption will be positive in the long term because the soil contains a finite amount of micronutrients.

The micronutrients in the soil and their availability to plants are determined by the minerals present in the original rocks and by the climatic weathering processes that have taken place in the soil over the years. In general, the leached highly-weathered soils of warm, moist regions contain smaller amounts of micronutrients than soils in cool, dry regions. However, there are exceptions and the total amount of an element present in soils is often a poor guide to the amount available for plant growth.

PLANT NUTRIENTS IN A FURROW SLICE

ELEMENT	AMOUNT, LBS/ACRE
Fe	70,000
Mg	8,000
S	1,000
Mn	1,000
B	40
Zn	20
Cu	5
Mo	2

Note the relative size of the total amounts of these elements that we might expect to find on an average acre furrow slice. Amounts can range from 70,000 pounds of iron to 2 pounds or less of molybdenum, yet both are considered micronutrients. Micronutrients are "micro" in the sense that only very small amounts are required by the plants, but they are just as important to crops as the primary nutrients.[3]

The availability of all micronutrients except molybdenum decreases as the pH increases from 5 to the alkaline range. In general, the most soluble micronutrients can be in too great a supply at a pH of 5 and may very well be at toxic levels for the plant. Generally, liming of acid soils is to be recommended in soils where the micronutrients are abundant. On the other hand, micronutrient shortages could be created by over-liming. Soils under continuous cultivation generally tend to become more acid. This may facilitate the release of indigenous micro-nutrients.[4] (Figure 6 & 7)

Farming practices that slow down root growth and development can induce micronutrient deficiencies. In addition, deficiencies frequently occur under conditions in the field where there is: (1) high organic matter; (2) high soil phosphates with low micronutrient levels; (3) high sand content of soil; (4) drought; (5) compaction; (6) high pH; and (7) land leveling.

FUNCTIONS IN PLANTS

MAGNESIUM

Chlorophyll contains one atom of magnesium in each molecule. There could be no green plants without magnesium. Magnesium aids in the uptake of phosphorus.

SULFUR

Sulfur is required for synthesis of certain amino acids. It activates specific enzymes. It is involved in the synthesis of some vitamins. Sulfur is also involved in the formation of oils and associated with the structural characteristics of protoplasm.[5]

ZINC

Zinc is needed for the oxidation processes in the plant and for the transformation of carbohydrates. It regulates the consumption of sugar in the plant and is necessary in several enzyme systems that regulate various metabolic activities.[6]

BORON

The role of boron in the plant is somewhat obscure. It is needed in the active growth tissue of the plant. Since boron cannot be translocated, a continuous source is needed throughout the growth cycle. Because of this unique role, boron may show up as reduced plant quality rather than reduced plant growth. Deficiencies may occur often when the plant is expanding rapidly, flowering or during periods of drought.

COPPER

Copper is a constituent of several important enzymes and plays a role in photosynthesis and chlorophyll formation. It is also important in the utilization of proteins. Copper does not move from the older plant parts to the younger leaves, and a lack of copper usually shows up on the leaf tips of the younger growth.

IRON

An iron deficiency results in failure of the plant to produce chlorophyll, the green color which functions in photosynthesis and starch production. While iron is not a part of the chlorophyll molecule a deficiency causes the characteristic chlorosis or yellowing of the plant. Iron also is involved in the enzyme mechanism and as a catalyst in all divisions. [7]

MOLYBDENUM

Molybdenum is needed for the symbiotic fixation of nitrogen by legumes and is essential for the reduction of nitrates in all crops. Molybdenum deficiency symptoms are similar to those on nitrogen deficient plants. The availability of molybdenum to plants is increased by liming and the addition of phosphate fertilizer.

MANGANESE

Manganese is needed in chlorophyll development. It acts as a catalyst, helps regulate reactions, and activates certain enzymes. It is required in nitrogen metabolism, in photosynthesis and carbohydrate breakdown.

DEFICIENCY SYMPTOMS[8]

BORON . . . .

Death of growing point. Rosetting and die-back, defoliation, chlorosis. Internal tissue breakdown and corky tissue formation such as in apples

CHLORINE . . . .

Chlorosis.

COPPER . . . .

Chlorosis and permanent wilting of upper leaves. In grain, it looks like frost damage. Poor pigmentation of carrot roots, small grain and onion bulbs.

IRON . . . .

Chlorosis between veins appearing light green to white in color. Veins remain green. Death of terminal growth. Appears on new growth first.

MANGANESE . . . .

Similar to iron but chlorosis between veins not so dominant on young leaves. Severe browning and dropping of leaves with maturity. Gray specks on oats and small circular dead spots may develop on underside of potato leaves.

MOLYBDENUM . . . .

Foliage greenish-yellow or yellow, similar to nitrogen deficiency. Cupping of leaf margin, motling of lower leaves and dead tissue around the outer edges.

ZINC . . . .

Rosette or little leaf on potatoes and trees. Chlorosis on leaves. On beans, older leaves are affected first, whereas from deficiency shows up first on young leaves. Corn plants show broad yellow band between midrib amd outer edge of leaf. Usually begins at base of leaf. Tips on onions are yellow and curled. Beans are light green with mottled chlorosis.

MAGNESIUM . . . .

Chlorosis; severe browning and necrosis of lower leaves. Broad leaves show blotchy appearance. In corn, leaves show yellow streak with a chain of dead areas.

SULFUR . . . .

Entire plant becomes pale green or light yellow, quite similar to nitrogen deficiency, but affects youngest leaves first, whereas nitrogen deficiency appears first on older leaves.

DIAGNOSIS OF MICRONUTRIENT DEFICIENCIES

The purpose of soil testing is to determine which fertilizer nutrients are deficient and, hopefully, to help predict how much fertilizer to apply for a given crop or cropping system. Soil tests can also be used to detect excesses of certain elements that may be toxic to plants or contribute to pollution of surface and ground water. Chemical analyses of leaves or petioles for micronutrients and calibration of the results with deficiency symptoms and response to fertilizers are often superior to soil tests, particularly for deciduous tree fruits and citrus. Crop nutrition can often be best controlled by a combination of soil and foliar analyses.

Soil testing for the micronutrient is particularly difficult because plant requirements for these elements are small, posing the problem of easy contamination of samples unless adequate precautions are taken. Small changes in environmental conditions are often sufficient either to correct or to induce deficiencies on soils with borderline deficiencies. When a plant shows deficiency symptoms, there can be no doubt that it is sick. But plants frequently grow out of deficiency symptoms and may appear to produce a normal yield. Conversely, yield can be reduced by micronutrient deficiency without external evidence of the deficiency.

The criteria now used to determine whether micronutrients will be used in fertilizers range from some dependence on soil tests to the philosophy that micronutrients should be used in all fertilizers as insurance against deficiency. We simply adopt the premise that some soil tests are good, that all of them need better calibration, and that soil tests can provide a very dependable guide for the use of micronutrient fertilizers on most crops, thus eventually displacing the insurance concept. [9]

SOURCES

BORON

Sodium Borate Pentahydrate (Tronabor)	14.9
Boron Trioxide (Borate 48)	14.9
Boric Oxide (Borate 68)	21.1
Solubor	20.5%

COPPER

Copper Sulfate	25
Copper Chelate	9-13
Organic Complexes	5-7

IRON	
Ferrous Sulfate	21
Ferrous Ammonium Sulfate	14
Iron Chelate	5-14
Organic Complexes	5-10
MANGANESE	
Manganese Sulfate	28
Manganese Chelate	9-12
Organic Complexes	8
MOLYBDENUM	
Sodium Molybdate	39
ZINC	
Zinc Sulfate	18
Zinc Ammoniated	36
Zinc Ammonium Sulfite	15
Zinc Silicates	Variable
Zinc Carbonate	52
Zinc Oxide	75
Ammoniated Zinc Oxide	10
Zinc Chelates	9-14
Organic Complexes	5-10
MAGNESIUM	
Magnesium Sulfate	16
Magnesium Oxide	56
Magnesium Carbonate	11
Potassium Magnesium Sulfate	11
SULFUR	
Elemental Sulfur	90
Ammonium Sulfate	24
Ammonium Phosphate Sulfate	14
Potassium Sulfate	18
Calcium Sulfate	15-18
Magnesium Sulfate	23
Ammonium Bisulfite	17
Ammonium Thiosulfate	26
Ammonium Polysulfide	45
Urea Ammonium Sulfate	6
Ammonium Nitrate Sulfate	6
Ammonium Nitrate Sulfate	6
Sulfur Coated Urea	13-15

SUPPLY

Because micronutrients are so closely related to metal production the supply/demand balance for metals will ultimately determine the supply and price of inorganic micronutrients. Most metals have been in long supply over the past year. Metal production cutbacks have been the order of the day and, as a result, inventories have been held in line. Micronutrient supplies should be adequate, but seasonal shortages may occur because of dealer reluctance to take in preseason inventory. Dealers will be cautious about inventory because micronutrients are high priced; they compete for bin space and farmers may curtail use because of declining commodity prices.[10]

COST/PRICE

Micronutrient prices have generally followed metal prices. Micronutrient price fluctuations have been less pronounced probably because metal by-products are a major raw material source. Prices have doubled since 1972 but declined in 1977. Micronutrient prices have also followed the price of acid used to prepare soluble salts (Figure 8). Other costs, i.e. energy, transportation, will continue to increase. The overall cost effects will result in nominal price increases.[11]

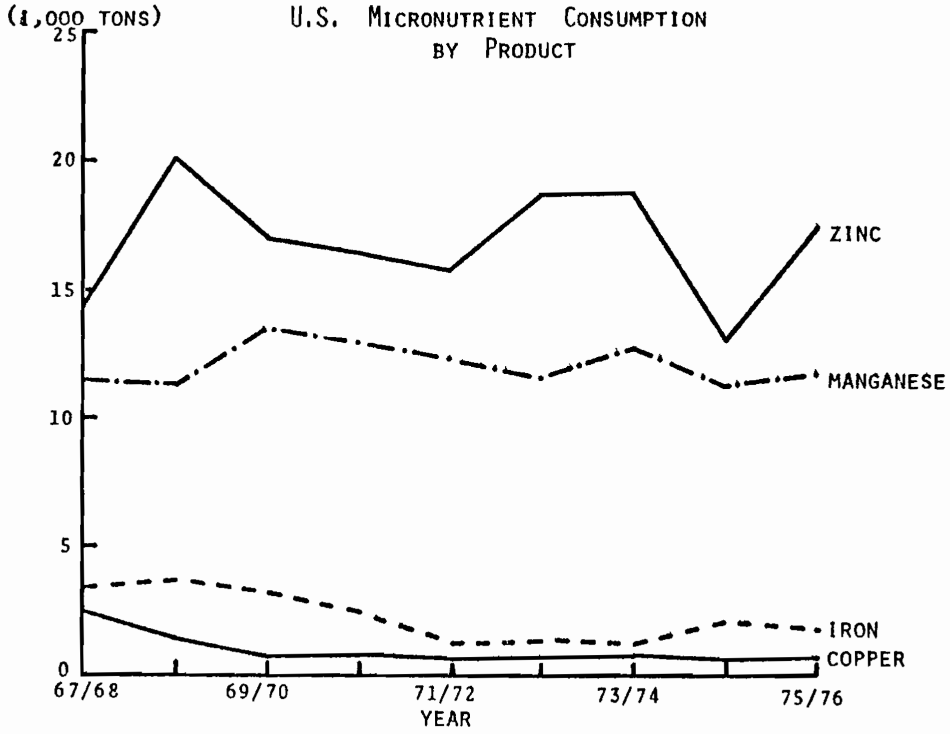


Figure 1

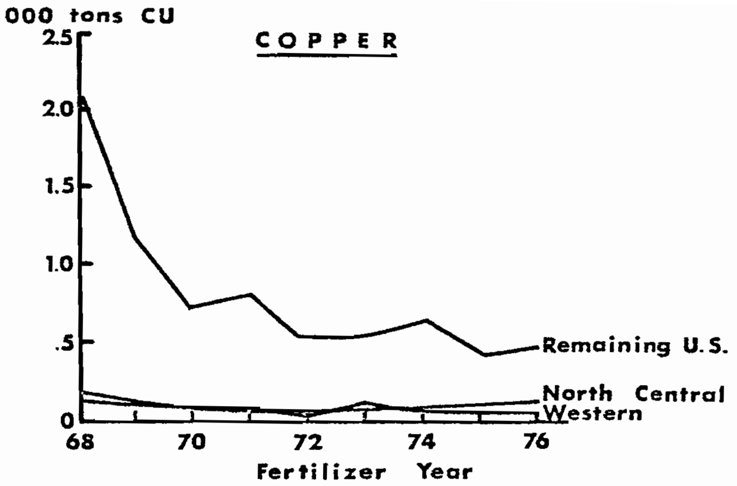


Figure 2

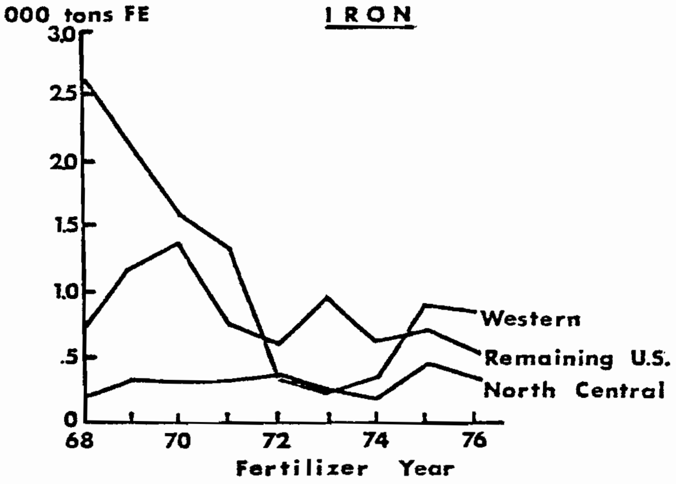


Figure 3

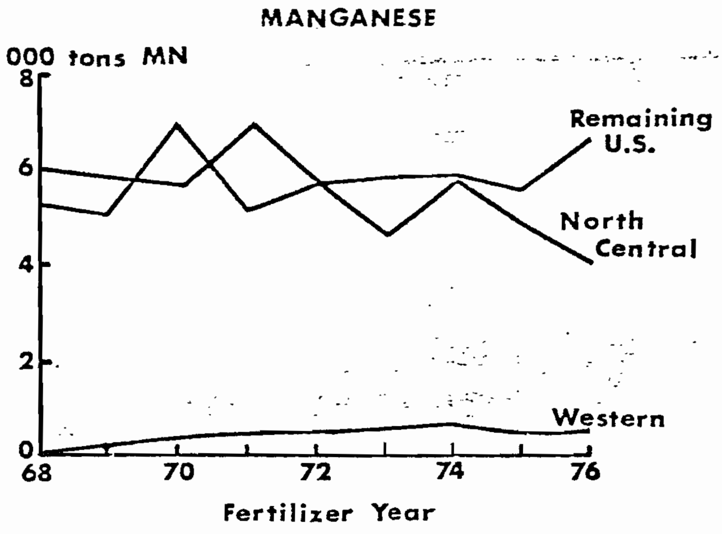


Figure 4

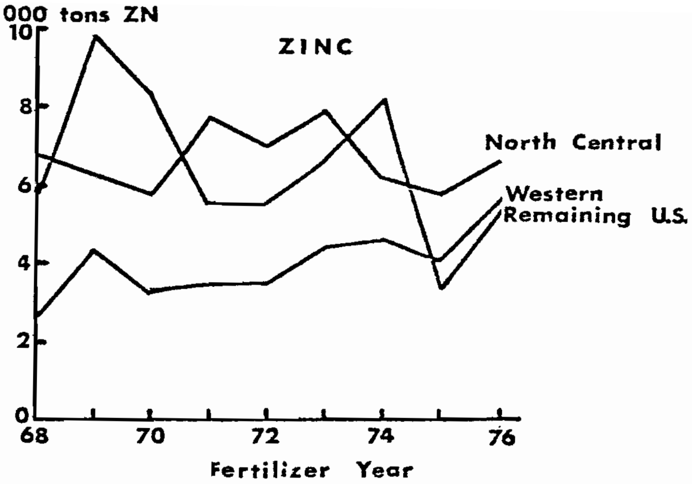


Figure 5

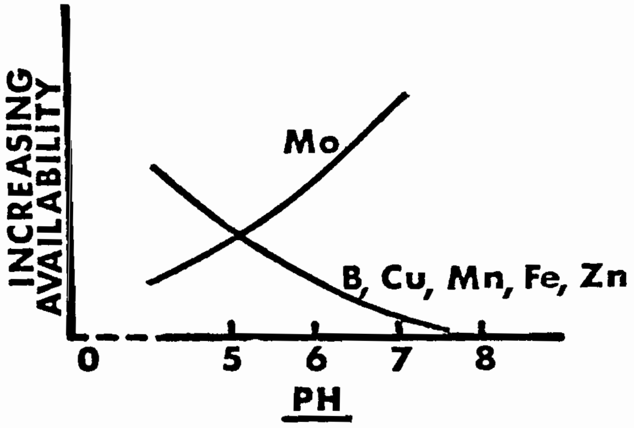


Figure 6

EFFECT OF N FERTILIZER ON UPTAKE OF Zn AND Mn BY POTATOES KLAMATH FALLS, OR, 1969

Treatment	Zn ppm	Zn Mg/Plant	Mn ppm	Mn Mg/Plant
Check	17	.13	18	.48
Zn Mn	27	.23	23	.63
N	20	.26	34	1.64
N Zn Mn	28	.76	35	2.10
Zn Mn-N_{BR}	21	.36	17	1.12

All treatments banded at planting time except N_{BR}

Source: T. L. Jackson, 1976

Figure 7

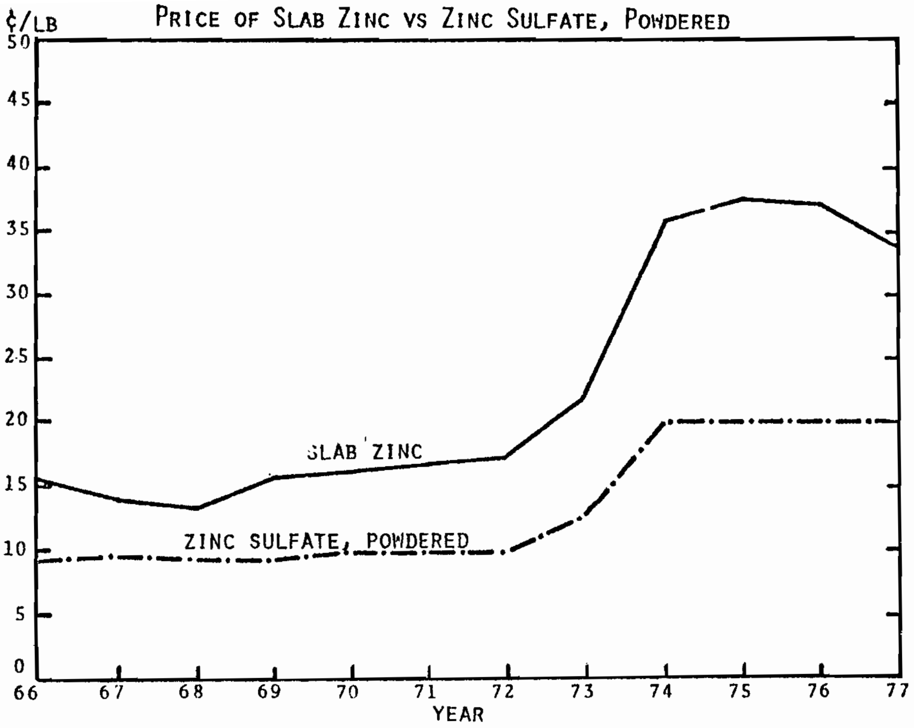


Figure 8

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MODERATOR BROCHSTEIN: Thank you Merle. [Applause]

The afternoon session will start at 1:30.

Are there any questions?

QUESTION - FRANK ACHORN - TVA: This is probably an area of marketing fertilizer where we can expand the use of nitrogen and P205 and K20 that has not been fully developed. It is very difficult to get a recommendation.

Now my question relates to — is it time for us to start producing maintenance type fertilizers that contain micronutrients, some of the micronutrients — the major ones are of course zinc, manganese, and boron in the eastern area. Is it a good thing for us to look strongly at now, or should we wait for the deficiency to occur and then attack that problem with a prescription type of attack?

MERLE SWITZER: Well, one of your usual good questions Frank. Maybe I can relate some of the experience we have had with it. As a basic producer we tried it one time — we actually produced some materials that contained micronutrients, such as boron. We found that, because of the extremely small amount that you add per acre, you can't really control the rate you are applying and if you have a toxicity problem at all you really leave yourself very open liability-wise, and so we discontinued that.

I think some other people have had similar type experience. So to add a micronutrient, such as that, to a major nutrient in a large plant, I don't really believe is too practical. I think the place to add them is out in the field with the blender. You have more flexibility of what rate you are going to apply, the other nutrients you are going to apply in relation to the micronutrients.

For example, I can give you one blender who blends probably 15,000 to 20,000 tons of blends a year and he makes 900 different blends. Well, if I went to our production guys and said I want that kind of thing, they would never do it. So I don't think the production plants for us is the way to do it — in the terms of N P & K.

I guess the other question you ask is should we just apply so much micronutrient regardless of where it is blended — should we just apply them to the soil as an insurance program? If our diagnostic techniques, which haven't been that good, keep continuing to improve I don't think we have to do that. There has been a lot of that done and I guess if you are in a high cash value crop such as potatoes or you are growing 30-40 tons per acre, you may have values of several thousand dollars per acre, I can tell you what those guys do — they put them on. If there is any question at all they put them on as an insurance program. With low value cash crops they don't.

So I suspect that the grower ultimately is really going to decide whether it is going to be one way or the other.

FRANK ACHORN - TVA: You showed a large demand for both calcium and sulphur in your area and I do know that in your area and in the north, in the eastern seaboard states that it is a practice to make triple superphosphate and gypsum from phosphoric acid and ship a carload of gypsum and a carload of triple superphosphate and mix them together. Will you solve this mystery of why we quit producing normal superphosphate, which is a mixture of triple super and gypsum?

MERLE SWITZER: You will have to answer that for here, we never really produce it out there Frank.

FRANK ACHORN - TVA: Sure need good old normal super. [Applause]

MODERATOR BROCHSTEIN: Questions? If that is all the questions, thank you for your attention this morning. Our afternoon meeting will start at 1:30 pm.

Wednesday, October 26, 1977

Afternoon Session
Herman G. Powers, Moderator

MODERATOR POWERS: I would appreciate your taking seats so that we can maintain the good schedule we are on after the morning session.

This afternoon we have several timely and interesting topics, starting with some of the basics in our Industry: Phosphate Rock, Phosphoric Acid, Sulphur, Sulphuric Acid, and then something somewhat new "In The State Of The Art" concerning "Fluid Fertilizers" and windup with the trends "In Distribution On How We Get It To The Customer."

The first speaker this afternoon session, is David W. Leyshon. Dave has been a member of the Board of Directors of The Fertilizer Industry Round Table, since 1969. He has had experience in phosphoric acid and fertilizer granulation, which goes back to pilot plant work and start-up work, as far back as the early 1950's, about a quarter of a century.

Dave has an extensive background in "International Projects." He has been involved in "Phosphate Rock" throughout the world. His present title is "Technical Manager Of Dorrco Fertilizer Plants Division of Jacob Engineering, Lakeland, Florida.

Dave will chair our Panel and will introduce each panel member as we go along. Dave Leyshon please. [Applause]

The Effect Of Varying Impurities In Phosphate Rock On Commercial Scale Manufacture Of Phosphoric Acid

Panel Session:

Dave Leyshon — *Panel Chairman*
Tas Kouloheris — *Panelist*
Art Bauman — *Panelist*
George Shearon — *Panelist*
G. M. Lloyd — *Panelist*

PANEL CHAIRMAN LEYSHON: We have assembled a panel of experts today to discuss problems related to the impurities found in phosphate rock used in the manufacture of phosphoric acid. When I read that opening sentence referring to experts to my panel I found unanimous disagreement. So we're getting off to a shakey start on what is a relatively complex problem. However, we'll do our best to introduce this subject to the Fertilizer Round Table.

This discussion today will relate mainly but not entirely to problems related to Florida rock. However, the problem is worldwide. From 1972 to 1975 the amount of 68 BPL and under phosphate rock increased from 60% of the total rock produced in the world to 80%. In future panels we hope to be able to broaden the scope of this discussion to other phosphates. I have asked Tas Kouloheris, who is the author of several recent articles on this subject, to give a summary of how he views the problems. Then we'll be calling on the other members of the panel to contribute specific experiences and perhaps challenge some notions regarding the processing of rocks containing increasing levels of impurities. Tas please. [Applause]

Panelist Kouloheris

Introduction

In the past five years, the Florida phosphate industry was surprisingly awakened from its lethargy to the sudden realization of the dramatic depletion[1] of our high grade rock reserves. The reaction to this was evident by the great number of land acquisitions that occurred in areas that were previously considered low grade rock. Such countries as Hardee, Manatee, DeSoto, etc. were rediscovered overnight. In addition, chemical plants were equally surprised to find out that their own mines started feeding them with grades of rock containing unusually low BPL and high I&A* and MgO. In attempting to process such rocks without any previous knowledge, many companies were forced to employ empirical know-how coupled with crude experimentations on a plant-scale. Of course, under these conditions, correlations of cause and effect and useful and practical conclusions cannot be obtained easily. While this was going on, Industry-represented by the Fertilizer Institute (TFI) — approached the Federal Government agencies and requested a redirection of their research priorities towards the solution of this problem. TVA and the Bureau of Mines in cooperation with TFI have now launched a well organized research program. With Industry's participation, the objective of this program is to research new methods of physical or chemical beneficiation and chemical processing of low quality phosphate rock. This program — well financed by the Federal Government is now underway. TFI's participation in this program consists of furnishing samples and reagents and providing industry's input through frequent technico-economic process reviews of the project. As expected, it will be sometime before industry can benefit from the practical results of such research. In the meantime, the problems of chemical processing of low grade and low quality rock are already facing industry. The phosphoric acid plant operators are in an urgent need of proper know-how. This paper will attempt first to present some idea of the penalties we pay now by processing low grade rock. Following this, the problems of low-quality rock processing will be analyzed. In addition, some techniques and methods of rock management at the mine and some correlations that can be applied at the chemical plant will be presented. It is to be understood that these will be guidelines rather than definitive solutions to the individual problems. Finally, some ideas will be presented as to further improving our present mining and processing techniques.

* Iron & Aluminum

The Penalties of Low-Grade Rock Processing:

It should be pointed out here that there is, ideally, a definite distinction between low-grade and low-quality phosphate rock. Low-grade signifies that the BPL content of the rock is unusually low — say in the low sixties — while the other troublesome impurities such as iron, aluminum, magnesium are still within the chemical processing limits. The main diluents are inerts of sand, silt and organics. In low quality rock, in addition to the above, the impurities of iron, aluminum, magnesium, calcium, etc., are such that the chemistry of rock digestion as well as the quality of the acid made are both affected. Our experience has shown that while chemically we can cope with the low grade rock, there are some penalties that the chemical plant has to pay for. These penalties can be summarized to be: Lower P_2O_5 production, lower evaporator's capacity, higher abrasion and higher consumption of defoamer. There is no doubt that, for a chemical plant with a rock handling, digestion and filtration capability already limited, the P_2O_5 production resulting from low grade rock will be lower. When you feed a plant at the rate of 150 TPH rock, analyzing 68 BPL you make one P_2O_5 production and another at 63 BPL rock feed. It's a simple arithmetic — even if you assume that at this low grade, your P_2O_5 metallurgical efficiency has not been affected. Figure 1 shows how the P_2O_5 production at a Prayon plant decreases linearly to the decrease of BPL in the rock. Similarly, for a chemical plant with a limited evaporator capacity, the effect of feeding a filter acid with lower P_2O_5 content will be significant. Low grade rock fed into the system produces low P_2O_5 filter acid; this in turn will require more water evaporation in the evaporators to make the 54% product acid. Figure 2 shows the evaporator capacity decrease as a function of the filter acid strength decreasing due to low grade rock processing. Sometimes a low grade rock may contain organics which have a tendency to stabilize foam[5] in the attack tank. Under these conditions, defoamer consumption can be observed to increase higher than the levels normally used in a Prayon system. In some other cases, higher organics may inhibit good crystal growth in the attack tank. As a general rule, also, low grade rock is associated with higher contents of insolubles in the form of quartz and other silica. Agitation and abrasion in the attack tank can be a new experience. Grinding of such rock is equally difficult and costly. There is also some evidence indicating that the silica content of low grade rock (whether amorphous or crystalline SiO_2) may have a significant effect on efficiency. All-in-all, the above described penalties are very significant and plant operators as well as plant management should become well aware of them. This will eliminate misunderstandings related to meeting production schedules and cost budget figures. We should all understand today that it is not the tonnage of rock fed into the system that matters, but rather the tonnage of P_2O_5 included in that rock. Miners, processors and management should have a clear understanding of this fact.

The Problems of Low-Quality Rock Processing:

For reasons of primary importance and practicality, we will define low-quality phosphate rock as the one that, along with the low BPL, contains high values of iron, aluminum, magnesium and carbonates. There is no doubt that other impurities do contribute to difficulties in processing. However, these, at least, are the impurities that we know more about. Again, from a practical rather than a mineralogical point of view, it will be important to know how and where these impurities may be found in the rock prepared by the beneficiation plant. It is also equally important to know what the phosphoric acid operator should expect if such impurities enter his plant. The literature[4] is full of numerous work done on the identification of mineral species and chemical compounds under which these impurities are found. We will deal only with some practical aspects of physically identifying these impurities and give some guidelines of what to do with them. However, prior to this, it will be helpful to know how the rock is being prepared at the mine before its shipment to the chemical plant. Figure 3 presents a block diagram of the beneficiation plant. It can be seen that beneficiation consists of the following steps:

1. *Desliming* for the removal of clay material usually found (when totally dispersed and free) in the colloidal fraction.
2. *Extraction of pebble,* producing one of the cheapest products but also one lower in BPL. This extraction is done by autogenous high pulp density scrubbing in log washers followed by screening. Thus any clay or other impurities superficially found on the pebble surface are removed. Product grade may vary from 50-70 BPL.
3. *Flotation Concentration,* producing one of the more expensive products but also one higher in BPL. Differential flotation and subsequent re-cleaning is employed to make a 70-72 BPL product.

Thus, the acid plant may receive a product that can be either totally pebble or concentrate or a blend of both. Under present conditions, most processors are fed with abundant, cheap, low-quality pebble that has been properly "sweetened" with high-grade, more expensive and valuable concentrate. This being the case, it is very important that the chemical processor as well as the miner know the source of and what type of impurities may contaminate the rock shipment. Following is an outline of these potential problems and their effect on the plant's operation.

1. *Insufficiently Deslimed Rock:*

Slimes consist primarily of colloidal clay material having a tendency to adhere rather rigidly to the pebble product and also to float with the concentrate during flotation. It is well known that clay is a "sandwich" of SiO_2 and Al_2O_3 layers with other Mg and iron impurities depending on whether the clay species is montmorillonite, attapulgite, or kaolinite. Thus, if the "as received" rock analyzes high in Al_2O_3, it should be expected that the viscosity and surface tension of the acid produced will be high creating significant problems with the evaporation stage[2]. Figure 4 shows the correlation of the viscosity of 54 acid to the Al_2O_3 content. In addition, during ammoniation in the DAP* manufacture, aluminum contributes to the formation of complex aluminum phosphates that form scale on the process equipment. They also inhibit ammoniation of P_2O_5 to diammonium phosphate, thus resulting in lower N-grade DAP[3]. The literature reports numerous crystalline compounds of aluminum and magnesium formed during ammoniation, that deleteriously affect the DAP plant's granulation, grade and capacity. Finally it is believed that both iron and aluminum influence the crystal growth and nucleation condition of gypsum. This may affect drastically the percent P_2O_5 recovery at the Prayon plant. This is shown graphically in Figure 5 where the Prayon System's performance guarantee is shown as a function of iron and aluminum for 68% BPL rock. It is believed that rigidly attached clay coatings on the phosphate particles can act as barriers that pacify the rock and prevent its attack by sulfuric acid. In addition, the formation of compounds such as $Ca_4SO_4SiF_6OH\ 12H_2O$ results in the production of small crystals which may blind the filter cloth. furthermore, aluminum and Mgo entering the attack system in the form of clay are known to increase viscosity of the slurry and effect the performance of the Bird filter. If the chemical analysis of the rock indicates that aluminum is the troublesome impurity, it is important to ascertain whether this is attributed to insufficient desliming. The rock sample should be screened through 150 mesh sieves and an Al_2O_3 balance should be established between the total rock, the +150 mesh fraction and the —150 mesh fraction. Should this indicate that the major portion of Al_2O_3 is derived from slimes, the mine should be immediately advised. It should be noted here that most of our beneficiation plants have been designed with one-stage cyclone desliming only. Also, those built five years ago or longer have not been designed specifically to accommodate high slimes matrix presently encountered by our mines.

*Di-ammonium phosphate

2. *Impure or Insufficiently Washed Pebble:*

As explained earlier, the pebble product is the most impure phosphate product. Its purity and BPL content also fluctuates widely pending on the nature of quality of the deposit in each mining section. Aluminum, iron, magnesium and carbonates may be found almost invariably in pebble in relatively large contents. Whether these impurities are found as internal inclusions within the pebble or as rigidly attached superficial coatings determine the potential of washing at the beneficiation plant. There is no doubt that if they are found as internal inclusions or replacement ions in the apatite lattice, the miner can do absolutely nothing about it. His only remedy is to "sweeten" this pebble by admixing it with more pure concentrate so that the resulting "blend" contains acceptable levels of impurities. A hypothetical case of such a "sweetening" blend is shown in Figure 5 with MgO as the major impurity. In some cases, MgO, CaO and carbonates are associated with limestone or dolomite particles usually concentrated in the upper fraction of pebble, i.e. —7/8 +4 mesh. If such is the case, this fraction should be scalped out from the pebble through a separate screen. In some other cases, this kind of contamination of the pebble may result from poor screening at the sizing section of the beneficiation plant whereby the +16 mesh portion of the pebble is being produced. Finally, insufficient washing of the pebble may result in high $A1_2O_3$, MgO, iron or carbonates. It should be noted here that washing of the pebble consists of high pulp density, surface attritioning in the log washer. If the impurities are rigidly attached coatings of clay and carbonates, it will be necessary that a careful control of the log washer performance is practiced. Following this, equally critical is the performance of the wash screens that remove the "coatings" previously peeled off by the washer. To identify whether the impurities of $A1_2O_3$, MgO and carbonates are caused by insufficient washing, the following technique is used. The rock sample is fractionated by screening into the —7/8 +16 mesh fraction and analyzed. Then the sample is submitted to vigorous laboratory scrubbing and washing. The scrubbed material is screened through the 150 mesh sieve and re-analyzed. If the impurity level has been improved, then, the problem is poor pebble washing.

The Correlation of Impurities to BPL:

It has been well known to all in the past that the so called typical analysis of processable rock had to be something like the following:

BPL: ≧68-70%
CaO/P_2O_5: ≧1.4-1.45
I&A: ≧2-3%
MgO: ≧0.3-0.4%

Today, with the introduction of low quality rock in the phosphoric acid plant those limits are not sufficient. There is a necessity of correlating the impurities to the BPL included into the rock. There is no doubt for each impurity such as I&A, MgO, carbonates, etc., there should be a ratio of BPL to that impurity above or below of which processability of the rock with the existing technology can be a problem. What we are trying to say then is that when the BPL of the low quality rock decreases, you cannot any longer adhere to fixed values of I&A and MgO as shown above. Figure 7 shows our experience from our attempts to correlate BPL and I&A from plant scale performance. Based on this experience we were further successful in correlating I&A and MgO in a manner by which our mine has now the following major impurities guidelines:

BPL/Mgo	170
BPL/I&A	20
BPL/CaO	1.50

It is to be understood that similar correlations — not necessarily the same as above — may be found for other chemical plants. The major criteria for establishing such correlations should be the type of final products made, the available capacity of the plant to absorb impurity fluctuations, the tilting pan filter's capacity and the Swenson evaporator's built-in over capacity.

Rock Management at the Mine:

Rock management at the mine as a means of controlling and securing the quality of the rock that the chemical plant requires to process economically is one of the factors that have been neglected. Traditionally, the mine is separated from the chemical plant. In the past, when the quality of the rock was high as well as consistent, this separation was not detrimental; today, a close rapport as well as mutual understanding of the technical and economic problems involved between miner and processor are both essential. A miner has to become a little of a chemical engineer and vise versa. When the P_2O_5 recovery at the mine is barely 60-65% of the P_2O_5 in the matrix, the processor will need all the help in the world to make it. With low quality rock, he has to make sure that his efficiency is not affected to the point where the overall recovery from P_2O_5 in the matrix to P_2O_5 in the acid has not dropped to the 50-55% levels and below. In addition to this rapport, the miner has to apply blending as a "sweetening" technique to delineate fluctuation in the rock quality. Up until recently this blending was limited only to BPL. Today, the miner has to learn that between a low BPL rock with processable impurities and a high BPL rock with unprocessable impurities, the former is better for the chemical plant. Separate piling on the basis of high $A1_2O_3$ and MgO products is needed. Establishing a program of blending on the basis of objectionable impurities rather than BPL is recommended. Finally, knowing what you have in your wet rock pile is necessary. An estimation of the tonnage of rock per pile containing various objectionable impurities is necessary. A periodic geo-technical survey of the wet rock storage piles is recommended. In large installations, the application of a reclaiming excavation wheel properly instrumented for running on an x-y-z axis system may be justified.

Required Improvements In
Washer & Beneficiation Plant

Until the time that a new beneficiation and/or chemical processing technique is developed to cope with low quality rock, there is an urgent need for improvements in our existing beneficiation plants. Most of our beneficiation plants have been built during the "fat cows" period, that is when the high grade rock availability was not a problem. Thus, standard designs of washers consisting of one-stage cyclone desliming and two-stage log washing were actually rough means of separating "clay balls" and "loose" slimes. Today, the problems of making a clean pebble are different. It may be that a two or three stage desliming chemically assisted by the use of dispersants is justified. Close control of the pulp density and physical condition of the "shoes" in a log washer can do a good job. Wet attritioners or scrubbers of the type we already have in the de-oiling section of beneficiation may be found to be better than the awkward log washers we use now. All in all, more plant type development work is needed at the washer to increase its capability to extract a cleaner pebble.

While we wait for TVA and the Bureau of Mines to develop new beneficiation and chemical processing techniques, we should not shy away from the challenge of the present to further improve what we already have.

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AUTHOR'S BIOGRAPHY

A. P. Kouloheris is Technical Manager of Gardinier, Inc., Box 3269, Tampa, Fl. 33601. He has over twenty years of experience in phosphate mining and processing, sulfides flotation, and solid-liquid separation. A holder of an M.Sc. in Chemical Engineering, he is a member of AIME and AIChE. He is also the Chairman of TFI's sub-committee for technical and economic process reviews of the low quality rock project presently carried out by TVA and the Bureau of Mines. He is the author of numerous publications and the holder of a number of patents.

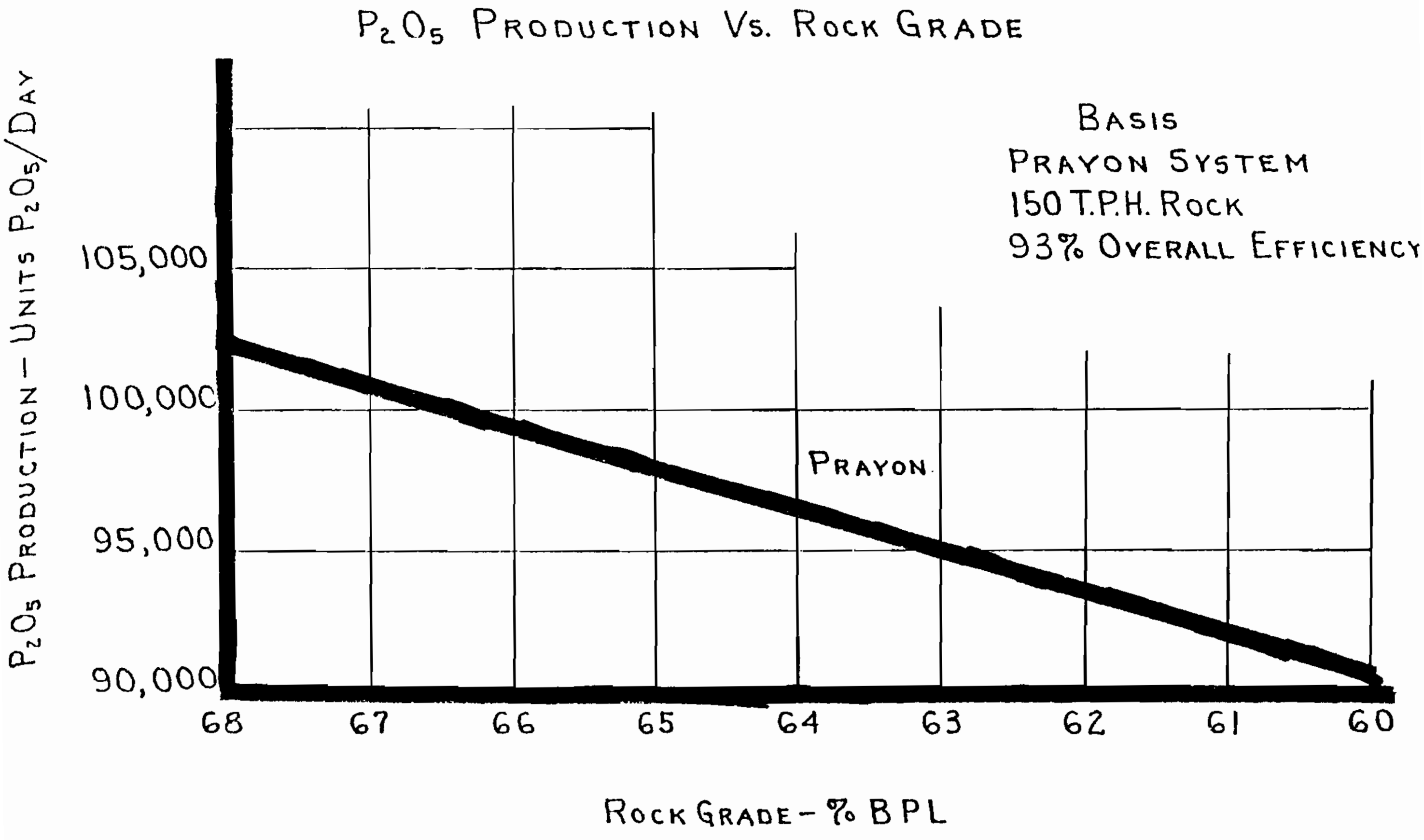


Figure 1
P2O5 Production Vs. Rock Grade

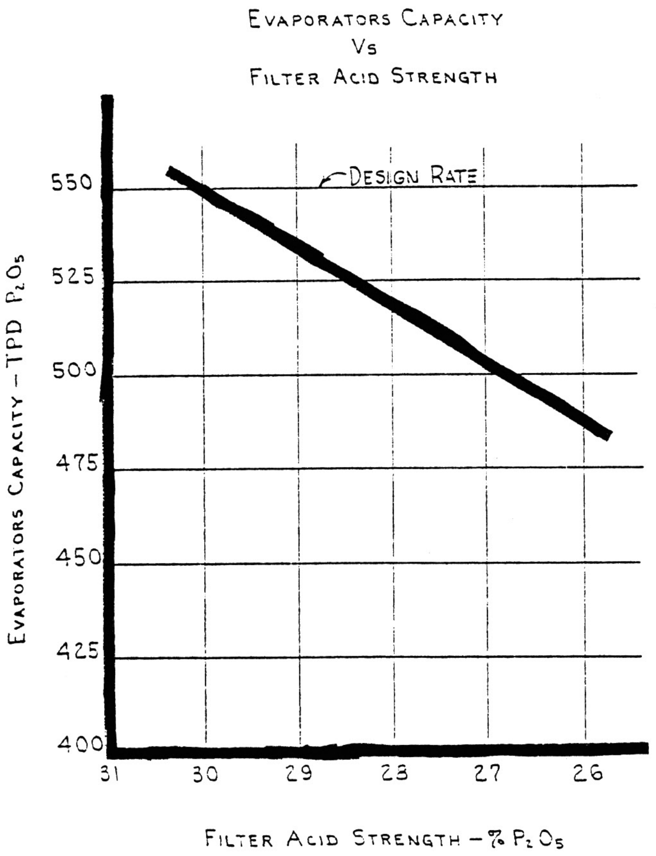


Figure 2
Evaporators Capacity
Vs.
Filter Acid Strength

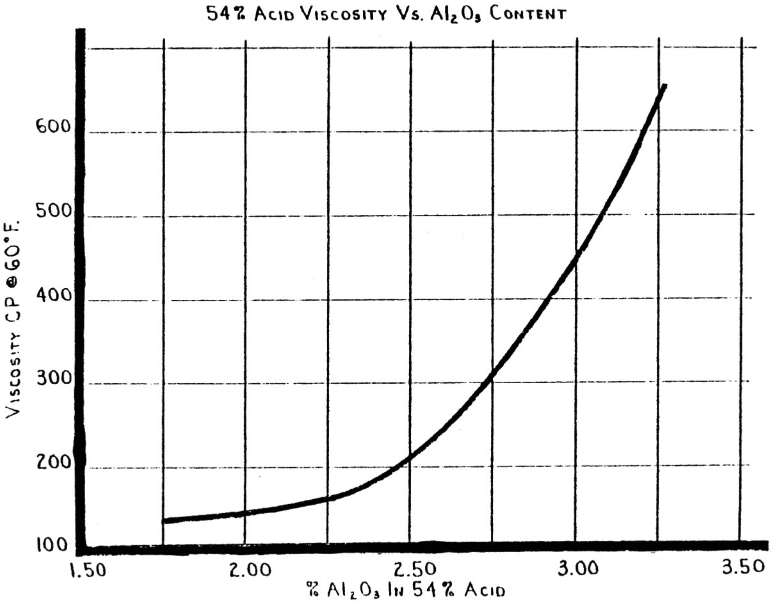


Figure 4
54% Acid Viscosity
Vs.
Al2O3 Content

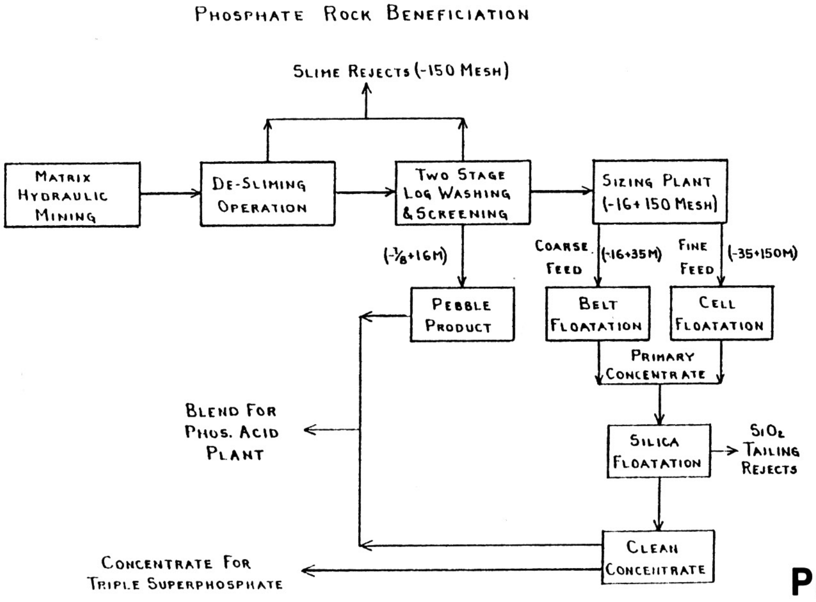


Figure 3
Phosphate Rock Beneficiation

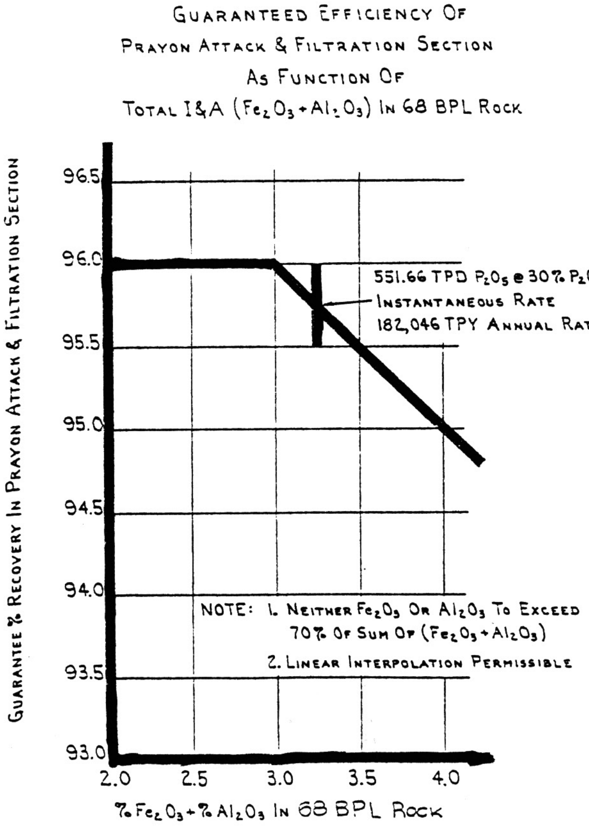


Figure 5
Guaranteed Efficiency Of
Prayon Attack & Filtration Section
As Function Of
Total I&A (Fe2°3 + Al2O3)
In 68 BPL Rock

Pebble To Concentrate Mix Ratios
For Obtaining Low Grade Rock *
With A 0.40 % MgO Content

Concentrate % MgO	Pebble % MgO 0.45	0.50	0.55	0.60
0.35	1:1	1:2	1:3	1:4
0.30	2:1	1:1	2:3	1:2
0.25	3:1	3:2	1:1	2:3
0.20	4:1	2:1	3:2	1:1

* The BPL Range Is 65 To 67 %

Figure 6
Pebble To Concentrate Mix Ratios For Obtaining Low Grace Rock* With A 0.40% MgO Content

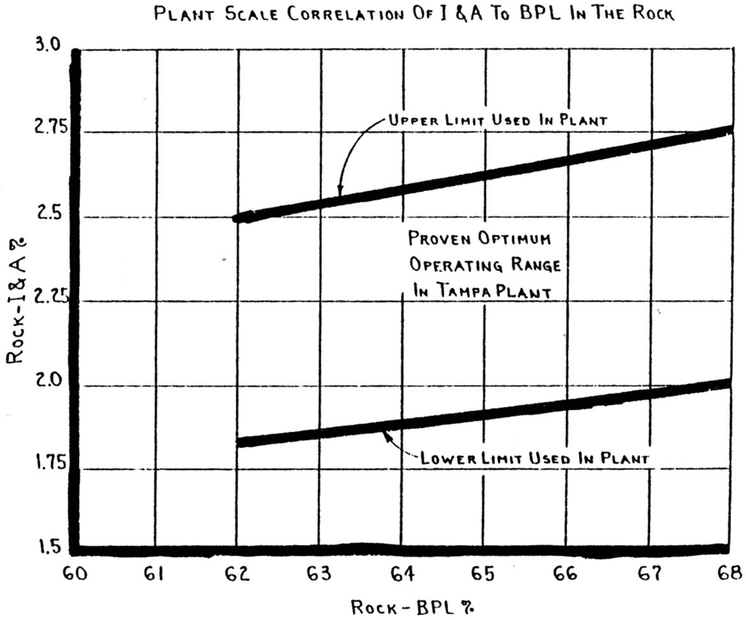


Figure 7
Plant Scale Correlation Of I&A To BPL In The Rock

PANEL CHAIRMAN LEYSHON: Thank you Tas. [Applause]

Tas has covered many of the areas of concern. To overcome at least some of the problems related by Tas I'd like to ask Art Bauman to present some of his experience in the mineral plant and mining and blending techniques for phosphate rock for use in the phosphoric acid plant.

Art Bauman is Manager - Development International Minerals and Chemicals, Bartow, Florida. Art please. [Applause]

Panelist Art Bauman

I've spent the last several years associated with our Mineral Operation and today I would like to discuss some techniques used to control the impurity levels of the rock fed to the acid plant. Blending is one technique that is often mentioned. This technique has been one of the basic tools that have enabled the miner and processor to operate.

The grade and purity of the phosphorite particles in the Florida matrix is a function of its geographical location as well as the weathering or leaching it has received since its deposition. This leaching varies across the ore body because of the surface topography as well as the underlying geological formations and their faults. These natural variations in the characteristics of the phosphate rock make blending an integral and necessary part of any Florida operation that is to ship graded products.

Our blending operation starts by getting the prospect data, sales and mine planning together to determine what is needed from where. Mines Planning then lays out the most economical mining pattern that will satisfy the shipment specifications and schedule. This sounds easy but our production schedules are not always met. We have unscheduled downtime in the mines due to dragline mechanical troubles, weather and electrical service interruptions.

These variations between desire and reality are buffered by our wet rock inventory. Our people like this inventory to be equivalent to 2½ to 3 months' production or at our present production rate — three million tons.

The inventory consists of the analyzed products of both pebble and concentrate from our washer and beneficiation plants. These are deposited in the storage area by product, i.e., pebble and concentrate as well as by grade and Iron and Aluminum contents.

The material when reclaimed from inventory through the tunnel beneath the pile is a blend from several sectors as required to give the customer his desired analyses.

Future operations will also of necessity use wet rock blending as a quality control procedure. In addition to the Central Florida control of BPL, Iron and Aluminum contents we will probably have to follow and control the shipment's MgO content. This is because the matrix encountered in the reserves south of the present operations has wide variations of Mg-O levels.

Foreign operators are facing this problem now. Rocks from India, Peru, Northeast Africa, Asia Minor and the carbonatites of Brazil and South Africa have a carbonate diluent and in some this consists of dolomite which is an MgO source. To date no one has demonstrated a truly efficient process for separating the carbonate minerals from sedimentary phosphate ores.

We are testing what we believe is a feasible method to effectively separate any liberated calcite and dolomite. Additional information on the process will be available when the legalities have been cleared. I can say that no exotic reagents, equipment or procedures are used.

It is clear, however, just as the marketing people yesterday decried the excess of supply over demand — our MgO supply in the rock will exceed the processors demands.

A possible answer to one of the published MgO problems — filter cloth blinding might be found in chemical flocculants.

Flocculants have not found an economic application as a filtration aid in the present Central Florida wet acid plant. They are applied in acid clarification generally at the 40 and 54% P_2O_5 level. One of the reasons why they haven't found a place in the gypsum slurry filtration is the rapidly and easily filtered gypsum crystal produced with Florida rock. Literature references attribute this to the soluble impurity suite present in the digestion slurry and specifically the Iron, Aluminum and Silica values.

High levels of MgO however, have been described as combining with Aluminum and Fluorine values in the digestion slurry to form a crystalline compound called Ralstonite. This compound forms long needle-like crystals which become embedded in the cloth and slow the filter rate. The use of flocculants should coagulate these troublesome crystals and prevent the filter cloth blinding.

In summary, present techniques such as blending will be required with future rock products more so than they are today. New techniques will have to be found, tried and perfected and some techniques such as chemical flocculation will find a new application when this type of rock enters the marketplace. [Applause]

PANELIST CHAIRMAN LEYSHON: Thank you Art. [Applause]

I would like now to call on George Shearon, General Manager, C.F. Industries, Plant City, Florida. George will cover the effects of some impurities on the production of phosphoric acid using a wet ground rock slurry. Does wet rock grinding make it easier or harder to handle lower grade rocks? George please. [Applause]

Panelist George Shearon

Two years ago I had the pleasure and opportunity to speak before the Fertilizer Roundtable regarding our experiences related to wet rock grinding. I would like to take this opportunity to bring you up to date, as to where we are at the present time, and make you aware of some observations that we have made during the past two years.

Quickly, I would like to cover the following items:

- Our early problems with wet rock grinding.
- Our observations related to plus 35 mesh, rock quality related to the clay content, CO_2 content of the phosphate rock, acid insoluble content in the phosphate rock, and operating with phosphate rock of varying levels of P_2O_5 or BPL.

First, I would like to make you aware of the type of phosphate rock that we normally process in our Plant City Complex. The BPL of the rock is normally 64% to 69% as received and over a period of a month, it will average 66.5 BPL to 67.5 BPL. The I and A to P_2O_5 ratio normally will stay between 0.08 to 0.09 and on occasion will go up to 0.10. When we operate for an extended period of several days at a I and A to P_2O_5 ratio greater than 1.0% we begin to have problems with DAP grade control. Our MgO runs at a 0.45% to 0.50% level. The source of our rock is two to three processers with the processers having several beneficiation plants and mining locations. In other words, a variable supply of phosphate rock. We process both pebble and concentrate in our plant.

Our normal procedure is to blend for BPL and I and A and at the same time blend rock considering the rock clay content. We do have highly variable BPL and I and A receipts.

Regarding phosphate rock quality, it is essential that the phosphate rock received be free of mud balls, slime and clay particles. A phosphate rock producer must insure that the phosphate rock that they ship to a wet rock grinding system is clean and free of clay. If the rock is not free of clay as produced, it should be sent to some other location, not to a wet rock grinding processer.

Another observation made was that the very fine phosphate rock produced by flotation from debris areas produces characteristics in the wet rock grinding system very similar to rock containing clay.

Clay in phosphate rock processed in a wet rock grinding system will cause slurry thickening, result in poor screening for a closed circuit system and can result in sanding out of the ball mill. The transfer of the rock slurry for any distance at all will be severely restricted if the rock contains any substantial amount of clay. Because of the clay, it is necessary to add additional water to reduce the slurry viscosity. This additional water causes an unfavorable water balance condition in the phosphoric acid plant and reduces the amount of water available for gypsum cake washing. Poor rock quality related to clay content can result in a substantial reduction in chemical efficiency when compared to clean rock.

During the past two and a half years, we have processed essentially all of the dirty rock that we initially had in our storage pile. Also, the receipts from the phosphate rock processers, for an extended period, have normally been quite good. In addition, it has been necessary for us to look for other methods to solve our clay problem, and we have experimented considerably with additives in the wet rock grinding system. We have had varying degrees of success and have used additives fairly frequently to aid in the problems of clay content.

During the past several months we have operated with essentially all clean rock and we have had a substantial increase in the chemical efficiency of our phosphoric acid plants. This recent chemical efficiency has been consistently at 1.0% and sometimes 2.0% greater than the efficiency experienced with dirty phosphate rock. We have experienced considerably less variations in free sulfuric acid and have had more consistent operation of the phosphoric acid plant. We have also had much less problems with foam control and have been able to reduce our defoamer consumption.

Recently our plant people met to brainstorm and analyze the factors that we would consider as significent in affecting the chemical efficiency or contributing to poor chemical efficiencies when processing "dirty rock". When we put things together we really get back to the basics. Simply, the processing of the "dirty rock" or the rock containing clay prevented us from producing a rock slurry at the wet rock grinding mill, of consistent solids content and of sufficient solids content to allow us to provide an adequate wash on the back end of the filter. This prevented us from obtaining the proper water soluble P_2O_5 recovery. In addition, the variable slurry solids content did not allow us to maintain a consistent mass flow of phosphate rock to the digestion system. To add to the problems, the accuracy of the density and mass flow meter system was affected by the changes in the type of the rock and the clay content. This variable rock feed to the digestion system resulted in extremely poor free sulfuric acid control causing serious problems with the chemical efficiency.

Another associated problem with rock containing clay is the rapid buildup in the Bird Prayon filter grids, resulting in poor gypsum cake washing, reduced recoveries, and required that we reduce rates to keep the losses to a minimum.

Regarding the phosphate rock BPL, we have processed blends of rock from 65% to 69% BPL. When we have good feed control we have found no significent difference in the performance and the chemical efficiency of rock blends between 65% and 67% BPL content. However, with lower grade rocks we found it necessary to reduce the specific gravity in the reactor to allow us to maintain filtration rates.

Regarding CO_2 levels, we found that rock CO_2 levels greater than 4% result in excessive problems of foaming and prevent us from maintaining the desired production rates. When we receive and process rock with high acid insoluable levels, we find that excessive quantities of SiO_2 settle out in our gypsum launder resulting in buildup and overflow. Finally, when we process ground rock with a 35 mesh fraction greater than 6%, we have chemical efficiency and control problems.

When we take a real good look at the phosphoric acid plant operation, we simply get back to the basics. It is essential that we have good feed control of the sulfuric acid, the phosphate rock, the phosphate rock BPL, and it absolutely necessary that the correct procedures for the washing and maintenance of the filter and other associated equipment be carried out. These keys to the success of a phosphoric acid plant are the same requirements that have been around for a very long period of time.

I should mention, that as we see it, things have changed over the years. We do not now maintain the same chemical efficiency in the phosphoric acid plant with the present receipts of lower grade phosphate rock as we did approximately 10 to 15 years. When we compare current experience and the experience in the past with the premium Central Florida 68 BPL pebble rock, we find that our current chemical efficiency is approximately 1.5% to 2.0% less than obtained at that time. Times have changed and the chemical efficiencies have changed, however, the techniques that have been used over the years to properly control a phosphoric acid plant are as essential now or are in reality more essential now than they ever were in the past.

PANELIST CHAIRMAN LEYSHON. Thank you George.

One major area we like to cover here is I. & A. and MgO and other soluble impurities.

I'd like to comment on Figure 5 which Taas showed, which is a correlation of yield vs. I. & A. across a Prayon digestion and filtration system. I think this curve is somewhat pessimistic in terms of the effect of I. & A.

The curve is similar to one which was in use by Dorr-Oliver in the early 1960's and was based on some data from an early cascade digestion system in Florida. Our more recent data would indicate a more general curve would show less effect of I. & A. on yield through digestion up to a point somewhere in the range of 0.15 I. & A./P_2O_5, around 4.5% I. & A.; in fact there is some feeling that higher levels of I. & A., particularly iron, may not be severely damaging to filtration or yield. Florida rock, of all the world's phosphates, yields one of the best filtering gypsums, if not the best, and P_2O_5

recoveries are also good, despite relatively high I. & A. levels. The downstream effects of high soluble impurities on fertilizer product grade are still there, of course.

One approach to the I. & A. problem, because it does exist if you want to make 54 or super acid or liquids or 18-46, is to blend high I. & A. rock with lower I. & A. materials.

G.M. (Mike) Lloyd would like to talk to you to present some ideas along this line.

Mike is Technical Assistant to the Vice President (maufacturing) at Agrico.

Panelist G. M. Lloyd

Agrico has long recognized that all South Florida rock users will be faced with increasing problems of "low grade" and/or "low quality" phosphate rock as the better quality rock reserves are depleted. In order to be ready to cope with the problems discussed by Taas in his opening remarks, Agrico has evolved blending-segregation procedures to insure optimum utilization of rock reserves while providing each of our chemical plants with rock of a specified quality. Rock quality specifications for each plant are a function of the product mix to be shipped from that plant. To date we have had relatively little opportunity to work with very low grade rock and have limited our efforts to I. & A. control.

Since we operate more than one mine with two or more draglines, we are able to both mine selectively (to a limited degree) and blend-segregate to produce a multitude of phosphate rock end products. In addition, the operation of our chemical production facilities offers a unique opportunity to regulate the impurity content of the rock supplied to each plant. In Florida, at our South Pierce Chemical Plant, we produce GTSP and 54% merchant acid. In Louisiana, at our Faustina Chemical Plant, we produce DAP and MAP. Therefore, we have an opportunity to use a "high quality" phosphate rock at Faustina and a "low quality" phosphate rock at South Fierce and produce on grade products at each location.

To achieve these goals, our blending must satisfy the following demands:

1. Customers — Grade and impurity content defined by contractual agreements.
2. Faustina — Impurity content is .08 maximum I&A/p_2O_5 ratio. BPL is of secondary importance from a chemical processing viewpoint; however, freight considerations do dictate a minimum acceptable BPL.
3. South Pierce — Impurity content limited to .1 maximum I&A/P_2O_5 ratio. Day to day BPL variations are held to a minimum and lowest possible acceptable BPL has not yet been determined.

While we use the I&A/P_2O_5 ratio as a primary standard for measuring phosphate rock quality for chemical processing, we are equally concerned with the MgO content of the phosphate rock since it is obvious that the ability to tolerate MgO will be affected by increased I&A content. In actual practice we are inclined to view an excessively high MgO level with at least as much concern as we show for an excessively high I&A content. We do monitor and exercise a more limited control of MgO/P_2O_5 ratios and we will expand this control function if and when we start consuming South Florida, or other similar phosphate rock, in our chemical plants. MgO can be a particularly bad actor in a chemical fertilizer plant and there is little or no doubt that we will find it necessary to develop new and/or more specialized approaches to chemical processing in order to successfully and economically convert high MgO content type phosphate rocks into satisfactory chemical fertilizer products.

Our phosphate rock impurity content control is initiated by decisions made with respect to dragline mining sites or locations. With more than one dragline at each mine we can mine to blend or segregate by dragline all pebble phosphate rock at various stages in the phosphate rock washing operation. Separation or combination is made on the basis of grade and/or impurity content. We are flexible enough that we can mine "high quality" phosphate rock with one dragline and "low quality" phosphate rock with a second dragline and either store each phosphate rock product separately, or blend them as they go onto or off the wet rock storages at the Mines and Pierce.

While blending may well be considered as the ultimate answer to "low grade" phosphate rock utilization, we do not consider blending as an adequate answer to the problems associated with utilization of "low quality" phosphate rock. This practice serves only as an interim solution that enables us to meet the specifications for phosphate rock impurity levels as determined by our present chemical plant operating demands. Blending could answer any Florida phosphate rock impurity problem if it were economical to blend Florida phosphate rock with phosphate rock from other parts of the country or world. It might even be possible to obtain a mixture that would retain the best chemical processing characteristics of each phosphate rock component.

We are always seeking other solutions and remain interested in conducting both laboratory and plant scale of methods that might modify the behavior of Fe, A1, and/or Mg in the phosphoric acid manfacturing process so that excessive amounts of these impurities could be eliminated (perhaps filtered out and discarded with the by-product gypsum) in a practical and economical manner during normal phosphoric acid chemical processing.

Whether or not a practical mining or chemical solution to chemical plant phosphate rock quality problems is developed in the near future, we will remain strongly committed to blending as a prime means of providing the best possible consistent quality phosphate rock feed to our chemical plants.

I am certain that it would be difficult to achieve a consensus among this group as to a proper definition for "low grade" and "low quality" phosphate rock and I am certain that Agrico's definition may well change in the future but this problem, no, I should say this opportunity will definitely influence the future of our industry.

Thank you for the opportunity to present my views on this subject. [Applause]

Questions and Answers

PANEL CHAIRMAN LEYSHON: Are lower grades an answer? Could the fertilizer industry achieve higher productivity by reducing slightly the product grades of TSP and DAP?

This has already taken place to a degree in TSP where several producers have been or are making a 44 APA grade.

I. & A. (as oxides) to P_2O_5 ratios of 0.12 to 0.18 (equivalent to up to about 5% I. & A. in 30% P_2O_5 rock) will make DAP grades of in the range of 16-48 to 15-45. Because the impurities are mainly catonic they displace ammonia and therefore the P_2O_5 to N ratio will be higher for the mol ratios we presently make.

Before we open discussion and questions from the floor, I have one more comment. We've dealt with the problems of impurities in Florida rock mainly in this discussion. However, Florida rock, even in the 62 to 68 BPL range ranks as one of the world's best phosphatic raw materials. It is low in sulfuric acid requirements and highly productive in terms of P_2P_5 filteration capacity.

In conclusion, we have not really offered many solutions to the problems of handling higher levels of impurities. We hope that present work going on in this area will lead to new solutions and that this discussion of the problems will contribute to increased interest. [Applause]

Panelist Shearon

The CAO and the P_2O_5 is slightly higher for the lower grade rocks. But I don't think that we have really seen a real significant difference that we have really measured.

DAVE LEYSHON: I would say that if you say 2.8 or 2.85 tons of sulphuric per ton of P_2O_5 to go down in BPL it might be a .05 on that. Let's say 2.9 versus 2.85, something like that.

PANELIST KOULOHERIS: It depends. I think in all fairness we have to say that you have to define your problem. If your problem of having a 64 BPL is also associated with high carbonates, then most probably the ratio of Calcium Oxide to P_2O_5 is going to be greater and you will expect them to have a greater consumption of sulphuric acid. You will also have a lot of foaming too. But in the areas of low grade rock that we talked about - we have not reached yet an area of high calcium oxide. So we are within limits of sulphuric acid. If you do go into a carbonate rock associated with let's say 60 BPL and CAO to P_2O_5 of 1.8, you are getting into trouble.

DAVE LEYSHON: Thank you. I think one more point would kind of establish maybe an upper limit some of the work that has been done on direct acidulation of matrix would indicate that the sulphuric acid to P_2O_5 requirement is somewhere around 3.0 to 3.1, which is the ultimate or maybe the ultimate. I don't know, — at least in the matrix samples that have been processed.

BUD DAVIS, TVA: Direct acidulation of matrix was mentioned yesterday and again today. I wonder, in view of the type of rock we will be dealing with in the future in Florida, what the panels' view is on the technical feasibility on this approach?

DAVE LEYSHON: Does anybody here want to tackle that question? Art Bowman I will give that easy one to you.

ART BOWMAN: In regard to the rock of the future, so to say, which will be in South Florida where the present mining operations are. The technique increases to be more complex than in Central Florida with the matrix containing clays, silica and phosphate particles. In South Florida we will have clays, carbonates, silica and phosphate particles. Consequently, the carbonate content will increase the sulphuric acid consumption even higher than what Dave was saying about acidulation of Central Florida matrix. So it will be more costly to go that route.

Another thing in light of the problem that George has had grinding with small portions of clay, there would have to be a technique worked out to grind the material, the coarse material, in order to get the acidulation efficiency expected in the plant.

ALAN LONGACRE, Fluor E&C Inc.: I would like to ask the panel in general what the experience would be in declining BPL concentration with the possible increase of halides such as fluorine and chlorine? Is this apt to be a problem with declining BPL?

DAVE LEYSHON: Art Bowman, I will ask for your comments.

ART BOWMAN: If I understand the question "You are asking about the increasing fluorides in low grade rock?"

ALAN LONGACRE: Is it a problem?

ART BOWMAN: I think it is because fluoride enters into most of the complexes which give problems in present operations. So it will be even so as we get to possibly higher levels of impurities such as magnesium and in solution.

DAVE LEYSHON: I will turn the meeting back over to Herman Powers here and that will conclude our panel discussion. We hope to be able to perhaps discuss this subject again in the future. Thank you. [Applause]

MODERATOR POWERS: Our next speaker is Mr. M.C. Manderson. He is a native of West Texas. He started in the fertilizer industry with Armour and spent some 15 years with Arthur D. Little in the Economic Analysis Division and presently he is head of his own consultant firm in Florida in Agricultural Chemicals.

Today he will speak to us on Sulfur — Sulfuric Acid Outlook in the Late 1970's. Mr. Manderson please. [Applause]

Sulfur-Sulfuric Acid Outlook In The Late 1970's

M. C. Manderson

DEMAND OUTLOOK

NORTH AMERICA

United States

A review of sulfur uses in the United States serves as a good introduction to world uses because United States sulfur applications are extremely varied. The United States enjoys the unique position of being heavily developed both in agriculture and in industry, and sulfur use is about equally split into these sectors on a world basis.

At the present time, about 45 percent of United States sulfur use goes into the production of phosphatic fertilizers for domestic consumption, and another 10 percent is utilized for producing phosphates for export. Another 4 percent is used for producing nitrogen and potassium fertilizers. In total, the fertilizer market accounts for slightly under 60 percent of sulfur use in the United States, of which 10 percent is for export. The balance of about 40 percent is split into a wide variety of different industrial applications, of which no single use accounts for more than about 5 percent of the total. This balance of about 60 percent agricultural and 40 percent industrial also holds true for the world as a whole, but can vary widely from country to country, depending upon the degree of industrial development. Sulfur use in a highly developed nation, such as Japan, with limited agricultural area, will be mostly for industrial uses. Conversely, in a developing nation such as Morocco or India, the majority of sulfur use will be for fertilizer manufacture.

In the future we expect that fertilizers will account for a gradually increasing share of sulfur consumption, both in the United States and for the world as a whole, whereas the use of sulfur in industrial applications will slowly decline in relative importance.

The relatively mature growth outlook for non-agricultural uses of sulfur is caused by various reasons, the most important of which, overall, is that competitive processes, which do not require sulfur, have gradually made headway in the chemical and allied products field. While each of these shifts away from sulfur use has been individually small, they have collectively brought about a maturing industrial sulfur market. Also, some products based upon sulfur (or sulfuric acid) have tended to lose position in the marketplace to more versatile and less expensive materials. For example, cellulose-based packaging products have in recent years lost position to petrochemical-based plastics, which do not require sulfur as a raw material. The manufacture of titanium dioxide pigments, which originally was produced only via a sulfuric acid-based process, is now giving away to a chloride-based approach, which offers not only a high quality material but also reduces undesirable wastes. In similar fashion, the traditional use of sulfuric acid for the pickling of iron and steel has been partially supplanted by a chloride-based process. And the maturing or declining demand for fluoride-based products in aerosols and as refrigerants due to environmental questions, will adversely affect sulfuric acid use for the production of hydrofluoric acid.

On balance, we expect that industrial uses for sulfur in the United States will grow at only about 1 percent per year over the coming five years or so, even though there will likely be robust future growth for sulfuric acid in the leaching of uranium ores. The use of sulfuric acid for leaching of copper oxide ores also has promising growth prospects, but not until after the current world oversupply situation for copper disappears and price levels recover.

On an overall basis, we expect that United States demand for sulfur values will increase at about 3.5 percent per year over the next decade. This growth rate assumes that no significant impact occurs in the use of sulfur for new applications. We will touch on this point later in the discussion.

Canada

At the present time, Canadian sulfur consumption is about 1.4 million long tons per year, or one-eighth of United States comsumption of about 11 million long tons. About 70 percent of this 1.4 million long tons goes into the production of fertilizers. This rather high dependence on phosphatic fertilizer production is caused by the fact that Canada has a somewhat more highly developed agricultural sector than industrial sector, particularly in the western area. Also, Canada's heavy dependence on phosphates for its sulfur utilization is partly caused by the fact that a substantial percentage of its phosphate production is exported to the northern fringe of the United States. If exports were removed from both the United States and Canadian production figures, it is likely that the two countries would have about the same share of sulfur going into domestic fertilizer use — about 50 percent of the total.

We expect sulfur use in Canada to grow at 4 to 4.5 percent per annum over the next decade, from about 1.4 million tons to about 2 million tons by 1985. The use of sulfur for fertilizer manufacture will continue to account for about two-thirds of Canada's sulfur requirements.

World Demand

At the present time about half of world sulfur use is divided equally between North America and Western Europe, and about 25 percent is concentrated in the Communist countries and about 15 percent in the Far East and Oceania. The remaining 10 percent is scattered throughout the rest of the world — in Latin America, Africa, the Near East, and the Middle East.

During 1976, world sulfur comsumption in all forms was approximately 42 million long tons of sulfur equivalent, or about the same as in 1974. The recent static demand was largely due to the collapse of the world phosphate fertilizer market in 1975, when historically high prices temporarily developed. With phosphate prices now sharply reduced and apparently stabilized, we are now observing renewed phosphate fertilizer demand, and hence a resumption of global growth in sulfur. Since 1965, world sulfur use has grown at an average rate of slightly below 5 percent per year, and we expect the growth outlook for this material to average between 4 and 4.5 percent per annum over the coming decade. We estimate that world sulfur demand will grow from the present level of about 42 million tons per year to between 60 and 65 million tons by 1985 — or about a 50 percent increase.

The somewhat slackened growth prospects for future sulfur use are accounted for by a number of factors, the most important of which is that comsumption of phosphoric fertilizers is now concentrated largely in the developed nations of the world and has begun to mature. Since sulfur used in the production of fertilizer phosphates accounts for about 50 percent of total world sulfur consumption, this particular end-use is of overriding importance in determining the long-range growth prospects for sulfur.

New Sulfur Uses

On the demand side, we have not given consideration in this discussion to possible new applications for sulfur. It is well know that considerable work is now underway to uncover new uses for sulfur, especially for construction purposes. Most of this effort is now centered on the use of sulfur as a partial substitute for either asphalt or aggregate, or both, in highway construction. In addition, some interest has recently developed in the use of sulfuric acid as an additive to irrigation water for treatment of alkaline soils in the southwestern United States, to improve the physical structure of the soils, and to bring about a more efficient release of soil nutrients. Also, the use of sulfur as an ingredient in concrete for construction purposes, its use as an ingredient in foams for insulation and in corrosion-resistant coatings has also been considered.

The potential market for sulfur as a partial substitute for asphalt in new highway construction and in repair of old roads is especially large. Based upon research work, sulfur use for this purpose could amount to 5 million long tons per year or thereabouts if sulfur replaced 30 percent of the asphalt now going into hot-mix paving in the United States.

Since total domestic sulfur consumption is now about 11 million long tons per year, even a modest penetration in the asphalt paving market could considerably improve the market outlook for sulfur. And this does not include the possibility of sulfur being used to replace some of the underlying aggregate in the road base— another application which offers promise in areas where coarse aggregate is not locally available.

Of course, the cost of sulfur must be favorable in order for this application to have serious impact in the near term. In the United States, asphalt now costs in the range of $55 to $60 per ton, or about the present price of sulfur. We believe that sulfur must be priced significantly below the cost of asphalt in order to facilitate reasonably rapid penetration into this market. This (economic) limitation, plus the conservation stance which most highway departments take in testing and screening new materials, suggests that sulfur use in hot-mix asphalt paving will not develop into a significant volume market in the United States within the next several years. On the other hand the prospects look considerably better in Western Canada, where sulfur prices are about 90 percent lower than in the United States.

SUPPLY OUTLOOK

NORTH AMERICA

United States

A review and forecast of sulfur production in the United States, broken down by sources of supply, is shown in the accompanying table. In 1976, the United States produced about 10.5 million long tons of sulfur equivalent, of which about 9.5 million tons were in the form of brimstone and about 1.0 million tons were in the form of by-product sulfuric acid from non-ferrous metals smelting. United States production for 1980 is estimated at between 12.5 and 13.0 million long tons.

- *Discretionary Production—Frasch Sulfur*

Over the coming few years, we expect that production of discretionary sulfur— primarily from Frasch operations— will increase only moderately above current levels because of the rapid increase in production of non-discretionary sulfur and sulfuric acid from petroleum and smelting. As the chart shows, the recovery of by-product sulfur values has increased rapidly in the past few years and we expect this trend to continue. This suggests that the share-of-market for Frasch sulfur will continue to decline.

- *Non-discretionary (By-product) Production*

U.S. by-product sulfur and sulfuric acid production

UNITED STATES: PRODUCTION OF
ELEMENTAL SULFUR AND OTHER SULFUR VALUES

(In Millions of Long Tons of Sulfur Equivalent)

	1970	1974	1976	1980 (Est.)	Annual Growth Rate 1970-76	Annual Growth Rate 1976-80
Frasch Sulfur	7.1	7.9	6.3	6.7	- 2%	+ 2%
Recovered Sulfur:						
Refinery	1.5	1.4	1.9	2.7	+15%	+ 9%
Sour Gas	-	1.2	1.3	2.0	+11%	+11%
Subtotal (By-Product)	1.5	2.6	3.2	4.7	+13%	+10%
Subtotal (All-Elemental)	8.6	10.5	9.5	11.4		
By-product Sulfuric Acid	0.5	0.7	0.9	1.2	+10%	+ 7%
TOTAL	9.1	11.2	10.4	12.6	+ 2%	+ 5%
(% from By-Product Sources)	(22%)	(29%)	(39%)	(47%)		

presently stands at slightly over 4 million long tons per year of sulfur equivalent. We estimate that recovered non-discretionary sulfur values will increase substantially in volume over the next few years to about 6 million long tons per year by 1980— or at an average increase of about 10 percent per annum.

This substantial rise in by-product recovery will come about for a combination of reasons. The recovery of sulfur from imported sour crudes will increase steadily because of tightening air quality standards in the United States. The diminishing supplies of natural gas, due largely to the Government's past policy of pricing it as a waste product and thereby offering limited incentive to develop higher cost reserves, has now reached the point where the need for sharply higher prices seems to be recognized. These higher prices will no doubt stimulate the search for and development of new reserves, part of which will produce sulfur as a by-product.

Of special regional interest will be the dramatic increase in by-product sulfuric acid recovery by the copper industry in Arizona and New Mexico. The Western States and the Federal Government have set much tighter air quality standards, and so the copper smelters are now embarked upon a major cleanup program in which the sulfur-containing smelter gases will be scrubbed to remove sulfur dioxide and the sulfur dioxide converted into sulfuric acid. As recently as 1970, less than 1 million tons of sulfuric acid was produced in this area. The current (1976) level of acid production has now increased to about 2.0 million tons per year, and by 1980, this total could exceed 3 million tons per year, if the U.S. copper industry were to recover from the present world oversupply and severely low prices. Since the Southwest is not industrially developed, such a large increase in sulfuric acid production is bringing with it the need to find distant markets for the output.

While there will probably be other sources of by-product sulfur production emerging in the United States, such as from coal gassification and from shale oil, we do not believe these will have any material effect on the sulfur supply picture until at least the mid-1980's.

Canada

Over the past decade, Canada has become the world's second largest producer and exporter of elemental sulfur. With a fivefold increase in sulfur production having occurred in Canada over the past ten years, the question arises as to what future production levels are likely to be in the decade ahead.

After reviewing the basis for Canada's past sharp increases in brimstone production, we conclude that Canada has now reached its maximum sulfur production level— at least for the next five years or so. Almost all of Canada's increased production has come about through the discovery and development of sulfur-containing gas reserves in the province of Alberta. Observers of the petroleum scene in western Canada have noted that the rate of new sour gas discoveries in Alberta has dropped over the past few years. On the other hand, a renewal of exploration activity in the foothills of the Canadian Rockies in Alberta and British Columbia (where most of the sour gas has been discovered) now seems to be taking place which, in time, could bring about a new wave of sour gas projects.

The accompanying table shows the past and near term outlook for sulfur supplies in Canada. We anticipate more or less a static situation between 1976 and 1980 where a modest decline in sour sulfur will be offset

CANADA: PRODUCTION OF ELEMENTAL SULFUR
AND BY-PRODUCT SULFURIC ACID
(in millions of long tons of sulfur equivalent)

	1970	1974	1976	1980 Est.
ELEMENTAL				
Sour Gas Sulfur	4.2	6.8	6.3	6.0
Refinery & Heavy Oils	--	0.1	0.1	0.2
Subtotal	4.2	6.9	6.4	6.2
BY-PRODUCT SULFURIC ACID	0.4	0.6	0.7	1.0
TOTAL	4.6	7.5	7.1	7.2

by an increase in smelter acid production. However, this rather prosaic near-term outlook should not be interpreted for developments which might occur after 1980. There now exists a great deal of uncertainty about the direction which sour gas sulfur production will take in the 1980-1985 period— just as there is about the level of by-product acid production in the early-to-mid 1980's.

If the renewed interest in exploration in the foothills area uncovers significant new reserves of sour gas, then sulfur production in Alberta would likely recover to past levels by the mid-1980's. If not, then sour gas production in Western Canada could tail off rather sharply.

The Canadian non-ferrous smelting industry is now beginning to face the same environmental pressures for SO_2 cleanup that its U.S. counterpart faced a few years ago. Thus, we anticipate further increases in by-product acid recovery from Canadian smelters in the post-1980 period. Canada has the potential for at least doubling its by-product acid output during the 1980's. And the marketing of such a large increase in Canadian production could have as profound an impact on the North American acid market as the smelter acid developments already taking place in the U.S. Southwest.

World Supply Outlook

Over the coming few years, there appears to be no major new developments in terms of overseas sulfur production. Large desulphurization projects are now under way or planned in the Middle East, but their impact will not be felt until the early-to-mid 1980's. The largest sulfur output will occur in Saudi Arabia under a phased program of desulphurizing the associated gas which is now being flared, which as of June 1977, was approximately as follows (design rate):

Starting in 1979	1500 tons per day
By the End of 1980	1000 tons per day [additional]
By the End of 1981	400 tons per day [additional]
By the End of 1982	900 tons per day [additional]
	3800 tons/day
	1.33 million long tons per year

As plans now stand the marketing of this sulfur will not be handled by ARAMCO, but rather by PETROMIN, the Saudi Government's oil agency. The initial production will be stockpiled and so the world market will probably not feel the impact of Saudi brimstone until at least the early 1980's.

Transportation difficulties will continue to pose problems for expanding sales of Iragi sulfur from the Frasch deposit of Mishraq in Northern Iraq. There is recent evidence that Poland's growing internal needs for sulfur, plus some modest curtailment of Polish production, will reduce Poland's recent practice of competitive pricing in the Western European market.

In summary, we estimate that world sulfur production capability will expand by about 9 million long tons between 1976 and 1980 from about 52 million to 61 million tons. About one-third of this increase will take place in each of three regions— the Western Hemisphere, Europe, and the Middle East-Far East.

As is true for North America, it appears that world supply developments after 1980 could be more interesting than that which we foresee over the near term— largely due to the projects that will emerge in the Middle East.

Supply-Demand & Price Outlook

The accompanying table presents the supply-demand outlook for North America (i.e., for the U.S. and Canada) for 1976 and 1980. After allowing for net exports, we conclude that about the same potential over-supply will exist in 1980 that existed in 1976— representing about 3.5 million long tons or 25-30 percent of local annual demand.

This fairly uniform relationship between supply and demand suggests that there will be limited pressure for any dramatic change in the competitive environment or in sulfur prices over the near term. On the other hand, it is possible that short-term supply imbalances in one region or another could precipitate changes in the competitive atmosphere which could trigger price changes. Also, the rising costs of energy may be expected to bring about a gradual increase in production costs, especially for Frasch sulfur, which in turn could influence sulfur pricing in the next year or so.

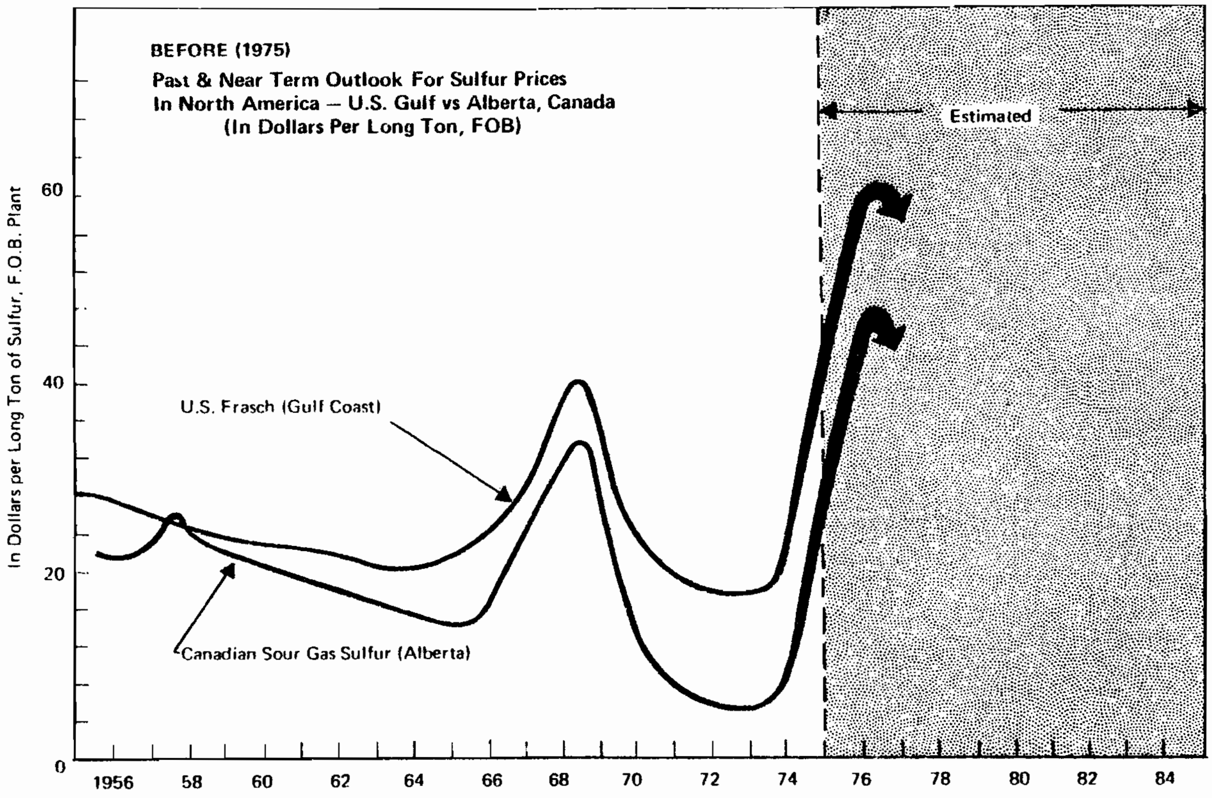
When we discussed the sulfur price outlook about two years ago at the Chemical Engineer's convention in Los Angeles, we predicted some weakness in prices due to the drop-off in world phosphate fertilizer demand (and hence in world sulfur demand) that appeared to be occurring at that time. A copy of the price chart that was presented in 1975 is shown here, along with a recent up-date of prices for U.S. Frasch and Western Canadian sulfur since that time.

As the chart shows, sulfur prices have leveled or weakened in the past two years, with the greatest decline occurring in Western Canada. There appears to be a reasonably good chance that Canadian prices will strengthen somewhat during 1978, due in part to the banner year which the sour gas producers are having in the export market.

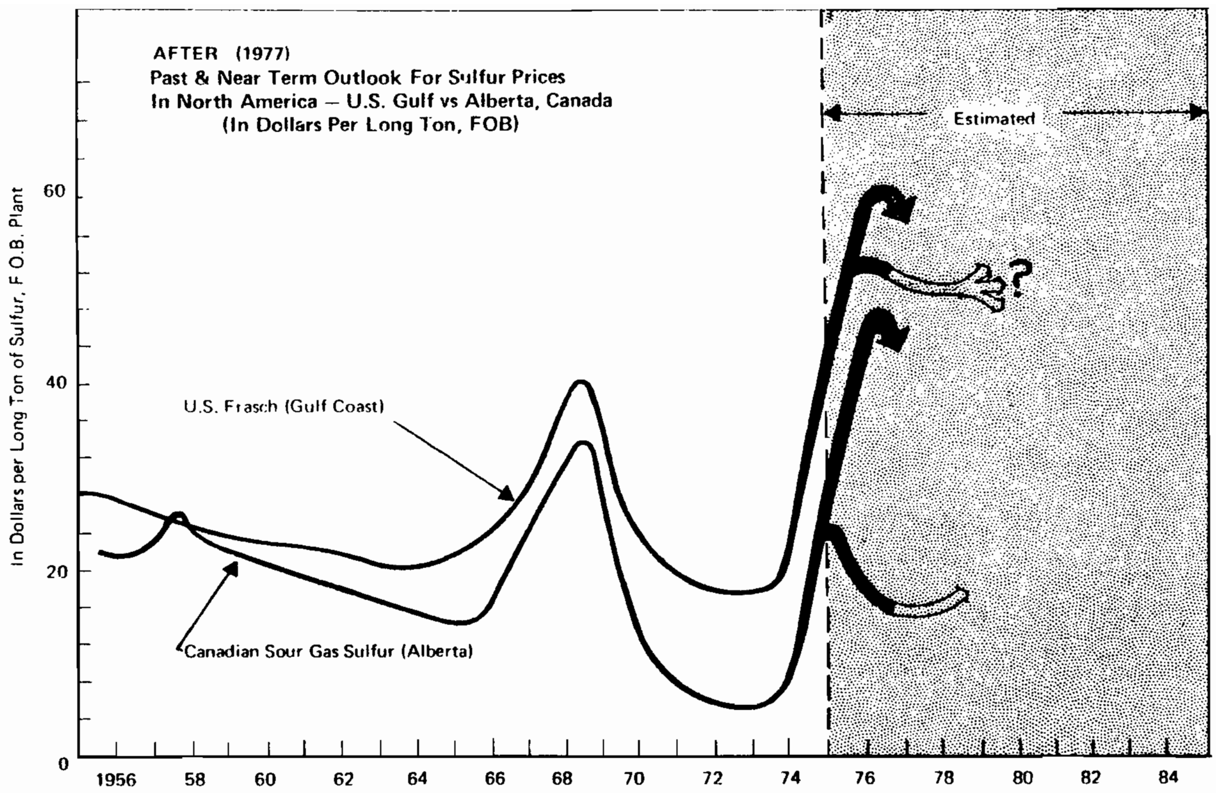
The near term sulfur price outlook for the Gulf Coast producers is more uncertain, because of the emerging threat of sour gas sulfur from Western Canada penetrating the U.S. Frasch producer's largest and most lucrative market— the phosphate district in Central Florida. Also, the price of Gulf Coast exports to Europe has weakened in recent months due to increased competition from Poland. Chances for stable prices for Gulf Coast sulfur, or conceivably, modestly higher prices would be enhanced if the price of sour gas sulfur in Canada does increase in the near future and if, as some observers believe, sulfur stocks in Poland are now moving to sufficiently low levels to reduce aggressive stance in seeking export sales.

NORTH AMERICAN SULFUR
SUPPLY-DEMAND, 1976 and 1980
(in millions of long tons of sulfur equivalent)

	1976			1980 (Estimated)		
	Frasch	By-Product	Total	Frasch	By-Product	Total
U.S.	6.3	4.1	10.4	6.7	5.9	12.6
CANADA	Nil	7.1	7.1	Nil	7.2	7.2
Total Supply	6.3	11.2	17.5	6.7	13.1	19.8
DEMAND	U.S.	Canada	Total	U.S.	Canada	Total
Fertilizer	6.2	1.0	7.2	7.3	1.2	8.5
Industrial	4.6	0.4	5.0	4.9	0.5	5.4
Total	10.8	1.4	12.2	12.2	1.7	13.9
NET EXPORTS (IMPORTS)	U.S.	Canada	Total	U.S.	Canada	Total
	(0.5)	2.4	1.9	(0.8)	3.0	2.2
Total Demand			14.1			16.1
OVERSUPPLY (DEFICIT)			3.4			3.7
% of local demand			(28%)			(27%)


BEFORE (1975)

Past & Near Term Outlook For Sulfur Prices
In North America – U.S. Gulf vs Alberta, Canada
(In Dollars Per Long Ton, FOB)



MODERATOR POWERS: Our next speaker, William R. Morand, is a native of Kansas. He is President of the National Fertilizer Association. He is Executive Vice President of Collingwood Grain Inc. He has had a background in grain, fertilizer, and an agricultural background of many years. He has been a salesman, a manufacturer, and a dealer. Formerly associated with Snyder Chemicals, Spencer Chemicals and Gulf Chemicals. Now he is quite busy in his capacity with Collingwood and extensions in livestock and also banking interests. They have the whole bit with suspension fertilizer, liquid fertilizer and blends. So it is fortunate this afternoon we have Mr. Morand to speak to us on Trends in Fluid Fertilizers. Mr. Morand please. [Applause]

MR. MORAND: Thank you Mr. Chairman. ladies and gentlemen I am very happy to be here.

Trends In Fluid Fertilizer

William R. Morand

I have spent most of my life associated with the fertilizer industry as a salesman, manufacturer and dealer. I have participated in the many programs that have made possible today's advanced technology. I have been a part of the early start of the liquid fertilizer industry. Liquids had a slow start and many in our industry could not move themselves to see its bright future. It had all the growing pains of a new innovation, but it just made sense that somehow technological breakthrough would come which would catapult liquids into a most prominent demand product for farmers. However, in addition to its many advantages, I think industry has witnessed what the dedication and enthusiasm of independent dealers working together in associations can do because, believe it or not, the independent used basic research and science to establish liquids as the farmers basic tool to agronomic success. My company started out with ammonia and quickly advanced to bulk blending plants, then liquid nitrogen, clear liquid mixes and now we are growing into suspension fertilizers. A careful analysis of past growth will lead you to why NFSA has selected as its 23rd Annual Convention theme, "Century III—The Fluid Age."

Liquid dealers formed an association to help them do a better job in 1954. At that time ortho phosphates were used and a very low analysis product was a result. In the early days, this presented a serious problem as dealers strived to economically sell liquids against higher analysis dry fertilizers. Today, the analysis problem has been whipped; and liquid fertilizers are growing by leaps and bounds. In the year 1954 the total tonnage of liquid fertilizer was an insignificant part of the total United States usage. By the year 1960 liquid nitrogen had captured 17.5% of the nitrogen market compared to NH_3 19% and dry nitrogens 63.5%. By the year 1970 nitrogen solutions had grown to 29.6% of the total nitrogen market. NH_3 has grown to 31.7% and dry nitrogen's share of the market has dropped to 38.7%. Now through the year 1976 indications are that nitrogen solutions has grown to 34.3% of the nitrogen market. NH_3 has dropped to 30.4% and dry nitrogen has dropped to 35.3%. Projections are that this trend will continue and market shares for liquid nitrogen will increase in direct proportion to increased supplies entering the marketplace. The significant inroads of liquids in the nitrogen marketplace cannot be denied, and all plant expansion to the future cannot ignore liquid's impact at the marketplace.

Now I want to make you aware of what is happening in the total fertilizer marketplace. In the year 1960 liquid fertilizer had only 8.2% of the market, NH_3 had 2.8% and dry fertilizer had 89%.

By the year 1975 liquid fertilizer had 20.1% of the total fertilizer market, NH_3 had grown to 9.9% and dry fertilizer had dropped to 70%. So that percentages do not confuse you, since 1960 liquid and dry fertilizers grew by almost identical tonnage; however, we cannot ignore that liquids are growing faster and every year their percent of total market is increasing. For the past two years, nitrogen solutions has surpassed ammonia in the direct application market. I predict this will continue at an accelerated rate. As a matter of fact, in the last five years, liquid growth is out stripping dry fertilizer and ammonia combined by well over 125,000 tons per year.

So you can better understand the reasons for this great market growth, I want to tell you why liquids have become so popular with the farmer.

A. *UNIFORM DISTRIBUTION AND APPLICATION* — Farmers today understand the importance of even distribution of fertilizer in broadcast operations and the precision placement of fertilizer in band applications. Because liquids are moved by pump with pressure through nozzles, you have an ideal situation for controlled application — no segregation of materials and a precision job.

B. *PRESCRIPTION FORMULATION* — Fertilizer, microcutrients and herbicides can be combined efficiently to fill the farmer's needs and what's more save trips over the field and give the farmer better economics.

C. *AGRONOMIC ADVANTAGES* — Most all sources of plant food can be applied as liquids and/or suspensions. Water soluble and poly phosphates have been well documented for some time as primary sources of phosphates and only liquids, for all practical purposes, can offer 100% water soluble fertilizer. Liquids have a low salt index allowing them to be placed closer to the seed without damage to germination. In liquids NH_3 is reacted with phosphoric acid which results in ammonium phosphate. In the soil ammonium ions are in close maximity with phosphate ions which research has shown results in greater phosphate uptake by young plants.

D. *APPLICATION SAVING* — With modern flotation equipment liquids can be applied to 500 to 800 acres per day. With banding operations, all the farmer has to lift is a hose. He hauls his fertilizer to the field in a tank. No mess — all easy — the modern way.

E. *Superior quality* — Last, but not least, is the quality of the end crop which was produced with prescription fluid fertilizer application. There are many documented cases where quality of grains, forages and pastures, the protien content and TDN's were superior to those of crops fertilized with ammonia and bulk blends.

With the information I have just given you, it is easy to understand the past tremendous growth of liquid fertilizer and its much easier to understand its growing popularity — not only in America, but around the world.

Thank you. [Applause]

MODERATOR POWERS: Our next speaker is equally well qualified to talk on the subject of fluid fertilizers because he is Secretary of the National Fertilizer Solutions Association, Mr. D. J. Willard, Jr..

Mr. Willard is a native of Maryland. He attended the University of Maryland, and is currently President of Willard Chemical in Frederick, Md. He is also Vice President of the Maryland-Delaware Plant Food Association. Mr. Willard will speak to us on the advantages of Fluid Fertilizers.

Mr. Willard. Thank you.

Advantages of Fluid Fertilizers

W. J. Willard, Jr.

Good afternoon. Your program shows my topic to be the Production of Fluid Fertilizer. Actually, your program should read, The Advantages of Fluid Fertilizer. The TVA guys talk on such things as production and technical materials and I will be talking on what happens out in the field.

It's certainly a pleasure to be here today and talk with you on Fluid Fertilizer. This is a subject that is dear to me since liquid fertilizer has been of tremendous importance in my life during the last eight (8) years. I'd like to give you a little history of how and why I went into the liquid fertilizer business. I think it might be of some interest to you.

During 1968, I was both farming and running a custom farming operation. Throughout the fall, we were custom-silo filling, combining corn for both ourselves and on a custom basis and we were trying to get our own wheat planted. It occurred to me that if we could get someone to come and custom-apply the fertilizer on our wheat ground it would save us much valuable time and money in our wheat planting operation. A call was made to a fertilizer company and the ordered fertilizer was delivered and spread on our wheat ground — although it was delivered and spread four (4) days later than promised.

During the following March, 1969, while I was out inspecting my growing wheat crop, I discovered a crop that could best be described as looking like waves in the ocean. Plant height ranged from 3 to 12 inches. What had happened was during the fertilizer application, most of the nitrogen was distributed right behind the truck. As I stood there looking out over my field of uneven wheat, I decided than and there — there had to be a better way and felt there was a good opportunity for a business that could do a better job for the farmer. After some research, I came to the conslusion that liquid fertilizer offered that better way I was looking for.

During January of 1970, Willard Chemical company, Inc. was formed for the purpose of manufacturing, selling and applying liquid fertilizer along with related agricultural pesticides. Our goals were then and still are today for our company to make a reasonable profit, while selling to satisfied profit making customers.

And now, I would like to go more into the meat of my talk, particularly the advantages of fluid fertilizer. Today everyone is certainly most conscious of labor costs and labor shortages. I feel that in todays market, labor saving has to be of number 1 importance. I's dirst like to talk about labor saving in a local fertilizer plant. In a fertilizer plant, there seems to be no comparison in the amount of labor needed to produce a ton of liquid fertilizer and a ton of dry fertilizer.

In both of my two facilities, two men can handle all incoming farmer orders, handle raw materials shipments, dispatch outgoing shipments of fertilizer and pesticides and manufacture 70 to 100 tons of fertilizer per hour while also writing the shipping tickets. This is all done with two [2] men. Now I would have to be honest with you and say these two [2] men have to hustle, but two men can get it done.

Compare this kind of efficiency with any dry installation you want and see what kind of a difference you come up with. It seems rather obvious that this type of efficiency is available because liquids adapt themselves very readily to automation. Of course, this is also true because liquids can be handled with pumps. It's certainly much easier to turn pumps on and off and open and close valves than it is to operate payloaders handling many tons of a dusty material and pumps are easier to control and manage than conveyors. Nurse trucks hauling finished products away from a fertilizer production facility can be quickly and easily loaded with the turn of a valve and the turning of a pump switch.

Without spending anymore time on production, I'm sure you've gotten my point that tremendous labor saving can be achieved in a fluid fertilizer plant. Before leaving the plant though, I would sure like to take this opportunity to touch on the tremendous pollution control advantages a liquid fertilizer plant has. I'm sure you can readily see that the fewer dry dusty products handled in a plant, the less dust pollution there would be. Enough on that.

I spoke of labor saving advantages in the plant and now I would like to talk about the labor saving advantages of fluid fertilizer on the farm. I'm sure it's these labor saving advantages on the farm that have caused the explosion in liquid fertilizer sales during the past few years. There are many advantages to fluid besides labor, but this one advantage you can readily and easily put a dollar and cents figure on.

First let us talk about the speed of application. It's not uncommon for liquid fertilizer to be applied at the rate of an acre a minute and this is certainly fast application. In this eastern part of the country where we do not have large or flat fields like they do in the west, I have had applicators in my own company apply as much as 300 plus acres per day. It is my understanding from some of my friends in the midwest it's not uncommon for an applicator to get from 700 to 1,000 acres per day in their part of the country. This speed of application is accomplished of course by the fact that we have some very modern efficient application equipment available today for liquids. The equipment can travel over the ground at high rates of speed and they are equipped for rapid efficient refilling of fertilizer. This rapid application is also achieved because we have well working marking systems available for our liquid application equipment used in the fluid fertilizer industry today.

Now this fast, efficient application does many things for many people. It certainly helps make the fertilizer dealer achieve a better profit. It helps the farmer because with dealer speed and efficiency the dealer can do the job for the farmer more economically. And in another area, the farmer appreciates meeting his time schedule and having his work done more timely. This is very important in the farmers eyes in achieving a good profitable crop.

The farmers time has been calculated to be worth from 40 to 400 hundred dollars an hour during the spring planting season, and anything the fertilizer dealer can do to save the farmer time is certainly putting money in the farmers pocket.

Many time and cost production experiments have been run to compare the difference in cost and time and comparing the application of one trip over the field with anhydrous ammonia, a second trip over with dry bulk blend, a third trip over applying pesticides — comparing this to a once-over efficient trip with all the N-P & K and pesticides in a uniform liquid application.

I think it's natural that we always relate our items to our own business. I would like to stop here and relate this once over application to my own business at Willard Chemical. The company is located just 50 miles northwest of where we are sitting today. The land is somewhat rolling and we are in an area where many people live and work in the Washington area, therefore, we have to be pollution-conscious. The farmers in our area cannot afford to have any soil washing from their fields onto the highways where you have so many urban people driving up and down the highways. This is just from regulation standpoint, and, of course, we all know that no sane farmer can afford to have his resources washing out of his fields. If his topsoil leaves, he is going to be out of business.

No-till corn came into existence in our area just about the time I decided to go into liquid fertilizer business. I would like for you to think I'm a very intelligent person and could forsee the impact no-till would have on the liquid fertilizer business, but this is not true. I would have to say though that no-till corn has had a tremendous impact on our business.

The two — no-till corn and liquid fertilizer go together like cheese and crackers. In the part of Maryland that is north and west of Washington, I would say that 75 to 80% of corn grown is no-till and in our no-till program with our customers, there are just 3 trips per year made over a corn field. The first trip we make with our liquid application equipment. We apply practically all of the N, about 1/2 the P and all of the K. We apply all the herbidices and if needed pesticides in a once over application.

The next trip over the field the farmer comes with his no-till corn planter. In a program we would recommend, he would apply a small amount of N, about 1/2 of his P, and no K along with his seed corn. We have many customers who have us apply all the NPK and put nothing in the planter but seed corn and they seem to get good results. So the farmer does have that versitility. The 3rd trip that's made over his corn field per year is the trip with either a field forage harvester, harvesting silage which would probably account for 5 to 10% of our customers' acreage — or the combine shelling the corn, taking the kernels only off the field.

I'm very enthusiastic about this type of system. I have farms of my own and I have some farmer customers that have gone with this 3 trip deal for many, many years and frankly don't see why we would ever have to till the soil. I will admit that on some occasion woody plants and briars start to get into the fields making it necessary for the farmer to go in and disc up the field to get rid of these.

As I mentioned before, my operation is close to D.C. and many of our fertilizer sales are actually in Montgomery county, a neighboring county to Washington, D.C. Montgomery County starts just a few miles from this hotel. The county Council of Montgomery County two summers ago arranged a tour of evironment-conscious people to tour the farms of M.C. and my company worked along with the county agent of M.C. setting up this tour. In conjunction with the tour, we did some survey work and from the results of the tour and survey, it was concluded that we are having almost no soil erosiion problems from agriculture in Montgomery County. We have the problems within the county concerning muddy water in the streams every time it rains. there is a lot of building going on in M.C. — being so close to Washington, but of course, the builders say it's the farmers muddying the water and the farmers say it's the builders. However, the farmers were happy to have this judgment made stating that agriculture was not polluting the streams with mud and silt and we were happy also to be associated with liquid fertilizer and no-till which helped bring about this kind of result in the farmers favor.

Now, I got off my subject a little bit about time saving, but really you can relate everything I have said back to time saving.

When our farmer customer uses liquid fertilizer in his corn planting, there's another place where time and labor saving come into play — he doesn't have to lift heavy bags to fill his planter. He doesn't have to work with a back-breaking scoop shovel and eating dust while filling his planter. He doesn't have to waste time jockeying an auger into position to fill his corn planter. The heaviest thing he has to lift is the end of a hose and he can either use a pump or gravity, either method to fill his corn planter tank with fertilizer. Depending on the rate of fill of fertilizer he could possibly even be putting seed corn in his seed corn boxes while the fertilizer was going into the tank. This, of course, saves the farmer time and money and saves his back. He also has the versatility of adding an insectcide to the starter fertilizer, if necessary. This saves purchasing a dry insectcide attachment. An insectcide in the liquid starter also eliminates the continual problem of chains coming off a dry insectcide attachment.

Now, I'd like to touch on some of the agronomic advantages of liquid fertilizer. And I'm sure, especially some of you die-hard dry guys, would say that fertilizer is fertilizer no matter whether it's liquid or dry — and agronomically it will all be the same. And you have a good valid argument. But before you form a definite opinion, I still contend that I can show you some ways that liquid fertilizer has agronomic advantages. Uniform distribution on the field is certainly an agronomic advantage and if you will remember back at the beginning of my talk, this is the very reason that gave me the idea of going into the liquid fertilizer business. If crop needs are determined by the use of soil tests, then a certain analysis is prescribed at a certain rate per acre. A good uniform profitable crop cannot be grown if the fertilizer is not put on the ground evenly. If the prescribed rate is 800 lbs. per acre, and some strips in the field are receiving 1200, and some strips are receiving 350 lbs.— obviously this is not uniform application. It will not give a uniform crop and will certainly not be as profitable to the farmer customer as uniform application at the prescribed rate and the prescribed analysis. Also, if segregation has taken place during transportation, if ballistics separate materials, where as some nitrogen phosphorous or potassium spread more heavily at different widths behind a spinner spreader, this, too, will give uneven distribution and an uneven crop and will certainly gnaw into the farmers profits.

Not too long ago, one of the leading land grant colleges ran tests and found that yields of corn varied from 154 down to 84 bushels per acre within the same swathe of a dry spinner spreader as a direct result of uneven application — ballistic segregation and segregation that occurred in transportation. Now, I'd like you to compare this with liquid fertilizer, where we have a homogeneous product. Every drop contains the same N, P, & K, plus any added micronutrients and (or) any compatible pesticide put on with the even distribution throughout the swathe. And also equally important is to have swathe-marking equipment such as we use with the liquid equipment which could be either a lime marker, a dye marker or a foam marker, so when the applicator goes back and forth across the field, it's known precisely where the swathe ends before and where it begins this time, for you not only have uniformity within the swathe, but also uniformity across the whole field.

The next item I'd like to touch on is the phosphate in liquid fertilizer. We all know that phosphate rock is mined from the ground. Liquid and dry phosphate all come from the same original source, but there is a difference. Liquid phosphate is 100% water soluble. Dry phosphate solubility runs 50 to 90%. There's been work done by Iowa State that definitely proved the higher the water soluability of a phosphate, the more of it becomes available to the plant — and produces higher yields. Another advantage we have in liquid phosphates is the fact that we have the option of ortho-phosphates or poly-phosphates — and I wouldn't want to get into the argument with you concerning the advantages or disadvantages of either one, but they are both readily available. Poly-phosphates of course are usually slightly more expensive and in some test work, poly-phosphates have proven to be advantageous. It would be my thinking that probably under some conditions, poly-phosphates are advantageous and if this were true in your case, you do have the option — you can go either route.

I'm sure one of the important factors that have attributed to the growth of liquid fertilizer is a weed and feed program which I have already touched on — but have not identified it as such, "Weed and Feed". In case any of you don't know what weed and feed is, it's a type of program which came about several years ago as the use of herbicides started to grow tremendously. Also at this time liquid fertilizer was really getting into the picture of American agriculture and the idea came to combine the two instead of applying herbicides or pesticides with water. Pesticides are combined with a plant food requirement for a crop and everything was put on in an once-over operation. The name weed and feed is very appropriate. This has, of course, been a tremendous attributing factor to the growth of liquid fertilizer.

One of the obstacles to overcome in the growth of liquid fertilizer is the more expensive form of ingredients. The liquid form of nitrogen is of course more expensive than ammonia. One hundred percent (100%) water soluable phosphates are more expensive than the dry forms and water soluable potash material is also more expensive than standard or granular. With these higher cost ingredients to overcome, the liquid fertilizer dealer had to have some other advantage to bring his product into a volume sales program. And, of course, weed and feed is a big item in overcoming the higher ingredient cost opposition. We have less application cost due to the efficiency of weed and feed. Of course, the weed and feed also plays an important role in the labor saving and timeliness which was already discussed previously.

As you can probably already see, I could talk to you the rest of the afternoon on the advantages of fluid fertilizer, however, I was asked to make this about 20 minutes and I believe my time is about up.

I have thoroughly enjoyed the opportunity to address you and thank you very much for your attention. [Applause]

MODERATOR POWERS: Thank you Mr. Willard and Mr. Morand for your excellent papers.

If the two previous speakers wetted your appetite more for fluid fertilizer interests our next speaker will talk on Selecting Equipment and materials of Construction for Fluid Fertilizer Plants.

It is a joint paper by two representatives of TVA, Hubert L. Balay and Homer L. Kimbrough.

Mr. Balay is a Field Chemical Engineer in the Process and Products Improvement Section of TVA and has been with TVA since 1966. He is a graduate of the University of Arkansas. Before joining TVA he worked for some 14 years with Spencer Chemicals. He has constructed numerous bulk blending, granulation, and liquid suspension fertilizer plants. He is also author and co-author to some 29 papers out of TVA.

Mr. Kimbrough is a graduate Chemist and worked with TVA's Research and Development Program from 1949 to 1953. For 11 years he worked for two companies in the fertilizer industry. He returned to TVA in 1964 as a Field Chemical Engineer. At present he is working as a Field Chemical Engineer in TVA's Field Development Program.

Selecting Equipment And Materials Of Construction For Fluid Fertilizer Plants

Hubert L. Balay — Homer L. Kimbrough

Presented by Hubert L. Balay

Introduction

The use of fluid fertilizer is growing rapidly, and many producers considering this production route are new to fertilizer manufacturing. Prospective manufacturers face a bewildering array of pumps, agitators, metals, plastics, pipes, valves, and even turn-key plants. The purpose of this paper is to provide a basis to help producers make intelligent decisions on selecting equipment.

Engineers are often asked by producers considering the liquid fertilizer business what kind of plant they should build. An intelligent answer can not be given to this question unless further information such as that shown in table 1 is available. This information includes: (1) the kind of liquid fertilizer to be produced, (2) the production rate, (3) the length of the fertilizer season, and (4) how the equipment will be used.

The kind of liquid fertilizer produced influences selection of materials of construction, types of storage and pumps, and the necessity for cooling. Production should be projected 5 to 10 years to reduce the possibility of selecting equipment that is too small for future needs. A plant of 10,000-ton annual capacity in Florida where the fertilizer season lasts 10 to 11 months can use a lower production rate and smaller equipment than a plant of the same capacity in Minnesota where the season may be only 10 to 12 weeks. A small plant operating 24 hours per day can produce as much fertilizer as a large plant operating only eight hours per day. Since most fluid fertilizer plants do not operate 24 hours per day, much of the equipment in the industry is underused.

An experienced engineer can answer many of the questions in table 1. But questions regarding projected tonnage, operating hours, grades to be produced and length of season can best be answered by the prospective fluid plant owner. Agronomists and economists with state universities and federal agencies can give assistance. Also many private companies are glad to provide this kind of information.

Picking a Pump

The engineer often is asked: what size and kind of pump should be bought. Answers to the questions in table 1 will provide enough information for making that decision. The kind and amount of material to be pumped will determine what kind of pump should be used and of what materials it should be constructed. Most pumps in fluid fertilizer plants are centrifugal pumps; however, if anhydrous ammonia is to be pumped, a suitable positive displacement pump with the proper working pressures should be used. A phosphoric acid pump should be constructed of type 316 stainless steel.

A complete piping layout of the plant should be made in sizing a pump. Many fluid fertilizer plant managers consider this a waste of money. But if the piping layout is not made and the size of lines, the number of fittings and valves in the line determined, and the total pressure drops calculated, the selected pump may either be too small to do the job, or capital which could be better used elsewhere will be spent on excessive pumping capacity.

For example, piping handbooks show that one standard 6-inch elbow is equal to 16 feet of 6-inch pipe. Designs which eliminate only a few eblows and tees can cut pumping costs considerably. After the piping layout is made, pump performance curves should be obtained to determine the size of pump necessary to do the job. Then it may benefit the prospective owner to depart from engineering and scientific practice and to consult with his peers in the fluid fertilizer business who already own pumps. The capacity of the pump required will not vary; however, some pump manufacturers are not familiar with the problems involved in pumping fluid fertilizer. Usually, each producer will have a definite preference for a brand of pump. If enough dealers are consulted, a concensus will emerge and the list will be reduced to 4 or 5 brands. At this point, cost may be the deciding factor. It may be more economical to buy a cheaper pump and expect some down time for repairs. It must be remembered that down time during a short fertilizer season can lose valuable business especially if spare parts are not readily available. In fact, availibility of spare parts is important enough to be given equal weight with the kind of pump and its price.

Picking Pipe

The most commonly used metal in fluid fertilizer piping is carbon steel. Properly designed carbon steel piping should last from 5 to 7 years. However, velocities through this piping must not be excessive to obtain this service life. Since fluid phosphates provide a corrosive-resistant coating on pipe, excessive velocity can wash away this coating and expose the metal surfaces. Also, excessive turbulence will cause erosion problems at elbows and tees. Eight feet per second is usually considered the maximum velocity for good pipe life. Welded construction usually works better than threaded construction because threading reduces the thickness of the pipe and creates stresses in the pipe joints making them more susceptible to corrosion. Working pressures should be known and the thickness of the pipe picked accordingly. This applies to any pipe.

Polyvinyl chloride (PVC) pipe often is used for fluid fertilizers; none of the fluid fertilizers will attack PVC pipe. Care must be exercised, however, in picking the proper type of PVC pipe. Some types will melt and sag if the pipe is heated. This could occur in a plant producing 10-34-0 with the TVA pipe reactor or fluid fertilizer by ammoniating orthophosphoric acid. Polyvinyl dichloride (PVDC) will take temperatures near the boiling point of water. If plastic pipe is used to handle hot products, PVDC should be bought. PVC and PVDC are brittle as compared to carbon steel and often break as a result of improper support, excessive pressure, or impact, such as that caused by a worker using the pipe for a step-ladder or striking it with a vehicle. The use of schedule 80, PVC pipe, even where schedule 40 may take the working pressure, is sonetimes recommended to help prevent this problem. Some of the properties of PVC and PVDC are shown in table 2. A sketch of an effective support is shown in figure 1. Joints in the PVC pipe are usually cemented. Properly made joints will be strong and will not leak; however, improper cleaning and failure to follow the manufacturer's instructions for cementing can cause these joints to leak or even fail during plant operation.

Stainless steel often is used in fluid plants to handle acids. Precautions given for carbon steel pipe also apply generally to stainless pipe, although a lower schedule number can usually be used because no allowance for corrosion is required. Some attention should be given to corrosion rates of the material to be transported in stainless steel. For example, for phosphoric acid type 316 stainless steel is satisfactory, whereas type 304 is not.

Other kinds of pipe, such as fiberglass and polyethlyene are available. Rubber hose often is used where flexibility is required. These materials have advantages and disadvantages. Suppliers of these products, especially rubber hose, should know the intended use, including kind of material to be transported, its temperature, viscosity, and the percent solids present when this is applicable.

Aluminum pipe most often is used for nitrogen solutions; however, PVC and carbon steel are satisfactory if the product contains no free ammonia and is properly inhibited. Most stainless steels are also effective, although they are expensive.

Purchasing Storage Tanks

Materials used in making storage tanks are much like those of pipe; namely, carbon steel, aluminum, fiberglass, stainless steel and plastics. Carbon steel tanks are usually the most economical for ammonium phosphate or ammonium polyphosphate fertilizers. Tank life varies from 5 to 10 years. If tanks fail in less than 5 years it is usually because of carelessness. Keeping carbon steel tanks full of some material, even if it is only water, will greatly extend their life. Diluting products to be stored for long periods so that the tanks will be full during storage is worthwhile. An analysis can be made on the diluted product or the final analysis calculated so the product can be used when the plant is started again.

Liners, paints, and floating oil on top of the fluid fertilizer in the tank can extend tank life; however, making an effort to keep the tanks as full as possible when they are not being used is probably the most economical method of extending tank life.

Rubber lining is required when carbon steel is to be used for storing acids. Reliable lining companies are available to provide this safe, economical way of storing acids. Testing of the tank for leaks after it has been installed is a good precaution. These tanks seldom leak; but if a leak does develop during transportation and installation, the results can be disastrous, especially in these days of concern over spills and stream and ground water pullution.

Fiberglass is economical and effective for storage of phosphoric acid and other corrosive materials. Results with fiberglass tanks have been excellent for the past few years. But because of previous problems, these tanks have not completely overcome their bad reputation. These problems mainly were caused by poor quality during manufacture. Present manufacturers generally have much better quality control, and results obtained with these tanks have improved greatly. The best advice is to buy a fiberglass tank from a reliable manufacturer. All tanks should be properly ventilated during filling, but this is especially important with fiberglass tanks. Improper venting causes pressure buildup in tanks which may split the tank.

Tank foundations are important, especially for cone bottomed or fiberglass tanks; however, all tanks should be kept level as they are filled and emptied. Figure 2 shows and economical and effective tank base for flat bottom metal tanks. This kind of foundation is not recommended for fiberglass and cone-bottomed tanks. Fiberglass and cone-bottomed tanks should be placed on concrete foundations reinforced with steel. Building a foundation is an engineering problem because of the weight and bearing area of the full tank. Fiberglass tanks can rupture if they tilt. Conebottomed tanks have a high center of gravity and can turn over if the foundation fails. Coating the top of the foundation with epoxy tar paint can prevent damage to the foundation by spilled product.

Cone-bottomed tanks are best for storing wet-process phosphoric acid and suspensions. Solids tend to settle out of these products and collect in the area away from the tank outlet as shown in figure 3. This hinders their removal. Cone-bottomed tanks as shown in figure 4 tend to collect the solids in the cone where they can be removed either during use of recirculated to the top of the tank for resuspension. The more slope on the bottom of the tank the better; however, even in tanks without steep slopes, sludge will tend to build up until its angle of repose has been reached. Also, sludge removal is simpler in cone-bottomed tanks.

Mix Tanks

Mix tanks face the same corrosion problems as pipe and storage tanks. They must, however, have more resistance to stress and heat deformation when acid and ammonia or hot water are used. This is necessary because of exothermic chemical reactions and violent dissolutions in mix tanks. Most mix tanks are made of types 304 or 316 stainless steel. Type 304 will work satisfactorily with phosphoric acid because residence time of the unammoniated acid in the tank is usually short. Type 316, however, gives longer life and the extra cost probably is a good investment. Carbon steel tanks offer low initial investment and longer life than most people expect when no chemical reaction is involved. A common problem with carbon steel tanks is formation of rust flakes that get into the fertilizer and sometimes cause stoppages in the application equipment. Straining of fluid fertilizers made in mild steel equipment is recommended. This is good practice with all fluid fertilizers. It is also more difficult to maintain the appearance of carbon steel than stainless steel tanks. Carbon steel tanks always appear rusty regardless of how many times they are sandblasted and painted.

Mix tanks are usually mounted on pipe lever scales and sometimes corrosion on these scales, as well as occasional buildup of solids around the moving parts, results in inaccuracies and excessive maintenance. Scales of the ribbon type are less susceptible to interference by solids buildup and corrosion. At least one mix tank manufacturing company uses a hydraulic scale upon which to mount their mix tank. These scales have proven accurate and reliable in fertilizer service. Electronic scales with digital readout have not been widely used but they can be expected to appear on the scene in the near future because of several unique advantages such as remote readout.

Agitators vary from crude homemade types such as pieces of screw conveyor stuck on a shaft and driven by a small motor to commercially manufactured high sheer agitators driven by 80-hp motors. The mixer that is chosen will depend upon the job to be done. Clear liquids produced by cold blending a liquid phosphate base, urea-ammonium nitrate solution, and potash requires very little agitation, and almost any kind of mixer will be satisfactory. These mixtures can be produced by merely recirculating with a pump. However, the amount of agitation required is a function of the production rate and should be given the same scientific consideration as that used to select a pump. Normally, turbine agitators with blades pitched at a 45° angle, such as shown in figure 5, are used for the suspension of solids in a fluid medium. This kind of agitator causes a downward pumping action which creates a vortex causing solids dumped onto the surface of the fluid to be sucked through the agitator, pumped to the bottom of the tank and then recirculated again to the top so they suspend effectively. If a chemical reaction occurs, such as that between ammonia and phosphoric acid, it is better to have the blades of the turbine placed vertically as shown in figure 6 so that the maximum agitation will occur at the end of turbines. Spargers should discharge near the ends of the blades.

High shear mixers as shown in figure 7 are normally used when solids other than potash are used in the mixture. These solids generally are mono and diammonium phosphate in the United States although triple superphosphate and other materials can be used when adequate agitation is available. Although agitators usually are made of either types 304 or 316 stainless steel, satisfactory agitators which give good service and long life can be made from carbon steel.

The shaft should be of sufficient diameter to resist torque created by starting the agitator in thick fluids having viscosities of 1,000 centipoises and above and to prevent vibration due to flexing of the shaft during operation. To prevent flexing some agitators have bearings not only at the top of the shaft but also on the bottom of the tank.

Valves

The valves most commonly used in the fluid fertilizer industry are butterfly, ball, accentric plug, and gate. Globe valves with suitable working pressures often are used with anhydrous ammonia. butterfly valves are most commonly used for flow control. These valves are reliable, easily repaired or replaced, comparatively low in cost, and may be made with a body of low cost carbon steel and internal or wetted parts of corrosion-resistant stainless steel. Carbon steel gate valves often are used as closures for storage tanks where only an on-off action is required. Eccentric plug valves are less popular because of the tendency to bind due to the corrosive action of fertilizer. Although ball valves are very satisfactory, they are expensive and are seldom seen in fluid fertilizer plants.

A common problem with all valves used for flow control in fluid fertilizer plants, especially those with quick opening devices used in conjunction with large pumps, is the tendency for operators to close the valve too quickly, resulting in damage to the valves or other portions of the piping system by the velocity head. This can be eliminated by putting hand wheels and screwed closures on the valves; however, this results in slow action and lower production rates. Another solution is to place an air compression chamber somewhere in the system to absorb the inertia in the fluid when the valve is closed. This can be done easily by merely placing a 5-foot vertical section of capped 6-inch pipe somewhere in the system between the pump and the valves so that air is trapped. The inertia is then absorbed by compressing the air in the chamber.

Some plants use automatic control valves. These valves are air operated but it is likely that some electronically-operated valves will be used in the near future as fluid fertilizer plants become more sophisticated. The question of whether to use manual or automatic valves often arises during discussions of plant design. This kind of equipment can cut labor costs and increase the production rate. A careful analysis should be made of the plant requirements to determine if the extra money invested in these valves and in auxillary equipment to operate them is justified. If labor costs are not decreased or the production rate increased, automatic valves may not be necessary.

Solids Handling

Probably the most frequent bottleneck preventing fluid fertilizer plants from attaining design production rates is the solids handling equipment. In some plants, large amounts of capital have been invested in mixing and pumping equipment while the solids are handled with a small grain auger. Some suspension grades, such as 3-10-30, are almost one-half potash. If excessive time is required to get the potash into the mixture, money spent on high quality mixing equipment will be wasted and the design production rate never attained. Solids handling equipment requires the same careful engineering study as pumps, mix tanks, pipes and other equipment. It should be remembered that a 30-ton per hour auger or bucket elevator takes 2 minutes to get a ton of solid into the mix tank. If a 10-ton batch requires 4-1/2 tons of potash, 9 minutes is needed to get potash into the mixer and the money invested in high shear equipment to suspend potash quickly has been wasted. The pounds per minute rate of solids handling equipment should be considered rather than the ton per hour rate. This is then figured into the production rate per hour along with the time required for adding fluid bases. Pump-out times and change-over times should also be figured into production rates. If solids other than potash are used, the bottleneck caused by small solids handling equipment can be even worse.

An alternative to large augers or elevators is the suspending of hoppers over the mix tank. Hoppers allow the solid raw materials to be accumulated while others mixing operations are being performed. These hoppers can then be emptied quickly by remotely operated or mechanically operated openings on the bottom of the hoppers. This allows potash to be added quickly to the tank thus maintaining the designed production rate. these hoppers should not be too big. If they are, solids left in them during shutdowns will pressure-set or pick up moisture from the atmosphere making the solids difficult to remove. Hoppers should be emptied when the plant is to be shut down for any length of time.

Conclusion

Before equipment is chosen for a fluid fertilizer plant, the production rate and grades should be determined, the length of season projected, raw materials selected, and future tonnages predicted. Physical properties of the raw materials and products should be studied and the materials of construction evaluated.

It may appear that services of a design engineer are required for even the smallest plant. This is not true because most producers building a plant know the grades required and the projected production requirements better than anyone else. Corrosion rates and other physical properties of the material to be handled can be obtained easily from the suppliers of the material. Pump sizing and plumbing requirements usually can be done by vendors of equipment if the information listed in table 1 is available.

Table 1

Data Required for the Selection of Equipment and Materials of Construction for Fluid Fertilizers

1. Kind (10-34-0, suspension, acid and ammonia, potash grade, etc.) to be produced.
2. Viscosity
3. Vapor pressure
4. Density
5. Corrosion rate
6. Production rate required (length of season, operating hours, etc.)
7. Location of plant (on rail, near highway, drainage, etc.)
8. Will plant be inside or outside. If inside will plant be heated.
9. Ventilation required (will pesticide be handled, etc.)
10. Kind of electric service available (220 V, 440 V, etc.)
11. Average relative humidity in area (if cooling is required)
12. Average temperature in area
13. Possible snow loads
14. Bulk solids to be handled (potash, MAP, DAP, micronutrients, etc.)
15. Will bagged solids be handled (micronutrients, clay, etc.)
16. Waste disposal (sewers or special handling required)
17. Water supply (city water or well, flow rates)

Table II
Properties of Polyvinyl Chloride Pipe

	Type of PVC		
Physical Characteristics	PVC Type 1	PVC Type II	PVC High Temp.
Flexural strength, lb/in^2	14,500	11,500	14,500
Heat distortion temperature, °F* at 264 lb/in^2	165	155	215
Impact strength at 73°F, ft-lb/in notch**	0.8	12	6.3

* Temperature at which pipe will distort
** Measured by IZOD impact test

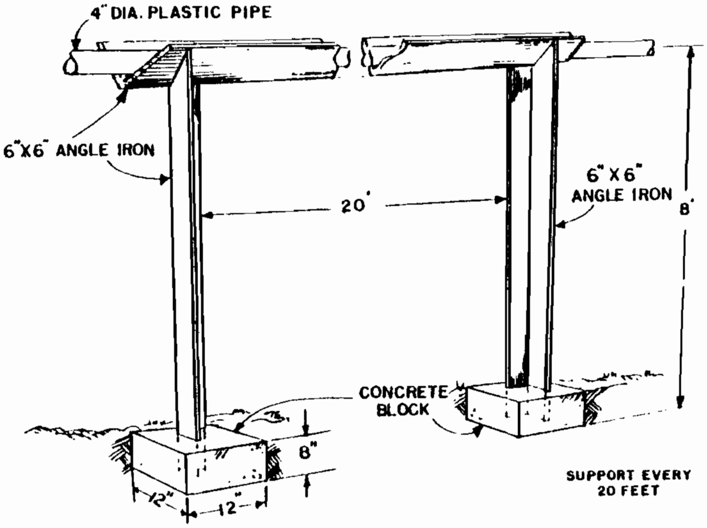


FIGURE 1
SUPPORT FOR PVC PLASTIC PIPE

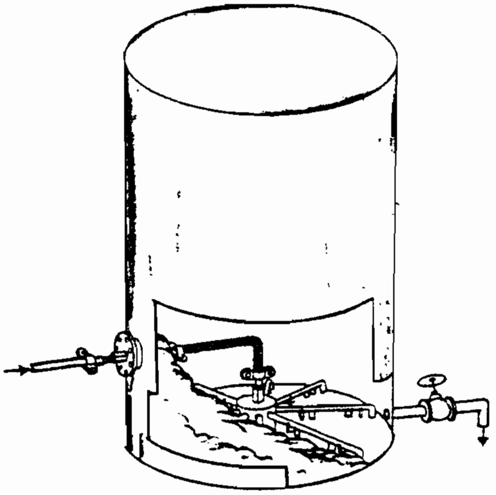


FIGURE 3
FLAT BOTTOM STORAGE TANK

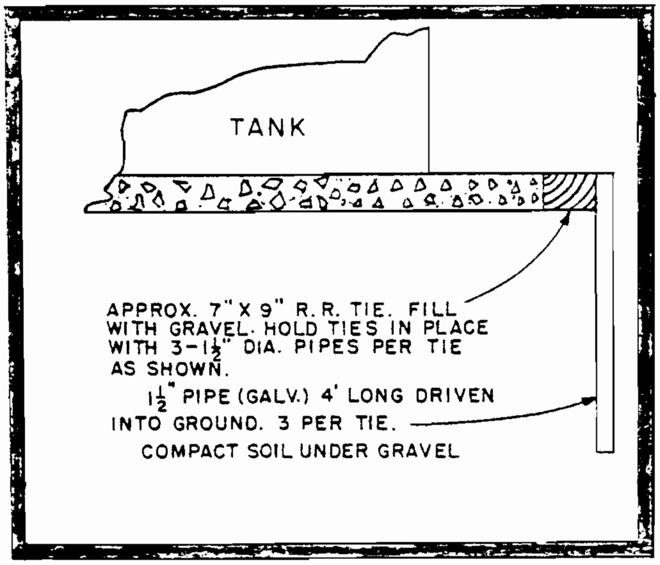


FIGURE 2
TANK FOUNDATION

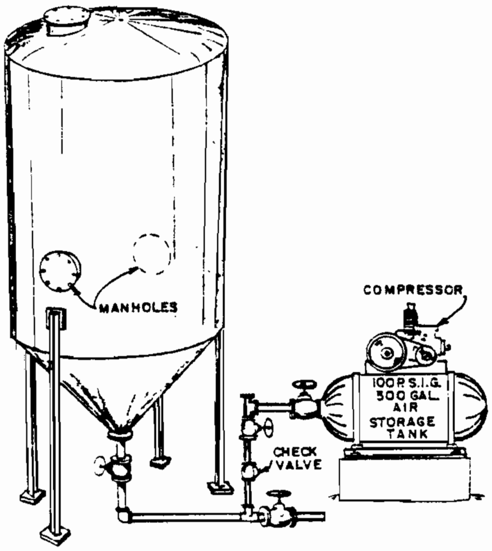


FIGURE 4
CONE BOTTOM STORAGE TANK

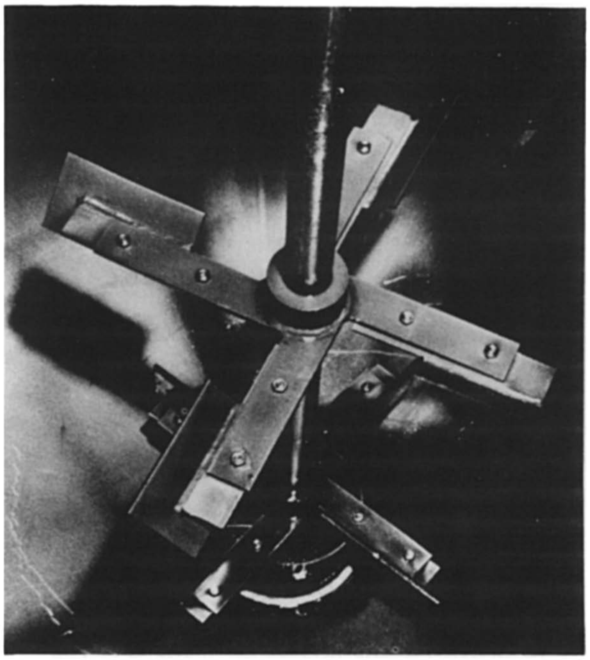


FIGURE 5
TURBINE-TYPE AGITATOR WITH PITCHED BLADES

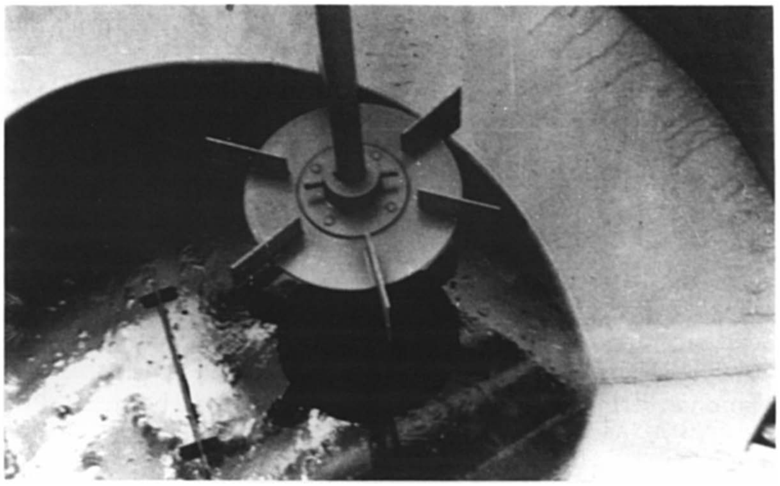


FIGURE 6
TURBINE-TYPE AGITATOR WITH BLADES HAVING NO PITCH

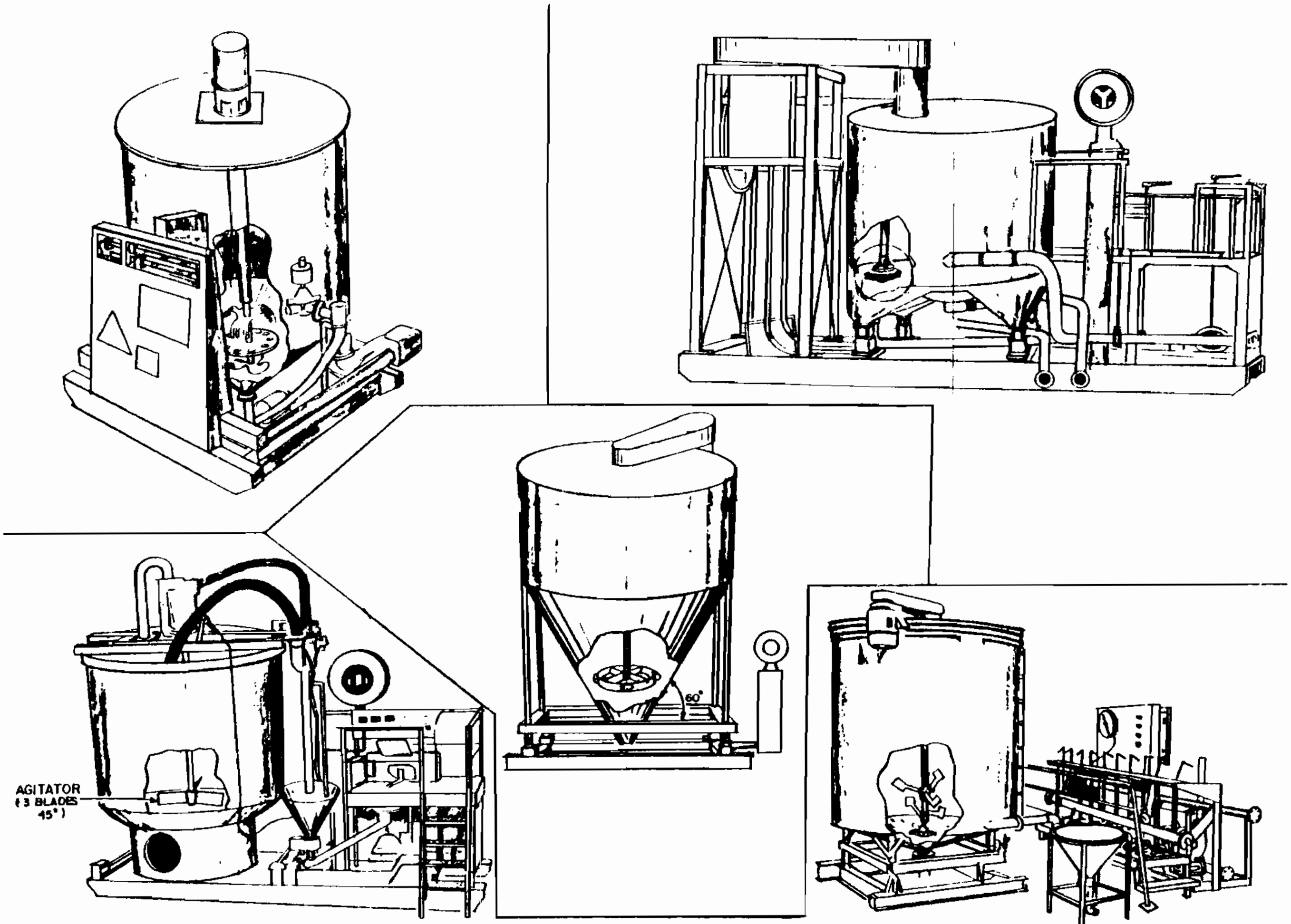


FIGURE 7
FIVE TYPES OF MIX TANKS FOR SUSPENSIONS

MODERATOR POWERS: Thank you, Hubert L. Balay and Homer L. Kimbrough for your most interesting paper. [Applause]

We will proceed to our next paper jointly authored by Norman L. Hargett and Louis Sills.

Unfortunately Mr. Sills could not arrange his schedule to be here today. Mr. Hargett will present the paper.

Mr. Hargett is a native of Mississippe. He was educated at the University of North Alabama. His present position with TVA is Fertilizer Distribution Analyst, Division of Agricultural Development, at the National Fertilizer Development Center. He has been with TVA for 15 years and authored and co-authored these following publications:

Fertilizer Summary Data.

The Directory of Fertilizer Plants in the United States.

Norman please. [Applause]

Fertilizer Distribution Centers In The U.S.[1]

by

Norman L. Hargett[2] and Louis G. Sills[3]

Presented by Norman L. Hargett

Introduction

How is 50 million tons of fertilizer distributed to the 2.7 million farms in the U.S.? Ninety producers of ammonia, phosphoric acid, and potash supply the basic fertilizer materials. But about 12,000 mixers and retail distributors distribute them to the farmers. And of the 50 million tons, 90 percent is distributed by bulk blenders, fluid mixers, and granulation plants. This is a dramatic change from the traditional fertilizer marketing pattern of 20 years ago when the role of basic producers was to supply intermediate products to mixing plants. These were owned and operated by wholesale distribution mixers who combined the basic materials into a small number of fertilizer mixtures which were then distributed to retail outlets for sale to the farmer. Today, the principal marketing pattern consists of the basic producers distributing to large-scale ammoniation plants, dry bulk blenders, and liquid and suspension mix plants.

Conventional ammoniation-granulation plants have undergone major changes in the past few years. These plants now use rather large quantities of phosphoric and sulfuric acid, anhydrous ammonia, and other fluids to produce granular fertilizer. Their use of run-of-pile normal superphosphate and nitrogen solutions is decreasing. Many of them are installing new melt-type processes. Although there are few new plants of this type, the production from each plant has increased. The granulation plants also provide an excellent way for incorporating micronutrients in mixed grades and for using byproduct materials.

Bulk blending became prominent in the middle 1950's with the introduction of granular disammonium phosphate. Because production and distribution by bulk blending was simpler and more economical than traditional methods, bulk blending grew at a rapid pace. Today it is the largest single system of manufacturing and distributing fertilizer mixtures in the U.S. Bulk blenders buy materials from basic producers or granulation plants and combine them in physical mixtures as specified by the farmer. One of the most important reasons for the rapid growth of bulk blending is the capability of providing the farmer with the services he wants and needs. These services include custom spreading, mixing, and incorporating pesticides and micronutrients into mixtures.

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 the limited supply of suitable phosphate materials. Similar to dry bulk blending, only a small capital investment is required for establishing a fluid mixed fertilizer unit. Also, suspensions have enabled higher analysis grades to be produced at a lower unit cost. Today, there are still limited supplies of basic materials; but fluids continue to have a strong and expanding position in the fertilizer market.

Both bulk blending and liquid mix fertilizer distribution systems provide an economical way of combining the intermediate fertilizer materials produced at widely divergent production points throughout the country. They also serve as storage facilities in the market area, and are the point of contact between the dealer and the farmer.

These systems are important links in the fertilizer distribution chain, yet, relatively little is known about this segment of the industry. The purpose of this paper is to describe the characteristics of U.S. fertilizer distribution patterns and the facilities used.

Survey of the Fertilizer Industry

In 1976-77, the Association of American Plant Food Control Officials (AAPFCO) cooperated with the National Fertilizer Development Center (NFDC) to conduct the second survey of U.S. fertilizer distributors. Results of the first survey were presented at The Fertilizer Industry Roundtable Annual Meeting in 1975. We are pleased that the Roundtable Committee has asked us to present these new survey results.

The 1976-77 survey is based on 6,149 questionaires

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[1] Presented at the Fertilizer Industry Roundtable, Washington, D.C., October 24-26, 1977.

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

[3] Fertilizer and Feed Control Service, Texas A&M College Station, Texas.

returned by fertilizer registrants throughout the U.S. Bulk blenders, fluid mixers, granulation plants, and a few basic producers were included in the analysis, but the 1,522 retail outlets responding to the survey were not included. Based on the reported fertilizer distribution in the 42 states participating in the survey during FY 1976, the 4,627 plants distributed 64 percent of the total fertilizer consumed in the U.S.

Four states— California, Minnesota, Mississippi, and Nebraska— did not furnish the requested data and are not included in the following analysis. Mississippi did conduct the survey but the data was not available for this summary. We hope these states can be included in future surveys conducted by AAPFCO.

The 4,627 plants in the survey indicated that they were manufacturers and that they mixed, blended, and/or granulated fertilizers. Table 1 shows the regional breakdown by types of fertilizer plants included in the survey. Appendix tables A, B, and C contain a regional summary for the data in the survey.

Regionally, 59 percent of these fertilizer plants are in the East North Central and West North Central states where 46 percent of all fertilizer materials was distributed in fiscal year 1976. Percentages of materials distributed by all plants in the survey are shown in table 2. Distribution by class indicates that more than 40 percent of all fertilizers was distributed as dry bulk or bagged blends in 1976. Fluid fertilizers (including mixtures, anhydrous ammonia, nitrogen solutions and other direct application materials) accounted for 31.5 percent; granulation materials accounted for 18.9 percent; and the remaining 9.5 percent consisted of dry direct application materials, such as ammonium nitrate (33.5-0-0), diammonium phosphate (18-46-0), and others. This was a slight decrease in bulk blend tonnage from two years ago and an increase in the fluid and granulation tonnages. Granulation percentages include diammonium phosphate plants that also have a significant production of other granular high analysis grades.

Granulation Plants

Granular homogeneous complete mixtures continue to be a major marketing channel for the three major nutrients. The conventional U.S. chemically mixed fertilizer granulation plant uses ammonia, nitrogen solutions, and ammonium sulfate as its principal nitrogen sources. Phosphoric acid, triple superphosphate, and normal superphosphate are the main P_2O_5 sources. Diammonium phosphate (18-46-0) produced in conventional granulation plants as an intermediate has become a popular source of both nitrogen and phosphate for granulating complete mixtures. Since the conventional granulation plant requires large capital investments and production levels, there are relatively few such plants in the U.S. The AAPFCO survey in 1974 listed 118 plants, and the latest survey of 42 states indicates 96 plants.

Thirty-six of the granulation plants did not have any other type manufacturing facility. The 36 plants indicated that they produced 2.4 million tons of fertilizer for an average annual throughput of 65,722. Of this total, 26 percent was sold to blenders or retailers for use in their plants or for resale. Raw materials and finished product storage amounted to 35.9 percent of the total annual distribution (table 3). The total of all granulation plants including units with bulk blend and/or fluid facilities, indicated a storage capacity of 11.4 percent of annual distribution. Only 9 percent of the 36 plants added pesticides, 82 percent added micronutrients, and only 2.0 percent of the total tonnage of the granulation plants was custom applied. Most granulation plants are in the South Atlantic and the East North Central regions. Many granulation plants have installed new melt-type processes which enable production to be increased. One plant anticipates production of 1,000,000 tons of complete mixtures for FY 1978. Another reports it will produce 300,000 tons.

Bulk Blend Plants

Bulk blending works best with well-granulated, closely sized, dry materials that will not deteriorate in storage. Bulk blending and granulation have been complementary developments as the 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 reported the use of urea as a nitrogen source than any other material. Ammonium nitrate is reported as the second most important. Diammonium phosphate and triple superphosphate were the main sources of P_2O_5 (table 4). Other materials used included 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.

Large numbers of bulk blend plants were built in the U.S. between 1950 and 1970 with only small increases since than and an apparent decline since 1974. Of the 4,627 plants included in the AAPFCO survey 2,468 had bulk blend facilities only which provided sufficient data to describe this part of the industry.

The typical bulk blend plant in the U.S. during 1976 had a total annual throughput of 5,593 tons of all materials. Table 5 shows a breaddown of this tonnage. Of this total, 2,991 tons was dry bulk mixtures. The average bulk blend plant also distributed 1,404 tons of dry direct application materials, such as ammonium nitrate and diammonium phosphate. The typical plant distributed 785 tons of anhydrous ammonia and 649 tons of nitrogen solutions. Average tonnages are only for plants handling these products and therefore are not additive.

While this 5,593-ton average annual distribution may appear to be high, a frequency distribution of these

2,468 bulk blend plants (figure 1) indicates the greatest number of plants in the 1,000-3,000-ton range (mode=2,126, median=3,049 tons). A total of 174 plants with tonnages above 10,000 distorts the curve and results in the higher average. The survey shows 57 percent of the respondents with tonnages of 1,000 to 3,999 tons.

Average storage capacity for raw materials and finished products was 42.0 percent of the total annual distribution (table 3) of the 2,489 plants. Storage is an important function of the retailer allowing basic producers to maintain monthly production levels in a highly seasonal market. The bulk blenders indicated that 60 percent of their storage was filled as of December 31, 1975, and 33 percent as of June 30, 1976.

Among the reasons previously mentioned for the rapid growth of bulk blenders, is that blenders have provided the farmers with services they want and need. One important service is bulk application or spreading. A total of 24.3 percent of the fertilizer was custom applied by the blenders, and 84 percent of the blenders offered spreader rental service. The method used most often for custom application was truck and/or floater application. As in the previous AAPFCO survey, the mountain region had the greatest percentage of fertilizers custom applied. The data for custom application indicate that the amount of material applied by the farmer is greater than the amount custom applied by the blender.

Other services, such as adding pesticides and micronutrients to fertilizer mixtures, are shown in table 6. Almost 57 percent of all bulk blend plants added micronutrients, 28 percent added pesticides, 38 percent added seeds to their dry bulk blend, and 21 percent had bagging facilities.

Eighty-five percent of all blend plants had no other manufacturing facilities. There were 260 plants with both bulk and liquid facilities; 33 that had bulk and suspension; and 182 that had all three.

Data relating to the form or type of business shows that 6.7 percent of these bulk blend plants were sole proprietorships, 3.9 percent partnerships, 47.9 percent corporations, and 42.0 percent cooperatives.

Fluid Fertilizer Plants

Fluid fertilizers include liquids and suspensions and both have been considered in this analysis. Excess elemental phosphorus production in the 1950's produced more phosphoric acid than was needed for the industrial market and this surplus was used in liquid fertilizer being neutralized with low-cost ammonia to produce 11-37-0 or 10-34-0. Production of urea-ammonium nitrate solutions further promoted the manufacture of liquid fertilizers. This high-nitrogen, nonpressure solutions was 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 reliability of fluid application systems.

Suspension fertilizers are defined as liquids in which salts are suspended by the incorporation of a suspending agent (clay). Complete solubility of phosphate is not required to suspensions; therefore, a wider range of phosphate materials can be used. Suspensions also permit the production of higher analysis grades than is possible with conventional liquids. Consumption of all fluid mixtures (liquids and suspensions) in the United States during fiscal year 1976 was 3.6 million tons. It is estimated that suspensions comprised 40 percent of all fluid mixtures.

The phenomenal growth rate of fluid mixtures leveled off in 1972 when phosphoric acid was unavailable for use in fluid fertilizers. In 1976, five states— Georgia, Illinois, Indiana, Iowa, and Texas — accounted for 46 percent of the total fluid mixtures consumed.

The AAPFCO survey shows an average annual throughput of 2,606 tons for the 429 plants reporting only liquid mix facilities. A typical plant having only fluid mixing facilities distributed 1,153 tons of liquid mixtures, 715 tons of anhydrous ammonia, 698 tons of nitrogen solutions, and 633 tons of liquid direct application materials, such as 10-34-0 and 8-24-0 (table 5). These plants also distributed significant tonnages of bulk and bagged dry mixtures and materials, such as ammonium nitrate and diammonium phosphate.

Comparable data for the suspension fertilizers mixing plants show an average annual throughput of 3,252 tons. This figure includes 1,369 tons of suspension mixtures, 529 tons of anhydrous ammonia, 670 tons of nitrogen solutions, and 857 tons of dry and liquid direct application materials (table 5). Similar to the liquid plants, these suspension plants also distributed significant tonnages of dry complete mixtures. Figure 2 shows a frequency distribution of all fluid plants (both liquids and suspensions) and indicates the greatest number of plants in the 1,000- to 3,000-ton range.

Storage capacity of the liquid fertilizer plants surveyed amounted to 25.9 percent of the total annual distribution. The suspension plants had a storage capacity of 23.9 percent of the total annual tonnage. Storage data were also obtained showing that 54 percent of the storage facilities was filled as of December 31, 1975, and 31 percent was filled as of June 30, 1976. Storage capacity by region and type of fertilizers is shown in table 3. As indicated, the storage capacity for fluids was much less than for bulk blends.

A total of 42 percent of the liquid fertilizer tonnage was custom applied (appendix table B). Forty percent of the tonnage was applied with either the truck- or floater-type applicators. Similar to the bulk blenders, farmer application of fluid fertilizers is greater than the custom application by liquid mixers.

The percentage of custom applied suspension fertilizers is higher than that for both bulk blends and liquids. Almost 75 percent of the suspension mixes was custom applied. Spreader rental service was offereda by 39 percent of the suspension mixers. A higher percentage of custom application for these plants is indicated because suspensions generally require more sophisticated application equipment.

Ownership data relating to all fluid fertilizer plants show that 14.5 percent of these plants were sole proprietorships, 6.4 percent partnerships, 63.7 percent corporations, and 13.3 percent cooperatives.

Other Services

Analysis of the questionnaires returned in the second national AAPFCO survey of fertilizer registrants has also provided a composite picture of the U.S. fertilizer market system. Of the 6,149 respondents, 4,627 had manufacturing facilities, bulk blenders, liquid and suspension mixers, and granulation or basic nutrient plants. A total of 41.3 percent of all the respondents (6,149) offered anhydrous ammonia for distribution, 68.4 percent offered custom application services, and 33.6 percent added pesticides to fertilizer mixtures. Of the 4,627 manufacturers reporting, 44.0 percent offered anhydrous ammonia; 76.1 percent provided custom application services; and 39.1 percent added pesticides to their fertilizer mixtures. Spreader rental service was offered by 70.9 percent of the manufacturing plants.

Survey results indicated that 7.5 percent of the total tonnage for all respondents was for nonfarm use. Granulators sold 5.1 percent of their annual tonnage for nonfarm use; bulk blenders, 3.7 percent; and fluid mixers, 1.9 percent. As was shown in the previous survey, more nonfarm or small-packaged fertilizers are sold from basic producers and/or granulators to consumers than from the small blenders.

About 71 percent of all the manufacturing plants had bulk blend facilities and 37.3 percent had fluid mix facilities. Sixty-five percent of the fluid mixers had both liquid and suspension facilities.

Table 1

TYPES OF PLANTS IN AAPFCO SURVEY[a]

Region	Total Returns	Bulk Blend		Fluids			Granulation		All Plants
		All	BB Only	All	Liq.	Sus.	All	Gran. Only	
New England	27	17	15	2	-	-	3	2	20
Middle Atlantic	211	144	135	35	8	1	13	3	177
South Atlantic	502	282	250	159	34	11	37	24	441
East North Central	1,400	955	785	488	35	16	17	8	1,283
West North Central	1,741	1,078	936	495	123	13	3	2	1,445
East South Central	273	193	183	53	7	14	15	4	246
West South Central	1,520	365	320	358	239	7	8	1	693
Mountain	342	181	133	86	27	1	-	-	233
Pacific	133	57	35	49	22	-	-	-	89
Total	6,149	3,272	2,792	1,725	495	63	96	44	4,627

a. AAPFCO Fertilizer Plant Survey--1976. Does not include any plants in California Minnesota, Mississippi, and Nebraska.

Table 2

DISTRIBUTION OF FERTILIZER MATERIALS BY CLASS--1976

Class	% of Total-Fertilizer	
	Survey Result[a]	USDA Report
Dry bulk blends	33.7	27.2
Dry bagged blends	6.4	14.1
Bulk granulation	9.9	-[b]
Bagged granulation	9.0	-[b]
Fluid mixtures (liquids & suspensions)	9.6	7.8
Anhydrous ammonia	9.5	10.5
Nitrogen solutions	9.4	11.8
Dry direct application materials	9.5	26.8
Liquid direct application materials	3.0	1.8
Total	100.0	100.0

a. AAPFCO Fertilizer Plant Survey--1976, including bulk blend, liquid, suspension, and granulation plants.

b. Granulation tonnage included in blends (mostly bagged).

Almost 10 percent of all the manufacturing plants indicated their form of business as sole proprietorships; 5 percent as partnerships; 54 percent as corporations; and 33 percent as cooperatives.

Directory of Fertilizer Manfacturers

The second edition of a directory of respondents to the AAPFCO survey is available through the National Fertilizer Development Center. The directory lists plant location, and plant type— bulk blend, fluid mix, or granulation and includes plant owner's or manager's name, telephone number, storage capacity, and related services offered by each plant. Requests, including prepayment of $4 per copy, should be directed to the National Fertilizer Development Center, Division of Agricultural Development, Economics and Marketing Research Section, Muscle Shoals, Alabama 35660.

Table 3

STORAGE CAPACITY OF BULK BLEND, FLUID, AND GRANULATION PLANTS[a]

Region	Bulk Blend	Liquid	Suspension	Granulation
	------% of total fertilizer distribution------			
New England	25.4	-	-	-
Middle Atlantic	42.2	23.4	-	25.8
South Atlantic	39.8	21.3	26.5	32.6
East North Central	45.2	30.4	24.8	57.0
West North Central	45.4	38.9	19.8	-
East South Central	47.4	28.7	26.7	14.4
West South Central	36.2	20.6	23.0	30.6
Mountain	34.2	34.3	-	-
Pacific	29.6	31.6	-	-
Average	42.0	25.9	23.9	35.9
No. plants reporting	2,468	429	59	36

a. AAPFCO Fertilizer Plant Survey--1976.

Table 4

TYPES OF MATERIALS USED IN BULK BLEND, FLUID AND GRANULATION PLANTS[a]

Materials	Bulk Blend	Liquid	Suspension	All Fluids	Granulation
			(% of plants)		
Ammonium nitrate	56.2	-	-	-	-
Ammonium sulfate	29.1	-	-	-	86.1
Urea	58.7	-	-	-	29.7
Diammonium phosphate	93.4	-	-	-	73.2
Normal superphosphate	12.5	-	-	-	73.2
Triple superphosphate	85.1	-	-	-	87.1
Potassium chloride	98.8	50.6	66.1	50.8	89.1
Nitrogen solutions	-	95.8	95.7	95.8	-
Anhydrous ammonia	-	21.2	29.5	20.8	76.2
10-34-0	-	91.7	89.8	91.3	-
Phosphoric acid	-	17.3	28.7	16.4	74.2
Solid phosphate (DP, MAP)	-	-	10.7	7.9	-
Clay	-	-	45.5	26.6	-
Monoammonium phosphate	-	-	-	-	34.6
Other	10.3	19.6	10.7	20.3	-
Ammoniating solutions	-	-	-	-	83.1
Sulfuric acid	-	-	-	-	85.1
No. plants reporting	(3,224)	(1,581)	(954)	(1,676)	(96)

a. AAPFCO Fertilizer Plant Survey--1976.

Table 5

AVERAGE THROUGHPUT FOR BULK BLEND, LIQUID MIX, AND SUSPENSION FERTILIZER PLANTS, 1976[a]

Class	Bulk Blend		Liquid		Suspension	
	Plants	Tons	Plants	Tons	Plants	Tons
Dry bulk blend mixtures	2,350	2,991	69	1,133	13	829
Dry bagged blend mixtures	997	1,647	41	255	7	385
Granulation bulk mixtures	371	3,347	54	1,003	12	1,369
Granulation bagged mixtures	703	536	64	299	21	1,480
Liquid mixtures	214	875	347	1,153	15	660
Suspension mixtures	14	459	17	720	50	1,369
Anhydrous ammonia	1,202	785	183	715	20	529
Nitrogen solutions	1,000	649	270	698	48	670
Direct application, dry	1,075	1,404	65	919	9	607
Direct application, liquid	158	414	235	633	8	252
Average throughput		5,593		2,606		3,252

a. AAPFCO Fertilizer Plant Survey--1976.

Table 6

OTHER SERVICES OFFERED[1]

Service	Bulk Blend	Liquid (% of Plants)	Suspension	Granulation
Adding Pesticides to Mixtures	28.1	36.6	80.0	8.9
Adding Micronutrients to Mixtures	56.5	55.2	62.7	82.2
Adding Seeds to Mixtures	38.0	4.2	13.6	-
Spreader Rental	84.0	54.1	39.0	20.0
Bagging Equipment	20.7	-	-	86.7
Soil Testing	83.2	73.2	83.1	51.1
Number of Plants	2,468	429	59	36

1. AAPFCO Fertilizer Plant Survey--1976.

APPENDIX TABLE A

REGIONAL SUMMARY OF BULK BLEND PLANTS--FERTILIZER PLANT SURVEY 1976

	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	7	117	213	698	846	154	277	122	34	2,468
Avg. size plant, tons	3,507	4,786	15,889	4,925	3,376	5,727	6,961	3,929	7,469	5,593
Storage cap., distrib., %	25.4	42.2	39.8	45.2	45.4	47.4	36.2	34.2	29.6	42.0
Fert., custom applied, %	20.1	24.4	10.6	27.1	32.4	18.0	34.4	46.0	18.9	24.3
Truck and/or floater, %	20.1	23.7	9.3	24.7	29.6	17.1	24.9	41.7	16.6	22.0
Other, %	-	0.7	1.3	2.4	2.8	0.9	4.5	4.3	2.3	2.3
Plants offering:										
Spreader rental, %	28.6	65.0	65.7	93.1	89.2	85.7	69.3	85.2	67.6	84.0
Add., pesticides, %	28.6	22.2	33.8	39.3	21.7	37.7	15.9	18.9	32.4	28.1
Add., micronutrients, %	57.1	64.1	82.2	64.6	42.7	72.1	41.2	60.7	85.3	56.5
Add., seeds to mix., %	14.3	36.8	54.5	41.1	27.4	80.5	38.6	19.7	8.8	38.0
Soil test, %	42.9	74.4	74.6	89.1	87.8	85.1	62.5	86.9	88.2	83.2
Plants w/bagging equip., %	0	27.4	37.6	28.2	9.5	20.8	18.1	13.1	73.5	20.7
All Bulk Blend Plants										
Number	17	144	282	955	1,078	193	365	181	57	3,272
Avg. size plant,[b] tons	9,055	7,806	17,674	6,076	3,720	9,193	9,198	5,048	8,856	6,892
Storage cap., distrib.,[c] %	23.0	37.4	37.2	43.2	51.4	36.0	32.8	32.6	23.3	39.9
Fert. custom applied,[b] %	11.0	15.0	12.2	31.0	34.4	29.0	25.2	45.3	35.8	26.0
Truck and/or floater, %	11.0	14.6	10.9	28.9	31.9	28.5	22.3	41.4	33.6	24.1
Other, %	-	0.4	1.3	2.1	2.5	0.5	2.9	3.9	2.2	1.9
Plants offerings:[c]										
Spreader rental, %	23.5	57.6	63.1	90.3	88.0	86.0	63.0	85.1	75.4	81.6
Add., pesticides, %	23.5	26.4	34.8	46.2	26.2	37.8	20.0	23.2	36.8	32.4
Add., micronutrients, %	64.7	66.0	81.6	66.3	45.7	72.0	43.3	69.1	86.0	59.1
Add., seed to mix., %	11.8	32.6	51.4	42.9	26.5	79.3	34.8	16.6	15.8	37.0
Soil test, %	52.9	68.1	74.5	88.2	87.6	82.9	61.9	85.6	93.0	82.4
Plants w/bagging equip.,[c] %	35.3	34.7	37.9	25.7	10.8	23.8	18.9	16.0	59.6	21.5
Non-farm tonnages,[b] % of distribution	89.7	11.6	4.3	1.9	0.8	3.4	6.6	2.8	8.4	3.7
Form of business:										
Sole proprietor, %	-	2.8	3.5	7.2	7.6	5.7	9.3	3.3	3.5	6.7
Partnership, %	-	1.4	2.5	5.2	3.1	6.7	5.8	1.1	-	3.9
Corporation, %	88.2	68.8	58.9	45.3	36.1	57.5	60.3	53.0	68.4	47.9
Cooperative, %	17.6	54.2	34.8	42.0	53.0	26.9	23.6	38.7	28.1	42.0

a. All data for bulk blend plants only based on returns of 2,468 plants.
b. Based on 2,950 plants.
c. Based on 2,750 plants.

APPENDIX TABLE B

REGIONAL SUMMARY OF FLUID MIX PLANTS--FERTILIZER PLANT SURVEY 1976

	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	28	27	110	7	212	17	21	429
Avg. size plant, tons	-	1,678	3,430	3,069	1,649	2,153	2,864	3,183	3,303	2,606
Storage cap., distrib., %	-	23.4	21.3	30.4	38.9	28.7	20.6	34.3	31.6	25.9
Fert. custom applied, %	-	90.2	61.3	54.9	57.3	66.5	32.0	49.5	18.9	42.0
Truck and/or floater, %	-	86.9	58.8	54.2	53.6	64.4	30.7	41.7	15.7	39.8
Other, %	-	3.3	2.5	0.7	3.7	2.1	1.3	7.8	3.2	2.2
Plants offering:										
Applicator rental, %	-	42.9	35.7	44.4	52.7	42.9	56.6	64.7	71.4	54.1
Add., pesticides, %	-	85.7	50.0	77.8	57.3	71.4	14.6	52.9	38.1	36.6
Add., Micronutrients, %	-	71.4	71.4	59.3	56.4	57.1	50.5	82.4	42.9	55.2
Add., seed to mix., %	-	14.3	7.1	25.9	1.8	-	2.8	-	-	4.2
Soil test, %	-	85.7	46.4	77.8	73.6	57.1	74.5	94.1	71.4	73.2
Suspension Plants Only[b]										
Number	-	-	9	16	13	12	7	-	-	59
Avg. size plant, tons	-	-	4,491	3,117	1,908	2,836	4,964	-	-	3,252
Storage cap., distrib., %	-	-	26.5	24.8	19.8	26.7	23.0	-	-	23.9
Fert. custom applied, %	-	90.0	65.5	65.8	80.2	81.9	93.8	90.0	-	74.9
Truck and/or floater, %	-	10.0	60.9	65.4	80.2	81.8	93.8	90.0	-	73.3
Other, %	-	20.0	4.6	0.4	-	0.1	-	-	-	1.6
Plants offering:										
Applicator rental, %	-	-	11.1	75.0	23.1	33.3	14.3	-	-	39.0
Add., pesticides, %	-	-	66.7	100.0	84.6	83.3	28.6	-	-	80.0
Add., micronutrients, %	-	-	100.0	56.3	76.9	50.0	28.6	-	-	62.7
Add., seed to mix, %	-	-	22.2	18.8	-	8.3	14.3	-	-	13.6
Soil test, %	-	-	88.9	87.5	92.3	83.3	42.9	-	-	83.1
All Fluid Mix Plants										
Number	2	30	129	446	462	49	323	71	47	1,559
Avg. size plant,[c] tons	13,000	4,228	9,889	5,817	4,062	6,808	5,890	6,649	6,830	5,727
Storage cap., % distrib.[d]	21.8	49.6	29.6	40.7	35.3	29.5	26.8	29.6	19.5	33.4
Fert. custom applied[c]	20.0	42.1	37.4	48.3	57.2	27.9	26.6	48.2	47.0	42.7
Truck and/or floater, %	20.0	40.3	34.0	47.0	55.6	26.6	25.5	43.8	43.0	40.8
Other, %	-	1.8	3.4	1.3	1.6	1.3	1.1	4.4	4.0	1.9
Plants offering:[e]										
Applicator rental, %	100.0	48.5	237.7	61.9	56.8	60.4	52 2	79.1	79.6	57.3
Add., pesticides, %	100.0	77.1	62.2	80.5	65.9	75.5	19.0	39.5	44.9	58.6
Add., micronutrients, %	100.0	80.0	86.8	80.5	72.9	69.8	53.6	76.7	67.3	72.5
Add., seed to mix, %	50.0	14.3	18.9	38.3	13.1	28.3	6.4	4.7	12.2	19.5
Soil test, %	100.0	77.1	74.8	89.3	85.5	84.9	71.0	81.4	87.8	82.3
Non-farm tonnage, % of distribution,[c] %	18.9	4.5	3.2	1.0	0.9	2.6	3.2	0.6	1.0	1.9
Form of business:										
Sole proprietor, %	-	26.6	5.7	7.8	15.2	17.0	27.7	9.3	6.1	14.5
Partnership, %	-	2.9	6.9	2.5	6.5	11.3	12.3	3.5	2.0	6.4
Corporation, %	100.0	68.6	81.1	75.2	58.8	60.4	48.0	60.5	59.2	63.7
Cooperative, %	-	8.6	5.7	12.1	18.0	14.3	9.2	23.3	24.5	13.3

a. All data for liquid mix plants only based on returns from 429 plants.
b. All data for suspension mix plants only based on returns from 59 plants.
c. Based on 1,559 plants.
d. Based on 1,672 plants.
e. Based on 1,725 plants.

Appendix Table C

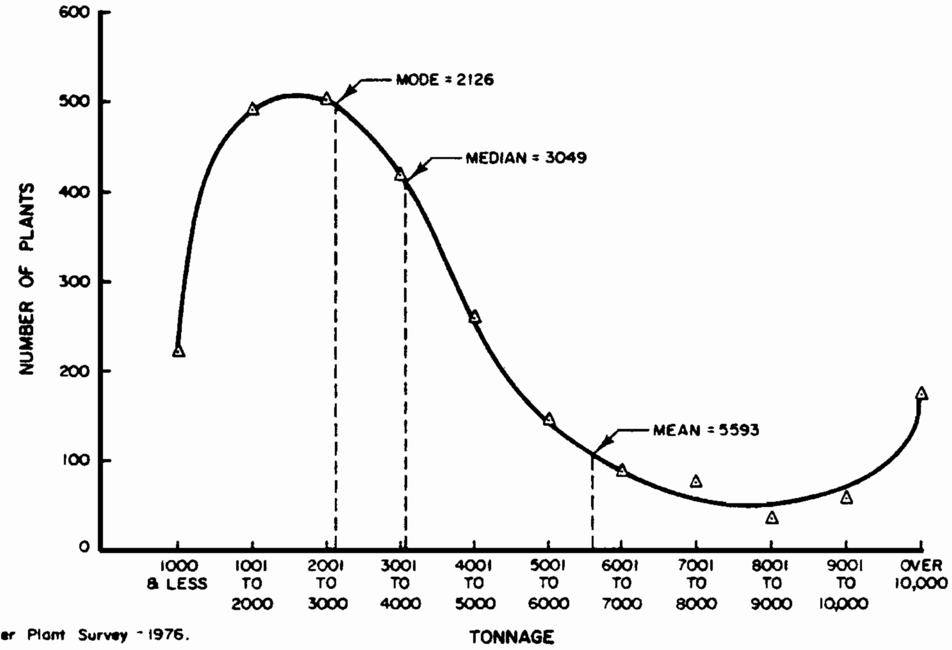
REGIONAL SUMMARY OF GRANULATION PLANTS--FERTILIZER PLANT SURVEY 1976

	Region							
	New England	Middle Atlantic	South Atlantic	East N. Central	West N. Central	East S. Central	West S. Central	Total
Granulation Plants Only[a]								
Number of plants	2	3	19	6	-	3	3	36
Avg. size plant, tons	20,000	61,667	69,053	50,417	-	125,000	125,000	65,722
Storage cap., distri., %	-	25.8	32.6	57.0	-	14.4	30.6	35.9
Fert. custom applied, %	-	-	2.8	-	-	-	-	2.0
Truck and/or floater, %	-	-	0.3	-	-	-	-	-
Other, %	-	-	0.1	-	-	-	-	-
Plants offering:[b]								
Spreader rental, %	-	-	36.0	-	-	-	-	20.0
Add., pesticides, %	-	50.0	4.0	25.0	-	-	-	8.9
Add., micronutrients, %	-	50.0	80.0	87.5	-	100.0	100.0	82.2
Add., seed to mix., %	-	-	-	-	-	-	-	-
Soil testing, %	-	50.0	77.0	37.5	-	25.0	-	51.1
All Granulation Plants								
Number of plants	3	13	31	15	1	13	-	84
Avg. size plant, tons	26,667	45,873	76,952	49,767	-	73,269	91,638	68,357
Storage cap., distri., %	54.5	28.4	30.6	43.8	-	26.2	33.9	31.4
Truck and/or floater, %	-	-	-	-	-	-	-	-
Other, %	-	-	-	-	-	-	-	-
Plants offering:[c]								
Spreader rental, %	-	-	40.5	11.8	-	46.7	25.0	27.1
Add., pesticides, %	-	30.8	0.8	17.7	-	26.7	25.0	14.6
Add., micronutrients, %	33.3	76.9	81.1	88.2	-	93.3	75.0	82.3
Add., seed to mix, %	-	-	2.7	-	-	20.0	25.0	6.3
Soil testing, %	-	30.8	67.6	70.6	-	66.7	37.5	56.3
Nonfarm tons, distri., %	0.6	18.9	2.0	10.9	-	1.2	11.4	5.1

a. All data for granulation plants only based on returns from 36 plants.
b. Based on 45 plants.
c. Based on 96 plants.

FIGURE I

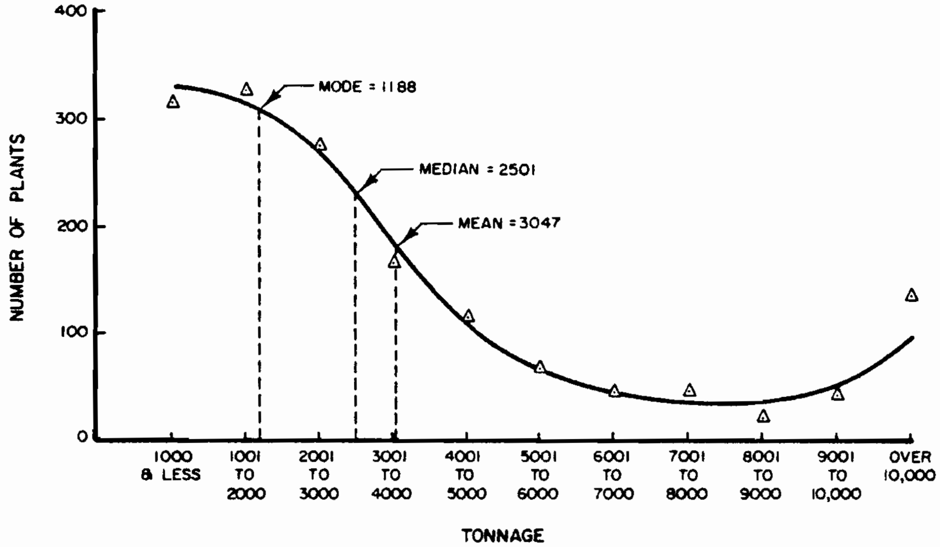
FREQUENCY DISTRIBUTION FOR U.S. BULK BLEND FERTILIZER PLANTS (1976)



Source: AAPFCO Fertilizer Plant Survey - 1976.

FIGURE 2

FREQUENCY DISTRIBUTION FOR U.S. FLUID FERTILIZER PLANTS (1976)



Source: AAPFCO Fertilizer Plant Survey - 1976.

NORMAN HARGETT: Thank you Mr. Powers. [Applause]

MODERATOR POWERS: Thank you Norman. [Applause]

Certainly if every last speaker on every program was as enthusiastic as Norman in presenting his talk it would really be great.

As your Moderator this afternoon, on behalf of the Board of Directors of the Round Table, I take this opportunity to thank the speakers. It has been a most fruitful afternoon in my opinion.

I have no announcements. I reckon that the Cocktail Party at six o'clock has set us a preference right now.

So with that we will adjourn until tomorrow morning at nine o'clock. Thank you. [Applause]

Thursday, October 27, 1977

Final Session
Moderators:
Rodger C. Smith
Paul J. Prosser, Jr.
Walter J. Sackett, Jr.

BUSINESS MEETING

CHAIRMAN SMITH: Will the business meeting of the 1977 Fertilizer Industry Round Table please come to order.

Before proceeding, I want to express thanks personally and in behalf of the Board of Directors to each speaker for his part in making this meeting the success that it is. Preparation of a paper is time consuming, often after normal working hours. But it has rewards to the writer in better understanding the impact of his work. We are again having excellent papers, good discussion and a very fine meeting. Again a request to each speaker is to submit to the moderator of your session a copy of your talk and prints of charts very soon — during the meeting preferably — if not already submitted. Without the papers, the proceedings cannot be printed. We will attempt to have distributed the 1977 proceedings much sooner than for 1976. Our apologies for their lateness.

Let me stress for any new attendees that the Round Table is a most democratic organization, open to anyone interested and open to suggestions as to program. If you have suggestions, please communicate to Paul Prosser, myself or any Board member. Be assured your views will be duly considered.

Now let me recognize that all important person to the continuity of the Round Table, our Secretary-Treasurer, Paul Prosser. Paul, let us have your report. [Applause]

Secretary-Treasury Report

Paul J. Prosser, Jr.

Thank you. Wait'll you hear it.

FINANCIAL STATEMENT

October 25, 1976 to October 24, 1977

CASH BALANCE - October 25, 1976		$ 4,787.15
Income October 25, 1976 - October 24, 1977		
Registration Fees - 1976 Meeting	$13,440.00	
Sale of Proceedings	716.00	
Transfer of Surplus Funds from Cocktail Party Fund	774.32	
Total Receipts October 25, 1976 - October 24, 1977		14,930.32
Total Funds Available October 25, 1976 - October 24, 1977		$19,717.47

(CONTINUED ON NEXT PAGE)

Disbursements October 25, 1976 - October 24, 1977

1976 Meeting Expenses	$ 1,566.35	
1976 Proceedings, including printing and postage, etc., to date	9,179.22	
Miscellaneous Expenses, including office supplies, postage, etc.	254.43	
Membership Letters, including postage	497.77	
Directors Meetings, including mail notices, postage, etc.	795.58	
1977 Meeting - preliminary expenses	150.99	
Total Disbursements October 25, 1976 - October 24, 1977		12,444.34
CASH BALANCE - October 24, 1977		$ 7,273.13
Less Reserve for Cocktail Party Fund		774.32
Total Cash Available October 24, 1977		$ 6,498.81

Respectfully submitted,
PAUL J. PROSSER, JR.
Secretary-Treasurer

While it's not evident from this blue eyed group this morning we had registered 349 people up until yesterday.

CHAIRMAN SMITH: Thank you Paul. Let's give Paul a hand of applause for the fine job he does year after year for this organization. [Applause]

CHAIRMAN SMITH: Now, let us call on the Chairman of the Nominating Committee, another person who has contributed much to the success of this organization — Wayne King. [Applause]

Nominating Committee Report

Wayne W. King, Chairman

Thank you Rodger. It's my distinct pleasure to place into nomination multiple names for membership to our illustrious Board. This is not too complicated, and I'll read the names first. There are three new members plus two changes. The first three gentlemen are Harold Green with Goldkist, Atlanta, Georgia; Donald Brunner, Missouri Farmers Association, Palmyra, Missouri and Bill Threadgill, Farmland Industries, Kansas City, Missouri. In addition to that with Agway our member, Mr. Litzelman has retired from the Board in favor of his associate, Al Malone. So then Al Malone will be voted on, and with Feeco International, Gene LeBoeuf is doing the same thing in favor of his associate, Glen Wesenberg. Now let me explain that. These changes are because these other gentlemen are more directly associated with what we have to do here, and I'm in accord with that. So without further adieu I'd like to place these names into nomination if we can get a second to it.

You have heard the nominations for Board of Directors, as follows:

Donald Brunner,
Missouri Farmers Association

Glenn Wesenberg,
Feeco International

Harold Green,
Goldkist

Al Malone,
Agway

William Threadgill
Farmland Industries

Is there a second to this motion.

VOICE: I second it.

CHAIRMAN SMITH: All those in favor, say Aye. Those against, Nay.

I declare the aforementioned, members of the Board of Directors. Welcome to all of you. [Applause]

WAYNE KING: I should like to emphasize that they are now declared members of this Board of Directors including the full responsibilities pertaining thereto.

CHAIRMAN SMITH: Two things amazing about this organization are the 2½ days' attendance to hear the papers and the attendance at the Directors' meetings. There are two meetings a year, one in mid Spring and one in July. The one in mid Spring comes right in the middle of fertilizer season and the one in July is in the vacation season, but the attendance is extremely high. The willingness of everybody makes possible this program each year. I for one certainly greatly appreciate what all the Board members do. [Applause]

Next a great host and great person who annually contributes much to the success of the meetings. He does a great deal to make the meetings go smoothly through his arrangements with the hotel and other services required — Tom Athey — Tom tell us about the 1978 meeting.

Meeting Place and Dates Committee

Tom Athey

After last year's meeting in Atlanta quite a few people wanted to go back to Atlanta so we're making arrangements to be there October 31, November 1 and November 2, 1978. Arrangements are being made with the Sheraton-Biltmore Hotel for those dates. We'll be looking for you there next fall.

CHAIRMAN SMITH: As we've discussed in the Board we would like any reactions that you have. You know we were in Memphis for a few years; we've been here many times, but considering transportation, hotel and access to much of the fertilizer industry and particularly those segments of the fertilizer industry that are particularly interested in the Round Table, Washington and Atlanta seem to make a lot of sense. Unless there's some further discussion on that why we'll accept as announced Atlanta next year.

Entertainment Committee Report

Tom Athey

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 that the Hotel Management did a magnificent job and that all of us enjoyed all of it.

Hosts

ATLANTA UTILITY WORKS
C&I/GIRDLER INCORPORATED
COMMONWEALTH LABORATORY INCORPORATED
DAVY POWERGAS, INC.
FEECO INTERNATIONAL, INC.
FESCO, INC.
HOWE RICHARDSON SCALE COMPANY
J&H EQUIPMENT, INC.
JACOBS-DORRCO DIVISION JACOBS ENGINEERING CO.
KIERNAN-GREGORY CORP.
PETROCHEMICALS COMPANY, INC.
THE PROSSER COMPANY, INC.
EDW. RENNEBURG & SONS CO.
ST. REGIS PAPER COMPANY BAG PACKAGING DIVISION
THE A. J. SACKETT & SONS CO.
STEDMAN FOUNDRY AND MACHINE CO., INC.
WEBSTER INDUSTRIES, INC.
WHEELABRATOR-FRYE INC.

CHAIRMAN SMITH: Thank you Tom for an excellent job as Chairman of "Meeting Place and Dates Committee" and "Entertainment Committee".

Another important function is publicity. Any industry is composed of a procession of people, necessitating publicizing the meeting. Walter Sackett handles well this important function.

Public Relations Chairman

Walter J. Sackett, Jr.

I get a lot of help. Everything is going all right as far as we're getting, I think, plenty of coverage by most of the publications that we contact. This year I want to thank in particular J. C. Pinder, secretary of The Fertilizer Society in England who sent a general notice of our meeting out to all of their membership.

I also contacted I.S.M.A. who has discontinued the World Fertilizer Review, but their Mr. K.L.C. Windridge and Mr. L.J. Carpentier made contact with member organizations about the meeting. So I appreciate that kind of cooperation. Thank you, gentlemen.

CHAIRMAN SMITH: Thank you Walter. All of us can assist greatly and be of service to others we know who would be interested in attending the Round Table by informing them what it is and the details regarding the 1978 meeting in Atlanta.

Perhaps the most difficult job regarding the Round Table is publishing proceedings. Al Spillman has done this for years methodically and meticulously. We will give him some help this year in this regard. Al, we appreciate what you have done and continue to do.

There are attendance lists at the back of the room, thanks to Stedman Machinery Company.

Is there other business to come before this meeting?

Again thanks to all who have actively participated in preparations and conduct of this meeting. Thanks to all of you who are, in fact, the Round Table. [Applause]

Now I call again on Walter Sackett who will moderate the next part of our meeting, Walter.

Moderator Walter J. Sackett, Jr.

Our first paper of this session is "Physical Properties of Granular Urea-Based NP and NPK Fertilizers," by George Hoffmeister and Cecil P. Harrison of TVA at Muscle Shoals, Alabama, with the paper presented by Mr. Hoffmeister.

George received his degree in chemical engineering at Rice University in 1942 and since that time he has had 35 years of experience in fertilizer research and development work at TVA, including about 25 years' work in the study of physical properties of fertilizers. He is presently supervisor of the evaluation section of our Applied Research Branch. George has numerous publications in this area of technology and TVA receives frequent requests for George's help, both for evaluation of materials and for establishment of test procedures and apparatus.

I'm sure that many of you also are familiar with the very excellent work George has done in development of bulk blending technology. His efforts in this area have undoubtedly been a major factor in the growth of bulk blending in the United States and in improvement in the quality of blended products. Of course, physical properties of materials are a major consideration in production of good quality blends.

Physical Properties Of Granular Urea-Based NP And NPK Fertilizers

George Hoffmeister — Cecil P. Harrison
Presented by George Hoffmeister

Most of the commercial experience with the use of urea as an ingredient of granular fertilizers has been in countries other than the United States[1]. The more common nitrogen sources in the U.S. have been ammonium sulfate and ammonium nitrate. However, there currently is increased interest in the possibilities of using urea in granular fertilizers. Probable reasons for this interest are

1. Increased availability of urea at favorable prices.
2. Industry adoption of the pipe reactor and pipe-cross reactor processes[2,3]. These processes are particularly adaptable to the use of urea because they eliminate the drying step[4], which formerly was somewhat of a problem with urea-based products[5,6].
3. Higher analysis products are possible with urea.

The increases in grades that are possible with use of urea are shown in Table I. The grades shown are based on the use of wet-process acid of an assumed purity of about 82% ammoniated halfway to diammonium phosphate (7.2 lb NH_3/unit P_2O_5). Grades possible using urea as the only nitrogen supplement are 28-28-0, 34-17-0, 36-12-0, 19-19-19, and 26-13-13. These are up to 100% higher than can be made with ammonium sulfate. TVA has produced and distributed the 28-28-0 grade on a demonstration scale for about 4 years and a 35-17-0 grade for 2 years. The 19-19-19 grade was studied extensively in pilot-plant work. Table I shows also grades of pipe-cross reactor products that have been tested with urea as an ingredient in the TVA pilot plant or on an experimental basis in a commercial plant. Since the pipe-cross process employs sulfuric acid, these products contain ammonium sulfate, which lowers the grade somewhat. However, the grades in most cases are as high or higher than can be obtained with ammonium nitrate supplement; also, they contain sulfur which often is agronomically desirable. The 20-10-10-10S product shown also contained 3 units of sulfur furnished as solid, byproduct ammonium sulfate. such use of urea in combination with byproduct ammonium sulfate offers a means of maintaining relatively high product grade while utilizing a relatively low-grade byproduct material that is an excellent fertilizer and a good source of sulfur.

Questions most frequently raised about the use of urea in granulation concern its effect on physical properties of the products. The present paper summarizes TVA physical testing of pipe reactor and pipe-cross reactor products made with urea.

Production Processes

The products tested were made by the production processes shown in Figures 1 through 5. The pipe reactor-pugmill granulator process (Figure 1) is used in TVA's demonstration-scale plant[2] to produce 28-28-0 and 35-17-0 grades from wet-process acid and urea melt (99% urea); a 19-19-19 grade was made by this process in the pilot plant. In the pilot plant, a pipe reactor-drum granulator process (Figure 2) was used also to make 19-19-19 grade from urea melt. Superphosphoric acid was used, since the study was directed toward an operation in which acid would be shipped overseas in concentrated form. The pipe reactor-drum granulator process was used also (Figure 3) to make several grades in which the supplemental nitrogen was furnished as solid urea (microprills or fines); grades made and tested were 19-19-19, 15-30-15, and 12-24-24. Products containing sulfate were made by the pipe cross-drum granulator process (Figures 4 and 5. Urea was furnished as melt in production of 33-11-0-4S and 33-11-0-6S products (Figure 4) and as solid in production of 32-16-0-4S, 17-17-17-5S, and 20-10-10-10S grades (Figure 5). All of the products tested contained some polyphosphate developed in the pipe and pipe-cross reactors; polyphosphate levels ranged from 3 to 43%. No dryer was used for any of the products except the 32-16-0-4S grade; products from the granulators were passed through a rotary cooler fed with ambient air and then were screened to nominal minus 6- plus 16-mesh size. With the 32-16-0-4S grade, a small amount of dryer heat was required because the large proportion of solid urea feed limited heat input to the granulator. Physical testing of products was carried out on the screened products as produced.

Caking Tests

Each product was subjected to standard caking tests[7] in either 3-pound or 50-pound moistureproof (7-mil polyethylene) bags under pressure (4 psi) equivalent to that at the bottom of a 20-bag stack of 50-pound bags. Storage was at ambient conditions in an unheated, well-ventilated warehouse. Three-pound bags were dropped twice (3-ft drop) before measuring percent plus 2-mesh lumps and lump hardness (light, medium, or hard); 50-pound bags were dropped only once. Parallel test series were made with unconditioned product and product coated with 2% of an untreated kaolin clay conditioner. Results with nonpotash grades are given in Table II. Storage of unconditioned 28-28-0 grade was excellent for a year at moisture content of 1.3%. This is about the average moisture level of the TVA demonstration plant product, and essentially no caking problems have been encountered during 4 years' distribution of that product. The 35-17-0 product, which contains a higher proportion of urea, shows objectionable caking when moisture level is about 1% or more if conditioner is not used. Moisture level in the TVA plant product ranges from 1 to 1.5%; therefore, a coating of 1 to 2% of kaolin is applied. Data in Table II show that this treatment is completely effective, and no caking problems have been encountered. Other data in Table II indicate that 33-11-0-4S and —6S pipe-cross reactor products probably will require conditioner if moisture contents exceed about 0.4%. TVA plans demonstration-scale production of this grade, and it is expected that a conditioner will be used. Data in Table II indicate that a coating of untreated kaolin should be highly effective.

Storage data on the potash grades are given in Table III. Good storage of unconditioned 19-19-19, 15-30-15, and 12-24-24 grades for 12 months was obtained with moisture content up to about 1.5%. An exception was one 19-19-19 product of 1.3% moisture content which developed 19% hard lumps in 12 months, but was satisfactory for 6 months. Pipe-cross reactor product of 17-17-17-5S grade and 0.8% moisture content has been satisfactory without conditioner for 6 months (only 10% light lumps); the test is still in progress. Pipe-cross reactor product of 20-10-10-10S grade (3 units S from byproduct sulfate) containing 0.7% moisture shows caking (24% medium lumps) in 6 months, but a clay coating completely eliminated caking. Nitrate-based products of this grade also normally require conditioner.

Overall conclusion of the caking tests of urea-based pipe reactor and pipe-cross reactor products is that caking tendencies are minimal at moisture levels that can be obtained in most cases without use of a dryer. For long-term storage of 2:1 and 3:1 $N:P_2O_5$ ratio products, use of a conditioner may be required, but an inexpensive clay coating should suffice.

Most of the products were available only in pilot-plant quantities; therefore, it was not possible to study caking tendency in large piles. However, caking of fertilizers in large piles often occurs deep in the pile center where both pressure and protection from external humidity are much the same as in the bottom bags of storage stacks. Therefore, the favorable results of the bag caking tests discussed above indicate also that caking should not be a problem in the center of bulk piles. In bulk pile storage, an additional concern is the effect of atmospheric humidity and temperature fluctuations on wetting, deterioration, and caking of the pile surface material. With the urea-based NP and NPK products, this was studied in both laboratory and small-pile (300-400 lb) tests, as discussed below.

Critical Humidity: Each soluble fertilizer salt or mixture has a characteristic "critical humidity" which may be defined as the maximum humidity in which the product can be exposed without causing it to absorb moisture. Various products differ not only in critical humidity but also in their tolerance for absorbed moisture; therefore, other tests, described later, are required for full evaluation of a product's resistance to humidity. For the urea-based products critical relative humidity was determined by the method[7] of exposing small samples to increasingly humid atmospheres in a humidity cabinet and noting the point where weight increase indicated moisture absorption. Results are given in Table IV, in comparison with values for several conventional fertilizers. The critical relative humidity of the urea-based nonpotash grades was 55 to 60%; this is about the same as that of ammonium nitrate (59%) which is generally regarded as a quite hygroscopic material. Criterial humidity of the potash-grade pipe-reactor products (no sulfate) was only 45%, which indicates very hygroscopic products. Critical humidity of the potash-grade pipe-cross reactor products (containing sulfate) was slightly higher (50%).

Laboratory Exposure-Penetration Tests: Laboratory exposure-penetration tests[7] were made to determine effects of prolonged humid exposure on penetration of moisture into bulk material. Results are given also in Table IV. Open-top cylindrical glass vessels 6.8-centimeter diameter by 20-centimeter high were filled level full with products and exposed 72 hours to moving air at controlled relative humidity of 80% and temperature of 86°F. Measurements were made of the amount of moisture absorbed per square centimeter of exposed surface and of the depth to which moisture penetrated. From these measurements, and the bulk density of the material, the moisture absorption capacity (%H_2O) of the granules was calculated. Absorption capacity may be considered to be the maximum moisture that a granule will hold before moisture is passed, by capillary action, to an adjacent granule. A product with high absorption capacity will tend to hold absorbed moisture on the pile surface, rather than allow it to penetrate into the pile.

Results in Table IV show that none of the urea-based products absorbed as much moisture or were penetrated as deeply as prilled ammonium nitrate. Deepest penetration was 12 to 14 centimeters into 33-11-0-4S product, as compared with 46 centimeters into ammonium nitrate (extrapolated value). The deep penetration of both these materials was due to a combination of high absorption rate and low absorption capacity. Products penetrated to depths of 5 to 7 centimeters included 17-17-17 and 20-10-10 products of both nitrate and urea base, and urea-based 32-16-0-4S, 12-24-24, and a 19-19-19 made from solid urea. Product of 19-19-19 grade made from urea melt showed only half as much penetration (3.4 cm) because of high (18%) moisture absorption capacity; this result was checked on three products. The moisture-affected layer was, however, extremely muddy because of the high-moisture content. Other products with low penetrations (1-3 cm) included 13-13-13 sulfate-basee NPK, TVA 11-55-0 ammonium polyphosphate, 18-46-0 diammonium phosphate, and urea-based products of 28-28-0 and 35-17-0 grade.

Small-Pile Storage Tests: Small-pile storage tests were made with 300 to 400 pounds of material exposed to open warehouse conditions in small, open-top wooden bins coated on the inside with epoxy moisture-proofing. Tests of this type correspond more closely to actual pile surface conditions in bulk storage than do constant-humidity laboratory tests, and results are sometimes different. However, because atmospheric conditions in the small-pile tests are not controllable, it is important to include conventional fertilizers in each test series for comparison. Results of a 9-month (January-September) test series with exposure to atmospheric conditions at Muscle Shoals, Alabama, are summarized in Table V. During the first 6 months, prilled ammonium nitrate became wet the full 20-inch depth of the storage bin. During this 6 months, diammonium phosphate (18-46-0), at the other extreme, was affected only to a depth of less than 1 inch. The urea-based non-potash grades, 28-28-0, 35-17-0, and 33-11-0-4S, were affected only to depths of 2 to 5 inches. The penetration (3 in) of the 33-11-0-4S was relatively shallow, compared with its deep penetration under constant high humidity in the laboratory tests; reasons for this are not clear. Most affected of the urea-based products was the 19-19-19 pipe-reactor product (no sulfate); it was extremely wet to a depth of 12 inches. The urea-based 17-17-17-5S and 20-10-10-10S pipe-cross products were penetrated to a depth of 6 to 7 inches in 6 months, which was essentially the same (7-8 in) as that of the corresponding nitrate-based grades. The affected portions of these two urea-based products were somewhat wetter than were the affected portions of the nitrate-based products.

The last 3 months of the 9-month test was during more humid summer months (July-September). Data in Table V show that both the 20-10-10 nitrate-based product and the urea-based 19-19-19 were penetrated the full 20-inch depth. The 9-month penetration of the 20-10-10-10S urea-based product was only 11 inches. Penetration of the 17-17-17-5S urea-based product, the 17-17-17 nitrate-based product, and the 33-11-0-4S urea-based product all were only 9 to 10 inches. The TVA 28-28-0 and 35-17-0 were penetrated only 5 to 6 inches.

Effects of Humidity on flowability: Further evaluation of the relative hygroscopicity of the various products was made in a laboratory "flowability" test. Results are given in Table VI. This test is designed to measure a property formerly referred to as "drillability"[7,8], which is simply the ability of a material to resist loss of flowability during exposure to high humidity. In the present procedure, a 500-milliliter sample of fertilizer is placed in a small (10-in-dia by 6-in-deep) inclined rotating pan and is exposed to a stream of humid air (90% relative humidity at 86°F.). The sides of the pan are equipped with small lifting flights. The pan is rotated at 12 rpm and measurement is made of the time during which the material remains free flowing. The end point (estimated 50% impairment of flow) is quite abrupt.

Results in Table VI show that materials which remained flowable for only about 10 minutes were prilled ammonium nitrate, prilled urea, and urea-based 32-16-0-4S, 33-11-0-4S, and 33-11-0-6S. Products with the longest free-flow times (140-169 min) were 13-13-13 sulfate-based NPK, TVA 11-57-0 ammonium polyphosphate, and 18-46-0 diammonium phosphate. Urea-based 17-17-17-5S and 20-10-10-10S were free flowing for 35 and 24 minutes as compared with 105 and 73 minutes for the corresponding grades of nitrate-based product. Free-flow time of the two 19-19-19 urea-based products was 16 to 20 minutes. TVA 28-28-0 and 35-17-0 demonstration-scale products had free-flow times of 36 and 52 minutes, respectively.

Conclusions

At product moisture levels attainable without use of a dryer in the pipe reactor and pipe-cross reactor processes, the caking tendencies of various urea-based grades appear to be minimal, although an inexpensive clay coating is probably required for long-term storage in 2:1 and 3:1 $N:P_2O_5$ ratio products. Chief effect of urea on physical properties is a lowering of the humidity resistance of some grades, particularly those containing potash and those of high urea content. Pipe-reactor products of 19-19-19 grade (no sulfate) had very low critical humidity (45%) and were deteriorated by humid exposure to the extent that bulk handling and distribution of this grade does not seem feasible without special precautions. Products of 17-17-17-5S and 20-10-10-10S grades made with urea by the pipe-cross process, however, were only slightly more hygroscopic than comparable commercial grades made with ammonium nitrate and should be as satisfactory as those products. Urea-based pipe-reactor products of 28-28-0 and 35-17-0 grades (no sulfate) have been made on a demonstration scale by TVA for 4 and 2 years, respectively; physical properties of these products have been good and bulk handling and distribution have been without significant problems. Urea-based 33-11-0-4S or 6S product, made thus far only on a pilot-plant scale by the pipe-cross process, is considerably more hygroscopic than the 28-28-0 and 35-17-0 TVA products and, although somewhat more resistant than ammonium nitrate to humid exposure, probably would require about the same protection in bulk handling as is usually afforded ammonium nitrate. Demonstration-scale production of 33-11-0-4S product for fuller evaluation is planned by TVA. Similar large-scale production and test distribution would be required for full evaluation of the physical properties of other products that have thus far been produced only in pilot-plant quantities.

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TABLE I

WET PROCESS ACID-BASED FERTILIZER GRADES

SUPPLEMENTAL NITROGEN	1:1:0	2:1:0	3:1:0	1:1:1	2:1:1
MAXIMUM POSSIBLE GRADES					
AMMONIUM SULFATE	18-18-0	20-10-0	18-6-0	14-14-14	16-8-8
AMMONIUM NITRATE	24-24-0	28-14-0	30-10-0	17-17-17	22-11-11
UREA	28-28-0	34-17-0	36-12-0	19-19-19	26-13-13
PIPE-CROSS REACTOR PRODUCTS TESTED					
UREA + AMMONIUM SULFATE	—	32-16-0 (4S)	33-11-0 (4S, 6S)	17-17-17 (5S)	20-10-10 (10S)

TABLE II

BAG STORAGE - NON POTASH GRADES

GRADE	UREA	% H_2O	% POLY	GRANULE HARDNESS LB.	% LUMPS AND HARDNESS UNCONDITIONED 3 MO.	6 MO.	1 YR.	2% KAOLIN 3 MO.	6 MO.	1 YR.
PIPE REACTOR (NO SULFATE)										
28 - 28 - 0	MELT	0.5	22	6	0	0	0	0	0	0
		1.3	19	–	0	0	8L	0	0	0
35 - 17 - 0	MELT	0.7	24	6	2L	20L	3L	0	0	0
		0.9	26	5	12L	50M	44H	0	0	0
PIPE - CROSS REACTOR (WITH SULFATE)										
32 - 16 - 0 - 4S	SOLID	0.5	12	4	(IN PROGRESS)					
33 - 11 - 0 - 4S	MELT	0.3	43	6	3 L	8L	9L	0	0	0
		0.4	–	5	0	17L	–	0	0	–
		0.7	10	4	22L	11M	14M	0	0	0
		0.9	7	4	13L	15M	–	0	0	–
33 - 11 - 0 - 6S	MELT	0.4	19	9	0	4L	1L	0	0	0
		0.5	3	4	13L	46H	–	0	0	–

TABLE III

BAG STORAGE - POTASH GRADE

GRADE	UREA	% H_2O	% POLY	GRANULE HARDNESS, LB.	% LUMPS AND HARDNESS UNCONDITIONED 3 MO.	6 MO.	1 YR.	2% KAOLIN 3 MO.	6 MO.	1 YR.
PIPE REACTOR (NO SULFATE)										
19 - 19 - 19	MELT	0.5	34	–	0	8L	0	0	0	0
		1.0	37	–	0	0	15M	0	0	0
		1.3	34	–	0	9L	19H	0	0	0
	SOLID	1.3	25	12	1L	0	1L	0	0	0
		1.4	24	–	2L	0	0	0	0	0
15 - 30 - 15	SOLID	1.5	25	12	0	0	0	0	0	0
12 - 24 - 24	SOLID	1.6	24	10	3L	0	5L	0	0	0
PIPE - CROSS REACTOR (WITH SULFATE)										
17 - 17 - 17 - 5S	SOLID	0.8	11	6	0	10L	–	0	0	–
20 - 10 - 10 - 10S	SOLID	0.7	17	3	18L	24M	–	0	0	–

TABLE IV

EXPOSURE - PENETRATION TESTS

				72 HR EXPOSURE AT 86°F, 80% RH		
GRADE	UREA	% POLY	CRITICAL HUMIDITY, %	MOISTURE ABSORBED, MG./SQ. CM.	ABSORPTION CAPACITY, % H_2O	MOISTURE PENETRATION, CM.
CONVENTIONAL FERTILIZERS (STANDARDS)						
34-0-0	AMM. NITRATE PRILLS		59	918	2.1	46.0
46-0-0	UREA PRILLS		75	324	3.2	13.0
20-10-10	NITRATE-BASED		55	372	6.7	6.9
17-17-17	NITRATE-BASED		55	433	8.3	6.3
13-13-13	SULFATE-BASED		70	238	11.0	2.7
11-55-0	AMM. POLYPHOSPHATE (TVA)		70	88	7.9	1.4
18-46-0	DAP		70	151	14.1	1.2
UREA-BASED PIPE REACTOR (NO SULFATE)						
28-28-0	MELT	22	55	377	16.0	3.0
35-17-0	MELT	24	55	465	26.2	2.3
19-19-19	MELT	35	45	538	18.5	3.4
19-19-19	SOLID	24	45	463	7.7	7.0
15-30-15	SOLID	25	45	–	–	–
12-24-24	SOLID	24	45	499	11.5	5.2
UREA-BASED PIPE-CROSS REACTOR (WITH SULFATE)						
32-16-0-4S	SOLID	12	60	382	7.4	7.0
33-11-0-4S	MELT	7	55	509	5.9	11.6
33-11-0-6S	MELT	3	55	606	5.5	14.5
17-17-17-5S	SOLID	11	50	467	9.2	6.1
20-10-10-10S	SOLID	17	50	375	6.9	6.7

TABLE V

Results of Small-Pile Exposure Tests[a]

	6 months (Jan.-June 1977)		9 months (Jan.-Sept. 1977)	
	Moisture penetration, in	Condition of moisture-affected layer	Moisture penetration, in	Condition of moisture-affected layer
Conventional Fertilizers (Standards)				
Ammonium nitrate prills	20+	Wet	-	
17-17-17 nitrate-based	7	Damp, granules soft	10	Damp, granules soft
20-10-10 nitrate-based	8	Damp, granules soft	20	Damp, granules soft
18-46-0 DAP	< 1	Dry, granules hard	1	Dry, granules hard
Urea-Based Pipe Reactor (No Sulfate)				
28-28-0	5	Slightly damp, granules soft	6	Slightly damp, granules soft
35-17-0	2	Slightly damp, granules soft	5	Slightly damp, granules soft
19-19-19	12	Mud	20+	Mud
Urea-Based Pipe-Cross Reactor (with Sulfate)				
33-11-0-4S	3	Wet	10[b]	Wet
17-17-17-5S	6	Wet	9	Wet
20-10-10-10S	7	Wet	11	Wet

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[a] Ambient exposure, Muscle Shoals, Alabama.

[b] This test was lost, but value shown was obtained in four previous 9-month tests.

TABLE VI

HUMIDITY RESISTANCE TESTS (FLOWABILITY)

GRADE		UREA	% POLY	CRITICAL HUMIDITY, %	MINUTES FLOWABLE AT 86°F, 90% R.H.
CONVENTIONAL FERTILIZERS (STANDARDS)					
34 - 0 - 0	AMM. NITRATE PRILLS			59	11
46 - 0 - 0	UREA PRILLS			75	9
20 - 10 - 10	NITRATE - BASED			55	73
17 - 17 - 17	NITRATE - BASED			55	105
13 - 13 - 13	SULFATE - BASED			70	156
11 - 55 - 0	AMM. POLYPHOSPHATE (TVA)			70	169
18 - 46 - 0	DAP			70	70 - 140
UREA - BASED PIPE REACTOR (NO SULFATE)					
28 - 28 - 0		MELT	22	55	36
35 - 17 - 0		MELT	24	55	52
19 - 19 - 19		MELT	35	45	20
19 - 19 - 19		SOLID	24	45	16
UREA - BASED PIPE - CROSS REACTOR (WITH SULFATE)					
32 - 16 - 0 - 4S		SOLID	12	60	10
33 - 11 - 0 - 4S		MELT	7	55	9
33 - 11 - 0 - 6S		MELT	3	55	11
17 - 17 - 17 - 5S		SOLID	11	50	35
20 - 10 - 10 - 10S		SOLID	17	50	24

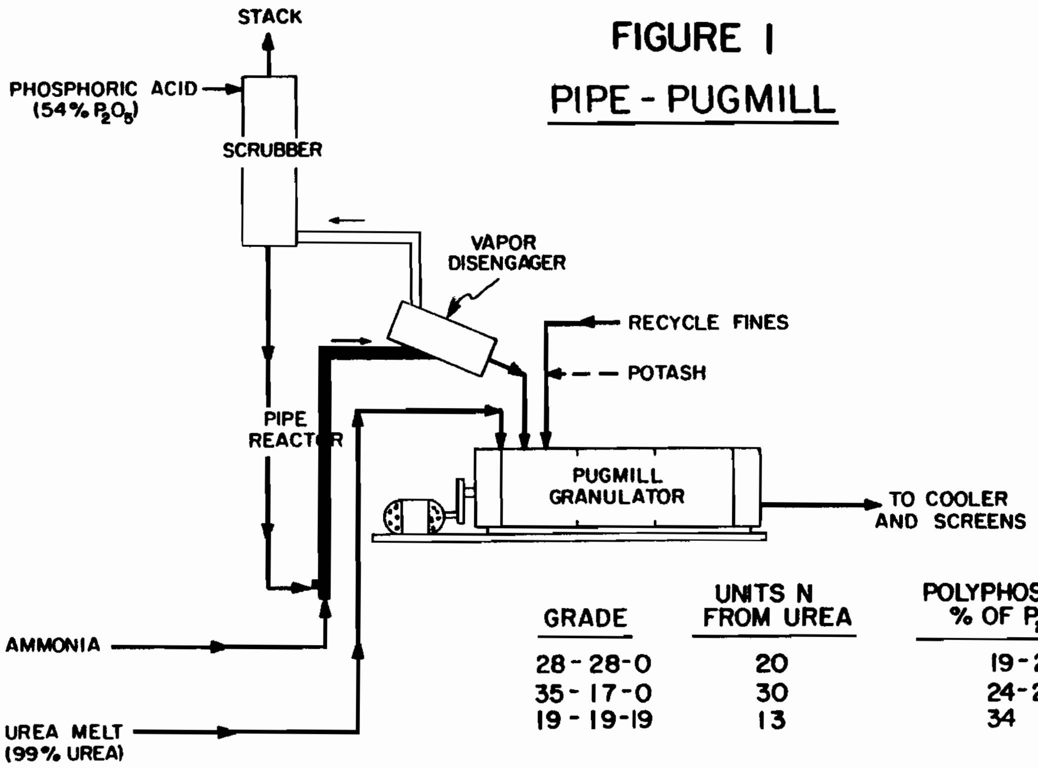
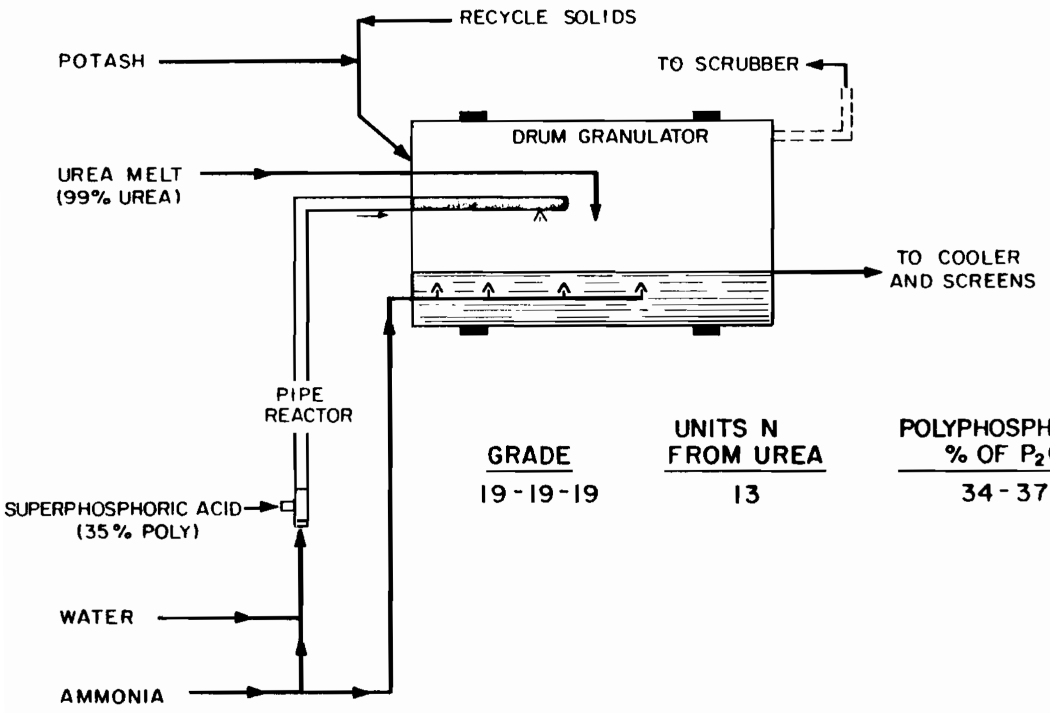


FIGURE I

PIPE - PUGMILL

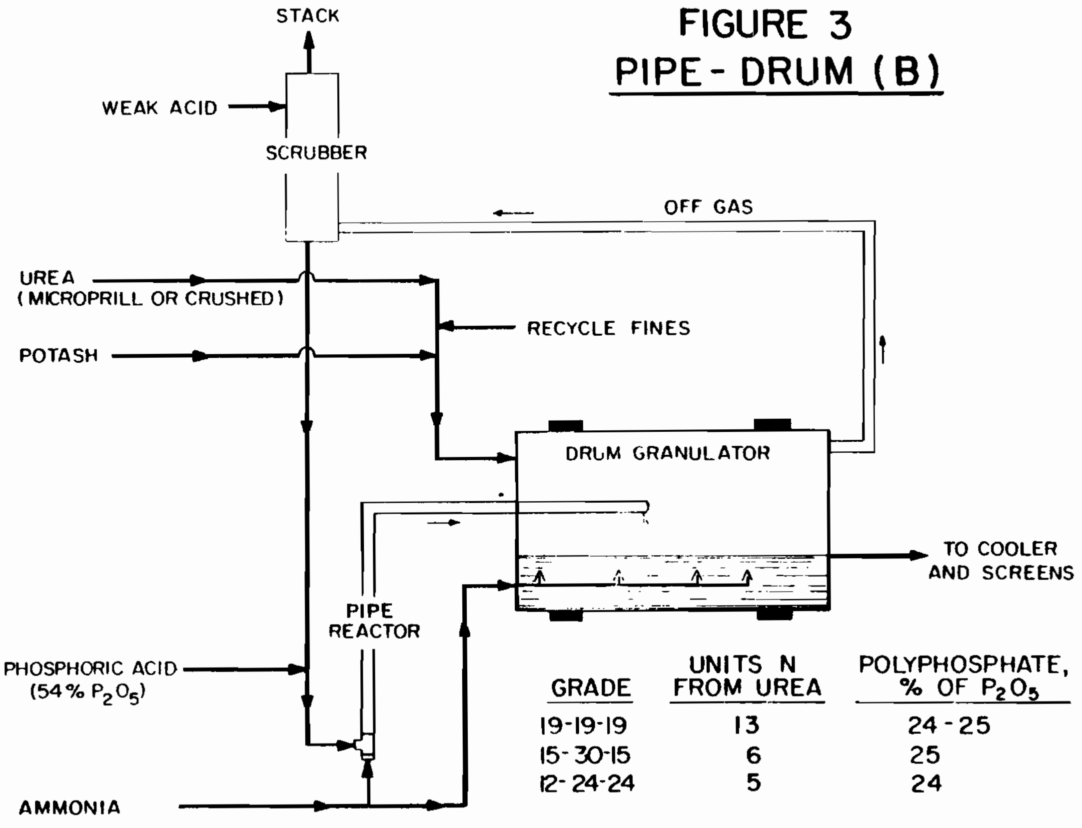
GRADE	UNITS N FROM UREA	POLYPHOSPHATE, % OF P_2O_5
28 - 28 - 0	20	19 - 22
35 - 17 - 0	30	24 - 26
19 - 19 - 19	13	34

FIGURE 2
PIPE - DRUM (A)



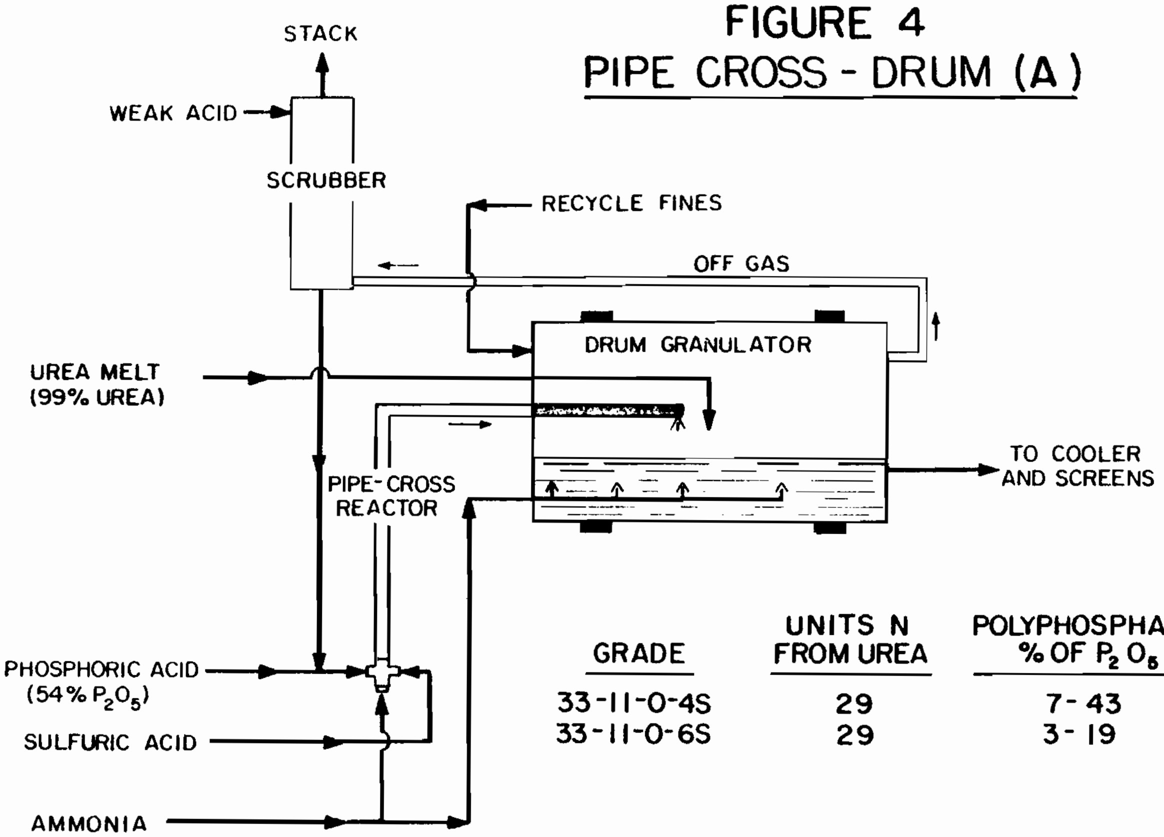
GRADE	UNITS N FROM UREA	POLYPHOSPHATE, % OF P_2O_5
19-19-19	13	34-37

FIGURE 3
PIPE - DRUM (B)



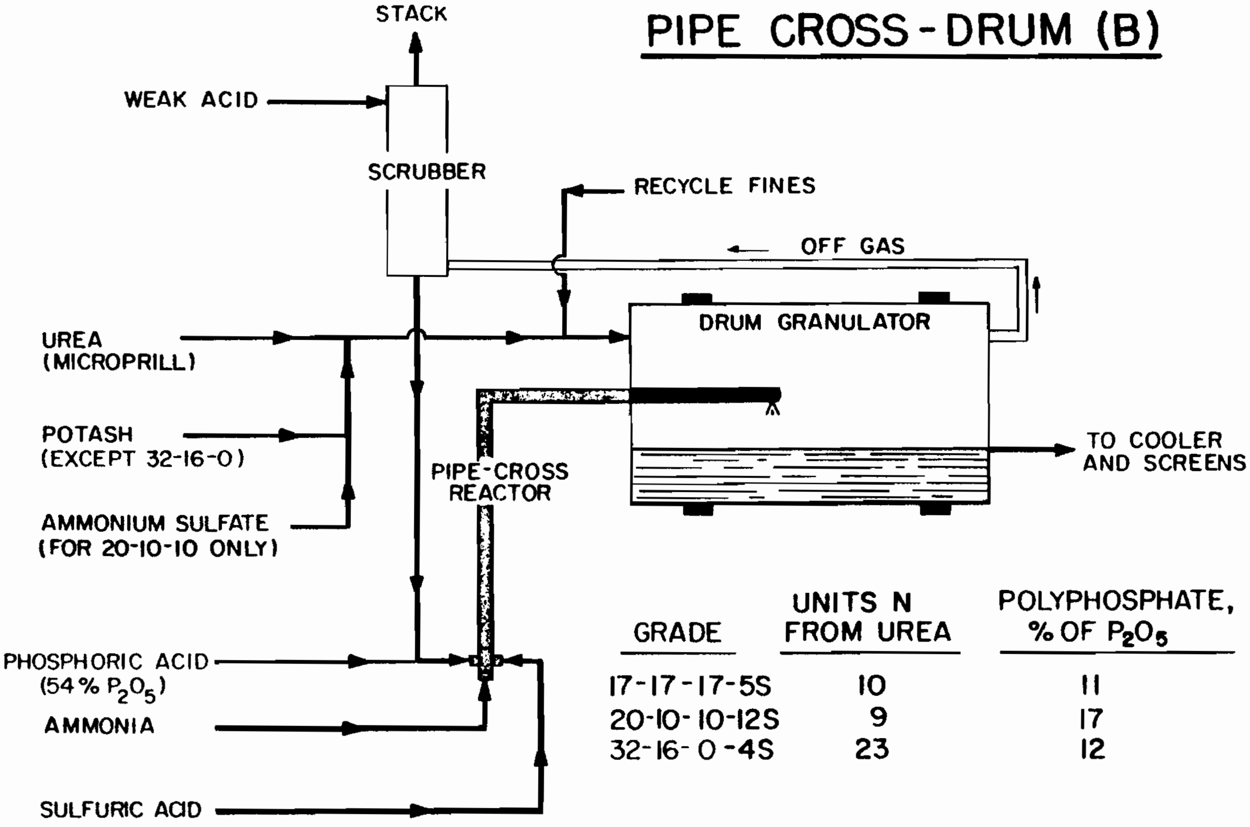
GRADE	UNITS N FROM UREA	POLYPHOSPHATE, % OF P_2O_5
19-19-19	13	24-25
15-30-15	6	25
12-24-24	5	24

FIGURE 4
PIPE CROSS - DRUM (A)



GRADE	UNITS N FROM UREA	POLYPHOSPHATE, % OF P_2O_5
33-11-0-4S	29	7-43
33-11-0-6S	29	3-19

FIGURE 5
PIPE CROSS-DRUM (B)



GRADE	UNITS N FROM UREA	POLYPHOSPHATE, % OF P_2O_5
17-17-17-5S	10	11
20-10-10-12S	9	17
32-16-0-4S	23	12

MODERATOR SACKETT: Thank you George for an excellent presentation. [Applause]

In the interest of moving the meeting along, I think, we'll hold questions until the conclusion of all of our talks this morning. Our next paper is on the "Potential Impact of the Toxic Substances Control Act on the Fertilizer Industry" by Mr. Karl Johnson of The Fertilizer Institute. Mr. Johnson has a B.S. in chemical engineering from Iowa State. He joined TFI in 1975. Presently is Vice President- Member Services. Prior to this he was with EPA from '70 to '75 and prior to that Atlantic Research Corporation and Dupont. Mr. Johnson please. [Applause]

Potential Impact Of Toxic Substances Control Act On The Fertilizer Industry

Karl T. Johnson

The Toxic Substances Control Act (TSCA) — what is it and what does it mean to the fertilizer manufacturer, processor or distributor?

These and myriad other questions are confronting all segments of the industry. Few answers are available at this time. However, some key features of the Act should be known by every person who manufactures, processes or distributes, fertilizers or fertilizer ingredients — because TSCA *could* affect every single one of them.

Purpose

The purpose of the Act, which became effective January 1, 1977, is to prevent the occurrence of unreasonable risk of injury to health or the environment which may arise from the manufacture, processing, distribution in commerce, use, or disposal of chemical substances and mixtures.

In passing the Act, Congress established as policy three concepts:

> (1) Adequate data should be developed by manufacturers and processors with respect to effect of chemical substances and mixtures on health and the environment.
>
> (2) Adequate authority should exist to regulate chemical substances and mixtures which present an unreasonable risk to health or the environment, and
>
> (3) The authority exercised over chemical substances and mixtures should not impede unduly or create unnecessary economic barriers to technological innovation.

Basic Features

The basic features of the Act are that the Administrator of the Environmental Protection Agency (EPA) is given authority to:

1. *Require testing of new and existing chemical substances and mixtures* that may present an unreasonable risk of injury to human health or the environment;
2. *Regulate,* when warranted, *the manufacture, processing, distribution, use or disposal* of a chemical substance or mixture (existing or new);
3. *Require pre-manufacture notification* to EPA of all new chemical substances and any significant new use of an existing substance; and,
4. *Require the maintenance of such records* and the *submission of such reports* as the Administrator may reasonably require.

What Substances Are Covered?

The term "toxic" in the title is somewhat misleading. Basically, all chemical substances and mixtures are subject to some provisions of the Act. However, requirements are less stringent for mixtures than for chemical substances.

Whereas the basic purpose of the Act is directed at particularly dangerous substances, all chemical substances not specifically exempted from coverage are subject to certain provisions of the Act. Substances not covered by this law are pesticides, tobacco and tobacco products, nuclear (radioactive) materials, food, food additives, drugs and cosmetics.

The definition of "chemical substance" and mixture" in the Act covers all basic and mixed fertilizers. Simplified somewhat from the language in the Act, they are:

> *Chemical substance — Organic or inorganic substances, combinations occurring by chemical reaction or occurring in nature elements and uncombined radicals. Does not include mixtures.*
>
> *Mixtures — Combination (man-made) of chemical substances that has been or may be achieved without chemical reaction.*

Is There Relief For The Small Manufacturer?

The law is applicable to all companies. However, small manufacturers and processors are to be given some relief from record keeping and reporting. EPA, in consultation with the Small Business Administration, is to define small businesses for purposes of record keeping and reporting requirements.

Small manufacturers will likely be required to submit information for the initial inventory of existing substances. In the proposed regulation (August 2, 1977) for inventory reporting, the definition used by EPA for small manufacturers as being one who (a) has only one manufacturing site and has either (1) less than $100,000 total annual sales or (2) has no more than 2,000 pounds annual production of each chemical substance. This does not exclude any fertilizer manufacturer I know.

Summary of Major Provisions

The Act is very complex and requires detailed study in order to appreciate its full impact. However, a few key items are highlighted below for your quick review.

Testing (Section 4). EPA may require testing of chemical substances or mixtures, if need is established due to risk or exposure, if insufficient data are available to make assessment or risk, and if testing is needed to establish data. Testing of mixtures is not required, unless effects cannot be determined reasonably, and more efficiently by testing individual chemical substances making up the mixture.

Premanufacture Notification (Section 5). EPA must be notified at least 90 days in advance of intention to manufacture a new chemical substance or use a chemical substance for significant new use. new chemical substance will be determined by absence from inventory of existing chemical substance compiled by EPA (Section 8[b]). At the end of the 90-day period (which can be extended for an additional 90 days), the chemical substance can be manufactured and marketed, unless EPA takes regulatory action.

Regulation of Hazardous Chemical Substances and Mixtures (Section 6). If a reasonable basis is found to conclude that a chemical substance or mixture presents, or will present, an unreasonable risk, then the EPA may prohibit or limit the manufacturing, processing, distribution in commerce, use, or disposal. Labeling, record keeping and testing for compliance may be required.

Reports and Record Keeping (Section 8). EPA may require manufacturers and processsors to maintain records and submit reports, including data on quantities made, categories of use, employee exposure and health and environmental effects.

An inventory (Section 8[b]) of existing chemicals is to be published. (Now estimated for summer 1978). A manufacturer, processor or distributor of any chemical substance or mixture shall maintain records of significant adverse reactions to health or the environment alleged to have been caused by the substance or mixture for a 30-year period in the case of employee health, and five years for other reactions (Section 8[c]).

Penalties (Section 16). A civil penalty of up to $25,000 for each violation of TSCA — each day a violation continues counts as a separate violation. Criminal penalty may be up to $25,000 a day and/or imprisonment for up to one year.

Exports and Imports (Sections 12, 13). Exports may be covered, if Administrator finds cause. Imports must meet requirements of the Act. Importers are subject to same requirements as manufacturers.

What Action Should A Person Take At this Time?

The EPA must promulgate implementing regulations for most provisions of the Act industry *must* take action. However, there are five actions I recommend to you in preparing for operations under this Act.

1. *Study the law* for its potential impact on your operations. When possible, attend meetings or briefings sponsored by the EPA or others which deal with the TSCA. A copy of the law can be obtained through EPA Regional TSCA Coordinators. TFI has a stock available also. Discuss with othes what approach they are taking to getting ready.
2. *Establish an organizational structure for internal implementation* of the Act. It may simply be identifying responsible individuals within the existing organization, or it could involve reorganization. Consider personnel needs, e.g., chemists, engineers, legal staff, toxicologists, public affairs.
3. *Compile a list of raw materials, intermediates, by-products, products handled by your company.* This will be needed to check against the inventory of existing chemical substances to be published by EPA or as a basis for reporting to the EPA the chemical substances which you manufacture.
4. *Review the Notice of Substantial Risk (Section 8[e])* for possible applicability to your company. Whereas most actions must await regulations, an important exception is found in Section 8 (e) which requires that any person who manufactures, processes, or distributes a chemical substance or mixture and "who obtains information which reasonably supports the conclusion" that such "presents a substantial risk of injury to health or the environment" shall immediately inform the Administrator of such information.

   The EPA has published proposed guidance concerning submissions of notifications under this section (Federal Register, September 9). It does not define substantial risk, but rather the criteria for examining the risk presented by a chemical substance or mixture.
5. *Check out information needed for premanufacture notification* if you are planning introduction of new chemical substances in 1978.

Inventory Of Existing Chemical Substances.

One of the first actions EPA must take is to prepare an inventory listing of existing chemical substances. To do this, each manufacturer will be required to report chemical substances he makes.

Mixtures will not have to be reported for the initial inventory. The definition for mixture clearly includes mixed fertilizers which are prepared by bulk blending dry materials and fluid fertilizers made by cold mixing (no chemical reaction).

The Fertilizer Institute is working on behalf of industry to help assure reasonable provisions and interpretations under the Act. For example, the Institute has submitted comments to EPA seeking that clarifying language be placed in the regulations stating that mixed fertilizers made in ammoniation granulation plants and hot mix fluid plants are also covered by the definition of "mixture" in the Act. We believe that they are, but the definition is written in a complex manner that should be clarified.

Reporting forms issued by EPA will be used to submit the list of chemical substances a manufacturer produces. The EPA has proposed four forms to be used, depending on the identity status. A Candidate List of Chemical Substances has been published by EPA to aid in identifying the chemical substances. These will be reported using a Chemical Abstract Service (CAS) registry number.

A number of fertilizers are not in the Candidate List, e.g., normal superphosphate, triple superphosphate. These substances fall into a category known as "complex reaction products" or possibly "of unknown or variable composition." As aid to reporting uniformity, The Fertilizer Institute is working with the EPA to develop a list of "descriptors" that can be used to report such fertilizers. These descriptors would be assigned a CAS number. The problem is to arrive at a description that is broad enough to cover the variability in these materials, but specific enough that EPA knows generally what is in the material. It is planned that we would have these ready when the EPA reporting regulations are made final.

Proposed regulations for inventory reporting were first issued on March 9, 1977. These outlined the procedures which manufacturers would follow in reporting the substances to EPA.

The EPA has significantly expanded the reporting requirements in a new proposal of August 2, 1977. If the new proposal is made final, it would require identifying not only what is manufactured by whom, but also where (by individual plant site), how much, and whether it leaves the plant site (includes intermediates). As you can well appreciate, this greatly increases the data gathering and reporting effort.

The time schedule that EPA currently has for the inventory of existing substance is:

November 1977	Final regulation published
February 1978	Inventory reports due from manufacturers (90 days following regulation publication)
Summer 1978	Publication of Inventory

Summary of Impact and Conclusion

The Toxic Substances control Act *will* affect the fertilizer industry. Basic producers will bear the greatest burdens. The affect on processors of mixed fertilizers will most likely be of an indirect nature, stemming in part from impact up the production chain. TSCA has been established tó regulate and control the use of *harmful* chemical substances. For this reason, I believe that the impact will be principally in terms of business operations (paper work and procedures) rather than on products.

However, I would point out that potential does exist for impact on the use of the products of the fertilizer industry. This is because the EPA must consider the environment as well as human health. The EPA Administrator, Douglas Costle, has initiated what he has termed "a serious examination" of phosphates for which he has stated (March 22, 1977) "there exists significant evidence of injury to human health or the environment." The Agency is nearing completion of the first phase of their work on phosphates, i.e., hazard assessment. This identifies the hazard as being the role of phosphorus in eutrophication of rivers and lakes. Human health was not the issue. The next step will be to identify and quantify sources of phosphate in the environment. Following that, alternatives for regulatory action will be developed. If it is determined that phosphate use in agriculture contributes significantly to the "eutrophication problem," you can expect to see a close examination of what control measures are available to reduce this contribution.

Realization of the full impact of this Act is yet to come. It will be some time — perhaps years — before the picture clears, i.e., before the regulators are all settled.

In the meantime, industry must gear up to provide EPA with the best possible facts to assure equitable, reasonable treatment of fertilizers under this new fertilizer law.

I would leave you with one recommendation. In coming to grips with the Toxic Substances Control Act, we must keep the term "unreasonable risk" in constant focus — in our own mind and in the minds of the regulators. Keep asking the question: "Does the way we handle and use chemical substances present an unreasonable risk?"

MODERATOR SACKETT: Thank you very much Karl. [Applause]

Our next paper is "Particle Size Analysis and New Standards" by Mr. Walter Mahlig of the W.S. Tyler Company. Mr. Mahlig has been with Tyler since 1937. He is the first vice chairman, ASTM Committee E-29 on particle size measurement. He is a member of American National Standards Institute, a member of the American Foundrymen's Society technical committee on sieving; a member of the Abrasive Grain Association; a member of the editorial staff, Handbook of Chemistry & Physics; a member of Fine Particle Society and a delegate to the International Standards Organization Committee TC-24 on particle size measurement. Mr. Mahlig, please.

Testing Sieves
Particle Size Analysis
And New Standards

Walter C. Mahlig

Testing Sieves

A Testing Sieve is a scientific precision measuring instrument and has the job of measuring literally billions of particles of material on a mass basis. To illustrate this point, if you have particles of material .001" in size, there will be 1 billion pieces of material in 1 cubic inch.

The job of the testing sieve is to determine if each one of these particles is fine enough to pass through the opening, which means that every particle must present itself to one of the openings in the sieve to determine if it should pass through. To do this job, a sieve itself has millions of openings as in the case of a 400 mesh sieve having an opening of 37 microns, there are some 12 million openings in the sieve.

U.S. Sieve Series

The sieve series in practical universal use in this country and in most places throughout the world is the U.S. Sieve Series, which is made according to ASTM Specification E-11-70. (See Figure 1)

This series is designed so that the openings between the various sieves are in the ratio of the fourth root of two. This means that the area of each succeeding sieve in this series is 1½ times the area of the next smaller sieve. The area of every other sieve in this series is just two times the area of the next smaller.

All of the sieves are made of woven wire screen and the wire diameters of each sieve are selected so that they increase in size in a uniform curve as the various openings increase.

The U.S. Sieve Series is a metric series and the sieves are designated by openings in millimeters or microns. The finest sieve is 37 micron which is the #400. There are wire cloth sieves available with openings finer than this, however, this particular sieve series ends at the 37 micron level.

The U.S. Sieve Series is in practical use all over the world and because of their U.S. affiliations, a great percentage of foreign users insist on U.S. Sieves.

The International Standards Organization of which some 30 countries are members has been trying to develop an international sieve standard.

Much pressure was exerted to base the sieve series on the preferred number sieves which increases or decreases in the ratio of the 10th root of ten. (See Figure 2) This series can be expanded by using the 20th root of 10 or even the 40th root of ten.

Unfortunately for the U.S., their series is based on the 4th root of 2 ratio and originally the two series seemed completely incompatible.

After a series of ISO Meetings, a compromise was finally reached. The ISO adopted a series of sieves in the ratio of the 40th root of 10 identified as R-40. By making some very slight modifications in the openings of the U.S. Sieve Series, it was found that every third sieve of the R-40 ISO series was the same as the 4th root of 2 sieves in the U.S. Sieve.

In 1970 a slight change in the U.S. openings was made to E-11-70 and this then made both ISO and U.S. sieves compatible.

The one problem that still exists in complete compatibility is the sieve diameter. While the openings and wire diameters of the U.S. sieves are metric, the diameter of the sieve is not. U.S. standard is 8" in diameter. A hard metric conversion would be 200 mm or about 7-7/8". A solution has not been found on how to resolve this problem.

Tyler Standard Screen Scale Sieve Series

In your work you have probably heard of other sieve series. One in particular is the Tyle Standard Screen Scale Sieve Series. Actually, this series was the original sieve series and was developed by W.S. Tyler, Incorporated before any other standard was in use. This sieve series introduced the square root ratio between the openings. Later, other sieves were added to complete the full fourth root of two series. (See Figure 3)

This originally came into being back in 1910 and was identified by the number of meshes per linear inch of each sieve, such as a 4 mesh, 8 mesh, 10 mesh, etc. When the U.S. Sieve Series was adopted, they did not use the same nomenclature as the Tyler Screen Scale Sieve Series, but merely used numbers approximating the number of meshes per inch. Instead of a 28 mesh sieve, they called it a #30.

Since many industries had firmly established their standards using the Tyler Standard Screen Scale Sieve Series, many of these meshes are still in use. The only difference between these two series is the identification method. The openings and wire diameters are identical and in order to eliminate confusion on each name plate, the U.S. Sieve Series number is shown and then at the bottom, the Tyler equivalent mesh number is also inserted. (See Figure 4)

Accuracy of Testing Sieves

Testing Sieves are used in virtually every industry and are made to manufacturing tolerances which are more than adequate for most users. These manufacturing tolerances permit a variation in the opening and also have a limitation on the wire diameter being used. As an example in the #400 sieve, which is the 37 micron sieve, they permit a variation in the average opening of plus or minus 7% which means this sieve could vary in average opening from about 34 to 39 microns and still be within the standard tolerances.

This tolerance is not even noticed in the handling of most materials, however, in many industries where the sizing is so critical, this tolerance in many cases may cause difficulty.

There are other industries which run into this same problem. One in particular is the abrasive grain industry who produces material having practically all of the grains falling between two seccessive sieves and this industry found that sieves made to the usual tolerances were just not accurate enough for them.

Matched Sieves

To produce sieves of closer tolerance consistantly is almost an impossible feat. Even to check the openings of a fine mesh sieve by measurement is virtually impossible. The 400 mesh sieve with the 160,000 openings per square inch would present many problems if one endeavored to check all the openings in a standard 8" diameter sieve. This, of course can be done, but is very costly.

In those industries where more accurate sieves are required, W.S. Tyler, Incorporated has made available, s service wherein these sieves can be obtained at a very nominal cost. This company has on file in their laboratory, a set of matched sieves which were selected by actual physical measurement and these sieves are as close to the desired opening as is possible to select.

When a customer is interested in more accurate sieves, they can obtain matched sieves. These are obtained by first running a sieve analysis test on the master sieve and then selecting from regular stock sieves, sieves which will give comparable results to the master. No attempt is made to measure the opening of the sieve being selected, but it is selected from the results obtained.

In many industries where this is being done, the material used for matching the sieves is the same as used by the customer. In the diamond powder industry, the sieves are tested using a bronze powder. When sieves are furnished in this manner, a test sheet is supplied showing the results obtained on the master sieve and also the results obtained on the matched sieve shipped.

These are probably the most accurate sieves obtainable on a commercial basis and it is a very practical means of supplying more accurate sieves than are available under the regular tolerances.

Certified Sieves

One other type of sieve which is available is a sieve certified by The National Bureau of Standards. The National Bureau of Standards at Washington has a service wherein a regular U.S. Standard Sieve can be sent to the Bureau and the sieve is measured by them and certified to conform to ASTM Specification E-11. This certification only means that the sieve is within the tolerance specified and they do not indicate whether the opening is a fine end or coarse end of the tolerance, but merely that it is within that tolerance. Therefore, a certified sieve is not necessarily any more accurate than a regular sieve as Tyler made sieves are all warranted to come within The National Bureau of Standard tolerances.

Care and Cleaning of Sieves

After each sieve analysis test, the sieves should be carefully cleaned and stored in a cabinet or in their original cartons. A soft brass wire brush should be used for cleaning the sieves and this is best done by brushing the underside of the wire cloth with a circular motion taking care not to exert too much pressure against the wire cloth. The frame of the sieve may be gently tapped with the wooden handle of the brush.

Occasionally it may be necessary to wash the sieves in a warm soap and water solution to remove the near mesh particles. The underside of the sieve can be brushed while in the water to aid in the cleaning action.

Most acid solutions are not recommended for cleaning sieves, as the acid will reduce the diameter of the wire and enlarge the openings. It will also make the wire cloth sleazy.

If the above methods fail, the safest method to use is to dip the sieves in a 5% solution of boiling but acetic acid and then after brushing the particles free from the openings, the sieves should be very thoroughly washed in water to remove all traces of the acid.

Ultra Sonic cleaners are very effective for cleaning sieves if one of sufficient wattage is used.

We have found that one having a capacity of 750 watts is necessary to remove the jagged diamond particles prevalent in your material.

The operators using these sieves should be cautioned that they are a scientific precision instrument and should be handled accordingly. A testing sieve will last for many, many years if properly cared for.

A testing sieve made from woven wire screen, if properly handled, will not vary in opening. We have sieves that were made some 20 years ago that have been in almost constant use and we find that there is no measurable change in the opening of the sieve even though the wire is considerably worn.

On any wire cloth specification the wear is on top of the knuckles and very little if any abrasive action takes place when the material passes through the opening and unless the sieve is dipped in acid or mistreated, the openings will not vary. Therefore, if properly handled in the laboratory and not abused, the sieves should last for a great number of years.

Handbook No. 53 (See Figure 5)

W.S. Tyler, Incorporated has available a handbook on Testing Sieves and Their Uses.

This is a very complete textbook and deals with the various phases from taking of the samples to plotting the analyses.

Incorporated in it are tables of the U.S. Sieve Series and Tyler Standard Screen Scale Sieve Series showing allowable manufacturing tolerances. Also is a table showing a comparison between various sieve series in use throughout the world.

This handbook should be in the hands of everyone using the sieves to fully acquaint them with this item.

If any copies are desired, please advise and I will be glad to send as many as you will need without any charge or obligation. They can be obtained by writing to the following address:

Mr. Walter C. Mahlig
Product manager
W.S. Tyler, Incorporated
8200 Tyler Boulevard
Mentor, Ohio 44060

Manual on Test Sieving Methods—STP-447

A.S.T.M. has available a Manual on Test Sieving Methods. This provides a sieve testing laboratory with general information on establishing a sieve testing procedure.

Copies can be obtained for $3.00 each by writing to A.S.T.M., 1916 Race Street, Philadelphia, Pennsylvania 19103.

Note: Figures #1 thru #5
continued on pages #177 thru #179

U. S. A. SIEVE SERIES AND TYLER EQUIVALENTS
A.S.T.M.—E-11-70

Sieve Designation		Sieve Opening		Nominal Wire Diameter		Tyler Screen Scale Equivalent Designation
Standard a	Alternate	mm	in approx equivalents	mm	in approx equivalents	
125 mm	5 in.	125	5	8	.3150	
106 mm	4.24 in.	106	4.24	6.40	.2520	
100 mm	4 in. (b)	100	4.00	6.30	.2480	
90 mm	3½ in.	90	3.50	6.08	.2394	
75 mm	3 in.	75	3.00	5.80	.2283	
63 mm	2½ in.	63	2.50	5.50	.2165	
53 mm	2.12 in.	53	2.12	5.15	.2028	
50 mm	2 in. (b)	50	2.00	5.05	.1988	
45 mm	1¾ in.	45	1.75	4.85	.1909	
37.5 mm	1½ in.	37.5	1.50	4.59	.1807	
31.5 mm	1¼ in.	31.5	1.25	4.23	.1665	
26.5 mm	1.06 in.	26.5	1.06	3.90	.1535	1.050 in.
25.0 mm	1 in. (b)	25.0	1.00	3.80	.1496	
22.4 mm	⅞ in.	22.4	0.875	3.50	.1378	.883 in.
19.0 mm	¾ in.	19.0	0.750	3.30	.1299	.742 in.
16.0 mm	⅝ in.	16.0	0.625	3.00	.1181	.624 in.
13.2 mm	.530 in.	13.2	0.530	2.75	.1083	.525 in.
12.5 mm	½ in. (b)	12.5	0.500	2.67	.1051	
11.2 mm	7/16 in.	11.2	0.438	2.45	.0965	.441 in.
9.5 mm	⅜ in.	9.5	0.375	2.27	.0894	.371 in.
8.0 mm	5/16 in.	8.0	0.312	2.07	.0815	2½ mesh
6.7 mm	.265 in.	6.7	0.265	1.87	.0736	3 mesh
6.3 mm	¼ in. (b)	6.3	0.250	1.82	.0717	
5.6 mm	No. 3½ (c)	5.6	0.223	1.68	.0661	3½ mesh
4.75 mm	No. 4	4.75	0.187	1.54	.0606	4 mesh
4.00 mm	No. 5	4.00	0.157	1.37	.0539	5 mesh
3.35 mm	No. 6	3.35	0.132	1.23	.0484	6 mesh
2.80 mm	No. 7	2.80	0.111	1.10	.0430	7 mesh
2.36 mm	No. 8	2.36	0.0937	1.00	.0394	8 mesh
2.00 mm	No. 10	2.00	0.0787	.900	.0354	9 mesh
1.70 mm	No. 12	1.70	0.0661	.810	.0319	10 mesh
1.40 mm	No. 14	1.40	0.0555	.725	.0285	12 mesh
1.18 mm	No. 16	1.18	0.0469	.650	.0256	14 mesh
1.00 mm	No. 18	1.00	0.0394	.580	.0228	16 mesh
850 µm	No. 20	0.850	0.0331	.510	.0201	20 mesh
710 µm	No. 25	0.710	0.0278	.450	.0177	24 mesh
600 µm	No. 30	0.600	0.0234	.390	.0154	28 mesh
500 µm	No. 35	0.500	0.0197	.340	.0134	32 mesh
425 µm	No. 40	0.425	0.0165	.290	.0114	35 mesh
355 µm	No. 45	0.355	0.0139	.247	.0097	42 mesh
300 µm	No. 50	0.300	0.0117	.215	.0085	48 mesh
250 µm	No. 60	0.250	0.0098	.180	.0071	60 mesh
212 µm	No. 70	0.212	0.0083	.152	.0060	65 mesh
180 µm	No. 80	0.180	0.0070	.131	.0052	80 mesh
150 µm	No. 100	0.150	0.0059	.110	.0043	100 mesh
125 µm	No. 120	0.125	0.0049	.091	.0036	115 mesh
106 µm	No. 140	0.106	0.0041	.076	.0030	150 mesh
90 µm	No. 170	0.090	0.0035	.064	.0025	170 mesh
75 µm	No. 200	0.075	0.0029	.053	.0021	200 mesh
63 µm	No. 230	0.063	0.0025	.044	.0017	250 mesh
53 µm	No. 270	0.053	0.0021	.037	.0015	270 mesh
45 µm	No. 325	0.045	0.0017	.030	.0012	325 mesh
38 µm	No. 400	0.038	0.0015	.025	.0010	400 mesh

a) These standard designations correspond to the values for test sieves apertures recommended by the International Standards Organization Geneva, Switzerland.

b) These sieves are not in the fourth root of 2 Series, but they have been included because they are in common usage.

c) These numbers (3½ to 400) are the approximate number of openings per linear inch but it is perferred that the sieve be identified by the standard designation in millimeters or µm,
1000 µm = 1mm.

Figure 1

TABLE OF BASIC SIZES

I S O PREFERRED NUMBER SERIES

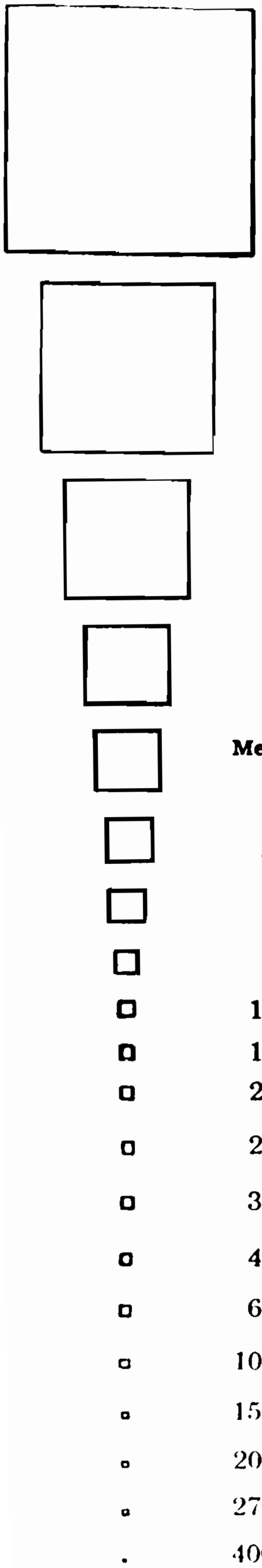
NOTE: Preference should be given to sizes in the R 10, R 20, and R 40 series, in that order.

Basic Sizes			Equivalent sizes* (for information)
millimeters			
R 10	R 20	R 40	inches
1.00	1.00	1.00	0.039 4
		1.06	0.041 7
	1.12	1.12	0.044 1
		1.18	0.046 5
1.25	1.25	1.25	0.049 2
		1.32	0.052 0
	1.40	1.40	0.055 2
		1.50	0.059 1
1.60	1.60	1.60	0.063 0
		1.70	0.066 9
	1.80	1.80	0.070 9
		1.90	0.074 8
2.00	2.00	2.00	0.078 7
		2.12	0.083 5
	2.24	2.24	0.088 2
		2.36	0.092 9
2.50	2.50	2.50	0.098 4
		2.65	0.104 3
	2.80	2.80	0.110 2
		3.00	0.118 1
3.15	3.15	3.15	0.124 0
		3.35	0.131 9
	3.55	3.55	0.139 8
		3.75	0.147 6
4.00	4.00	4.00	0.157 5
		4.25	0.167 3
	4.50	4.50	0.177 2
		4.75	0.187 0
5.00	5.00	5.00	0.196 9
		5.30	0.208 7
	5.60	5.60	0.220 5
		6.00	0.236 2
6.30	6.30	6.30	0.248 0
		6.70	0.263 8
	7.10	7.10	0.279 5
		7.50	0.295 3
8.00	8.00	8.00	0.315 0
		8.50	0.334 6
	9.00	9.00	0.354 3
		9.50	0.374 0
10.00	10.00	10.00	0.393 7

*See note to text.

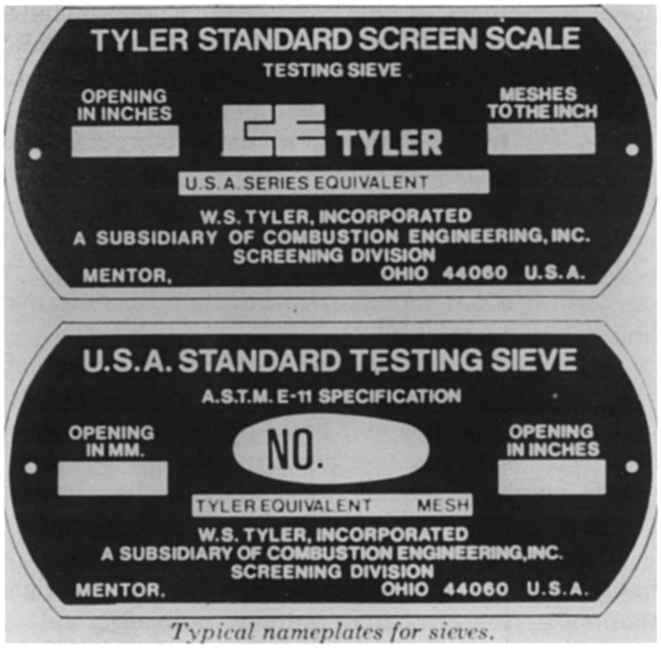
Basic Sizes			Equivalent sizes* (for information)
millimeters			
R 10	R 20	R 40	inches
10.0	10.0	10.0	0.393 7
		10.6	0.417 3
	11.2	11.2	0.440 9
		11.8	0.464 6
12.5	12.5	12.5	0.492 1
		13.2	0.519 7
	14.0	14.0	0.551 8
		15.0	0.590 6
16.0	16.0	16.0	0.629 9
		17.0	0.669 3
	18.0	18.0	0.708 7
		19.0	0.748 0
20.0	20.0	20.0	0.787 4
		21.2	0.834 6
	22.4	22.4	0.881 9
		23.6	0.929 1
25.0	25.0	25.0	0.984 3

Figure 2



Mesh	Openings in Inches
	1.050
	.742
	.525
	.371
3	.263
4	.185
6	.131
8	.093
10	.065
14	.046
20	.0328
28	.0232
35	.0164
48	.0116
65	.0082
100	.0058
150	.0041
200	.0029
270	.0021
400	.0015

Figure 3



Typical nameplates for sieves.

Figure 4

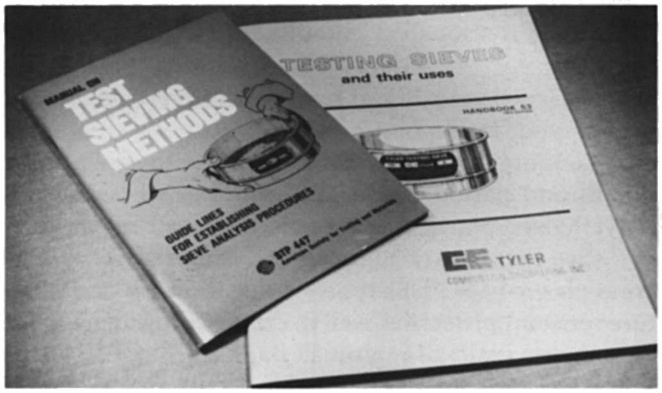


Figure 5

MODERATOR SACKETT: Thank you, Walter, for the obvious hard work that you put into the presentation [Applause]

Our next paper is "Packaging Systems and Bag handling" by Robert F. Kendall of St. Regis Paper company. Mr. Kendall has been with St. Regis for 27 years in various sales and marketing positions. He's now the manager of systems engineering. Mr. Kendall.

Packaging Systems And Bags Handling

Robert F. Kendall

LADIES AND GENTLEMEN: We've had an interesting meeting over the past few days. We've talked about such things as pipe cross reactors, raw material supply outlook, dust control, energy conservation and many other subjects to help you produce the best quality product at the most economical cost.

It isn't enough, though, to sink your bucks into product improvement and economy of manufacture. You can have the best darn fertilizer there ever was in your bins, but it is not going to "ding" the cash register sitting there in the bin.

And it is not enough to swing open the door and holler "come and get it"

Today's market conditions require that you do all you can to see that your product arrives:

Where the user needs it
When the user needs it

In good usable condition and at the lowest total cost

One of the ways to get it there is in a bag. Now, a bag is essentially a flexible container of a size and weight that one person can handle without mechanical aid.

As such it is probably the most flexible of the various distribution means open to you. It can be handled by the greatest variety of material handling and transportation means, and stored almost anywhere that there is a reasonable amount of shelter from the elements.

It carries your brand name and advertising all the way to your final point of use.

You are probably all familiar with sewn open mouth and pasted valve multiwall bags. Low density polyethylene plastic bags are also used for fertilizer.

(See Picture #1) You may not be as familiar with cross plastic bags. This type bag has strength and puncture resistant properties well in excess of low density poly and conventional multiwall bags.

Another type bag available is the pinch bottom style multiwall bag. This is a bag with glued ends that provides the most complete and sift proof closure available in a multiwall. With a heat sealable inner ply, it can also provide a sealed package equivalent in moisture protection to a sealed drum. With a reinforcing ply of cross plastic, it is even used to ship dry caustic soda beads.

You need more though than a bin full of good product and a properly designed package. Ther package must be accurately and economically filled, closed and prepared for shipment — at rates consistent with the production needs of your manufacturing and shipping.

Some examples of the types of equipment available to handle these functions are:

1. Valve bag filling and weighing machines
2. Open mouth bagging scales and sewing machines
3. Automatic valve bag applicators
4. Automatic open mouth bag applicators (See Picture #2)
5. Automatic pinch bottom bag weighing, filling and closing line for granular products
6. Similar automatic pinch bottom line for difficult powdered materials
7. High speed fully automatic valve bag weighing and filling line for granular products
8. Pinch bottom bag closer
9. Conveyors for filled bags
10. Automatic bag palletizers
11. Semi-Automatic bag palletizers
12. Shrink wrap tunnels and related equipment
13. Stretch wrappers for low energy plastic film wrapping of pallet loads

All of these, however, are only components in your overall packaging system. Your packaging system can be defined as the system that starts with the package and takes your product.

From bin
To loading dock
It can be pretty simple.

Here's a cement packaging system from around the turn of the century. Open cloth bags, string ties, and a lot of labor.

By 1908, cement packaging had been improved to include filling and weighing machines and bag conveyors.

These are both systems. They include a package and a means to take the product from bin to loading dock. In fact, this 1908 system is essentially the same as many still in use.

There are, however, more automated, efficient and accurate bag systems available today. These systems include:

AUTOMATIC BAG APPLICATION
MEASURING, FILLING AND CLOSING
PRINTING, CODING, CONVEYING
FLATTENING, CHECKWEIGHING
PALLETIZING, SHRINK AND STRETCHWRAPPING

One company that has gone to a relatively automated system is the New Jersey Zinc Company. While their product, zinc oxide, is not fertilizer, this series of slides will serve to illustrate the approach taken and the results attainable. Most of what you will see would be applicable to a fertilizer operation.

1. An automatic valve bag applicator places valve bags on the packer
2. The packer fill the bag
3. The packer shuts off at desired weight
4. The bag is discharged to a conveyor (See Picture #3)
5. The next bag is applied and the cycle repeats
6. Filled bags from three fully automatic packers are joined at a single conveyor line
7. Controls insure that bags intermesh on the conveyor and don't ride atop one another
8. Bags enter a bag flattener
9. Bags are shaped and flattened and much of the air in the powdered product squeezed out
10. Bags are checkweighed and off weight bags are

returned for recycling

11. Bags enter an automatic palletizer
12. Where they are turned as needed
13. To form the desired palletizing pattern
14. The finished pallet load leaves the palletizer on automatic conveyors
15. The pallet enters a pallet press
16. Where 6 tons of pressure is applied to stabilize the load and squeeze the remaining air out of the product
17. An operator places a polyethylene shrink shroud over the pallet
18. The shrouded pallet enters a shrink oven
19. From which it exits a half minute later with the shroud tightly shrunk to pallet and load
20. (See Picture #4) We thus go from the empty bag and the product in the bin, to well protected loads ready for transport to the ultimate user

Why automate?

How does one go about justifying the cost of a system such as we have just reviewed?

Obviously, there are savings in direct labor costs, reduction in package cost, less product loss due to off weights, fewer broken bags, more stable unit loads, better protected unit loads — and other tangible and intangible benefits.

But very important, too, is the reality of the labor force. Production managers and plant managers don't want to agonize about whether Joe Doaks and his buddies are going to go out tonight and "hang one on" and not show up tomorrow.

Perhaps even more significant is the fact that Joe Doaks won't be there forever and his replacement may be hard to find.

Peter Drucker, the management consultant, in a recent Wall Street Journal article on declining unionization, points out that there is a shortage of young people entering the blue collar job market. The low birth rate of the early 60's reduces the total number. Also, improved educational opportunities have raised the level of expectations of many young people above those of their parents and taken them out of this job market. The ones who are available for the blue collar jobs often feel themselves to be "losers" before they start and are more difficult to motivate and manage.

The alternate — A system that minimizes labor — is appealing.

We need to be careful though that we don't go too far too fast in our pursuit of automation. For decades, the automatic factory has been forecast as imminent, and yet, it never arrives.

(See Picture #5) Some years ago, my company had an artist put together this concept of a futuristic automatic system for bagging of industrial products. As you have seen, we've come a long way, but will probably never achieve the fully automatic factory. The basic reason is that automation involves more than just the development of sequential machines. It calls for feedback devices that sense variations in the system, analyze them, and make appropriate corrections. In the motion picture, "Modern Times", Charlie Chaplin is fed lunch while at work by an automation that keeps putting food everywhere but where his mouth is. Charlie was a little short for the machine, and it could not adapt.

Machines have been developed that can adapt better than Charlie's automation and they are able to cope successfully with an ever widening range of operations.

Bearing in mind that we don't want to go off the deep end, what then are some of the steps to successful automation?

Users Management Attitude

One very important consideration is *your* attitude. You must be willing to commit to provide qualified personnel, and their training, suffer through startup problems, accept a reduction in flexibility, and spend a lot of your time and effort working with your own and your supplier's people. It is not just a matter of simply answering yes to the "motherhood and flag" type questions like:

Do you want labor saving devices?
Do you want more efficient packaging lines?
Do you want better weight accuracy?

You must *not* have the attitude that once the equipment is delivered, installed and wired, you need only push the big green button and sit back. It doesn't happen that way very often.

Qualified operating and maintenance personnel

You need qualified operating and maintenance personnel. If the packer operator job is an entry level job, just a half notch above floor sweeper, you need a rewrite of the job description and probably some different faces. If the maintenance department is heavy on big hammers and cutting torches, you may have to introduce some new skills into the department.

If the maintenance department works on a maintenance pool basis with each millwright or electrician going out on maintenance calls on a rotational basis, you'll have to change that to insure only the trained and qualified people are sent out to service the automatic line.

Training

Which brings me to the subject of training. Your system supplier will usually offer some training for your personnel. This should cover not only the operators, but the maintenance personnel as well. *Take it,* but don't scatter your efforts here in trying to train everybody.

Get a *few* men trained to really know the system. A well planned and engineered system probably won't need much work, but it will require someone with knowledge of the adjustments. If relatively few people are responsible, they can get to know the system and its idiosyncrasies well. When it needs adjustment, they will have the familiarity to know what to adjust and do it promptly.

Reasonable Expectations

Have reasonable expectations. High speed is not the only criteria. Reliability efficiency and versatility are also important. A high speed unit may look great on paper and be very impressive at the supplier's demonstration. It's more plodding cousin that chugs along hour after hour at a slower rate and has the versatility to change sizes or grades quickly may well put out more tons per shift.

Establish a distinct list of performance you require. Keep the specifications flexible, but with enough definition. Make your supplier fully aware at the outset of your expectations.

Coordinated Design

Look for the coordinated design. Each of the components you put into a system has to work in harmony with the components ahead and behind. They must be interlocked and the controls and interlocks planned for ease of operation by the operator and service by the maintenance force.

The system must be free of bottlenecks that would pull the whole system performance down.

This is an area where you'll find you can get your supplier involved in the system design. Suppliers have increasingly become capable of offering complete systems. This includes packages and packaging equipment made by the supplier combined with proven components purchased outside and integrated into a system by the supplier with appropriate interlocks and controls.

Packaging material quality

You probably need to upgrade your packaging materials quality and uniformity. As we have noted earlier, a man is more adaptable than a machine. When he gets a bunch of bags that hve been distorted in storage or shipment or that vary in size or other characteristics, he can adapt and still use them.

Not so with the automatic machine. Undistorted packages with relatively close dimensional uniformity are needed for reliable operation. Bags meeting these requirements are available from most producers.

Product process control

You may need to look at your product process control. If your product has great variations in density or flow characteristics, your operators, at times probably try to cram bulky product into too small a bag. We've seen operators slow down the operation and kick or beat on the bag. The automatic machinery won't do this. A refinement in the process control may be better than going to a larger bag.

Proper services and environment

You'll need proper services and environment. You'll need an adequate electrical supply.

If you don't already have good voltage regulation, you may need some improvement.

Your compressed air supply should be clean and free of condensed moisture.

An enclosed heated area would be a good investment if not a requirement.

Communication

And last, but certainly not least, you need good communication. Tell your system supplier everything he needs to know — maybe more than you might feel he needs to know.

Listen to his advice.

Bring all affected levels in your company into the act. Specifically, let the line operator know what is going on. Nothing is quite as unsettling to a worker as a lot of hustle and bustle of engineers measuring, taking notes on clipboards and obviously planning something that may affect his job. If you don't give him the facts, he'll end up believing the scuttlebutt in the lunchroom. Don't kid yourself that sabotage, both planned and subconscious, does not occur.

Don't forget the department supervisor. If he is not involved in the planning and committed to making the system function, it will always be that "engineer's nightmare that the front office unloaded on me", and it will never really get off the ground.

I would like to wind up by emphasizing that the cost of automation is measured not only in capital investment dollars, but in planning and organizing for successful application.

There is a lot available to you.

The whole field of bag packaging is one where there have been a number of significant developments in the last few years — developments which your industry has generally not taken full advantage of. I hope that you may have picked up an idea or two from my talk that you can use profitably in your own situation. Thank you. [Applause]

Figure 1

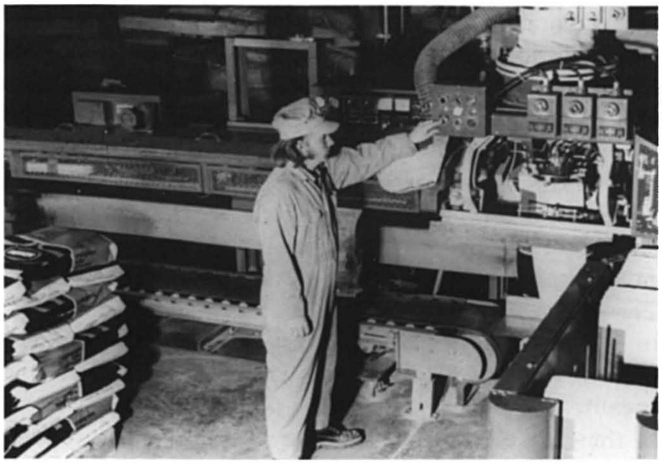


Figure 2

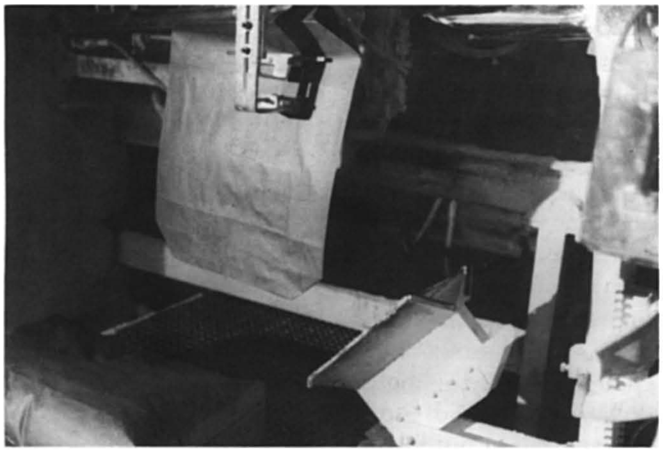


Figure 3

Figure 4

Figure 5

MODERATOR SACKETT: Thank you, Bob, for an excellent presentation. Do we have any questions for any of this morning's speakers? Any questions at all? O.K.

I do want to thank this morning's speakers for their excellent cooperation as far as getting papers and copies of their slides in to me. I'd like to urge any of the other speakers to get their papers and slides or glossies into their moderators immediately. We're going to try to really improve the speed of getting the Proceedings out this year, and it will be a great help.

Now I'll turn the mike over to Paul Processer. Paul. [Applause]

MODERATOR PAUL J. PROSSER, JR.: Good morning. You will recall that in our invitation to the Round Table Meeting was a suggestion that those who wish to participate in a series of three to five minute talks would be permitted to do that. At this time we have 5 volunteers. Briefly the subjects will be:

"The Lock and Dam 26"
"Solid Wastes Management Recovery"
"Bulk Fertilizer Shipping Towers"
"Asbestos Pollution"
"Stabilized Sludge Free 60% P_2O_5 Wet Process Acid"

Our first speaker is Mr. Ron Schroeder. He is a native of Minnesota, and he is presently the executive director of the National Committee on Lock and Dam 26. Mr. Schroeder.

MR. RON SCHROEDER: Thank you very much, Paul. I didn't volunteer. Someone called and asked if I would present this, and I'm very happy to do that, as a matter of fact, because I think it's a very important project not only for the Fertilizer Industry but for the economy of the United States.

The Lock and Dam 26

Ron Schroeder

If I could just take a minute, I would like to briefly and very quickly review what the National Committee is and what it's about and what the project is. One, the National Committee is made up of 75 national and regional members. The Fertilizer Institute, CF Industries, all the grain companies, every major farm organization in the United States is a member of this committee as well as four major unions and many other organizations too numerous to mention. Why did so many people get together to form a committee to push for legislation to rebuild a lock and dam on the Mississippi River? Well, because two years ago it looked as though that project would fail. The railroads in particular and the environmental groups were opposed to it. They had spent a great deal of time in opposition to it saying that it was going to be a detriment to the environment. The railroads, of course, were in it because they felt that they were going to lose traffic. So it was about a year and a half ago that I was asked to take over the head of the committee, and we have since worked on trying to persuade Congress.

I'm happy to report that a week ago the House of Representatives passed the bill 330 to 70, and last June the Senate passed it by 71 to 20. The trouble was the Senate passed version was somewhat different than the House version, in fact quite a bit different, and the House refused to act on it because it raised revenues and they said these measures should originate in the House and so on. I'll get into that in just a little detail in the end.

Let me show where lock and dam 26 is for those of you who may not know. This map shows the upper Mississippi River and the Illinois River going up to Chicago. The red dots on the river are locks and dams that are currently in place on both the upper Mississippi and the Illinois. There are 25 locks on the Mississippi, seven on the Illinois. All of them are 600 foot locks. Lock 26 is here at Alton, Illinois right at the confluence of those two rivers, and Lock 27 the last lock on the entire river system to New Orleans is just 18 miles downstream. Now the problem in brief is simply this lock is 40 years old. It's outdated and falling apart and has to be either rebuilt or replaced or repaired. It's a very small lock, 600 feet in length. All of these locks are 600 or 1,200 feet in length. This one 27 is 1,200 feet and an auxiliary lock of 600 feet. This lock down here 27 can carry about 150 million tons of commerce a year. These locks total about 105-110 million tons a year; that's their capacity. Lock 26 carried last year 59 million tons with 13½ hour delays. So as you can see, it's operating at half the capacity of the northern system and a third the capacity of the southern part of the river system. So it's a problem, and it has to be rebuilt and enlarged. So that was the purpose of our committee to try to do that.

Now we fought all kinds of questions along the way. We had environmental problems. The environmentalists as I said were opposed to us. The railroads fought us. They said that the engineering things were inadequate and this and that and so and so. They fought one battle after another and we won each of them. The one battle that we could not win and we are currently fighting is that of the user fee question on user taxes or fuel taxes on the river system. As I said, the Senate passed their version in June with a user tax called the Senator Domenici of New Mexico tax; it was his baby, and that passed the Senate by a slim margin and it calls for a segmented toll on all the cargos on the river. The important thing is that it has a 1% value added tax. In other words you pay up to 1% of whatever the value of your cargo is on the river system. That's dangerous because in the case of fertilizer it's an expensive cargo. In the case of let's say sand or gravel it's very cheap cargo; and, therefore, it won't hurt. The higher, the more expensive the product, the higher the tax is. So it varies from place to place, from river segment to river segment. On the upper Mississippi river where you have 25 locks it's very expensive because you're paying for the operation and maintenance of all 25 of those locks. On another river like on the lower Mississippi river where there are no locks at all it's very cheap because there is no operation or maintenance to speak of. So that tax we feel is just bad, and the House of Representatives felt the same way; that's why they refused to act on it.

They passed their own version as I said a week ago, and that version called for a 4¢ a gallon fuel tax on all commercial traffic on the inland river system. Now that tax will raise about 50 million dollars a year, and by the time lock and dam 26 is built 10 years from now it will have raised about 500 million dollars or more than enough to pay for the dam. The dam is a 421 million dollar project. So the dam will be paid for by the revenue raised by this user tax or this fuel tax.

In the case of the Domenici tax they would have raised somewhere in the neighborhood of 500-600 million dollars each year; and as you know, you're not going to pay it; the fertilizer industry won't pay it necessarily. It will be passed on to your customers, and that's why every farm organization in this country is on this committee and fighting to get a reasonable user fee implemented.

There's no question right now, Paul, in closing, that lock and dam 26 will be rebuilt. We won that battle, I think. The question remains as to what kind of tax will there be on the waterway commerce, and that could be as low as a 4¢ a gallon fuel tax which amounts to about 19¢ a ton from Minneapolis to New Orleans to as high as the Domenici Plan, which calls for on- lets take soybeans as an example- one bargeload of soybeans, one bushel of soybeans Minneapolis to New Orleans would cost about $2.75 in additional cost, from current cost about a 45% increase in the cost of transportation for soybeans. Of course, as the product costs go higher if we were to haul one bargeload of diamonds down the river, we'd pay for the whole system at one shot under that plan.

Paul, I've taken my time. It's a much more complex than I've just outlined, but I appreciate the time to tell you about it. If you get a chance before you leave town, if you'd call your Senator and ask him to support the House passed version with a 4¢ a gallon fuel tax because we expect it up for a vote possible today, more likely tomorrow or Monday; and so if you get a chance to talk to your Senator, please do so. Thank you. [Applause]

MODERATOR PROSSER: We are grateful to Mr. Schroeder for having taken the time to come and tell us about a problem that's going to cost us money as most things do.

Out next volunteer is Mr. Bruce Eder. He is director of marketing of the Solid Waste Resources from Eugene, Oregon.

He has requested a moment to discuss what he calls "Solid Wastes Management and Resource Recovery". Mr. Eder.

Solid Wastes Management and Resource Recovery

Bruce Eder

Thank you very much, Paul. Gentlemen, it's very wonderful to be here and to have an opportunity to share with you what is a very innovative idea in managing solid waste materials.

Industrial wastes having been pretty much taken care of by burning, burying and barging materials in the past, my company has innovatively designed a process for operationally treating solid wastes with earthworms and using their castings or the by-product of the worm processing to use as a primary crop soil conditioner and soil amendment which can be used in addition to chemical fertilizers to increase crop yields.

I'd like to show a few slides if I might. Ever since industrialized society has been producing products mankind has always had a good enormous amount of by-product to deal with. Many industries have reused their by-products to create new products, but solid waste disposal remains one of this country's and one of this world's largest problems as we research it today.

Some typical situations — At a paper processing mill we have a pile of sludge. This paper sludge is a very useful ingredient in the process that we have developed as a mixing medium and as a bedding material for the earthworms to work with to create the soil conditioner.

This is a rendering dewatering process which creates again paper sludge. This is in Japan, in fact, so it's not isolated to this country as all of you industrial people well know. All of the world manufacturing facilities accumulate solid waste.

This is 100,000 tons of paper sludge accumulated in the backyard of one paper producing firm in Washington State. It needs to be dealt with. In fact, this pile existed there and caught fire and the Environmental Protection Agency is taking a dimmer and dimmer view of solid waste management issues especially related to landfilling.

Public Bill 94580, the Resource Recovery Act of 1976 is in the final regulation developmental stages now, and landfilling criteria in the future will be extremely more costly than it's ever been. The limitations and specific details of that are being organized at the very present time in Washington, D.C. by the Solid Waste Systems Division of the E.P.A.

This is our own sewage plant in Oregon. They take the material out of the metering ponds. They take and run it to the other end of the facility and bury it in the land within 100 yards of the river. The Department of Environmental Quality for the State of Oregon has forced them to do a study to reorganize this type of operation. It's definitely detrimental to the water situation being adjacent to the landfill.

We started out with a concept the idea being to take industrial waste materials and mix them properly with sewage treatment, paper and pulp industry materials, dairy feces and livestock feeding waste materials and separated domestic garbage. Many, many natural fibrous celluous materials can be used when properly mixed and within the right chemical perimeters. The sludge is mixed properly; it's fed to the worms; it goes through a fertilizer or soil amendment processing operation out to the marketplace and back into primary and secondary crops, domestic gardening, reforestation, parks and recreation and obviously the cycle goes around one more time.

We had to take this concept and expand it into an operational facility. The concept was of no use whatsoever. So we had to engineer and design an operational facility. This is the prototype model here of our headquarters which will be built and on line April in Eugene, Oregon. It is the first facility of its type in the United States that we're aware of. We are similar to but different from any other attempts and processes that have been designed and developed over the years to deal with solid wastes in that we use worms. You can see the large worm beds here. This is an eight-hour one-shift day plant with 22 worm beds. We process in a 9,000 square foot building 50 tons per 8 hour shift of resource material. We run it for a 32 day cycle in the worm beds using 1,000 worms per cubic foot of material to digest. This plant has 84 million worms working in it. On a three shift basis we have 252 million or 252,000 lbs. or 1,000 worms to the lb. The ratio of raw material to product yielded is about 350 tons of product for every 1,000 tons of material, that we put into the system. There's a natural loss due to the processing of the material through the worms. They use it to survive. It drys out in the processing and loses a lot of its weight as moisture.

In the plant itself we take the material in on the front end of the plant where it says solid wastes storage. We have direct control of materials to be put into bin hoppers, and we have overflow storage and we put materials in there for special mixing so that a range of materials, 150 tons a day, can be handled in one area here and custom blended for the right chemistry. It goes down a conveyor line, goes through a pulverizer grinder and into a mixing machine and into the large hoppers, and it's then taken out to the worm beds you saw on the earlier slide. After 32 days then the product is rendered by the earthworms. We migrate them from one bed to another through a patented process. We bring their castings or the by-product back into the plant, run it through a metered hopper. We can at that point put various additives in it. We dry it in dryers and sterilizers. We then run it through a screening process so that only the finest particles go down onto the cenveyor belt line for automated packaging, palletizing and then it goes out to our shipping dock.

You see where the screening process takes place we have a bypass overflow that runs undigested or larger material back to the original line, and it is remetered back into the processing to go back out to the beds; and we give it one more try.

This is an example of some of the material here being blended. We have three different types of wastes here. We have Coca Cola bottling waste; it's a sugar by-product. We have paper waste; and we have, I believe, it was beet pulp. These three different materials here will be blended into a mixture and then fed to worms. The ratio being 1,000 worms per cubic foot of material, and they do an awful efficient job!

The idea here is quite innovative in that we get paid for all of our raw resources materials. It's an industrial problem. Most industries pay $25-35 per ton of material disposed of. New York City as we've researched it spends over 50 million dollars a year dealing with solid wastes on the municipal level. there's a sewage treatment plant in Colorada Springs that spends $120 a ton to deal with their material.

The process here has a workforce. It's a nine man operating plant due to automation, but it has a workforce of 252 million creatures for three shift operation that eat and reproduce for a way of life. Of course, we don't have a number of problems to deal with in terms of financially taking care of and sustaining this workforce except for the initial capital investment

These are some of the machines we'll be using. This is a picture of a factory in Japan. We have the licensing rights for the United States, Canada and South America for this process. It was actually developed and patented originally in Yokahoma, Japan by a company that won the coveted Japanese environmentalist award. This is a type of conveyor hopper here where we take the castings in. We start running them down the line, running them through the plant. We have various checkpoints where volumes of material and quality of material checks are done. This is a mixing and blending machine for studying inside of the machine looking at its innerworking parts. This is one of the screening sifters with conveyor points running up to it and away from it. This conveyor belt here takes the product into another portion of the factory where it's put into the metered hoppers rescreened and then into the packaging hopper. So it's a totally automated process, and this is the product we're actually working with.

When we use sewage treatment sludge, we can range in nitrogen between 4-6%. When we use various other fibrous materials, we're considerably less. We're in competition with the fertilizer industry. We're a soil conditioner at the base bottom level. In quart sizes we would sell retail potting soil in large bulk volume for primary crop use. We look at this to be a supplemental way of helping to offset some of the nitrogen shortages that this conference has dealt with and that are projected and forecasted for the future.

We took the standard mix of four different brands in the pacific Northwest of 10-10-10, and our biochemist along with another independent laboratory and the University of Tokyo studied this material. They took 10-10-10 and they custom blended and reduced the nitrogen content down to 3-10-10. When that bulk by dry weight was mixed with 30% ratio of our material we got 14-24% higher crop yield than a 10-10-10 alone used on the comparable crops, and this includes corn, tomatoes, cabbage, rice, soybeans and Chinese cabbage. The reason we believe for this, and the research pretty well documents it, and I have technical data to back it up, the material we're looking at here is a natural organic material. It has a moisture absorbency factor. It tends to take chemical fertilizer and hold it in the ground very much like a sponge, releasing it. I know there are slow release and fast release chemical fertilizers, but it releases it on the natural time schedule when the plant roots need it; and the results from that type of combining of products were better than we had actually expected. I believe that we can work with the chemical fertilizer industry not necessarily mixed together but on a side by side basis where at point of purchase or in the field these products can be used hand in hand to condition soil and to make the chemicals more available to the plants.

I'll finish up now. I've used my time I realize, but this is a reality. These are bags of fertilizer in Japan. They have 11 plants on line here. We'll have our first in the United States soon. We already have 17 committments from private investors and industrial Boards of Directors to build plants in various locations in the United States. This is an idea that is happening now, and it'll be a reality very soon physically in operation.

That's ½ days' volume in this one plant. We believe that this idea will be the dawning of a new age in naturally treating solid waste materials on a resource recovery whereby the product yielded is the profitable and positive end result of one of the country's worst problems, a problem that has thus far been solved by negative capital investment and negative cash flow. We would like to be responsible for turning that around.

Thank you very much for your time and attention. [Applause]

MODERATOR PROSSER: Thank you very much, Bruce. I never thought that you could generate much enthusiasm over a few worms; but when you have a lot of worms, it's different!

The next speaker doesn't need a whole lot of introduction from me. he is Mr. Michael Sackett. He's from Baltimore and is Executive Vice President of A. J. Sackett and Sons Company. He is interested in talking on "Bulk Fertilizer Shipping Towers." Mr. Michael Sackett please.

[Sorry, Mr. Eder did not furnish slides]

Problems Associated With Bulk Fertilizer Shipping Operations

Michael Sackett

I'm going to use my brief time before you to address three problems typically associated with a bulk fertilizer shipping operation. I then propose to show you the approach my company has taken to their solution.

The first problem is dust:

When granular product is run thru a single deck system and then thru a tailings mill, considerable dust is generated at tower levels, maybe 20 or 30 feet above plant floor. Without a collection system, this dust filters down and spreads thru the tower, which multiplies the problem, creating a poor in-plant environment.

The next problem is product degradation:

Running product thru an impact mill breaks up run-of-pile lumps. That's what it is supposed to do. Unfortunately, a mill rotor running at 700 or 800 RPM, also pulverizes the granules. In effect, creating more dust out of a once valuable product.

Finally, money:

A shipping tower can involve a relatively large investment in non-productive extras such as elevators higher and drives larger than they need to be.

We have defined the problem. Here is what I believe to be an effective solution:

-1 *Take the milling and screening operation out of the tower and put it on the ground, and*

-2 *Reduce the mills rotor speed in order to minimize product degradation.*

Obviously, these things can't be done with conventional equipment. A new machine was needed.

The machine we developed for such a job, we call a BULK CONDITIONER. This is basically a floor-mounted surge hopper containing a low-speed motorized rotor to replace a tailings mill and a stainless steel perforated plate for screening.

When mounted over an elevator boot, the BULK CONDITIONER drastically reduces tower dust by eliminating both the single deck screen and mill normally required.

Product degradation is also substantially cut due to the BULK CONDITIONER'S extremely low rotor speed, about 10% that of a normal mill. It is subsequently not dependent on a high impact to be effective. Tower costs are also lower because there is less machinery up there to support. The mill and single deck screen have been eliminated and as a result, shorter elevators and smaller drives are required.

There is literature available in the back which will describe this arrangement in detail. At the end of these sessions, please feel free to pick up a brochure. Thank you. [Applause]

MODERATOR PROSSER: Thank you very much, Michael. Our fourth speaker in this session also doesn't require any introduction from me. He is the No. 1 delegate from the Confederate States of America. Mr. Pete Cox, please.

Asbestos Pollution

Edwin Cox III

At a recent meeting held at the Bureau of Standards and sponsored jointly by the Bureau of Standards and OSHA, Mr. Willard C. Dixon of OSHA stated that, in the event an inspection found over 2.0 fibers per milliliter as the worker's environment, the owner could demonstrate that the fibers were not of the regulated minerals:

Chrysotile
Crocidolite
Anthophyllite
Amosite
Actinolite
Tremolite

This is a significant change over earlier rules in which the simple fiber count violation constituted a violation of OSHA regulations from which there was no appeal in fact.

The background of the problem is the chrysotile in times past has been considered to be a carcinogen, based on the incidence of cancer among chrysotile workers in England. The British adopted the fiber count method for "asbestos" plants because any fibers in the air could properly be considered as "asbestos".

The environments of workers with crocidolite in Australia, particularly a woman (who developed cancer) engaged in packing gas mask cannisters during World War II rendered the same type of regulation feasible.

Fiber counts are done at magnifications between 400x and 450x, and assume an aspect ratio (length to width ratio) of 3:1 or more.

Subsequent study of the problem in greater detail has revealed several interesting facts.

1. The word "asbestos" is without meaning — it applies to a family of minerals which may be either fibrous or non-fibrous in nature. This family of minerals is divided into two sub groups, Serpentines and Amphiboles. Chrysotile is the sole fibrous form of a Serpentine. It does have non-asbestos forms, antigorite and lizardite.
2. These three minerals exhibit the same X-ray diffraction pattern and have the same chemical composition. The distribution is simply one of morophology.
3. The same distinction applies to the fibrous and non-fibrous forms of the other named minerals.
4. Asbestos Actinolite and Asbestos Tremolite are so rare as to have no means of their own, but rather the distinction is made by using the names Asbestos Actinolite and Non-asbestos Actinolite.

   In summary of the above brief discussion, in the event an inspection finds that a plant has a fiber concentration in excess of 2.0 fibers per milliliter, the plant operator should insist that the fibers counted be analyzed to determine whether or not they are one of the regulated minerals.

It is apparent that the inspector should not discuss "asbestos" but rather should refer to one of the six regulated minerals, which are:

Chrysotile
Crocidolite
Anthophyllite
Amosite
Actinolite
Tremolite

If the owner desires to have this work done, it can be accomplished by scanning electro microscopy, which is commonly employed by most major laboratories and is available at most universities. The aspect ratio can be obtained, obviously, by cleavage fragments which are more than 3 times longer than they are wide, but which are not fibrous in nature and which, when broken, will break into small fragments and not into fibers.

The importance of this to the industry is obvious when Dr. Brownley's paper, yesterday, is considered. The particles of apatite had aspect ratios of greater than 3:1, as did the MAP crystals which he grew. If these had been collected as dust, then they would have an aspect ratio of 3:1 and would have been counted as fibers by OSHA. That they are, for example, MAP and not a regulated mineral, is obvious to the owner who is skilled in the fertilizer industry, but may not be obvious to the OSHA inspector. [Applause]

MODERATOR PAUL PROSSER: Thank you very much, Pete. Our last scheduled speaker is Mr. Jack Frederick. He has been in the fertilizer business since 1950. He started with Baugh Chemical Company, worked for Davison and is presently employed by W. R. Grace. He wishes to speak on "Stablized Sludge Free 60% P_2O_5 Wet Process Acid." Mr. Jack Frederick, please.

Stabalized Sludge Free 60% P_2O_5 Wet Process Acid

J. C. Frederick

Conventional 52-54% P_2O_5 wet process acid as produced contains various metal phosphates, fluosilicates, etc., which are inherent in the phosphate rock used in manufacturing phosphoric acid. The above salts, both dissolved and suspended along with gypsum not removed by filtration, slowly precipitate during further processing at phosphoric acid plants and in storage and shipment of merchant phosphoric acid.

This precipitation product is commonly referred to as "sludge" and can amount to as high as 10-12% of acid shipments in addition to sludge precipitation at point of acid production. Since this sludge has a P_2O_5 content of 45-50% it must either be cleaned out of tank cars at destination and used at that point or returned to point of manufacture for further processing. Because of the 45-50% P_2O_5 content of sludge, waste disposal is not an economical alternative.

During 1973-74 W.R. Grace & Co., after extensive laboratory scale investigation of a process developed by R.N. Hill, Lakeland, Florida, acquired rights to Hill's process to "stablize" the sludge normally associated with production and shipment of 52-54% wet process phosphoric acid. In addition to this stabilization process, it was found a 60% strength sludge free acid could be attained versus conventional 52-54% acid with sludge. The term stabilization is used since the various salts are not removed but are treated in a manner which solubilizes these same salts.

To further investigate the production of 60% stabilized acid, a pilot plant was brought on stream in late 1975 and 60% sludge free acid has been shipped by tank car to various locations in the United States.

This acid has been used successfully to produce granular DAP-MAP, granular N-P-K's, liquid and suspension N-P-K's, and high poly liquid 10-34-0 through TVA type pipe line reactors. In all cases upon unloading at destination there were no heels of sludge in any of these cars. For testing purposes some of these cars were held 5-6 months at point of production before shipping and upon unloading no sludge remained.

The economic benefits of this acid to the fertilizer industry are as follows:

1— The shipment of 60% acid versus 52-54% acid results in a 12% freight savings.
2— The 60% acid will reduce fleat car leasing the same 12% for comparable P_2O_5 tonnages.
3— Storage at destination increased by 12%.
4— Tank car cleaning is no longer necessary.
5— The accumulation of sludge at both phosphoric acid production points and destination is eliminated.
6— Inherent losses of P_2O_5 due to handling and cleaning of sludge from cars, tanks, lines, etc., are also eliminated.

These same savings would of course apply to water movement of 60% acid.

Although I am not prepared at this time to comment on the process used to stabilize 60% acid I can say costly processing steps such as solvent extraction, calcining of rock, or removal of sludge at production point are not involved.

Additional minor development work is still underway and we hope to have this acid commercially available in the very near future.

Thank you for allowing me to present this short paper as part of "New Developments of Interest to the Fertilizer Industry". [Applause]

MODERATOR PROSSER: Thank you very much, Jack. We appreciate that. I want to express our gratitude to all of the people who have participated. If there are any other volunteers from the floor we will give you a minute or two or three to state your case. Anybody have anything they would like to offer the group? Yes, sir.

GLENN FEAGIN - I.M.C.: I have one short thing I think they should know. I don't know whether you are aware of it or not but the Department of Transportation under Section 49 Code of the Federal Register has published and is enforcing some very strict rules on transportation of hazardous material. Now for your information ammonium nitrate is hazardous plus all our acids, anhydrous ammonia, a 15 page list of them. They have not determined whether blends of ammonium nitrate are hazardous materials or not. It means that you have to instruct your people. You have to label them. Every time you ship 1,000 lbs. of ammonium nitrate or more you have to give the farmer four labels to go on his truck. So if you're not aware of this you should look into it, and we do need some information from someone about these materials that would be covered. Thank you.

SAM HOUGHTALING - Davy Powergas: There was a paper given earlier on penetration into triple 17 and triple 19. I just went through an in-plant test in Cochin, India. We had a hole in the roof, and they attempted to repair the hole in the roof during the monsoon season so we had 100% humidity. As a matter of fact it was ankle deep in spots of the warehouse. The triple 17, the triple 19 had about 2" maximum penetration after two weeks in 100% humidity in the building. The 28-28-0 had been in the building approximately three months, and it had a penetration of about 2½". Now this is practically no humidity control and that's what they had.

MODERATOR PROSSER: Many thanks. Any other comments? May I remind the speakers please, as Rodger has done several times, I would like to have the papers. I have a little slogan. It's not the same 7 P's but I have a 7 P slogan. It says, "Papers Prior Publishing Proceedings Prevent Prosser's Punishment." Thank you. [Applause]

MODERATOR PROSSER: Now, Mr. Rodger Smith, I think, would like to make a closing remark.

CHAIRMAN RODGER SMITH: Thank you, Paul. Well, gentlemen, this 27th Round Table is about to come to a close. You have demonstrated that this is your meeting, your opportunity to share your views on subjects of particular interest to you and to your fellow people in the industry, your opportunity to learn what is going on in your phase of the industry and in other phases, learn what some of the problems are, a chance to rub elbows and get down to the nitty gritty on particular things that are concerning you. I think it has again served the basic purpose of the Round Table as projected in the beginning. One of the things that the Directors particularly tried to achieve in putting this agenda together was what might be termed balance, that is, balance between various stages of the industry, the granulation, fluid mixes, the blending and the production of individual basic raw materials nitrogen, phosphate and potash and other materials. As we learned yesterday afternoon, people in Florida and other areas working on phosphate rock have very bad problems which directly affect what we can do in the mixed fertilizer industry and what changes will probably have to occur in the future. It is a desirable trend to have good representation of what the problems are and what developments are occuring in the industry.

At this time I'd like to once again thank all of you for your participation. It's you who really make this Round Table. I want to thank the Directors. I want to thank Paul, Tom, Wayne, Al Spillman for the tremendous job that they do. I certainly want to thank the moderators for their excellent job and all the speakers. We've had excellent papers very well presented. Projectionists, I want to thank you.

QUESTION: I want to ask Paul what happened to the 7 P's, sir.

CHAIRMAN RODGER SMITH: Yes, what about those 7 P's, Paul?

PAUL PROSSER: A young man from Howe Richardson sailed off in the boat last night.

CHAIRMAN RODGER SMITH: Is there anything that anyone else would like to bring up to this meeting before we close? If not, I declare this 27th meeting of the Round Table adjourned. Have a good trip home, and we look forward to seeing you in Atlanta next fall. [Applause]

Comments by Albert Spillman

Editing Chairman

Our 1977 "Proceedings" are "Highlighted" with thorough "Discussions and Illustrations" of "Up-To-Date Technical Data" covering the latest "Research and Developments" — Plant Equipment, Materials, Particle Size, Quality Control, Environmental, Formulation, Packaging, Drying and Cooling and many other important, valuable discussions of much interest. I am sure you will enjoy reading all of the timely reports, suggestions and information.

Many thanks to Our Chairman, Secretary-Treasurer, The Prosser most cooperative Secretaries, Directors, Moderators, Speakers and many in Our Audience, for helping me promptly when I called on you many times for various information needed to complete Our Proceedings.

My Special Thanks to Chairman Smith and Secretary-Treasurer Prosser for their very special activities obtaining promptly and assembling the necessary "Speakers Papers, Slides and drawings." This additional help permitted the final "Proceedings" to be mailed much earlier.

Our 28th Annual Meeting will be held in Atlanta, Georgia, Tuesday, Wednesday and Thursday, October 31, November 1st. and 2nd., 1978. Many of our Members will be arriving in Atlanta Monday Evening, October 30th. Make your reservations early. Sheraton-Biltmore Hotel — Atlanta, Georgia.