PROCEEDINGS
OF THE
29th ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1979

October 30, 31, November 1, 1979

Shoreham-American Hotel
Washington, D.C.

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NOTE #1—RESIGNED

NOTE NO. **#2—ELECTED TO BOARD AT 29th ANNUAL MEETING**

NOTE #3—NOW WITH OCCIDENTAL CHEMICAL CO.—WILL CONTINUE AS DIRECTOR

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OUR ROUND TABLE
IS PROUD TO REPORT
THESE VALUABLE
PROCEEDINGS
COVERING OUR 29th
ANNUAL MEETING

Tuesday, October 30, 1979

Morning Session
Frank T. Nielsson, Chairman

Frank P. Achorn, Moderator

OPENING REMARKS- CHAIRMAN NIELSSON.

It is with special pleasure that I call this 29th annual meeting, of The Fertilizer Industry Round Table, to order. In the early days, we were all building granulation units. Once we admitted that there were manufacturing problems, this Round Table became an open forum for problem solving.

As time went on, bulk blending took up a bit of our attention. Then, we talked a little bit about liquid fertilizers. However, the recent sessions have dealt deeply with the legal problems brought on by OSHA and EPA regulations.

This meeting today, this year, is in sort of the transition stage. We have got some granulation, some energy conservation, an entire morning that will deal with suspensions fertilizers. We will talk some about OSHA and EPA discussion and we have some safety observations.

In the coming years, I can see a decided swing to phosphoric acid, its production and its use. We will probably be having future discussions about uranium extraction from phos-acid. The standard problems that deal with granulation, OSHA, EPA, safety and energy conservation, will be with this group for a long time to come. So, don't go away. Keep coming around, because there will always be something for each one of you, that you can take home and tell your boss that "I learned something".

We are looking forward to our keynote speaker this afternoon, The Honorable Bob Bergland, the U.S. Secretary of Agriculture. Meanwhile, we open the meeting with a crystal ball examination of the primary nutrients: nitrogen, phosphate and potash. The Moderator is Frank Achorn. He is a Senior Scientist at T.V.A. He is Vice Chairman of this Round Table. Frank, take it away. (Applause)

MODERATOR ACHORN: It's always a pleasure to share the podium with Frank Nielsson since he was one of the first bosses I ever had. They couldn't hear anything but Frank and I when we were around. I notice from our supply and demand panel that we have this morning three economists and one chemical engineer.

Now, on supply and demand, I have a memorandum that was written to another gentlemen in T.V.A., concerning me, by the manager of National Fertilizer Development Center, and I want to share that with you this morning. Before I present that, I want to tell you that the manager is an agronomist, and for years I have been telling him how much better chemical engineers are than agronomists.

He had to go out of town one time when we were having a staff meeting, and the guy that was conducting the staff meeting received this memorandum from him. It says, Frank Achorn was in a plane wreck and washed up on an island inhabited by cannibals. To his astonishment, he found that the inhabitants had set up a butcher shop. On this particular day, the shop was featuring boiled brains. Five seashells purchased one pound of brains from chemists, computer experts and agriculturalists. Ten seashells purchased one pound of brains from agronomists. Fifteen seashells purchased one pound of brains from economists and forty seashells purchased one pound of brains from chemical engineers. Of course, Frank was gratified that the brains of his engineering peers should bring by far the most. Frank asked the butcher, "How come?"

The butcher mentioned, and it's appropriate this morning, he mentioned "It's a matter of supply and demand." the butcher explained. "All five seashell brains are run-of-the-mill quality", he reported. "The agronomists' brains bring more because they are especially good for the young and aged." "the price of the economists' brains is still higher because they are a gourmet item, highly prized because of their raunchy flavor."

"Then, judging by these prices, you must believe engineers' brains best of all", Frank stated. "Are you kidding the butcher replied? "It's merely a matter of supply." "You just wouldn't believe how many engineers we have to boil down to get a pound of brains."

So, with that, I will start the session. I think that it's appropriate that the first speaker be an economist, because he's got raunchy brains. The first speaker is John Douglas, and I want to give particular thanks to John for coming. He took my guidance. I fell off a ladder not to long ago and broke two ribs. John recently fell off a ladder and broke one elbow and two wrists, so it took a lot for him to get here today, and we sure appreciate him coming. John is well-known by the industry. I don't think I need to give too much of an introduction for him. He certainly is appreciated for his work at T.V.A. and for the industry as a whole. He is a graduate of Iowa State, has a PhD from Iowa State, and he went to Harvard University. John's had about thirty years' experience in the industry, and I am sure all of you are well acquainted with him. John. (Applause)

Nitrogen Outlook = 1980's

John Douglas

Introduction

Economic analysts generally agree that the world is setting on the edge of another recession — or perhaps already into one. Sharply higher prices and reduced supplies of oil and other forms of energy are major contributors to the trend.

In contrast, the changes in energy are sounding an upbeat note in the nitrogen fertilizer industry. New energy relationships have sharply reduced fertilizer supplies, and led to much higher fertilizer prices. The net effect has been to shorten the traditional up-and-down cycle in fertilizer prices and profits. The net effect may also be misleading to some nitrogen fertilizer producers. For many producers, prices are rising, yes, but they are rising from a net loss position; more importantly, they have not risen rapidly enough or far enough to (1) overcome losses of last year and (2) to simultaneously stay abreast of continuing soaring costs of energy and other general operating costs.

Many well remember how concern over world food supplies in the mid-1960's greatly increased fertilizer demand, leading to an upswing in prices and profits, then to a period of overbuilding of new plants, and finally to an industry depression by 1968. From then through 1971 the industry lost money, plants were closed and plans for new plants were scrapped. And demand began overtaking supply.

Then by 1973 the situation was again rosy as nations around the globe raced to increase food production. Changing trade patterns in grains led to induced added chemicals for fertilizers. And the fertilizer industry of the world entered another upswing. Prices of fertilizers doubled and redoubled. But prices of farm products fell as more production became available and the world learned more about accommodating the changed trading patterns. These changing price relationships ended this cycle abruptly in 1976, and the fertilizer business was again in the doldrums.

The 3-year downswing hit the phosphate industry first and the nitrogen industry shortly thereafter. As new plants were coming on-stream in 1976 and 1977, supplies were exceeding demand. And it appeared to all market researchers that the nitrogen fertilizer industry was heading for increasingly large surplus supplies which would continue throughout the mid 1980's. However, many unexpected changes have taken place in the world nitrogen market in the past year. The bottom line of all these changes is that the prospect for an oversupply of nitrogen which "capacity" data had suggested has not disappeared.

In 1977-78, production costs began climbing rapidly. Then in 1978 and 1979 many nitrogen producers suddenly faced a doubling of energy costs. Raw materials began to cost more than the manufactured product was selling for. In some cases, even the newest, most efficient plants could not show a profit, and many units were closed.

Unusually cold weasther last winter in Europe and Asia and the political chaos in Iran further reduced production of both phosphate and nitrogen. Also much of the new capacity of the world is located in areas where the numbers of new plants have exceeded the numbers of trained personnel, thus production is lower than expected.

The picture is further clouded by changes in world trade patterns which have developed over the past five years. World trade in nitrogen has shifted away from the traditional experienced suppliers such as Japan and Western Europe to other areas much newer and less experienced in the game of producing and distributing such massive amounts of materials — and normal growing pains are persistent. The result is that the world is entering the 1980's with a tight nitrogen fertilizer supply situation. And solutions to the vexing problems of short supply will be just as troublesome as were those of oversupply of the past three years.

Trends In Demand — Worldwide

Nitrogen fertilizer demand generally is increasing only slightly faster than anticipated a few years ago. Food grain prices are holding at relatively high levels, or even increasing. Higher grain prices have been generated primarily by increasing imports by the U.S.S.R. and China. The higher food grain prices, in turn, have caused fertilizer demand to grow slightly faster. If many nations, including the U.S., continue to emphasize all-out food production, demand for nitrogen fertilizers will continue to expand even more.

Worldwide demand for nitrogen is increasing about as expected. If farm prices continue strong — or climb even higher — 1980 demand for nitrogen could be even stronger than expected.

Supply Trends

Supply of nitrogen fertilizers has not kept increasing as expected. Changes in energy costs and availability have led to sharply reduced supplies.

The to-be-expected operational problems of new plants coming on-stream faster than manpower can be trained, too, has reduced a supply below that expected. And massive changes in world trade patterns have exacerbated the worldwide fertilizer supply position.

The world has the "paper" capacity to produce all the nitrogen we need — and more. Earlier studies indicated a 1 million ton surplus of nitrogen worldwide for 1980. But production is falling considerably short of what is on paper. This means tightness in supplies, at least in the short run.

Soaring prices of naphtha, fuel oil, and natural gas — triggered by the OPEC cartel's actions — have caused many ammonia plants to be shut down. Some may never be operated again, or they may operate at lower levels than previously expected. And some plants which are operating on high cost naphtha or fuel oil are said to be operating at levels barely sufficient to produce required urea — while importing supplemental ammonia. Completion of some new plants has been delayed, or they are being brought up to rated capacity more slowly than anticipated. Availability of trained operators is more of a problem in developing industries than had been expected.

It is impossible to pinpoint the extent to which all of these factors have reduced nitrogen production. But a substantial chunk of the expected tonnage is not being produced. Unless nitrogen prices go even higher and/or energy and feedstock prices retreat, further reductions in ammonia manufacture can be expected.

Japan, entirely dependent on imported hydrocarbons, has closed one-fourth of its nitrogen capacity and announced plans to shut down another 26 percent this fall (1979). Formerly a major exporter, its nitrogen exports have been cut in half and likely will shrink further. Probably, they will supply their own internal needs, but they will not be a major exporter for the future. Barring a major intervention by their government based on political - not economic- consideration.

Indonesia has done an outstanding job of building and operating new nitrogen plants in recent years. Regretably, however, addition of gas collection facilities has not kept pace. As a result, 1979 exports were less than half what had been expected. And there will probably be further delays in expansion of nitrogen exports during 1980 as gas collection facilities are built.

Western Europe, also traditionally a major exporter, has been caught in the cost-price squeeze. Few closures have been announced. However, with between 10 and 20 percent of its capacity based on expensive fuel oil or naphtha, many plants obviously are financially endangered. The cost of naphtha has shot up to over

$325 per ton, thus putting the raw material cost per ton of ammonia produced in these plants to over $250. Also, Europe has had several unexpected severe plant operating problems.

The net result has been a surge in ammonia imports to Western Europe in 1979 coupled with significant reductions in nitrogen exports. Prices nearly doubled on the ammonia imports — from $110 to $200 — but even so imported ammonia is attractive at today's feedstock prices. The area's imports could well continue to increase - and exports decrease. It would not be surprising to see Western Europe become a net importer of nitrogen within the next two years — as contrasted to their former position as the major net exporter for the world.

Eastern Europe and the U.S.S.R. had been expected to fill much of the gap in nitrogen fertilizer supply in 1979 and during the 1980's. In fact, many feared the impact the area's expected larger output could have on the world market. But that impact is yet to be realized, for several reasons. The Iranian situation in the spring of 1979 led to temporary closure of Iranian ammonia plants. It shut off for a time gas deliveries to the U.S.S.R. and further into some of Eastern Europe. Gas flows reportedly have been resumed, but at greatly reduced rates. And the region's expanding industry has had the usual "growing pains" in trying to get plants operational and to deliver the ammonia through newly operating distribution channels. All of this, plus greater emphasis on domestic food production, has kept this region's nitrogen exports from reaching expected levels. Little improvement is in sight at the moment.

Mexico also has had its "growing pains." Short interruptions of production have been reported twice this year. There are the normal problems of operating so many new plants with so few trained people, plus reported shortages of spare parts for maintenance.

Canada has doubled capacity and production in the past five years. Domestic use is at record levels and record amounts are being exported to the U.S. This has generated a tight supply situation. With high grain prices and the prospect of even larger domestic consumption in 1980, there is a distinct possibility of a cut in exports to the U.S. Two new plants, however, are under consideration. Growth of fertilizer consumption in Western Canada has been phenomenal and is the "thinking" behind both of these plants. Regardless, these new plants will not be available to supply added exports until well after 1980. And we can expect smaller exports from Canada until the new plants are complete and operational.

The United States

Where does this leave the United States? First, with escalating commodity prices portraying an increasingly rosy picture for farmers, we can expect significant increases in demand for nitrogen materials for 1979-80. Wheat prices have risen by more than 50 percent in the past year and continue upward. Corn prices are also up significantly. Cattle prices are near an alltime high. With such high farm prices, we well expect agricultural nitrogen demand to be at an alltime high in the current year. Small decreases in demand for industrial nitrogen will not come close to filling increased agricultural demand. And last year's demand consumed all that was produced and imported, *plus* some 0.5 to 1.0 million tons which came from inventory reduction. Thus, we will need an increased supply probably in excess of 1 million tons of nitrogen.

Where is this coming from? We have no new capacity scheduled for the next few years. Currently, the U.S. has a total rated production capacity of 24.4 million tons of ammonia counting both idle and operating units. But over 4.0 million tons (over 16 percent) of this is closed, generally as a result of cost-price squeezes which arose as energy costs escalated wildly and nitrogen prices plummeted in 1977 and 1978. And we cannot expect these plants to reopen until energy prices decrease or nitrogen prices increase significantly.

A portion of the increased demand will come from increased operating rates of those plants which are operating. In all probability, we can expect an additional .5-.75 million tons of nitrogen to be made available by these increased operating rates.

A fraction of the increased demand may come from reduced industrial use and an even further reduction in inventories. However, very little additional material can be squeezed out of the inventory lines without seriously disrupting the total logistics system for production and distribution of this vital material.

Some would have you believe that all the increased demand can be met by increased imports. And increased imports may help. We can expect more imported ammonia if current news publications are to be believed. But these increased imports may well be offset by equally large increased exports of urea, UAN solutions, ammonium phosphates, and other higher value finished nitrogen fertilizers. For example, last year we expected increased imports of close to 1 million tons ammonia. And we got it. But at the same time, few expected to see exports of finished nitrogen materials increase — but they did. And as a result, the U.S. ended the year with essentially a positive net Export-Import balance in total nitrogen. And early indications for 1979-80 point to a continuing strong pressure from world markets for *exported* nitrogen from the U.S. thus, it is not certain at all that we will have a net import balance for nitrogen even if the imported ammonia does arrive as expected.

And no one knows how or if we will be able to handle all the projected new imports of ammonia. There are only a few ammonia terminals available to unload it — and limited numbers of railroad cars, pipelines, and barges available to distribute it. We know that our systems for handling imported ammonia were almost overworked this past year and relatively few new systems will be available next year. The total logistics system will be called upon to change very rapidly — more rapidly than ever before. And problems will arise. This much we know. We do not know how well we will be able to surmount these problems.

Nitrogen Summary

Past projections of a continuing increasingly large oversupply of nitrogen fertilizers for the world through the mid 1980's are simply not true today—and they probably won't be until prices of oil and natural gas decrease or prices of ammonia increase significantly. With increasing farm prices, demand is growing about as expected—although there might be a somewhat unexpected increase during 1980 crop year.

Supply, however, is far below expectations as a result of many factors including weather, cost-price squeezes, political chaos, and normal "growing pains" of trying to open more new plants than there are trained operators. We can't put precise numbers to this supply shortage but it is certain that the shortages in supply over that planned for and expected are significant and are worldwide—and in all probability, will not easily or quickly be overcome.

Most certainly the supply/demand balance will not be brought back into balance until the cost-price squeeze on much of the world's nitrogen fertilizer industry is relaxed by a reduction of production costs or significant increases in world prices.

Boiling It Down

Short-Term 1980

Supplies of nitrogen fertilizers almost certainly will get progressively tighter. Only those who plan and order early will be assured of an orderly supply. There are no surpluses left to supply those who sit and wait until the last minute in hopes of getting lower prices. Prices won't get lower! Particularly is this so in an atmosphere of double digit inflation. This was not the case of debacle year 1975. Then we had relatively flat costs. Now we have soaring costs. With costs boldly advancing, and if fertilizer prices suddenly retreated, the collision would be best described as a debacle.. Many producers would be bankrupt. Those who wait for lower prices will simply run a high risk of not getting what they need.

Intermediate To Long Run (early to mid 1980's)

In the longer run, I feel confident that we (the world) will overcome the current tight supply situation and will somehow produce all supplies needed to help feed our over growing population. The course of this action is fraught with various perils to planners and doers in the industry.

The world industry faces major changes in trading patterns brought about by changing world politics, new economics of energy and other raw materials, economics of transportation and distribution, and other factors. Any change in trading patterns, no matter how small, tends to exaggerate inbalances of supply and demand. The big changes we are seeing now will tend to make a tight situation seem to be much tighter. It probably also will extend the time frame of that tight situation.

The current business recession may affect the fertilizer cycle. However, crop prices remaining high in relation to nitrogen fertilizer prices will almost certainly overweigh most side effects of the general business down cycle upon the fertilizer up cycle—as long as we avoid a full blown depression.

We know from past experience that when prices of fertilizers get too high in relation to crop prices, demand quickly falls off. At the same time—we also know that prices must rise to make profits be there before the industry will commit to new plant investments. Thus, the industry is doomed if it raises prices too high and the world populace is doomed to less food if prices aren't raised high enough to ensure adequate profits to the industry.

In 1973-74 the world saw prices of nitrogen and phosphate fertilizers doubled and redoubled almost evernight. And then came 1975 and farmers over all the world rebelled against these high fertilizer prices at times when prices of their farm products were going down. So far, at least in this cycle, prices of farm products have kept pace with nitrogen fertilizer prices. Prices of major farm products today are 30 to 50 percent higher than they were in 1978. It is true that the price of nitrogen fertilizers has increased since 1978. However, as of October, increases of nitrogen fertilizers have not kept pace with the increase in prices of crops. The net result is that the crop-fertilizer price ratio as it pertains to nitrogen fertilizers is still an exceedingly good relationship. If we should see prices of farm crops drop precipitously or alternately, prices of nitrogen rise chaotically as they did in 1974-75, the current upward cycle in the nitrogen industry could well be brought to a screeching halt before it gets underway.

On the other side of this coin is the pressing need to get fertilizer prices up if new production facilities are to be built. The world seemingly has recognized the fact that it has seen the last of cheap energy in the form of hydrocarbons. Little, if any note has been taken of the fact that we also have seen the last of enexpensively produced new nitrogen fertilizer. Our industry uses massive amounts of energy in producing nitrogen. Yet, for the past two years, 1978 and early 1979, much ammonia was sold at less than the value of the hydrocarbon used in producing it in many plants. The average prices of fertilizers have not increased in relation to the average costs— and not nearly fast enough to encourage new plant construction.

The investment costs incurred in building the needed new plants will be truly astronomical when gauged against old investment costs of the existing industry. A new ammonia plant started today will cost in excess of $200 per annual ton of production. In earlier days, an investment cost of $50 per annual ton was considered high. And no one is going to build these plants until prices go high enough to pay for all production costs, plus fully equitable profit returns on the increased investment costs.

I have no doubt that new plants must be built. They will be built or there is no way to continue feeding nor expanding population. We must all recognize, however, that the day of truly low cost nitrogen is gone. Just as there is no more cheap energy there is likewise no more low cost nitrogen fertilizer. Somehow, the world will continue having adequate supplies of nitrogen fertilizer but we must all realize that it will never again be cheap. Thank you. (Applause)

MODERATOR ACHORN: John, we certainly thank you for that excellent presentation and, I might add, we expect you to continue to help us solve these problems.

Again, we are blessed with another excellent speaker. To present the phosphate situation, Mr. William Rohrer. He is the Senior Vice President of Phosphate Chemicals Export Association. He was the former Vice President for both Grace and the Davidson Chemical Company. He is an economist, or, he is more than an economist. He is an excellent businessman, and he's a graduate of Yale University. Bill please.

Outlook For Phosphates 1979 - 1982

William M. Rohrer

Introduction

As most of you are aware, calendar 1979 will be known in fertilizer circles as a record year for the world phosphate industry. From the standpoint of supply, phosphate rock production will exceed 131 million tonnes, while deliveries will be an estimated 129 million tonnes. World trade in rock will total about 53 million tonnes in 1979.

As far as processed phosphates are concerned, world trade will exceed 5.5. million tonnes, P_2O_5. Overall, world consumption of P_2O_5 derived from all sources will exceed 30 million tonnes in 1979.

The U.S. phosphate industry which accounts for about 27% of the world trade in rock and 60% of free world trade in processed phosphates is producing at record levels and, given ample supplies of raw materials, will continue to do so through 1982.

Unfortunately, a number of unforseen events hampered P_2O_5 production in several key exporting and consuming countries in early 1979 which shifted the onus of additional supply on the United States. Spot sulphur shortages precipitated by the political upheaval in Iran, and production and logistical problems in Poland and Canada created chaos in the sulphur market early in the year. In addition, technical difficulties both in wet-process acid plants, and at the mines, reduced P_2O_5 production in key exporting countries in north Africa.

Unfornately, many of these same problems will be with us through 1982. With increasing domestic requirements and limited increases in production capacity, the U.S. phosphate industry will be hard pressed to substantially increase exports of processed phosphates in the short-term.

The sulphur supply problem will be with us for several years. In the future, Poland will commit additional tonnage for domestic use and supply increased tonnage to the U.S.S.R. and its other comecon partners, effectively reducing supplies to the western world. U.S. sulphur exports w ill be about one million tonnes this year to help meet demand. However, most of this sulphur is being drawn from inventories, which are rapidly being depleted. The recent mishap at the port of Vancouver will only exacerbate the sulphur situation, short-term.

Overall, the phosphate supply picture looks extremely tight as we enter the 1980's. Production capacity will be strained and consumers will have to act quickly and decisively if they are to procure sufficient supplies of phosphate fertilizers.

Demand

As the first slide illustrates, world consumption of P_2O_5 from all sources has increased steadily since 1968, except for 1975 and 1976 when drastic increases in fertilizer prices reduced consumption. However, since 1976, consumption has increased 4.5% annually to reach an estimated 30 million tonnes, P_2O_5 in fertilizer year 1979. By 1982, consumption could exceed 34 million tonnes, provided raw material supplies are adequate.

A summary of estimated world consumption by geographic region in 1979 is given below in million tonnes, P_2O_5:

	Consumption 1979	% of Total
E. Europe & U.S.S.R.	8.9	30%
North America	5.7	19
Western Europe	5.6	19
Asia	5.3	18
Other Regions	4.5	14
TOTAL	30.0	100%

Increasingly, world demand for finished phosphates has outpaced indigenous production capabilities, forcing major consuming countries to rely on imports to meet their needs. As the next slide illustrates, export demand for finished or processed phosphates will total about 5.8 million tonnes, P_2O_5 in 1979. The *Europe/Africa Region* which includes Western Europe, Eastern Europe, the Middle East and Africa, is the largest importing region taking 51% of the total, followed by Asia/Pacific (24%), Central and South America (21%), and North America (4%).

By 1982, export demand for processed phosphates will approach seven million tonnes, P_2O_5 .

Regional Demand. By region, demand in Europe/Africa will increase about 6% annually through 1982 with the largest increases occurring in Eastern Europe, including the U.S.S.R. Substantial growth is anticipated in the Asia/Pacific Region, particularly India and Indonesia. China represents a major opportunity. Although it has purchased limited quantities of solid fertilizers to date, the potential here is vast and virtually untapped.

Latin America, particularly Brazil, will continue to be a major importer of substantial quantities of P_2O_5 into the 1980's. The country's import requirements could well exceed one million tonnes, P_2O_5 in 1982, making it the leading importer of processed phosphates in the world.

In summary, demand for phosphate fertilizers will continue undiminished through 1982. Traditional importers such as Brazil, India, Turkey, and Italy, will continue to rely heavily on imports to meet their total needs. Two major question marks are China and Russia. China reportedly is consuming more P_2O_5 each year, and in all probability, will become a major importer of processed phosphates in the future.

Russia has drastically reduced exports of phosphate rock to the western world and, in the short-term, will be hard pressed to meet both its own needs and the needs of its comecon partners. In the longer term, the U.S.S.R. will be a net importer of P_2O_5, obtaining rock from such sources as Morocco and processed phosphates from the United States and other producing countries.

Phosphate Supply

Although supplies of phosphate rock are ample at present, the supply of finished phosphates will not keep pace with the increasing demand in the near term. In 1979, supply will fall short of demand by some 300,000 tonnes, P_2O_5. Sulphur shortages coupled with the limited additions to wet-process acid capacity will increase this shortfall in the near term.

Phosphate rock. Since 1978, world production of phosphate rock has increased about 7% annually and will reach an estimated 131 million tonnes in 1979. About 76% of the total is produced by the United States, Russia, and Morocco. About 40% of total production is exported. As shown on the next slide, total rock exports have ranged between 41 million tonnes and 55 million tonnes since 1973. Exports have increased steadily since 1976 and will total an estimated 53 million tonnes in 1979.

As the figure also illustrates, Morocco and the United States combined account for about 60% of world trade. At one time the U.S.S.R. was also a major exporter, but in recent years, it has reduced rock exports by about 50%.

At present, world rock production is exceeding consumption and should continue to do so through 1982. However, rock quality is declining and future production in both the United States and Morocco will be of lower grade products. According to ISMA, 79% of the planned production increases in the western world will be less than 69 BPL rock.

According to TVA estimates, world rock capacity is presently 157 million tonnes. By 1982, capacity is expected to increase by 11% and reach 175 million tonnes. As shown on the next slide, the largest expansions will take place in Africa. Russia's importance as a world producer will diminish.

From all indications, rock resources will be more than adequate to meet anticipated demand through 1982.

Processed Phosphates. As mentioned previously, demand for processed phosphates in world trade had increased substantially in recent years. As shown in the next slide, the United States has been the principal beneficiary of this increased demand.

U.S. exports of processed phosphates will account for close to 60% of the world trade in 1979 or roughly 3.3 million tonnes P_2O_5 in calendar year 1979. As the next slide illustrates, the U.S. will account for about 86% of the world trade in DAP, 59% of the trade in TSP, 53% of the trade in MAP, and 24% of the trade in wet-process acid. Other major exporting regions in 1979 are North Africa (725,000 tonnes, P_2O_5), Western Europe (500,000 tonnes, P_2O_5), and South Africa (440,000 tonnes, P_2O_5).

As illustrated in the next slide, U.S. exports of processed phosphates have more than doubled since 1974, increasing 19% annually through 1979. Two products have spearheaded this rapid rise in exports: diammonium phosphate, which has almost tripled in volume since 1974, and wet-process ortho-Phosphoric acid which has more than tripled.

However, supplies of processed phosphates have not kept pace with demand, and the shortfall in 1979 could exceed 300,000 tonnes, P_2O_5. While supplies from the United States will be up an estimated 10% in 1979, supplies from such exporting countries as Morocco, Tunisia, and Mexico will be down from 6% to 20% because of the problems discussed previously.

Supplies of processed phosphates will be extremely tight over the next several years for a number of reasons including: (1) the lack of increased availability from the United States, (2) the inevitable delays encountered in bringing new wet-process acid capacity on stream, and (3) inadequate supplies of sulphur.

U.S. Supply. The U.S. producers of finished phosphates are operating at record rates to satisfy both the strong domestic demand and the expanding export market. Unfortunately, phosphoric acid capacity is being stretched to the limit as shown on the next slide, and little relief is in sight, short-term. Although a number of additions or expansions to wet-acid capacity totalling 1.7 million tonnes, P_2O_5 by 1982, have been announced in recent months, about half the tonnage will be dedicated to meeting domestic needs and a major part of the balance is targetted for the U.S.S.R.

At best, U.S. supplies of processed phosphates to the world market will be up only 5% in 1980, and only minor increases can be anticipated through 1982.

Wet-Acid Capacity. According to the TVA, world wet-process acid capacity will increase 23% by 1982 to reach 35.8 million tonnes, P_2O_5. The most significant gains will be in Asia, particularly Jordan, Turkey, and India, followed by Africa as shown in the following slide. Unfortunately, capacity isn't production and, given the history of operational difficulties and low production rates at facilities currently on stream in lesser developed countries, no significant relief from the supply shortages by the addition of new capacity can be anticipated short-term.

Inadequate Sulphur Supplies. The principal factor that will adversely affect the P_2O_5 supply short-term, will not be the lack of new wet-process acid capacity but the lack of adequate supplies of sulphur. Although Mr. Bixby will cover this topic in much greater detail in the following talk, I must touch on it since its implications on the phosphate industry are enormous. The lack of adequate sulphur supplies has already reduced production of P_2O_5 in several major producing countries, and a continuing shortage will seriously delay start-up of much of the new capacity scheduled to come on stream over the next three years.

Sulphur supplies in the western world are extremely tight at present, and according to some experts, could fall short of demand by about one million tonnes in 1980. U.S. inventories are being depleted at a rapid rate in an attempt to make up the shortfall. Unfortunately, they will continue to be drawn down in 1980. This acute supply situation is not expected to ease until 1982 at the earliest. The end result is that additional pressure will be put on the U.S. phosphate industry with its more secure sulphur supplies to increase exports of processed phosphates.

Outlook to 1982

Overall, phosphate *demand* has been increasing about one million tonnes per year and this trend should continue, short-term. However, the reliance of such major consuming countries as Brazil, India and Turkey on imports to meet their total P_2O_5 needs will increase, particularly if the sulphur situation worsens. Additional pressures on the export market could develop if both the U.S.S.R. and China increase their imports significantly.

From a *supply* standpoint, the situation is grim. The united states does not have adequate capacity to meet both its needs and the burgeoning export market. Unfortunately, such major exporters of P_2O_5 as Morocco and Tunisia, may have to limit production, both at existing facilities and at new plants scheduled to come on stream shortly, because of insufficient sulphur supplies, further aggravating the world supply situation.

Although an estimated 6.6 million tonnes, P_2O_5 of new wet-acid capacity is forecast to come on stream between now and 1982 (4.8 million tonnes in western world, 1.8 million tonnes in the eastern world), it is unlikely that adequate sulphur will be available for a major portion of this new capacity.

At this juncture, let me comment briefly on *prices* of phosphate fertilizers. As you all know, phosphate prices have risen sharply in 1979, fueled primarily by rapidly increasing raw material costs and escalating energy costs. The following slide illustrates the impact of increasing raw material costs on the cost of production of DAP. As expected the impact of increased sulphur prices on the total cost of production is substantial.

Given the present market situation, sulphur prices will continue to increase, short-term, putting additional upward pressure on phosphate prices. In addition, energy costs will increase a minimum of 12% to 16% annually through 1982, putting further pressure on fertilizer prices.

To date, only minimal consumer resistance to the current price levels for phosphate fertilizers has been noted. Further significant increases, short-term, could adversely impact demand. However, consumers must recognize that the days of inexpensive phosphate fertilizers are past and future prices will have to reflect the increasing costs of such key fertilizer inputs as energy, raw materials, and capital. Thank you. (Applause)

NOTE: The discussions mentioned by Bill as "Slide Illustrations", were only for the Audience to follow on the screen as Bill proceeded with his talk.

MODERATOR ACHORN: Bill, we certainly appreciate that fine advice and guidance.

The next speaker is Dean Gidney. Now, to me as a young fellow coming into the fertilizer industry, that was a long time ago, whenever they said potash, I thought of Dean Gidney. I guess that's carried on through most of our careers. Dean is the President of the Potash Company of America. He has been on the Board of Directors and Chairman of the Board of Directors of the Phosphate Potash Institute and of the Fertilizer Institute. Please, Mr. Potash, Dean Gidney. (Applause)

Outlook For Potash — 1980's

Dean R. Gidney

Ladies and Gentlemen: I am very honored at being asked to address the Fertilizer Industry Round Table Conference and believe that this is the first time that I have done so since 1960 at which time we were engaged in establishing standards and nomenclature for various potash products.

During the many intervening years, I don't know how many times I have made a presentation concerning the outlook for potash—and I don't know how many times you have heard my presentations and those of others. The only thing that I can say for sure is that not since the time of the Korean War, except for a brief period in 1974, have I felt that the outlook for potash has been so good—at least from the producer's point of view.

You are all well aware of the fact that potash is a worldwide industry and what effects one part of the world quickly effects the entire world. It is an industry of trade between producing and nonproducing nations and even between producing nations—as witness the fact that Canada supplies approximately 2/3 of United States' potash requirements, although the U.S. is also a major producer.

We will start with what my table No. 1 shows in world production and consumption of potash in the calendar year of 1978. These figures are certainly not sacrosanct, but they have been obtained from many organizations with skill in this area. Principal statistics are from such organizations as the Potash/Phosphate Institute, ISMA and the International Fertilizer Development Center. In view of the fact that they are not exact to begin with, they have been rounded off in order to present a general picture of the supply/demand position during the calendar 1978. I would prefer to have used the recently completed 1978/79 fertilizer year, but current statistics are not, as yet, available covering that period.

In studying the chart, we start with North America which, as you know, includes production from both Canada and the U.S. with Canada supplying approximately ¾ of the total. Consumption in North America has approximately 2,300 metric tons of K_2O below production making this surplus available for export.

Western European production, which includes Israel, was almost in exact balance with Western Europe consumption. Western Europe countries in the order of tonnage produced are West Germany, France, Israel, Spain, United Kingdom and Italy. Consumption in Western Europe, of course, includes all of the other countries in that area which are not producers of potash.

The next area and the most important, insofar as potash production and consumption are concerned, is Eastern Europe. Unfortunately, this is the area in which our statistics are the most questionable. We have done our best to determine production and consumption statistics from the U.S.S.R., but this is not easy and we, frankly, admit there is a possibility of substantial error in both of these figures.

The biggest producer in Eastern Europe is, of course, the U.S.S.R. which produces about ¾ of the total in that area and the other producer is the German Democratic Republic. Our statistics indicate a surplus of 2,400,000 tons of production over consumption in the entire eastern European area. This tonnage, of course, becomes available for export to other areas.

However, in discussing the U.S.S.R. and its worldwide export, we must comment on their performance during the current year during which they have not lived up to their avowed intentions and commitments. They have fallen short on deliveries in many areas of the world and, as a matter of fact, at one time were trying to buy some potash from North American producers to fulfill their obligations. In addition, we have seen no sign of the approximately one million tons of potash which the U.S.S.R. is supposed to send to the U.S. as as part of their well publicized deal with occidental.

There are many reasons being put forth as to why the soviet union has fallen down so badly on its potash obligations this year and most of these explanations center around logistic problems. This includes the difficulty of moving large tonnages of potash within the Soviet Union, plus the limited vessel loading facilities at port. The large imports of grain into the soviet union have contributed to difficulties in domestic transport and port congestion. Whatever the reason, Soviet's supplies to many countries in the world, including Brazil, Philippines and even allegedly to Finland, have fallen far short of contract volumes. If this situation does continue, the apparent balance in the world potash market could be drastically upset with demand moving ahead of available supplies.

The remainder of the geographical areas on the chart are basically consumers of potash, although there is some slight production in the people's republic of China and some production in Chile. We have attributed a minor figure to China and have not used any figure for production in Latin America.

There are undeveloped potash reserves in Brazil and in Thailand and allegedly there are some potash deposits in the People's Repubic of China. With reference to Brazil, these deposits, in the Province of Sergipe, have been investigated for many years, but not Brazil is receiving help from the French potash industry directed toward the possible development of the deposits. It is hard to estimate when there might be any product from the Brazilian deposits, but it is probable that this will be at least 5 years away.

The deposit's in Thailand are located along the Loation border which certainly presents some difficult logistic, as well as political problems. Recent reports indicate that one American producer is interested in discussing the development of these deposits, but here, our guess is that any such development could be 8 to 10 years away.

With reference to the deposits in China, the only ones concerning which we have any definite information are the Brines Of Quing Hai Lake in the Qing Hai Province located in Western China. During a recent visit to the People's Republic of China, we were shown product from this lake and it turns out to be a good quality potassium chloride. However, we are unable to get any information concerning the possible extent of this potash and possible plans for its reclamation. We were told that there are underground deposits of potash in China, but received no specific information as to their location or extent. The fact that the People's Republic of China is now an active buyer in the world market would indicate that their own resources are limited and that development costs at this time are deemed to be too high.

The total, as you can see, indicates production of 25,400,000 metric tons of K_2O and consumption of almost the same amount. The small indicated surplus of 350,000 tons is not really a surplus at all since transit losses and other usages could quickly wipe that out.

As a result of this performance in 1978, potash inventories on a worldwide basis are, undoubtedly, at their lowest level of the past decade.

We then turn to Table No. 2 which is presented merely to indicate the international nature of world potash trade. This lists exports by producing countries during calendar year 1978 and indicates that Canada is by far the largest exporter with approximately 2/3 of their exports coming to the U.S. East Germany is next and the U.S.S.R. next. It should be remembered that a very large portion of U.S.S.R.'s exports go to the comecon countries so there is not really this tonnage available for free world countries. West Germany is a major exporter as is the U.S.A. Also, of course, the U.S.A. is a very large net importer because of deliveries from Canada, as well as minor imports from Europe.

Looking at the other countries on the list, Israel is a major exporter and they have to be as they are large producers with a very small domestic market.

Table No. 3 is also presented in order to emphasize the importance of world trade in the postash industry. This table lists the principal importers of potash during calendar year 1978. These represent gross importers rather than net importers, and as expected, the U.S.A. is by far the largest importer. Among the next 7, it is interesting to note that 3 of them—Poland, Czechoslovakia and Hungary are comecon countries. Brazil is by far the largest importer in Latin America and there is no reason to believe that Brazilian imports will do anything but continue to increase in the immediate future. Japan has been a consistently large buyer of potash and will continue to be, although there is no probability of any large increases in Japanese consumption in the years ahead.

This item is a brief overview of the current world potash situation insofar as production, consumption and world trade are concerned. However, the title of this address is: "The Outlook For Potash"—so you are not as much interested in what has happened as in what we think will happen in the next several years. Table No. 4 indicates our forecast for fertilizer years 1981/82 and 1984/85. This takes us forward about 5 years and it is as far as we wish to go at this time. In looking at changes in the available world supply during this period, the principal increase will probably come from the Soviet Union, although there are many questions as to just how much this increase will represent and how quickly it will come on stream. I, personally, feel that my estimate of 29 million tons of K_2O as available supplies in 1981/82 could very possibly be too high.

Some increases will, undoubtedly, take place in Saskatchenan during this period, but there is not time for them to be of major importance.

My company, Potash Company of America, is as you know, developing a mine in the province of New Brunswick and the current target date for that mine is the end of 1981 or the first half of 1982. Therefore, we will not contribute much, if anything, to the available supply in the 1981/82 fertilizer year. Final capacity of the mine should be about 540,000 metric tons of K_2O — so even when in complete production, this will not dramatically affect world potash availability.

The recent report which I have seen concerning Denison Mine's plans for their potential new Brunswick operation indicates that initial production could be in 1983. I am not aware of the anticipated capacity of that mine.

Other planned increases include an approximate 50% in production in Israel and possible production of 600,000 metric tons of K_2O in Jordon. We do not believe that the Jordon production will be available before 1983.

At all events, if our supply estimate is good and if world demand continues to go at current levels, the potash/demand situation in 1981/82 should be in almost exact balance.

Looking forward to 1984/85, again if our figures are reasonably correct, we find that available world supplies will not meet the total world demand.

This outlook may be a little different from some which you have seen which have been based not on estimates of total available world supplies, but on rated productive capacities of the various world producers. The rated capacities, in general, exceed our estimates of total available world supplies by somewhere between 10 and 15%. In the past, we assumed that if demand warranted, world production would be close to capacity levels, but recent experience indicates that this is not the case. In addition, there are always such factors as the ever present logistic problems, possibilities of strikes, port breakdowns and even unforeseen operation problems at existing mines. We, therefore, feel that the estimates of available world supply are of more significance than rated capacity when we try to determine whether or not we are in a buyer's market or a seller's. All indications now are that a seller's market should continue for at least 5 years and probably beyond.

In any forecast of this sort, there are always other factors which should be considered. Specifically with reference to fertilizers, there is always weather, but this is a variable and an unpredictable factor. Of far more importance is farm income and obviously, historically, potash and fertilizer consumption has followed farm income. No matter how good an investment fertilizer may be, it is difficult to sell to the man or to the country who does not have the ability to pay.

Outside of Europe, North America is, of course, the principal world potash market and the outlook for farm income in North America, under the period of discussion, is certainly good. We do have to realize, however, that in the even export channels for U.S. agriculture production should contract, the result in decline in farm income and acres planted could reverse the current trend in potash and other fertilizers. We do not foresee this happening, but there is always that possibility.

This brings up one other factor which could effect the demand for potash, as well as other fertilizer materials in the years ahead. This is the factor of price. For many years, it was assumed that the demand for potash and other fertilizer materials was inelastic and that the same amount would be used regardness of price. This misconception arose because the price changes over a period of many years were relatively small and, as a matter of fact, potash prices in 1969 were lower than they were when I first joined the industry in 1937.

Now that we realize that demand for these materials is elastic, we are concerned with and confronted with the point of dimenishing returns. We saw this happen in some fertilizer materials in 1975 and it could happen again if prices rise too rapidly relative to farm income. This does not mean that potash prices should not rise and will not rise. They must be increased to cover the constantly rising costs of production such as fuel, labor and supplies. In addition, if the new capacity which will be required within the next 10 years is to come on stream, potash prices must be at a high enough level to command the type of return on investment which will encourage the development of the new mines and refineries.

TABLE # 1

WORLD PRODUCTION AND CONSUMPTION OF POTASH - 1978

(,000 M/T K_2O)

	PRODUCTION	CONSUMPTION	SURPLUS	DEFICIT
NORTH AMERICA	8,200	5,900	2,300	-
WESTERN EUROPE (Incl. Israel)	5,600	5,600	-	-
EASTERN EUROPE	11,400	9,000	2,400	-
LATIN AMERICA	-	1,460	-	1,460
ASIA	200	2,460	-	2,260
AFRICA	-	370	-	370
OCEANIA	-	260	-	260
TOTALS	25,400	25,050	4,700 - 4,350	4,350
APPARENT SURPLUS			350	

TABLE # 2

EXPORTS OF POTASH - 1978

(,000 M/T K_2O)

PRODUCER	TONS
Canada	6,105
East Germany	2,725
U.S.S.R.	2,410
West Germany	1,110
U.S.A.	780
France	680
Israel	570
Spain	250
Italy	50
United Kingdom	40
Total	14,720

TABLE # 3

PRINCIPAL IMPORTERS OF POTASH - 1978

(,000 M/T K_2O)

COUNTRY	TONS
U.S.A.	4,800
Poland	1,350
Brasil	980
Japan	760
Czechoslovakia	670
India	540
Hungary	540
United Kingdom	420

TABLE # 4

WORLD POTASH SUPPLY/DEMAND FORECAST

(,000 M/T K_2O)

	CALENDAR	FERTILIZER YEARS	
	1978	81/82	84/85
AVAILABLE WORLD SUPPLY	25,400	29,000	31,600
TOTAL WORLD DEMAND	25,050	28,700	32,000
SURPLUS	350	300	
DEFICIT			400

There is also the caveat that many areas of the world which need potash will not be able to pay for it. The so-called developing countries will have to use so much of whatever funds are available for energy over the years ahead that it is very possible that they will have to forego such essential items as potash.

In general then, we can see that the outlook for potash over the next 5 to 6 years is excellent, but there are those factors, such as ability to pay, farm income, etc. which could change, to some extent, this very optimistic outlook. As you have noted, our forecast indicates that the potash consumption line will cross the potash production line along about 1985 and unless there are major additions to world capacity, the GAP between demand and supply will increase after that date.

I don't want to end this presentation without paying a justly deserved tribute to the potash/phosphate institute which commenced operation in 1935 as the American Potash Institute. Throughout the last 44 years, this organization has provided invaluable service to American and world agriculture in the promotion of potash usage in a balanced agricultural program. A few years ago, the phosphate industry joined the potash industry in supporting this organization and this has added additional strength to the organization and to its efforts. The primary effort now is being directed toward research and we are confident of further major contributions from the Potash/Phosphate Institute to world agriculture because of the extremely high caliber of its personnel and their dedication to scientific truths rather than to fad or fancy.

Again, thanks for this opportunity and I hope to be with you about 5 years from now to see just how well or how badly we have forecast the world potash position during this period.

Thanks. (Applause)

MODERATOR ACHORN: Dean, we certainly thank you for that excellent presentation. As usual you always have wonderful comments and wonderful guidance for us. (Applause)

MODERATOR ACHORN: The next speaker is David Bixby, and, David, whenever I think of sulfur, I think of David Bixby. David was the Supervisor of Chemical Engineering Research for the Agrico Chemical Company. He is now the Director of Fertilizer Technology and Research for The Sulphur Institute. He's been with The Sulphur Institute since 1962. He has presented many papers concerning sulfur and its various uses throughout the years. David, please. (Applause)

The Outlook For Sulphur

D. W. Bixby

I am tempted to say that the short term outlook for sulphur supply is tight, the midterm outlook is problematical, the long term outlook is cautiously optimistic, the very long term outlook is rosy indeed, and sit down. But that would give you a long lunch break and I know you'd much rather hear statistics than relax over a cool drink!

Many people have been talking about the current shortage of sulphur. I want to go on record right away by stating categorically that no such shortage exists in nature. Millions upon millions of tons of pure brinstone have been recently discovered and are available for the taking at our convenience, with minimal mining costs and a somewhat higher shipping cost. *(Slide 1)*
Here we see, according to one model, an ocean of molten sulphur, which may be two miles deep, on Io, the innermost moon of Jupiter, as recorded by Voyager I. So we can say with confidence that the very long term outlook for sulphur is terrific. *(Slide 2)* And look at the view the staff will have!

Meanwhile, back on Earth, tomorrow, next month, and the next few years are less easy to predict.

Most of you know that, at the moment, the sulphur supply is tight. The spot market has all but disappeared.

Periodically, some can be offered, but not in large quantities or with any degree of consistency. With consumers competing for material, the spot market price is becoming a reflection of demand, and is now twice what it was a year ago. With little immediate prospect of increased supply or a lessening of demand, the situation is unlikely to return to normality any time soon.

The strain on the world sulphur supply and the non-inflationary portion of the rising prices are the result of a slowdown in world production and distribution. It has been said that "he who lives by the crystal ball must learn to like ground glass." The unforseen events which shattered the ball of last year's sulphur forecaster, who had already anticipated a moderate shortage, were three: Canada, Iran, and Poland, all major producers of sulphur, were for various reasons, all forced to cut back on production.

In Canada, a 12-day longshoremens strike caused severe shipping problems in Vancouver. Very little sulphur was shipped during the strike and afterwards the rush to catch up on orders caused a shipping bottleneck. Cansulex deliveries for the remainder of the year are now pegged at 82% of 1979 contract levels. Only recently Texasgulf Canada, which has had problems with their prilling system, declared force majeure on Vancouver shipments, removing their contribution to the world market till the end of the year.

In Iran, the political turmoil had disrupted supplies from that country, curtailing an annual production of over ½ million tons. This in turn played a part in damaging Poland, which receives most of its crude oil from there, via the Soviet Union. As a result, compounding the problems already caused by the severe winter and flooding of the open pit mine at Machow, the Poles are said to cut back on sulphur production as an energy saving measure. Exports to the West may have been reduced by over a million tons this year.

World consumers have turned to the U.S. to alleviate the shortage. Our exports through July already exceed *total* 1978 by 50%. Inventories of Gulf Coast Frasch producers have been depleted by nearly a million tons since the first of the year as they have demonstrated their key role in maintaining a balanced sulphur market. They are now operating close to capacity, up from 77% or so last year.

We cannot say with certainty just when the supply-demand lines crossed, but this has happened, and barring a decline in demand from a severe recession, we believe sulphur will remain in tight supply for some time to come.

Let us then turn, for a few minutes, from the rather bleak picture of the present situation to see what the future may hold—the long term view we spoke of earlier. First, let us look at the potential sources of sulphur available to supply anticipated demand. *(Slide 3)* The world's total sulphur resources are vast, but only a fraction is now mineable or recoverable at competitive prices. Here we see graphically the estimates made by U.S. Geological Survey in 1972 for sulphur reserves thought to be Frasch mineable, and those occurring in sour gas and petroleum. The "identified" column is the sum of "recoverable" and "marginal" material, judged to be recoverable for $65 or less per metric ton expressed in 1979 dollars. The "probable" column is made up of the "hypothetical" and "speculative" categories. *(Slide 4)* This slide shows the likely sulphur content of pyrites, smelter gas, and tar sands. The roughly 2 billion tons in the left hand columns of these two slides may last perhaps *20* years with the present trend in world consumption rates. In other words, they will be used up before the turn of the century. For the present, however, the world position on sulphur resources is adequate. Later, we will be into the "probable" columns, indeed we already are with some new oil discoveries. Meanwhile, we will presumably begin to exploit the sulphur resources of the future *(Slide 5)* which are very large indeed.

(Slide 6) Here we show two pie charts depicting the slices allotted to the various sulphur sources in 1977 and estimated 20 years hence. In the year 2000 new *Frasch* sources replace depleted mines, supplying the same tonnage, but reduced to 11% of the total. *Sour gas* from Canada is supplying sulphur from newly discovered field but less than in 1978. This is supplemented by new sources in the USSR and the Middle East. *Petroleum* refining from Mexican and Mid East sources plus oil sands is way up, supplying 22% of world needs. *Coal* has become the world's most important energy source, with 140 million tons of S being emitted annually from burning and processing plants, with millions of tons recovered as brinstone, pyrites or sulphuric acid. *Pyrites* deposits, known in 1979 but not exploited are now mined. The less energy intensive mine-to-acid cost from pyrites as compared to other voluntary sulphur provides an added incentive. *Smelter* recovery contributes 15 million tons per year, also as acid, with another 15 million tons also recovered, but as a throwaway product.

And so we see that involtary sources, accounting for 49% of world sulphur use in 1977, now account for 77% of it, with most of this coming from coal and oil. Sulphur from coal predominates in coal rich areas, whereas sulphur from oil predominates in areas more dependent on petroleum. Voluntary sulphur (Frasch and pyrites) contributes only 26 million tons of world usage. The market is dominated much more by sulphur as sulphuric acid than it was in 1978, thus requiring major changes in marketing patterns.

Please bear in mind that the large pie chart is our attempt to predict a source pattern for sulphur *use.* It does not show the predicted surplus of material which could come out of synfuel plants. No one could predict the size of this surplus given the outside circumstances which will affect it. These include political, economical and environmental considerations, to name only a few. We *have* assumed coal, in one way or another, will provide the sulphur to take up the slack between demand and the more predictable supply from other sources. In 2000 the world consumption pattern will also have changed significantly. *(Slide 7)* Fertilizer manufacturing in 2000 will require 65 million tons of sulphur annually, compared with 27 million tons in 1978, with 60 million of that used to make P_2O_5. Growth rate for fertilizer will have slowed but it will still be the most important consumer of sulphur.

Sulphur as an essential plant nutrient will have come into its own. In 2000, removing sulphur from the atmosphere, and continued production of concentrated fertilizers (without sulphur) has accentuated sulphur deficiencies in the soil. Farmers have been forced to supply sulphur to the soil in order to produce crops profitably. The world in 2000 is using 4 million tons of sulphur annually which is intentionally incorporated in fertilizer or applied to the soil.

Having covered the easy material, namely the very long term in a whimsical way, the long term in a debatable way, and the present in a factual way, let's look at the next five years, a venture which could be called hazardous. I say this only partly in jest because amateur forecasters like me are not equipped to deal with the big picture, complete with such remifications as whether this or that country's balance of payments position will allow them to purchase raw materials or build plants, whether a recession is coming, whether fear of the "greenhouse effect" will throttle coal usage, what might happen in China, etc., etc.

This slide *(Slide 8)* shows our supply forecast by sources, for the Western World through 1985. Pyrites stays about the same. Frasch production stays fairly constant, with Mexican and Iraqi increases making up the decline in some U.S. facilities. Freeport has announced its intention to produce about 300,000 TPY at Caillou Island, which is not included here. The largest growth is in the hydrocarbon plus remelt category, a rate of over 6%. Polish imports rebound and grow up to 2½ million tons. Substantial production in Saudi Arabia has already begun and will grow to capacity by 1985, but much will not be immediately exportable and has been placed in the unavailable category. Overall, supply to the Western World increases from nearly 38 million tons in 1979 to nearly 50 million tons in 1985.

Here *(Slide 9)* we have a regional supply forecast. The U.S. goes to 14 million tons in 1985, with all of the increase in the byproduct area. Examples are Amoco's 1100 T/D Wyoming operation, scheduled for 1982, and Pursue's Mississippi plant scheduled for nearly 1300 T/D in late 1980. Shale oil makes no contribution in this time frame, coal gasification makes a little.

In Western Europe, production from the big Lacq gas field in France declines somewhat, but increased refinery production and smelter acid make up for it.

Canadian gas declines, even with new discoveries, but tar sands and smelter acid increase. Melting contributes 2 million tons annually in 1985, assuming that the logistical system is modified to handle it.

In Asia, Japanese refining and smelting increases slightly. In Latin America, Mexican Frasch increases by a million tons, Mexican sour gas and petroleum add at least another 800,000 tons, and probably more.

This slide *(Slide 10)* shows how the main new Western World sources of sulphur supply might contribute to reducing expected differences between supply and demand. In 1980, GCOS and Syncrude make up the tar sand contribution, with a probable project in Venezuela in 1985 and one or two more in Canada by 1990. Oil shale may develop slowly. Recovery from utility stack gases is presently small but should gain. Coal processing is moving very slowly but we have assumed problems will ultimately be resolved and that several U.S. projects will materialize as well as one in South Africa. Thus we show a total of 1.5 million tons in 1985, 3 million tons in 1990 and, by pure extrapolation, 5 million tons in 2000.

Turning to the relationship between supply and demand, this slide *(Slide 11)* shows how things could look in the next five years. Estimated effective supply is shown in red, and unavailable material in green. Supply is simply production plus imports and of course is flexible to the degree that the rate of production from voluntary sources as well as inventory adjustments by both producers and consumers may dictate. Voluntary production U.S., Mexican, Poland is assumed to be at our estimate of capacity 1980-1985. At the top is what we judge will be unavailable, in Canada, Saudi Arabia, and Iraq.

Superimposed on the supply bars are three different demand growth rates. Supply is short in 1985 at the top rate, cuts into inventory at 4.5%, is adequate at 4%. If we pick the middle path, we are going to be marginally less well off than we were in 1978. The point to remember is that the things that are going to make the difference either way are as large as the differential between supply and demand we are looking at here.

(Slide 12) Here are some examples of sensitive areas which could cause swings, some in both directions. I'll not discuss them because time is short, but you get the idea and could doubtless add a few of your own.

Well, it's time to try to summarize and these last slides *(Slide 12)* list some of the points that might be made. Demand growth continues, affected primarily by fertilizer requirements. Overall, an adequate supply, but little if any surplus. Canada, Mexico, and Poland reach export capacity which they are close to today. There may be a little spare U.S. Frasch capacity, some new at Caillou Island and the possibility of reactivating Caminada. *(Slide 13)* Major new supplies will come from Saudi Arabia and other Mid East countries. Mexico is adding Frasch capacity shortly and may be recovering a great deal more as well, if we start buying gas in quantity. Poland may start a new Frasch mine by 1981 or 1982. In Canada, remelting to meet demand will continue and increase. The Alberta-Vancouver logistical system there will be capable of handling about a million tons per year more in 1980 than it was in 1977. The ports of Prince Rupert and Thunder Bay will be used more also. Synthetic fuels will make a contribution in 1985, although progressing more slowly than we would have expected five years ago. *(Slide 15)* The main new U.S. supplies will come from sour gas recovery—wells in the overthrust belt and in the south central states. The USSR and China have ample supplies, but they will be used internally. Canada could make tow or three times as much smelter acid if economic conditions justify it.

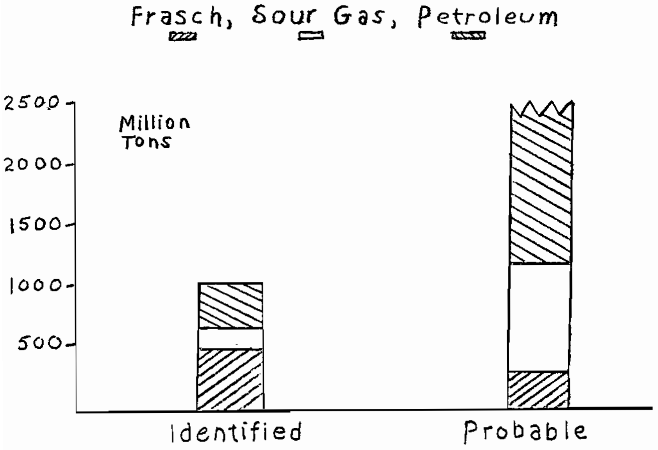
Let me conclude by saying once again there seems to be plenty of sulphur on our own planet Earth but the days of low extraction cost are over. The outlook depends on economics, particularly energy cost, as much as anything else. The trouble is that economic experts represent all shades of opinion so you choose a color to match your mood of the moment. We only hope we have illuminated the display a little to make the selection process easier. Thank you. (Applause)

Slides 1 and 2 were illustration sketches and were not available.

Slides discussed— No. 3 thru No. 13— are shown as follows.

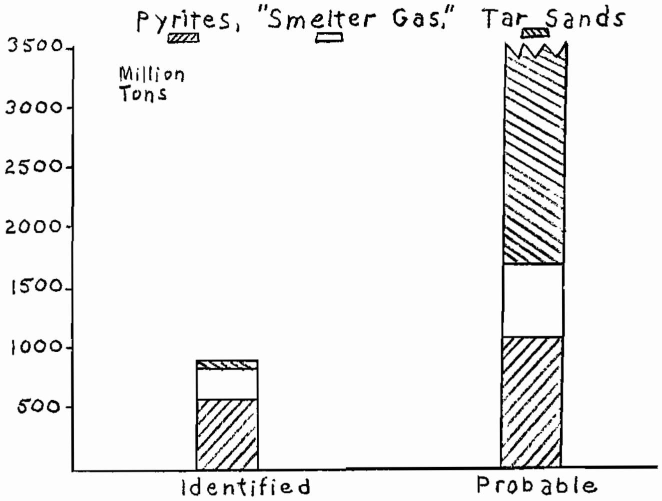
Slide 3

World Sulphur Resources



Slide 4

World Sulphur Resources



Slide 5

World Sulphur Resources
Future Sources

Probable Reserves:

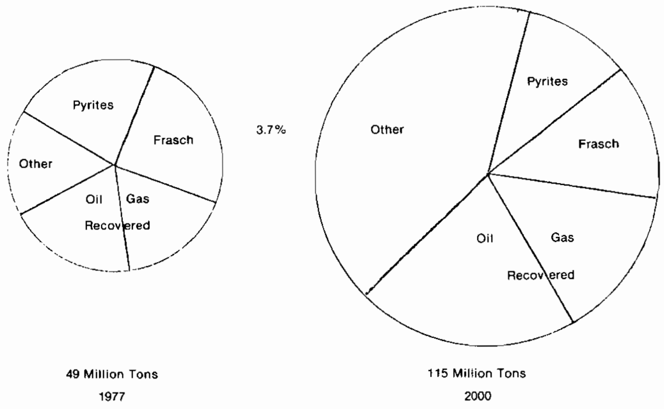
Coal >200,000 MM Tons S

Oil Shale >200,000 MM Tons S

Gypsum – Very Large

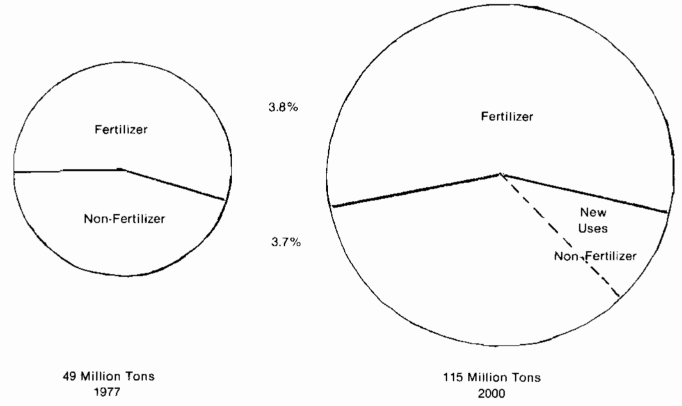
Slide 6

Source of Sulphur Used



Slide 7

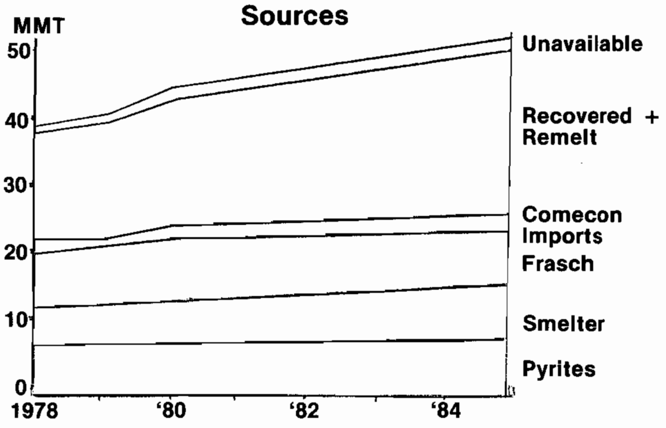
End Use of Sulphur



Slide 8

Sulphur Supply - Western World

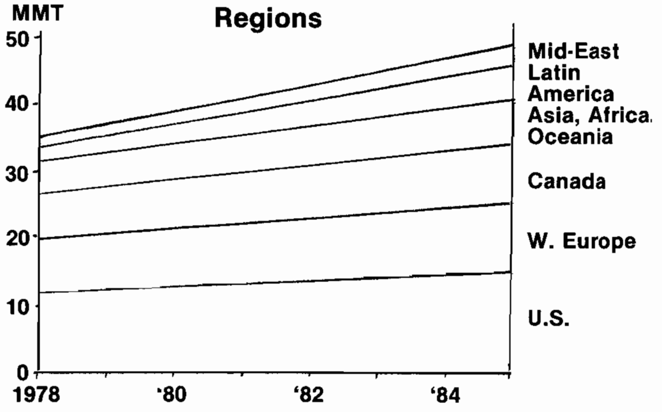
Sources



Slide 9

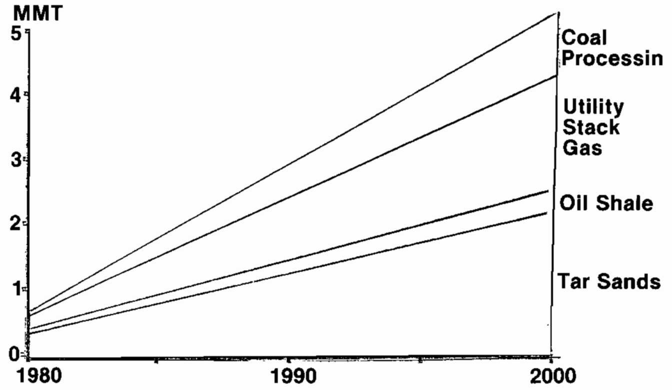
Sulphur Supply - Western World

Regions



Slide 10

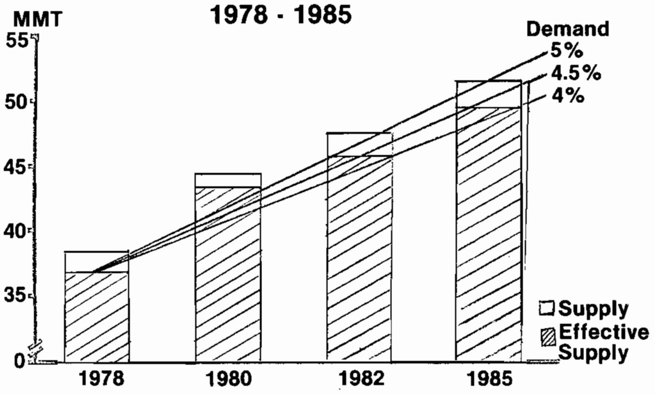
New Sulphur Sources



Slide 11

Sulphur Supply / Demand - Western World

1978 - 1985



Slide 12

Effect of Variables Western World

	Thousand Tons Change		
	+	—	Year
New Uses		500— 1000	85
Polish Exports	500— 1500		80-85
Mid East Variables	1000	500	80-85
New Frasch Mines/Restraint (U.S.)	500— 1000	500— 1000	80-85
Fertilizer Exports to Comecon		1000	85
New Frasch Mines (Mexico, Poland)	1000		80-83
Canadian Variables	1000	500	80-85
New Recovery Plants V.S.	1000		80-83

Slide 13

Outlook for Sulphur

1. Continued Growth in Demand
2. Balanced Condition, Adequate Supply, No Surplus
3. Canada, Mexico, Poland at Export Capacity
4. U.S. Frasch, some Spare Capacity, Some New
5. Saudi Arabia and Other Mid-East Main New Source
6. New Polish and Mexican Frasch by 1982
7. Canadian Remelt Through 1980's
8. Coal Processing Significant After 1985
9. Main New U.S. Source — Sour Gas Recovery
10. USSR & China — No Help to Western World
11. More Smelter Acid Potential from Canada, if Economic

MODERATOR ACHORN: David, we certainly thank you for an excellent presentation.

Gentlemen, it's your turn. We are going to bring these experts up here, and we're going to let you fire questions at them. Now, I would like to reiterate something we always say, and it's certainly truthful. The Fertilizer Industry Round Table has never been bashful. So, if you have any questions concerning these extreme shortages (and I know some of you do), why don't you ask your questions now.

Questions and Answers

Moderator: Frank Achorn

QUESTION—Bill Coates: I came from The United Kingdom. Perhaps it is impertinent of me to open this discussion. However it is surprising to me Gentlemen, in view of the remarks this morning, that not one of the Speakers mentioned other methods of solubilizing phosphate. When one thinks that all of the sulfur, which clearly is going to be in short supply and, perhaps even more important, extremely expensive, finishes up in a waste heap. Very little of it finishes in the fertilizer. In Europe, of course, there has been the development of solubilization of phosphate by nitric acid in which very little of the product, either the rock or the solvent, is lost. Is this not something which must come to the States where there's a tremendous flywheel of capital investment here which indicates that phosphate must be solubilized by sulfuric acid. Surely, the days are not far off where you must be thinking about going back to the use of nitric acid for this process?

MODERATOR ACHORN: We are speaking about nitric phosphate, a revival of nitric phosphate as we have had in the past, and which we have many excellent processes for.

DAVID BIXBY: Would you care to answer that question?

ANSWER—David Bixby: That could be the subject of a symposium in itself, I'm afraid. It's certainly true that that is a valid afternative method for solubilizing phosphate. One must remember that the nitric phosphate, which comes from ammonia, of course, is equally subject to the energy restrictions placed on Frasch process sulphur or any other fertilizer process, and so I have the feeling that insofar as the cost is concerned, there won't be too much advantage to be gained from going the nitric phosphate route. Of course if sulfur is just plain short, and you must seek an alternative, then that's a choice that must be left to the fertilizer manufacturers.

MODERATOR ACHORN: Of course, the nitrogen supply is short, as John pointed out to us, so we can expect some problems along that line. Do any of the rest of you have an answer to that? Are there any other questions?

QUESTION—John Kronseder: In reply to that nitric question, you know, we have been this way before. It seems to me that's a repeat of some things we had a few years ago. My question is really in regard to the nitrogen supply. You talked about the high cost of the raw material for nitrogen, and we are getting into a period now where we are talking about the utilization of coal, to make gas from coal for various purposes. Of course, all of these processes are available for making ammonia. Have you considered that aspect in our present supply?

ANSWER—Dr. John Douglas: I think the question is, have we considered the possibility of getting large increases in the supply of nitrogen from production of coal in intermediate term future. I have no doubt that the United States, by the year 2000 and before, will have a relatively significant share of its total production of nitrogen coming from coal-based hydrocarbons. I have serious doubt, however, that we can expect any large amount of new nitrogen capacity in the world or in the United States to come on stream and help us out, certainly not this year and probably not within the next five years. There is too much additional work to be done on improving the existing known technology. The technology of producing nitrogen from coal has been known for many, many years. However, it was known and used in an era which is different from that of today. It was known in an era wherein when you went to the

T.V.A. plant in 1948, you had to wear two new shirts a day because of the coal dust that came out. It was known and used in a time when you went to that same T.V.A. plant, you would hear two or three explosions during the day also in that coal based plant. Our government today will not allow us to operate plants under those conditions, and rightly so. To overcome the large problems of not only producing it cheaply, but producing it environmentally clean, will require additional technology and development. We are working on it some at T.V.A. We have a pilot plant coming on stream next year, but, at most, it only produces 135 tons of ammonia a day. This will not help the overall supply of ammonia in the United States, nor can we really expect much help from this route within the next five years, in my opinion.

JOHN KRONSEDER: I hate to take issue with you on this, but the processes that we are now using are environmentally clean, and they are proven, and we are building plants of this type in South Africa. They do produce gas, and we can, from the synthesis gas, make any number of products, including ammonia. I agree with your assessment of the next five years, but all of these plants, even ammonia plants, take a long time to build. Five years is a short time now for changing our investment. I hope that the realistic future is not quite as pessimistic as you point out.

JOHN DOUGLAS: I don't think we have any difference whatsoever. I think we will have additional ammonia produced from coal. I think it will come on relatively rapidly in the 80's but not within the next five years.

MODERATOR ACHORN: What might help John along here and jog his memory just a little bit, too, is that I remember when I was working in the ammonia plant at T.V.A. years ago, coal cost $5.00 a ton. I think the last estimate on our bid for coal to generate electricity was around $35.00 a ton. So, even though the technology may be there, the cost of manufacturing it very probably could be as high as it is with natural gas or higher.

DR. JOHN DOUGLAS: All of the estimates that we have made, and we have done the best we could on estimating the cost of coal versus natural gas, indicate that, even with no further increases in price of coal, the price of natural gas would have to exceed $3.50 per million BTU before it would be a break-even project to produce ammonia from coal. Now, Bud Davis is here in the audience somewhere, and he might be able to give you a better breakdown on this than I can. Am I about correct, Bud?

BUD DAVIS-T.V.A.: Yes, I would agree with the economic data that you just presented. Our best estimate is that, with a large grassroots plant, you would have to have natural gas at about $3.60 per thousand cubic feet for coal, at $27.00 a ton, to be competitive. We do anticipate that, in the future, the price of natural gas will increase at a relatively faster rate than the price of coal on an energy basis. So, I agree that, at some point in the future, it would be economical for us to produce ammonia from coal in the United States. I also would agree that we won't have much ammonia production in the U.S. before 1985. We do have a project at T.V.A. that should help us better find the economics of producing ammonia from coal. We will be starting that pilot (or demonstration) plant up sometime during 1980.

DR. JOHN DOUGLAS: I had two questions relayed to me in writing. They relate to this same question generally of where is our next nitrogen coming from. We are going to need more nitrogen in the United States. We are going to need more nitrogen in North America over the next five years. We do not have enough capacity in North America to continue supplying the demand, even if we continue importing large amounts of nitrogen. We will need more nitrogen produced in the United States. It is my distinct impression, my opinion at least, that we will have more nitrogen produced in the United States. I will ask Frank to read these two questions and hand them to me as I attempt a vague answer.

MODERATOR ACHORN: How many U.S. and world plants are likely to re-start within three years? What is the likelihood of new U.S. gas base construction in the light of current gas supply constraints? What year of start-up?

DR. JOHN DOUGLAS: How many U.S. and world plants are likely to re-start within three years? I would hesitate to place a number without prefacing my projection on the number. I would say not a single one is going to reopen until the price of ammonia goes appreciably above what it is today. Although we have had some price increases in ammonia and nitrogen products in the United States and worldwide, the price increases that have come along so far have not been sufficient to cover the escalated costs of energy required to produce nitrogen and certainly not sufficient to encourage a board of directors to try to start up a new plant when they know that it was a loser to begin with. It will take some time to convince them before they want to start up a loser again. Let's assume for a minute that the price of ammonia does rise to a point that it will cover the increased energy costs and will promise some hope of furnishing a profit to the man who starts that plant. We saw this happen in '73, '74, and '75. All I can do in projecting how many of them are likely to re-start is go back and see how many of the plants that had been closed in the period 1968 to 1971 and how many of those were we able to reopen? How many reopened in one form or another, either on-site or by moving them to another site and getting them reopened? Even with the tremendous price increase where prices of ammonia went from $50.00 at the plant one year to $200.00 the next year and to $300.00 the next, we only got 50% of the old plants back on stream. By this time, about half of those wish they hadn't gotten back on stream. I would suggest that, probably, if the price of ammonia and the price of nitrogen products appreciates as I expect it will, we will get some of these plants back on stream. We will get some of them back probably next year and more the next year, 1982. Probably, not over 50% of them in the final end run, because 50% of them have been closed in such a condition that no one would really want to try to reopen them.

Now, the second question, and this is the one I am going to go out on a limb, and I know I'm going to arouse, shall we say, some "Round Table type discussion." What is the likelihood of new U.S. gas base construction in light of current gas supply constraints, and what is the year of start-up? In other words, are we ever going to build any other gas base plants in the United States? Well, I'd like to change that just a little bit and put it in North America plants first. I will guaran-damn-tee you we are going to have some more natural gas base plants in North America. There are going to be at least two or three or four more built in Canada within the next two to three years and will be started up within the next three years. Now, a little less certain (and this is a point that most people, or some people at least, will probably want to discuss with me in greater detail) is that I *would* project that we will find ways to build additional gas base plants within the U.S. There will be some specific cases, somewhere, where someone has the gas, has control of the gas, and the marginal value of that gas in producing ammonia and nitrogen fertilizer products is higher than its marginal value in other uses. We will also see within the next five years, additional gas base plants built within the United States, Mexico and Alaska. I don't think we have seen the last of gas base plants. Thank you.

MODERATOR ACHORN: I think gas will be the dominant source of feedstock for years to come.

DR. JOHN DOUGLAS: For at least a decade.

MODERATOR ACHORN: Okay, I have some bashful people in the audience that don't like to get up to the microphone, and they handed me some questions here. Dean, one of them was for you. Is there any possibility of deep well mining in the U.S., itself, of potash?

DEAN GIDNEY: There is exploration going on, as you know, in the states of North Dakota and Montana. The potash which occurs all across Saskatchewan comes down into those states, but, by the time it gets there, it's at a very great depth, I think, 8,000 feet on down. I believe CF Industries, I.M.C., Kalium, and some others, along with the railroads, have been exploring in that area. At that depth, the potash has got to be mined by solution mining. At present, the principal solution miners in the world are Kalium Chemicals Ltd. and Saskatchewan. They have the know-how to do this. They are talking about doing it. When and how much, I have no idea. My guess is that it's quite a long time away, but as prices go up, something like that becomes more attractive. I think I would almost use John's phrase, I wouldn't expect it in the next decade, but the potash is there, and if it's recoverable and economic, somebody's going to get it.

MODERATOR ACHORN: So, we are free to declare war on the Canadians if we want to put in some deep wells.

DEAN GIDNEY: Not yet, Frank. In addition to our Saskatchewan situation, we have this new mine coming on in the Canadian province of New Brunswick. So, we don't want any wars with Canada. Although, as you did say earlier, no holds are barred in this meeting. I do want to make one remark about my comments relative to the Saskatchewan Government and the Potash Corporation of Saskatchewan. I want everybody to understand that it's nothing personal in this at all. I know the people in the government, I lnow the people in the P.C.S., and they are all fine people. I like them, get along very well with them, I just disagree idealogically with them. I think what I resent the most is having the player with the most cards making the rules for all the others. So, when I talk about those people, they are allright, they are good producers, good suppliers, but we sure would like to play under a different set of rules. No war with Canada, Frank, please. New Brunswick is in Canada, too.

MODERATOR ACHORN: The state of events now may cause a nervous breakdown in both nations

MODERATOR ACHORN: Bill Rohrer, I've got one here concerning phosphate rock production in Morocco. Is that production down now?

BILL ROHER: No, the rock production in Morocco is not down. It is extremely limited. The biggest difference is in the Spanish Sahara, which, as most of you know, was taken over by Morocco. They had a 60 mile conveyor belt, which the Germans built for them, to the Port of Aiun, which the Polisario Front finds very simple to blow up periodically, so they don't use it any more. Now they are running armed convoys by truck the 60 mile run, and, needless to say, that doesn't work very well. The Moroccans are pretty much limited to their own production, and as Jack Turbeville described to us last week, in Argentina, they have high graded their deposits, and they are going to lower and lower mining levels. The grade is dropping, and they are having sporadic problems in their phosphoric acid plants, so we are told. So, the production is way off in phosphoric acid and concentrates. I hope that answers his question.

MODERATOR ACHORN: I assume it did. Okay.

QUESTION: Paul Kram, Swift Ag. Chem., now known as Estech General Chemicals, Inc. All of you gentlemen have recast your supply curves very nicely. Have any of you recast your demand curve in light of a credit crunch, particularly since October 6th, and what will the impact of the Federal Reserve on credit availability to the farmer do to your demand curves or your price levels?

DEAN GIDNEY: Well, I'll answer that first with reference to potash. We have reconsidered the demand curve in view of the costs of money. Obviously, it's going to have some effect on fertilizer consumption. Our conclusion relative to potash was that so long as farm income stays at its current levels or improves, so long as the market for U.S. exports is as great as it now is and will possibly go greater, we don't feel that this credit crunch will have a particularly devasting effect on potash demand. Obviously, it will have some effect.

PAUL KRAM: Let's say that the credit crunch will hit to the tune of two and a half to three billion dollars worth of farm income in the United States for the coming year. That's a hell of a lot out of that income. I just think the crunch is going to be very real and very strong this Spring.

DR. JOHN DOUGLAS: I believe that your analysis of the credit crunch places it in much greater significance than any analysis that we have made at T.V.A. You may be correct. We have looked at the credit crunch as a part of the overall combination of crop/fertilizer price relationships, with the credit crunch generally merely adding to the price of fertilizer to the farmer. At the present time, the price of nitrogen, and the price ratio of nitrogen, and the price ratio of potash to farm crops is still in very good relationship. In other words, the price of crops is sufficiently high in relation to the prices of nitrogen and potash to where we see no reason, even with another price increase based upon this credit crunch, to expect any significant reduction in demand. Now, the price of phosphates, true, has gone up so much more rapidly and for so much longer than the prices of nitrogen and potash, that it is now getting close to the area that we begin to worry. We admit that we are not smart enough to tie it down to specific figure, maybe somebody could, but I've never seen it if it is done. The price of phosphate is getting up to the point that we could foresee, with continued price increases of phosphate over the next six months, like we have had over the last six months, if the price of crops went down any at all, with credit crunch imposed upon that price relationship, we could get to a dangerous point where we would expect to see decreases in demand—price-induced decreases in demand.

PAUL KRAM: Thank you. I won't disagree with you. Mine is only a guess.

QUESTION FROM THE AUDIENCE: There have been recent price increases in hydrofluoric acid, and there has been continuing talk of HF. Do you see, and perhaps someone in the audience knows, any increase in pressure on the fertilizer industry at fluorine recovery to help alleviate what seems to be chronic shortages of HF in the country? Now, it's not directly what you have discussed here, but it is related, I think. I am curious to find out.

ANSWER FROM THE AUDIENCE: For your information, at the recent A.C.S. meeting here in Washington a month ago, there was a symposium on that very point. We do have reprints of that session, if you are interested. We can make those available to you.

MODERATOR ACHORN: I will ask you, what is the increased demand for fluorine? Is that in solar energy recovery? Is that what you are talking about, and do you think that's practical?

ANSWER FROM THE AUDIENCE: Well, primarily for aluminum fluoride, fluorcarbons and other fluorine containing materials. I don't know what it is for over and above the fertilizer industry.

COMMENTS FROM THE AUDIENCE: I think one point that might be very germane here is the fact that, obviously, fluorcarbons have gone down due to the aerosol problem; however, due to this energy crunch, I think there's greater and greater emphasis toward the use of freons in heat pumps. Now, this is one area that hasn't been stressed too much. By the same token, I think the heat pumps, particularly in areas in the southern part of the country, can do a lot to save energy in terms of burning natural gas or what have you. So, regarding Frank's question, the growth in fluorine chemicals could be in freons for pre-heat pumps. That doesn't louse up the atmosphere either.

MODERATOR ACHORN: Well, Bill, I guess the question might be directed to you. Do you think we have a plentiful source of fluorine in Florida at the present time?

BILL ROHRER: I would like to refer that to someone like Charlie Harding.

CHARLIE HARDING: I don't know exactly how much fluorine is recovered down there, but I don't think there will be much more recovered because, as I understand it now, the whole area is pretty well covered with the fluorine recovery as it is. I don't know of anybody that's in trouble down there by not recovering fluorine. Maybe somebody knows more about it than I do.

MODERATOR ACHORN: I thought you had a big lot of it in all of your gypsum ponds anyway.

CHARLIE HARDING: Recovering that might be something a little different.

QUESTION FROM THE AUDIENCE: My second question is, today they are supposed to release the Commission Nuclear Energy report on Three Mile Island. As I understand it, they fell just one vote short of recommending a complete moratorium on nuclear power plants in the United States. How is this going to affect the economics of investment in uranium recovery from phosphoric acid plants? How will it affect the overall economics?

BILL ROHRER: Whether or not this country has a moratorium on nuclear power plants is sort of academic. The worldwide demand for phosphoric acid will continue to be strong. Whether we recover uranium from phosphoric acid or not, the money is there, they will buy the acid. I think we do have a problem in this country because of our operation of the nuclear power plants. I think the administration and everybody else in government fully appreciates that we have to continue with the nuclear option, whether we want to or not.

QUESTION FROM THE AUDIENCE: So, in essence, you see it as not a particular problem?

MODERATOR ACHORN: I would like to add one thing. I had the pleasure of just riding on a nuclear submarine. I understand we have a goodly number of them that have operated safely for years. Probably, If we follow safety procedures, we can operate safely in domestic plants. We are getting off on a political subject. We need to get back on our fertilizer subject. We have a question from an unknown author. "At what price will DAP demand be forced downward, and do you expect the farmer to stop using DAP if the price gets too high?"

BILL ROHRER: I heard John try to answer that a few minutes ago. My crystal ball is no better than his. In fact, he had a good answer at T.F.I. in September. They came up to John and asked him "how high is this DAP price going?" and he said, very simply, "untill the price depresses the demand". That's all you got our of John then. I don't know what else to add. There's no real way to guess.

MODERATOR ACHORN: Here's something else here that's interesting. "Isn't it the practice of the U.S. farmer to buy phosphate when the price of phosphate is low and use his reserves when the price of phosphate is high?"

BILL ROHRER: That's an interesting comment, but I don't think that reserve situation has really been proven. There certainly are residual phosphates in the soil, but whether they are available to the plants after a year or two of non-fertilization remains to be seen. I'm sure all farmers would like to buy phosphates when they are low, but I don't think they are going down for a while.

MODERATOR ACHORN: Okay. "What do you think will happen to the ammonia import recommendations?" John.

DR. JOHN DOUGLAS: Now, here we come to a question that is purely and simply not an economic question. It is not a question pertaining to the fertilizer industry. It's purely and simply politics. I wouldn't dare touch it with a ten foot pole!

MODERATOR ACHORN: Do we have any other questions?

QUESTION-Loren Hopwood: When you were discussing the relative cost of production of nitrogen from coal and gas, is there a possibility of increased technology to narrow the margin more than what you were talking about $3.60 natural gas versus $27.00 coal.

DR. JOHN DOUGLAS: I wouldn't hesitate at all to answer that one. Yes. If there were not, we wouldn't be working on it as hard as we are and spending as much of the limited resources that T.V.A. has in trying to improve the systems. We don't know how great the possibility is, nor how great the rewards may be. The answer to your question is yes, we do think that is is possible to use perhaps less B.T.U. than we now think we have to and to produce a plant costing less than we now think it would cost.

QUESTION-Walter Horn: John, on ammonia, to start up these shut-down plants, all other things being equal like energy cost, what does the price have to go to from what it is now in order to start up 50% of them? How much tonnage would that be?

DR. JOHN DOUGLAS: That's a very difficult question to answer, because it depends on each individual case. It depends, to some extent, on what the plant is re-valued at and what its value is on the books when you re-start it. If you can buy it for zero and have no investment cost, then you start looking at production costs and an equitable return on investment. If you have to pay a high price for it, that means a different price on the ammonia in order to bring it back on stream. It also depends on the cost of the gas that you are going to have to start up this plant. Are you going to be able to get $2.25 gas or will you have to pay $3.50 for your gas? This is one of the questions. Basically, I think looked at in general, and this is really a broad brush approach, you cannot expect any, if any, of the plants to reopen until the net back price to the producer, at the plant, approaches or exceeds $140.00 a ton. This assumes that you have about a $2.00 to $2.25 gas price. This may be overly optimistic—I don't know—that's the figures we use. It assumes minimum investment costs in reopening that new plant. It's going to require about $140 a ton net back, excluding costs of storage and transportation (this is spigot cost), in order to ensure that the man recovers his out-of-pocket costs. The boards of directors are not going to open the plants up until they come out with a book profit which covers depreciation, full costs of production, and a return on investment, especially since they have been losers in the past and there has to be some element of risk added on that. But, at $140 a ton (when the price of ammonia hits that), I think we will see some of the plants start back up, slowly but surely.

MODERATOR ACHORN: Gentlemen, we have to stop the questioning now. It's almost reached the noon hour. I want to express my sincere appreciation to the four speakers. I think it's very seldom I am able to share a platform with such notable individuals. They certainly have made a contribution to the industry and to the Fertilizer Industry Round Table today.

I also want to thank you for being such an attentive audience. I know of noone, especially you that are over 50 years old, that can sit in those seats that long without having to go do something.

I want to tell you one other thing. Please check the message board. Thank you. (Applause)

Tuesday, October 30, 1979

Afternoon Session
Moderators: Albert Spillman - Frank Nielsson

MODERATOR SPILLMAN: It is my pleasure to be with all of you today as it has been for the past 29 years. (Applause)

We have an excellent, interesting program this afternoon covering important discussions affecting many of our day to day problems on operations.

Our Speakers will inform you on the latest information available on Transportation Outlook, Storage and Transportation of Anhydrous Ammonia, In-Plant Energy Conservation — with "Specific Examples" on Electrical, Mechanical, Fuel and Process. We will also have the Honorable U.S. Secretary of Agriculture, Robert Bergland, with us around 3 P.M. He is our Keynote Speaker and is very sorry that he could not be here with us this morning as scheduled.

When Secretary Bergland arrives it may be necessary to break in on the completion of the Speaker in motion to permit Secretary Bergland to start his talk at once. Chairman Nielsson will meet Secretary Bergland at the front door of our meeting room and will make "The Introduction."

Our first Speaker this afternoon, Edwin M. Wheeler, has been President of The Fertilizer Institute since 1968 and is the full time chief executive of the industry's national trade association. The over 300 members of The Fertilizer Institute include dealers, distributors and equipment manufacturers, as well as producers, manufacturers and brokers.

Utilizing the skills of its 14 committees, the Institute Staff of 20 people represents the industry before Congressional Committees, Independent Government Agencies, such as the Interstate Commerce Commission, Federal Power Commission, as well as the Environmental Protection Agency, Department of labor and OSHA matters. From dealer assistance to U.S. and Canadian monthly fertilizer production and inventory figures, the range of overall industry services encompasses many areas.

Ed Wheeler is a native of Kansas. He was raised on a farm, is a lawyer by profession, and graduated from Washington University in Topeka, Kansas, where he received his Juris Doctor degree in 1955. He served in the law offices of the Kansas Railroad Committee, South Western Bell Telephone Company and just prior to joining the Institute, was Assistant to the President of the Santa Fe Railroad System. Please Mr. Wheeler. (Applause)

Transportation Outlook in the 1980's
Edwin M. Wheeler

Low cost food in the U.S. is now and forever dependent upon a reliable and reasonably priced transportation system. Just the fertilizer industry alone is paying $2 billion a year to move its products to our farmers. Of this sum, nearly 65% or $1.3 billion goes to our nation's railroads. We expect this tonnage to rise at between 2.5 to 3% per year over the foreseeable future. Thus, from our current delivery of 51 million tons a year to the farmer we are on the way to 60 million tons on a near term basis. Always, this is premised on a viable rail system.

Farm exports, even with the current Russian embargo, are on the rise. From my early days with The Fertilizer Institute (1968) farm exports have steadily risen from $6 billion to their current $32 billion. Without resuming Russian grain shipments, all forecasters believe we will move 150 million metric tons of grain and fibre with a $35 billion price tag this year. Yet, without a viable and growing transport capability, we will slip backward. As the world's leading agricultural exporter (the U.S. ships 60% of total world grain trade) we must see that our port, rail, truck and barge network is not only equal to the task but is preparing for the inevitable future growth.

World population today is at least four billion people and all the demographers now believe by the year 2000 the globe will have on it and must feed six billion souls. Think about it — 18 billion square meals a day! This will be a young socially restless group not content to be malnourished. The productive agricultural genius of the farmers of the world will be *the* issue of the day. Far more so than petroleum based energy. But, this will require a much enlarged transport system. Yes, there will be a real growth of the tonnage our railroad's must move.

Conrail, the Rock Island, Milwaukee and to a lesser degree, the Illinois Gulf Central are in financial trouble. However, South Pacific, Santa Fe, Southern, C&O, N&W, etc. have just reported their earnings which are the highest in their history. So, we do have viable railroads — some are sick — but the body is well and growing.

As spokesmen for the nation's fertilizer producers and retailers, we not only support a strong rail system but are willing to pay for it. What we object to and strenuously is the railroad proposal to remove all rate regulation when the railroad has a monopoly at a given location. When the railroads are competitive with each other we would be well satisfied to let the free market set the rates. Where only one of them is the single source of transport we insist the government shield us from the potential rail robber barons.

Agriculture will grow in the U.S. far beyond anything we have yet experienced. Young farmers will have some ups and downs, but each down will have ever higher "ups". The world looks to us as their farmer. We will be equal to the task if we insist upon a transportation system that can move the outpouring from our cornucopia." Thank you. (Applause)

Edititing Note: Mr. Wheeler gave his discussion from "rough notes". By error or our tape recorder operator failed to start the machine. Mr. Wheeler very kindly gave us "the highlights by careful translation."

MODERATOR SPILLMAN: Thank you, Mr. Wheeler, for that fine discussion on the Transportation Outlook, how it will effect the industry, both the Fertilizer and Chemical Divisions.

We will have time for questions and answers immediately after we give all of our discussions, so please stand by.

Our next Speaker, Travis Hignett really needs no introduction. I have been a friend of his for 35 years and have made many visits to his T.V.A. Muscle Shoals, Alabama Headquarters. We have discussed many plant operating problems during the years and received lots of help from Travis and his associates. It is my pleasure to introduce to you Travis P. Hignett, Special Consultant to the Managing Director, I.F.D.C., Florence, Alabama.

Mr. Hignett's "Biographical Sketch" shows that he is a native of Iowa; graduating from Drake University; between 1929 and 1933 he was with the U.S.D.A. Fixed Nitrogen Research Lab as a Junior Chemist; from 1933 to 1938 he was with the Research Corporation of America as a Chemical Engineer; 1938 through 1973 he was with T.V.A. as Director of Chemical Development, and is now retired from T.V.A. Presently, since 1974, he has been a Consultant, first with T.V.A., then for I.F.D.C. (International Fertilizer Development Center) in International Fertilizer Studies. It is my pleasure to introduce Travis Hignett. (Applause)

Transportation And Storage of Ammonia

Travis P. Hignett

Introduction

Over half of the nitrogen fertilizer consumed in the United States is supplied, directly or indirectly, by ammonia that is transported some distance from the plant where it was produced. According to estimates for the 1978-79 season, at least 7.25 million short tons of ammonia was transported from, to, or within the United States, of which 5.60 million tons was from domestic production and 1.65 million tons was net imports[1].

About 5 million tons was used for direct application and the remaining 2.25 million tons of transported ammonia may have been used to produce solid and fluid mixed fertilizers, ammonium nitrate, and other products, and short 0.4 million tons was exported.

World trade in ammonia is also growing rapidly; it increased from 3.05 million metric tons in 1976 to 4.03 million tons in 1977. A preliminary estimate indicates over 5 million tons in 1978. A recent ISMA report lists 192 ships that are suitable for transporting anhydrous ammonia, of which 60 have a capacity of more than 5,000 tons and 9 have capacities in the range of 30,000-46,500 tons. These ships also are suitable for carrying liquefied petroleum gas (LPG) and many of them are used alternatively for this purpose.

Another ISMA report lists 153 maritime ammonia terminals throughout the world with an aggregate storage capacity of 2.73 million metric tons[2] . Individual capacities range from a few hundred tons up to 121,000 tons. The list did not include inland terminals that are not accessible to ships. Twenty-five of these marine terminals are located in the United States; their total capacity is 724,000 mt. The total refrigerated storage capacity in North America is reported to be nearly 5 million short tons.

These statistics serve to highlight the growing importance of transportation and storage of ammonia both in the United States and in world trade. The purpose of this paper is to present information on storage and transport of ammonia by alternative methods with special emphasis on economics. The discussion will be confined to the wholesale level. Transportation methods that will be considered are ship, barge, rail, pipeline, and truck.

Properties of Ammonia

A brief review of the properties of anhydrous ammonia may be helpful. Figure 1 shows the vapor pressure versus temperature. For storage at atmospheric pressure at sea level ammonia must be cooled to —33°C. At higher altitudes where the atmospheric pressure is lower, lower temperatures (—40°C in some cases) are required. In the usual atmospheric temperature range of 0° to 40°C, the vapor pressure is about 4-15 atm absolute. Some other properties of anhydrous ammonia are tabulated below:

Characteristics	**Value**
Boiling point[a]	—33.4°C (—28°F)
Freezing point[a]	—77.7°C (—108°F)
Latent heat of vaporization[a]	327.4 kcal/kg (589 Btu/lb)
Solubility in water at 25°C[a]	0.456 g/g H_2O
Vapor pressure kg/cm^2 (psig)[b]	
—18°C (0°F)	1.10 (15.7)
0°C (32F)	3.35 (47.0)
38°C (100°F)	13.87 (197.2)
Specific gravity	
—18°C (0°F)	0.6749 (5.63 lb/gal)
0°C (32F)	0.6385 (5.33 lb/gal)
38°C (100°F)	0.5831 (4.67 lb/gal)
Explosive mixture	16%-25% NH, in air
Specific heat at 0°C	1.10

a. At atmospheric pressure.
b. Gauge pressure (psig = pounds per quesre inch, gauge).

Ammonia has a high coefficient of expansion; at 100°F it occupies 16% more volume than at 0°F. For this reason pressure storage tanks must not be filled to capacity; usually they are filled to about 85% of capacity to allow room for expansion.

Storage of Ammonia

Ammonia storage tanks may be classified as fully refrigerated, semi-refrigerated, or pressurized, and a similar classification can be applied to transport equipment. Fully refrigerated storage tanks are equipped to maintain a temperature of about —33°C at which the vapor pressure of ammonia is atmospheric *(see Figure 1)*. In semirefrigerated storage tanks, the ammonia is kept at a moderately low temperature, such as 0°-10°C, at which the gauge pressure is only 3-5 atm. This permits the use of much lighter steel tanks than if the temperature were uncontrolled. Unrefrigerated pressure storage tanks usually are designed for pressures up to about 18 atm which should be adequate for any ambient temperature normally encountered in most climates.

Pressure storage including semirefrigerated storage is economical for quantities up to about 2,000 tons; in the upper portion of this range, spherical semirefrigerated storage tanks may be used while in the lower portion of the range, horizontal cylindrical tanks with hemispherical ends are used. For storage or transport of more than 2,000 tons, fully refrigerated tanks are commonly used.

A simpliefied diagram of a refrigerated ammonia storage facility is shown in Figure 2. In this case liquid ammonia under pressure is received from the ammonia plant synthesis loop. As the pressure is reduced in the flash tank to nearly atmospheric, part of the ammonia evaporates; the negative heat of evaporation reduces the temperature of the remaining liquid to about —33°C at which temperature it goes to the storage tank. The ammonia vapor is liquefied by compression and water-cooling and returned to the flash tank. Ammonia received from the ammonia plant contains small amounts of dissolved gases, H_2, N_2, Ar, and CH_4; these gases, called "flash gases," are not condensed and must be purged from the second-stage compressor loop. When the storage tank is not being filled, a relatively small amount of ammonia evaporates as heat is conducted into the tank through the insulation. This ammonia vapor is compressed by a small compressor, liquefied by water cooling, and returned to the storage tank. When the tank is being filled, a larger quantity of ammonia vapor is formed, requiring the use of a larger compressor. As a rule of thumb, the power requirement for refrigeration of liquid ammonia is about 1 HP/mt/h/°C. Thus, 480 HP would be required to cool 10 mt/h from 15°C to —33°C[3].

Refrigerated ammonia storage tanks are of two types. One type is of double-wall construction with the annular space between the walls filled with loose perlite insulation and kept slightly above atmospheric pressure with dry air, nitrogen, or inert gas. The other type of tank is of single-wall construction, insulated on the outside with foam glass, styrofoam, polyisocyanurate foam, or polyurethane foam. Although the investment cost for the double-wall tank is greater than for single-wall construction, maintenance costs usually are lower.

Terminals for shipping or receiving liquid ammonia are similar in principle to the in-plant storage facility although there may be important differences. In some locations considerable expense may be involved in harbor improvement, construction of a pier, and preparation of a terminal site. High capacity pumps and large, well-insulated pipelines are needed for ships to load or unload rapidly with minimum vaporization of the refrigerated ammonia. The distance of the terminal from the loading pier is important because a 10-incryogenic pipeline suitable for transport of ammonia from a ship to a terminal or vice versa may cost $200/ft.

Terminals that receive ammonia by rail or pipeline must have extra refrigeration capacity to cool the ammonia as it is received. Quite often such terminals will have some pressure storage to even out peak refrigeration loads. For injection into a pipeline or for loading trucks or rail cars, ammonia from refrigerated storage must be warmed to about 40°F. This may be done by a heat exchanger fired with natural gas or propane. Here again, auxiliary pressure storage is useful for rapid loading or pipeline injection. Facilities for pipeline injection have been reported to cost $500,000. For the above reasons the investment and operating costs of an ammonia terminal are likely to vary widely and usually are greater than that of an in-plant storage facility. Estimated capital costs for refrigerated storage facilities are shown in Figure 3. The cost of in-plant storage includes only the storage tank, its foundation, and refrigeration equipment required for normal in-plant storage and use. Maritime terminals or land-based terminals for receiving and distributing ammonia are likely to cost roughly 50% more than in-plant storage, especially if they are remote from any manufacturing facility.

Ammonia will vigorously attack copper, silver, zinc, and alloys containing copper such as brass or bronze. Storage tanks, transport vessels, and pipelines are usually constructed of low carbon steel. Each grade of steel has a transition temperature below which it is subject to brittle fracture. Brittle fracture usually begins at a notch or crack near a weld where stress occurs. Thermal streess relieving after fabrication will lower the steel's transition temperature. Stress relieving is expensive and may be impractical. For this reason, a vessel or pipeline must operate at a temperature above the transition temperature of the steel. A minimum temperature of about 40°F usually is specified for receiving ammonia in pressure vessels or non-cryogenic pipelines.

The problem of stress corrosion cracking of pressure vessels may occur over a wide range of temperatures and pressures. Stress corrosion cracking is not fully understood, but it occurs less often when a small amount of water is added to the ammonia. Addition of a minimum of 0.2% water is required if the ammonia is to be transported in pressure vessels or pipelines.

A detailed description of the design, construction, and operation of ammonia storage and transport facilities is given in the book *Ammonia*, part IV[3].

Transportation of Ammonia

Ocean Shipment

For overseas shipment of ammonia, ships are equipped with well insulated tanks or holds to contain liquid ammonia at slightly above atmospheric pressure and at a corresponding temperature of about —33°C. The ships are equipped with refrigeration facilities which, in principal, are similar to those of a storage facility. The ships are also equipped with pumps of sufficient capacity to discharge the cargo at a rapid rate.

The following tabulation taken from an ISMA report lists ships that are suitable for transport of anhydrous ammonia or other similar liquefied gases at minimum temperatures usually ranging from —34°C to —48°C[4].

Ships Suitable for Ammonia Transport

Capacity, tons	Number of Ships
30,000 to 46,500	9
20,000 to 30,000	4
10,000 to 20,000	18
5,000 to 10,000	28
2,000 to 5,000	33
Less than 2,000	100
Total	192

The cost of ocean transport depends on a large number of factors—the cost of the ships or the cost of chartering the ship, distance, ship speed, fuel cost, crew cost, port charges and time in port, number of destination ports, and the supply and demand for shipping space. The last factor is an important one which causes freight costs to fluctuate widely. For the last year or two (1977-78), available shipping space has exceeded demand and, as a result, freight costs have been low. In contrast, demand exceeded supply in 1974-75, and freight costs were high.

Information received from a ship brokerage firm on current (September 1978) approximate spot rates for overseas shipment of anhydrous ammonia follows:

Approximate Freight Costs for 15,000-ton Lots of Anhydrous Ammonia[a]

Origin	Destination	Freight, $/mt
Persian Gulf	Turkey	28-30
	Unites States	47
	Brazil	44
	India (East Coast)	22
U.S. Gulf Coast	Brazil	28
	United Kingdom	24-25
	Mexico	10-11
Holland	U.S. East Coast	25
Russia (Baltic or Black Sea)	United States	35

a. Freight costs for 30,000-ton lots are about 25% lower; for 8,000- to 10,000-ton lots, they are about 15% higher.

In 1979, spot rates started rising and some rates have been reported to be 50+% higher than those shown above. However, when there are definite plans to ship large quantities of anhydrous ammonia, long-term charters may result in lower freight costs. It should be emphasized that the total cost of shipping and receiving ammonia includes not only the freight but also the cost of operating loading, receiving, and storage terminals. Assuming that a maritime terminal of 30,000-ton capacity costs $6 million, the annual operating cost can be estimated roughly as follows:

	Annual Cost, $
Depreciation, 6.67% (15 years)	400,000
Maintenance, 2.5%	150,000
Taxes and insurance, 2%	120,000
Utilities	10,000[a]
Labor and overhead	60,000
Total annual cost	740,000
Cost/ton of capacity	24.67

a. Assuming that the ammonia is received and withdrawn at —28°F.

If such a facility were to receive 100,000 tpy, the cost per ton of throughput would be $7.40. Similar calculations indicate that the annual operating cost of terminals of 10,000- and 20,000-ton capacity would be about $42.40 and $32.00/ton of capacity, respectively.

The optimum size of a marine terminal depends mainly on the capacity of ships that are expected to serve it and should be 25%-50% larger than the ship's capacity to allow for delays due to storms, shipment schedules, etc. The estimated terminal costs for receiving 100,000 tpy in terminals of different capacities follow:

Terminal Costs for Receiving
100,000 tons of Ammonia per year

Terminal Capacity	Annual Terminal Cost, $/ton of Capacity	Size of Shipments, tons[a]	Number of Shipments/ Year	Throughput Cost, $/ton of NH_3
10,000	42.40	7,500	13.3	4.24
20,000	32.00	15,000	6.7	6.40
30,000	24.67	22,500	4.4	7.40

a. Size of shipment is assumed to be 75% of terminal capacity.

Thus, the terminal cost per ton of ammonia for any given annual throughput decreases as the size of the terminal decreases. However, a smaller terminal capacity requires a larger number of shipments in smaller ships which will increase freight costs. Therefore, determination of the minimum cost of importing ammonia involves a balance between freight costs and terminal costs. In the above illustration it was assumed that the size of shipments was not limited by harbor depth, pier space, etc. If harbor improvement or pier construction is required, the cost of these facilities must also be considered.

Terminals of 30,000-ton capacity or larger are commonly used for ocean-going shipments. Smaller terminals may be suitable for coastal shipments or shipments by inland waterways when the ammonia is used at a more or less steady rate. The largest known marine terminal is located at Odessa on the Black Sea in U.S.S.R. It will have a capacity of 121,000 mt when completed. Ammonia will be received from several large ammonia plants through a 10-inch pipeline over 1,000 miles long which is under construction.

Shipment of Ammonia by Barge

Barge shipment of anhydrous ammonia is economical for countries or regions that have inland or coastal waterways and is extensively used in Europe and the United States. Self-propelled barges are commonly used in Europe where inland waterways are often narrow or shallow. Their capacities may range from 500 to 3,000 tons. Most of the larger barges are fully refrigerated, and smaller ones are semirefrigerated. For most of the inland rivers and canals, barges of about 1,000-ton capacities are suitable; larger self-propelled barges may be useful for coastal shipping.

In the United States, towed barges are commonly used, and several barges are lashed together and propelled by a single tugboat. A tow may be formed by 6-12 barges or more depending on the width of the waterway. Barges for transport of anhydrous ammonia usually are fully refrigerated, and their capacities may be in the range of 1,500-3,000 tons; smaller ones are used mainly where the depth or width of the waterway is insufficient for larger ones. Most of the barge movement of anhydrous ammonia is up the Mississippi River and through inland waterways adjacent to the Gulf of Mexico. Several large terminals are located on the river. Figure 4 shows a terminal at Pine Bend, Minnesota, on the upper Mississippi River with an 8-barge tow of anhydrous ammonia arriving at the terminal. Similar terminals are located at various points along the river and its tributaries. A typical terminal may have a storage capacity of 60,000 short tons of ammonia consisting of two 30,000-ton tanks. Since the upper part of the river is frozen during the winter, the terminals that are served by barge need to be filled by late autumn.

Ammonia from the terminal is transported by truck or rail to retail outlets, usually within a range of 100 miles or less. Ammonia from the terminal also may be used to produce solid or liquid mixed fertilizers, nitrogen solutions, etc. Some of the larger mixed fertilizer manufacturers receive ammonia by barge.

Most barges are owned by or are under long-term lease to major ammonia producers or petrochemical companies. Consequently, cost information is scarce, and short-term availability of barge transport cannot be relied upon. However, favorable rates may be available when barges would otherwise be idle. Some shippers may own both barges and towboats. Others may lease barges and contract for towing, and various other arrangements are possible. A well-planned program is necessary for economical barge transport since the economics depends on full utilization of the equipment. Where waterways are navigable only part of the year as in the northern part of the United States, barge transport may be at a disadvantage unless some use for the barges can be planned in other areas during the winter. Alternate use for LPG transport helps to solve this problem. In 1968 there were about 85 barges available for ammonia transport in the United States, of which 66 were designated for ammonia only. At present there are about 40; most of them are owned by ammonia-producing companies.

The cost of barge transport was estimated with the help of operating cost estimates made by the corps of Engineers and with the comperation of the TVA Navigation and Regional Planning Branch. The estimated cost of a fully refrigerated barge of 2,500 ton capacity was $1.7 million as of December 1976. Eight barges could be towed by a 6,500-horsepower towboat costing $3.1 million. Alternatively, 3 barges could be towed by a 4,200-horsepower towboat costing $2.2 million. The estimated annual and daily operating costs of the towboats and barges are shown in table 1. Using these costs, the following costs per ton of ammonia were calculated.

Orgin and Destination	Water Distance Miles	Time, Days		Estimated Cost	
		Upstream	Return	$/ton	-/ton-mile
Houston, TX to Fortier, LA	416	3.50	3.50	4.15	1.0
to St. Louis, MO	1,274	11.00	6.25	10.24	0.8
Lake Charles, LA to Fortier, LA	273	225	225	267	1.0
to Hannibal, MO	1,260	10.00	6.12	9.56	0.8
Fortier, LA to Hannibal, MO	1,148	9.11	5.58	8.71	0.8
to Minneapolis, MN	1,692	13.43	8.22	12.96	0.8

The above estimates used cost data as of December 1976; present costs would be higher, especially fuel costs. The calculation assumed that the entire round trip was charged to ammonia transport. An additional 10% of the round trip was allowed for loading, unloading, and delays. Some published barge rates are lower than the estimates which indicates that some of the assumptions may not be valid in all cases. Similar estimates for a 3-barge tow gave costs per ton about 45% higher.

One advantage of transportation by refrigerated barge is that the ammonia does not have to be warmed when it is withdrawn from storage or cooled when it is unloaded to storage, thus saving energy in comparison with transport by rail or pipeline. The energy requirement for cooling 1 ton of ammonia from 68°F. to —28°F. is about 40 kWh. Warming ammonia from —28°F. to 40°F. in a fuel-fired heater requires about 200,000 Btu per ton. In comparing costs per ton-mile, it should be noted that water distances between points on the Mississippi river may be 50% greater than by rail or pipeline. However, distances by intercoastal waterways paralleling the Gulf Coast compare favorably with rail distances.

Transportation of Ammonia by Pipeline

Transportation of anhydrous ammonia by pipeline is economically attractive in some cases. Examples of long distance transport are found in Mexico, U.S.S.R., and the United States. Pipelines may be used to transport ammonia from manufacturing plants to maritime terminals for shipment, to factories that produce finished fertilizers, or to market areas for direct application. A pipeline may serve some combination of these purposes.

In the United States two major pipelines are in operation. Their locations are shown in Figure 5. The Gulf Central pipeline extends from southern Louisiana northward through Arkansas and Missouri to northern Iowa, then westward into Nebraska, a total distance of about 1,300 miles. A branch extends from Missouri through Illinois to northeastern Indiana, a distance of about 400 miles. Various sections of the pipeline are 10, 8, and 8 in. in diameter. The cost of the pipeline was reported to be $70 million (completed in 1969). Seven ammonia producers are listed as injection points of which five are in Louisiana, one in Iowa, and one in Indiana. There are 37 terminals at 28 locations including storage facilities at ammonia production plants. The total capacity of storage facilities connected to the pipeline is about 1,500,000 tons with an average of about 40,000 tons per terminal. In addition, the pipeline itself holds about 70,000 tons. Some of the terminals can also be supplied by barge or ship from the Mississippi River. It is possible to transport ammonia from one terminal to another so that ammonia received by barge or ship at some terminals can be transferred to the pipeline for further shipment. Some of the receiving terminals are owned by ammonia producers or companies that purchase the ammonia, and some are owned by the Gulf Central Storage and Terminal Company.

The Mid-America Pipeline System (MAPCO) is supplied by one ammonia producer in Texas and three in Oklahoma. It extends through Kansas and Nebraska to northern Iowa. The line from Borger, Texas, to Garner, Iowa, was originally built in 1969 at a cost reported to be $12 million. Much of the pipeline was laid parallel to MAPCO's other pipelines that carry LPG and refined petroleum products; thus, the expense of acquiring right of way was minimized. The diameter of the pipe is 8 and 6 in. in different sections, and its length is about 720 miles. The branches connecting the Oklahoma plants were added later, and still more recently an extension from Garner, Iowa, to Mankato, Minnesota, was added. The total length including all branches is over 1,000 miles. There are 15 storage terminals connected to the system with a total capacity of about 300,000 tons. The terminal at Garner, Iowa, is served by both the MAPCO and Gulf Central pipeline systems; Ammonia received by one pipeline can be transported further by the other. In addition to storage terminals there are various truckloading stations along the pipelines where trucks may be loaded for transportation to retail distributors' storage facilities or to liquid fertilizer manufacturing plants. Also there is at least one station for loading railcars, and many of the storage terminals are equipped to load railcars as well as trucks.

The pipeline systems have sufficient flexibility that ammonia can be transported from one storage terminal to another. The direction of flow can be reversed in sections of the pipeline to bring ammonia back from a farther terminal to a nearer one.

The initial capacity of the Gulf Central pipeline was 3,000 tpd, and the MAPCO line's initial capacity was 1,300 tpd. Both capacities have been increased by adding pumping stations; the present capacity probably is twice the initial capacity. It was estimated that 2.5 million tons would be moved by pipeline during this year (1979)[5]. Lee and Inkofer estimate that the capacity of 10-in and 8-in pipelines with pumping stations spaced at 40-mile intervals is 3.0 million and 1.7 million tpy, respectively. The investment cost was estimated at about $70,000 and $45,000/mile for the two sizes using 1969 cost levels when the pipelines were built. The maximum operating pressure of a pipeline depends on its diameter and wall thickness; about 1,500 lb/in^2 may be typical. For details of pipeline construction and operation, see reference [6].

Some of the ammonia is used by manufacturers of ammonia nitrate, nitrogen solutions, and solid or liquid compound fertilizers. Some larger manufacturers have their own storage terminal; smaller manufacturers or distributors may contract for space in the storage facilities owned by the pipeline companies, or they may purchase ammonia from terminals owned by ammonia producers. The area served by the two pipeline systems contains several hundred manufacturers of liquid compound fertilizers, thus a substantial portion of the ammonia may be used for this purpose. However, the major use of anhydrous ammonia is for direct application, and most of this is applied in a few weeks in the spring. During the peak season the pipeline systems are operated at full capacity, and transport may be available only to those companies that have contracted for it in advance. At other times when surplus is available, ammonia may be accepted for transport on short-term contracts.

Specifications for anhydrous ammonia to be shipped by pipeline are:
Temperature: Not less than 35°F. (2°C) or
more than 85°F. (29°C)
NH_3 content: 99.5% minimum by weight
Water content: 0.2% minimum by weight
Oil content: 4 ppm maximum by weight
Inerts: 0.5 cr/g maximum

When ammonia is transported from one refrigerated terminal to another, it must be warmed from —33°C to at least 2°C and then cooled again at the receiving terminal. This is necessary because the pipelines would be susceptible to brittle fracture at temperatures below 2°C, as discussed previously. Many terminals have 100- to 1,000-ton pressure storage capacities for ammonia at above 2°C in addition to 18,000- to 77,000-ton refrigerated storage.

The pipeline systems are common carriers and are subject to regulation by the U.S. Government (Interstate Commerce Commission) which requires that the rates be published. Example rates are shown in Table 2. Ton-mile rates are shown in figure 6. When the contract is on an annual basis, the ammonia is received at a steady rate throughout the year. During the offpeak season the excess of input over withdrawal is stored in either the shipper's terminals or the pipeline company's terminals until the peak season.

The rates shown are for transportation only. If the ammonia is loaded directly from the pipeline into trucks, there is a truckloading charge of $1.25/ton if the loading is done by the pipeline company. The charge for loading rail cars is $2/ton. When the ammonia is stored in the pipeline company's storage terminal facilities, there is an annual charge of $24.50/ton of storage space plus $2.00/ton of throughput. Thus, if the annual throughput is three times the contracted-for space, the cost is ($24.50 ÷ 3) + $2.00 or $10.17/ton. Terminal charges for various space: throughput ratios are shown in Figure 7. If the storage facilities are owned by the shipper or consignee, he will have a more or less equivalent expense.

In the case of ammonia delivered to a purchaser who uses it at a steady rate (an ammonium nitrate manufacturer, for example), a lower terminal throughput charge is available depending on the use pattern. For example, a manufacturer who uses ammonia at an annual rate of 80,000-90,000 tons and at a weekly rate of 1,520-1,720 tons may contract for 1,700 tons of storage space at $24.50/ton/year plus $1.36/ton of throughput. If the throiughput is 85,000 tpy, the total terminal charge amounts to $1.85/ton ($0.49 space charge + $1.36 throughput charge).

Of course, terminal costs are encountered regardless of the method of shipping; in the case of shipment by barge to the northern part of the United States, the throughput ratio is likely to be lower than that for transport by pipeline because the barges can be used only part of the year. Therefore, terminal storage costs are likely to be higher per ton of throughput. The total terminal capacity connected to pipelines is about half of the estimated current annual movement of ammonia by pipeline, indicating that the average throughput ratio may be about 2.

Transportation of Ammonia by Rail

Ammonia is transported by rail in the United States mainly in cars having about 80-ton capacities, although a few older cars of 25- to 30-ton capacities are still in use and some larger cars are available. In general rail transport is used for shorter distance than pipeline or barge transportation, but this is not always the case.

For transport by rail (or truck) the ammonia, if taken from refrigerated storage, must be warmed to at least 2°C since abrupt cooling to —33°C causes stresses that may result in cracking of the steel tank. However, there are under development railcars that are capable of receiving refrigerated ammonia at —33°C and are so well insulated that the temperature is only 1°-2°C/day. Such cars would have an obvious advantage for transporting ammonia from one refrigerated terminal to another.

Representative freight costs for transportation of ammonia by rail in 77.5-ton minimum carloads are shown in Table 3. The rates are based on the supposition that the railroad will supply the cars. However, since the railroads have few if any cars suitable for ammonia transportation, the shipper actually supplies the cars and the railroad gives an allowance (reduction in freight cost) to compensate the shipper for the expense incurred in supplying the car. The allowance is based on the distance that the car is moved by the railroad. The shipper may own the car, or he may lease it on long- or short-term lease. In either case the cost per ton-mile of owning or leasing railcars depends on how much use the shipper makes of them. In practice, the cost is likely to exceed the railroad's allowance unless the cars are kept in constant use.

The freight cost depends on the weight of ammonia per car; the cost per ton for a small-car shipment (25-ton) may be twice that of a 78-ton carload. Also, a lower rate applies to multicar shipments, usually 5 or more 78-ton cars per shipment, subject to a guaranteed annual volume which may, for example, be 36,000 tons. An example of rail freight costs, as affected by size of shipment, is tabulated below:

Minimum Weight/Car, tons	Freight: Cost, $/ton for 307-mile Distance
Single -car	
25.0	27.20
70.0	18.65
77.5	12.96
Multicar[a]	
77.5	9.23
80.0	9.08

a. Five or more cars per shipment, 36,000 tons annual minimum.

Transportation of Anhydrous Ammonia by Truck

Truck transportation is the most expensive method of moving anhydrous ammonia and hence is used mainly for short distances, usually less than 100 miles. However, the use of trucks is growing in the United States because many rail lines are being abandoned leaving a growing number of locations without rail service. Each state has its own regulations governing the total weight of trucks that are permitted to operate on its highways. Therefore, there is some variation in the capacities of ammonia trailers; a common size is 16-18 tons. The trailers may be owned by the company that produces and markets ammonia, or they may be owned by the trucking company. They are used to transport ammonia to retail distribution centers or to small manufacturers of liquid fertilizer. They are also used to transport LPG. In some western states a tractor may be permitted to pull two trailers in tandem. This arrangement reduces the transport cost to the point that it may be more nearly competitive with rail transport.

Some examples of truck transport costs are shown in Table 4. The first part of the table shows average rates from several trucking firms; the second part shows some specific point-to-point rates. The rates were those in effect at the end of 1978; some increases have occurred since including a fuel cost surcharge. Ton-mile rates are shown in Figure 8.

Total Transport and Storage Costs

In the United States, about 5 million tons of anhydrous ammonia is used for direct application each year. Probably as much as 75%-80% of this amount is used in the spring. In any given area most of it is used within 1 month. This means that most of the ammonia used for direct application must be stored in the market areas—part of it in local retail storage facilities and part in large terminals served by pipelines, barges, rail, or some combination. Since the annual throughput of the storage terminals probably is no more than twice their capacity, terminal storage costs are high. A typical total cost for storage and transport of ammonia produced in Louisiana, Texas, or Oklahoma to a retail center in Iowa might be:

Pipeline transportation from plant to terminal	$10.00
Terminal storage charges	13.70
Truck transport from terminal to retailer	9.50
TOTAL	$33.20

The above total does not include the retailer's storage cost or transport to farms. While this cost may seem high, it should be noted that to supply an equivalent amount of nitrogen as urea (8.0 million tons) or ammonium nitrate (10.9 million tons) probably would be much more expensive. In addition, the cost of converting ammonia to urea or ammonium nitrate would have to be considered.

It should be noted that the hypothetical retailer in Iowa has several alternatives open to him. He may receive direct shipments from the ammonia producer by rail at a cost of about $25. He may receive truck shipments loaded directly from a pipeline. The cost would be about $21 ($10 pipeline transport plus $1.25 truckloading charge plus $9.70 truck transport charge). He may receive shipments by rail or truck from a river terminal served by barges. Some of these alternatives may be attractive for filling the retailer's storage facilities during the offpeak season, but during the peak season all transport facilities are overtaxed. When the retailer needs to replenish his supply during the peak season, he may have no other choice than to receive ammonia from whatever terminal storage facility can supply his needs.

Comparison of Various Methods of Ammonia Transportation

Figure 9 shows a comparison of ammonia transportation costs by barge, pipeline, rail, and truck for U.S. conditions. Barge transport costs are estimated for eight 2,500-ton barge tows and do not apply to narrow or shallow waterways. It is evident that barge transportation is the most economical method between points that are located on waterways that permit passage of tows of several large barges.

One disadvantage of barge transport is that water distances are often longer. For instance, the estimated distance from Fortier, Louisiana, to Hannibal, Missouri, is 1,150 miles by barge and 820 miles by pipeline. Another disadvantage is that barge transportation on some rivers is likely to be interrupted by ice, floods, and periods of low water. Terminal storage capacity must be increased in relation to throughput to provide for these interruptions. As a result, increased terminal costs may at least partially offset the lower transport cost. The extent of this disadvantage depends on the character of the waterways.

An advantage of barge transportation of ammonia from one refrigerated terminal to another is that the expense of warming the ammonia and then cooling it again is avoided. The cost of these operations is illustrated by the following tabulation:

Warming from —28°F to 40°F, 200,000 Btu x $3.00/million Btu =	$0.60
Cooling from 68°F to —28°F, 40 kWh x $0.03 =	1.20
Total cost per ton of ammonia	$1.80

Assuming that the efficiency of converting fuel to electrical energy is 33% the total energy requirement for warming and cooling is about 614,000 Btu per ton of ammonia.

Combinations of barge and pipeline transport can be useful in some cases. As ammonia imports increase we may find imported ammonia delivered to marine terminals, then transported by pipeline, barge, or a combination to the market area.

Pipeline transport of ammonia appears to be substantially cheaper than rail while truck transport is the most expensive of all. However, many more points can be reached by truck than by rail, and more points can be reached by rail than by pipeline or waterways. The comparison in Figure 9 applies only to the United States and is not necessarily valid for other countries. Also, it does not include recent fuel cost surcharges which may range from 3% for rail to 10% for trucks.

Energy Requirements

Energy is on everyone's mind these days so I will close with some comparisons of energy requirements. The estimated energy requirement for transportation is:

Method	Btu/ton-mile	Remarks
Ocean vessel	200-300	One way, 13.5-16.2 knots
Barge[a]	275	One way, Lake Charles to Hannibal
Barge[a]	440	Same, round trip
Pipeline[b]	410	
Rail[c]	700	
Truck[c]	2,500-2,800	

[a] Calculated for 8-barge tow, 20,000 tons of ammonia.

[b] Ian Beach, "Waterways of Tomorrow," New Scientist July 12, 1973.

[c] J. R. Lee, "Marketing Techniques in a Period of Shortage," 1974 Chem. Eng. Prog. 70 p 25-70.

It is evident that transportation by water requires the least energy per ton-mile on a one-way basis, although the total distance needs to be considered; waterways are sometimes circuitous

The following tabulation shows the total energy involved in transportation of ammonia from a producer's refrigerated storage to a retailer's pressure storage tank. The illustration is based on transportation from Fortier, Louisiana, to Hannibal, Missouri, storage terminal and thence to a retailer 70 miles from the terminal.

Thousands of Btus per Ton of NH_3

Item	Pipeline and Truck	Barge and Truck	Pipeline and Truck[a]	Direct Rail to Retailer
1. Heating NH_3	200	——	200	200
2. Transportation to terminal	336[b]	505[c]	336	——
3. Cooling at terminal	414	——	——	——
4. Maintaining refrigeration at terminal	478	478	——	——
5. Heating NH_3 for truck loading	200	200	——	——
6. Transportation to retailer by truck	185	185	185	——
7. Direct transport to retailer[d]	——	——	——	560
Total	1,813	1,368	721	760

a. Direct truck loading from pipeline.
b. 820 miles.
c. 1,148 miles one way plus return of empty barge.
d. 800 miles.

The illustration shows that the energy required for transportation is not a large percentage of the total energy involved in distribution of anhydrous ammonia through refrigerated storage terminals. Direct shipment to the retailer's pressure storage would use much less energy whether directly by rail from the producer to retailer, or by pipeline and truck with direct transfer from pipeline to truck. However, pressure storage of large quantities of ammonia is not economical feasible, and would require vast amounts of energy to produce and fabricate the steel tanks required for large-scale pressure storage. For transport from one refrigerated terminal to another, transportation by refrigerated barge saves about 500,000 Btu per ton of NH_3 over rail or pipeline. The saving may be more or less, depending on the barge size, the number of barges per tow, the directness of the water route, and whether the barge must be returned empty.

Achorn has summarized energy requirements for transportation, storage, and application of anhydrous ammonia as compared with urea or ammonia nitrate[7]. The estimates are summarized below and conversion energy has been added.

Energy Requirement, Thousand Btu/ton of N

	NH_3	Urea	NH_4NO_3
Transportation	758	1,383	1,755
Storage	478	56	77
Application	1,878	1,100	1,488
Subtotal	—	10,900	320
Conversion[a]	—	390	1,561
Ammonia loss[b]	—	390	1,561
Total energy from ammonia plant to soil	3,114	13,829	5,201

a. Fuel equivalent of net steam and mechanical or electrical power for conversion of NH^3 to urea or ammonia nitrate.
b. Based on ammonia losses of 1% and 4% for urea and ammonia nitrate, and 32 million Btu/ton of ammonia.

The above calculations do not include any losses during transportation, storage, handling, and application. It seems evident that direct application of ammonia requires less total energy than urea or ammonia nitrate. Considering only transportation costs, less energy is required for ammonia transportation than other nitrogen fertilizers. However, transportation cost and energy requirement for ammonia nitrate would be much lower if the ammonium nitrate were produced in the market area using ammonia brought in by barge or pipeline. This is done in several cases.

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Table 1. **Estimated Operating Costs of Towboats and Ammonia Barges on the Mississippi River System (December 1976)**

	Towboats		Refrigerated Barge
	4,200 hp	6,500 hp	2,500-ton capacity
Investment (New December 1976)	$2,200,000	$3,100,000	$1,700,000
Annual Operating Cost, $			
Return on investment	258,400	364,100	187,000
Administration & Supervision	94,500	130,000	3,000
Subtotal, fixed cost	352,900	494,100	190,000
Wages & fringe benefits	325,000	350,000	—
Fuel	400,000	666,000	—
Maintenance & repairs	80,000	105,000	20,000
Supplies	38,000	44,000	—
Subsistence	28,000	31,000	—
Insurance	65,000	93,000	28,000
Other	9,000	11,000	8,000
Subtotal	945,000	1,300,000	56,000
Total annual costs	1,297,900	1,794,100	246,000
Cost per day	3,768	5,200	696

Table 2. **Cost of Transportation of Ammonia by Pipeline (Selected Published Rates)**

Origin	Destination	Rate, $/ton	Distance, miles	¢/ton-mile
Borger, TX.	Mocan, OK.	4.60	109	4.22
	Beatrice, NE.	7.73	450	1.72
	Garner, IA.	10.36	720	1.44
Mocane, OK.	Conway, KS.	5.25	197	2.66
	Blair, NE.	7.45	465	1.60
	Port Neal, IA.	7.99	530	1.51
Verdigris, OK.	Conway, KS.	6.12	319	1.92
	Blair, NB.	8.34	590	1.41
	Garner, IA.	10.05	735	1.37
Enid, OK.	Conway, KS.	5.30	200	2.65
	Garner, IA.	9.63	615	1.57
Luling, LA.	Eldorado, AR.	5.70	290	1.96
Donaldsonville, LA.	Cowden, IL.	12.30	770	1.60
	Terre Haute, IN.	12.90	894	1.44
	Huntington, IN.	14.10	1,047	1.35
	Spencer, IA.	14.30	1,077	1.33
	Aurora, NE.	15.00	1,312	1.14
Fortier, LA.	Garner, IA.	14.30	1,027	1.39
	Aurora, NE.	15.30	1,352	1.13
	Hannibal, MO.	9.65	820	1.18

Table 3. **Selected Rail Freight Rates for Anhydrous Ammonia**

	Distance,	**Single Car Rate[c]**		**4 Multicar Rate[d]**	
From Donaldsonville, LA, to:	**Mile[d]**	$/ton	¢/ton-mile	$/ton	¢/ton-mile
Jackson, MS.	211	10.95	5.2	—	—
Little Rock, AR.	402	15.35	3.8	11.20	2.8
Macon, GA.	578	17.28	3.0	—	—
Springfield, MO.	685	21.07	3.1	15.83	2.3
Peoria, IL.	846	24.29	2.9	18.96	2.2
Des Moines, IA.	1,021	27.76	2.7	22.48	2.2
Omaha, NE.	995	26.91	2.7	21.69	2.2
From Enid, OK. to:					
Jackson, MS.	661	19.06	2.9	—	—
Little Rock, AR.	406	15.35	3.8	11.20	2.8
Macon, GA.	1,035	25.13	2.4	—	—
Springfield, MO.	307	12.96	4.2	9.23	3.0
Peoria, IL.	612	19.40	3.2	14.35	2.3
Des Moines, IA.	474	16.57	3.5	12.16	2.6
Omaha, NE.	413	15.35	3.7	11.20	2.7

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a. Published rates February 1979.

b. Shortest distance by rail.

c. Minimum weight per car—77.5 tons.

d. Five cars or more per shipment, subject to annual volume of 36,000 tons.

Table 4. **Cost of Transportation of Ammonia by Truck**
(Average of rates from several trucking companies, effective September 1978)

Distance, miles	$/ton	¢/ton-mile
0 to 20	6.50	32.5 and up
50	8.62	17.2
95	13.02	13.7
140	17.84	12.7
190	23.76	12.5
240	29.80	12.4
290	35.66	12.3
340	42.14	12.4
390	48.03	12.3
440	53.18	12.1
490	59.35	12.1
630	75.78	12.0

Point-to-Point Rates (Intrastate)[a]

From	Tp	Distance, Miles	$/ton	¢/ton-mile
Omaha	Freemont, NE	43	6.56	15.3
Dubuque	Manchester, IA	45	7.10	15.8
Winona	Rochester, MN	45	7.70	17.1
Cincinnati	Circleville, OH	80	12.10	15.1
Lathrop	Fresno, CA	119	8.20	6.9
Lathrop	Sacramento, CA	60	5.60	9.3

a. Green Markets, April 3, 1978.

Note: Figures#1 thru #9
on pages #35 thru #37

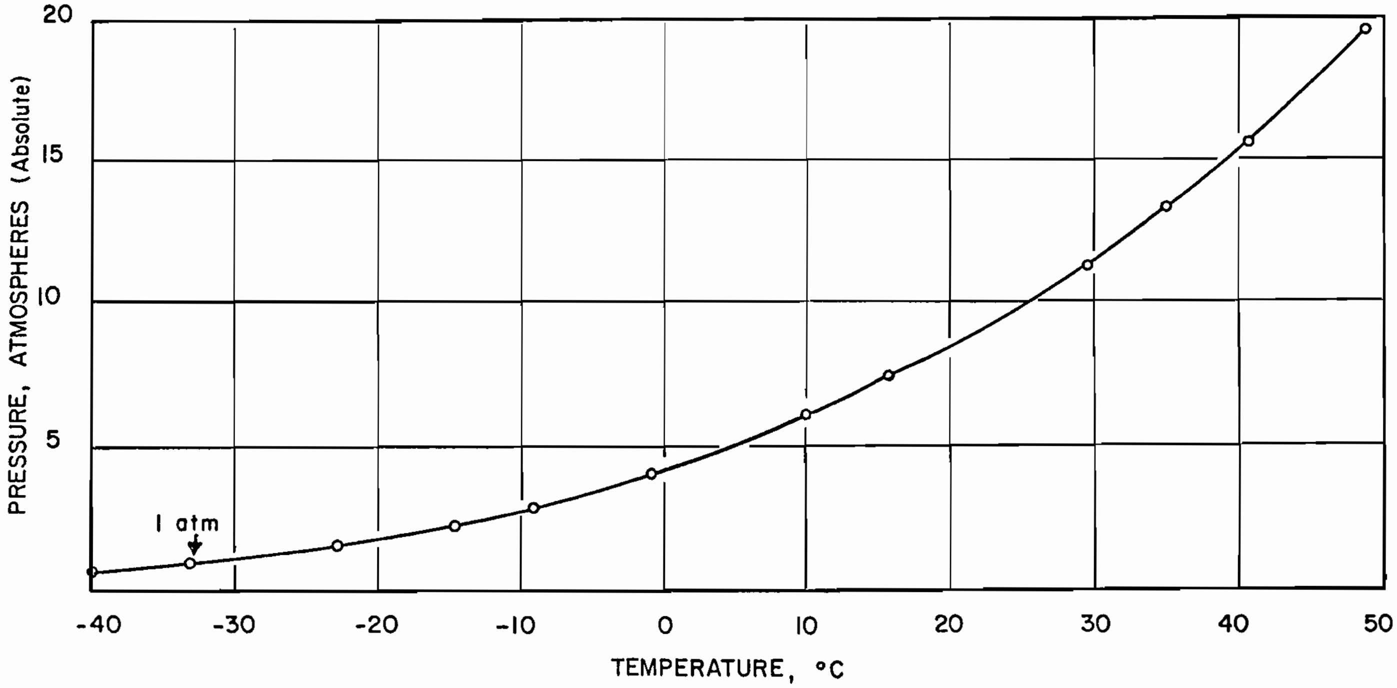


Figure 1. Vapor Pressure of Anhydrous Ammonia vs. Temperature.

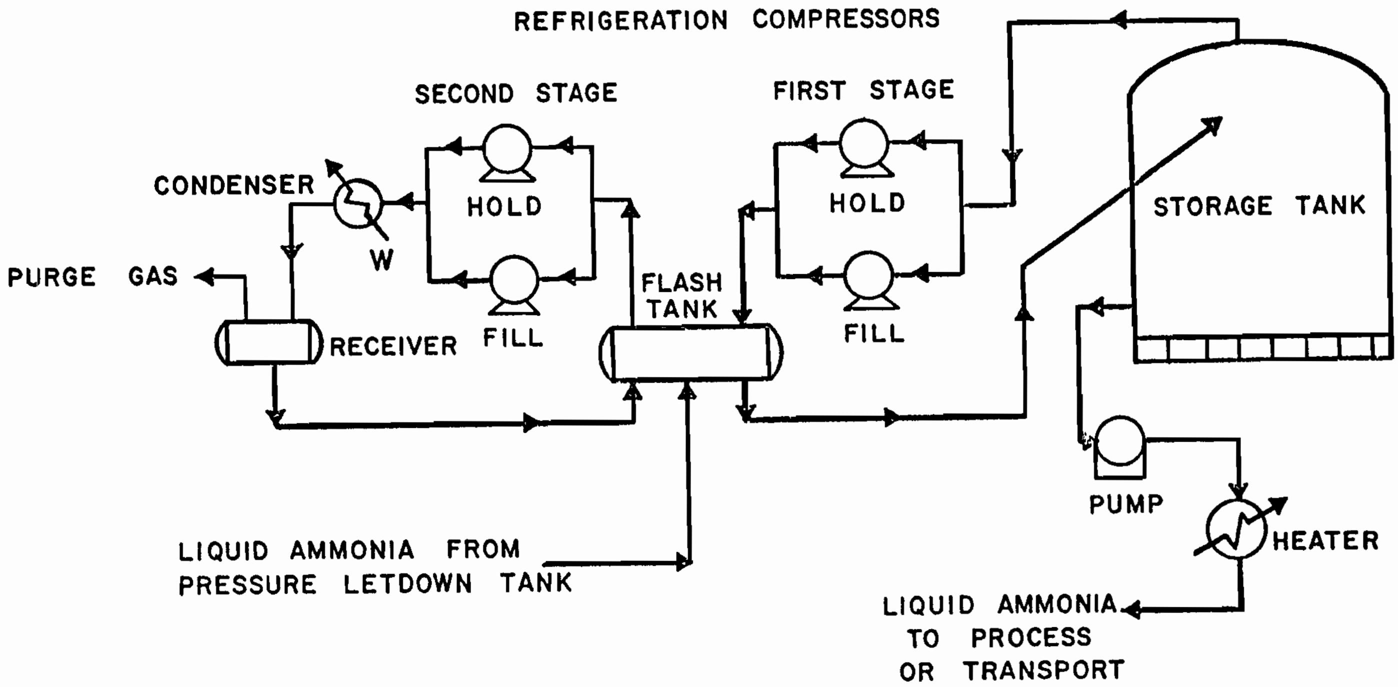


Figure 2. Simplified Diagram of Refrigerated Ammonia Storage Facility.

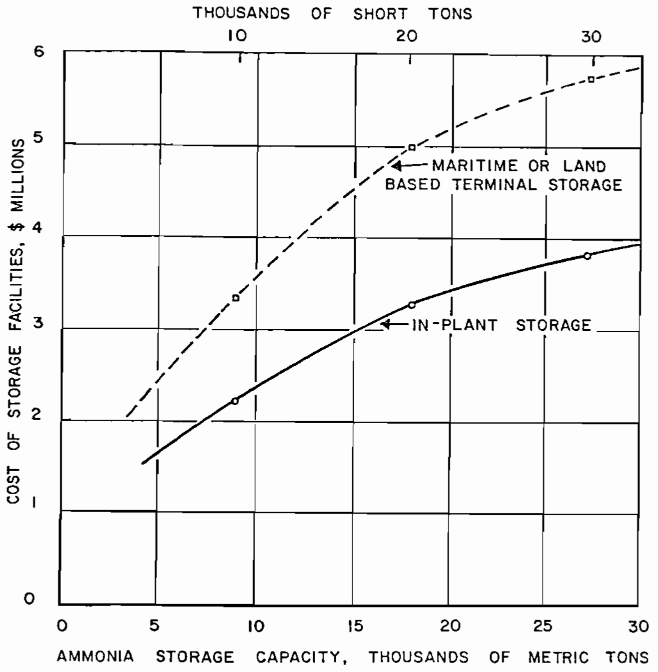


Figure 3. Estimated Capital Cost for Refrigerated Ammonia Storage Facilities.

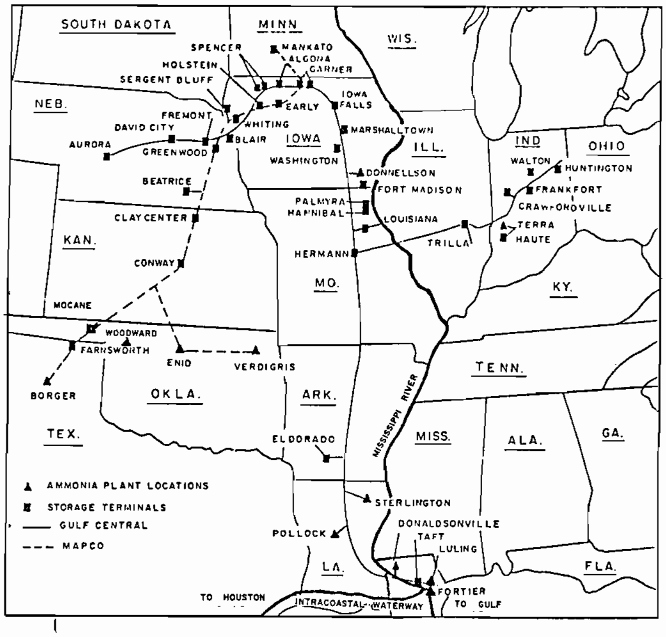


Figure 5. Location of Anhydrous Ammonia Pipelines in the United States.

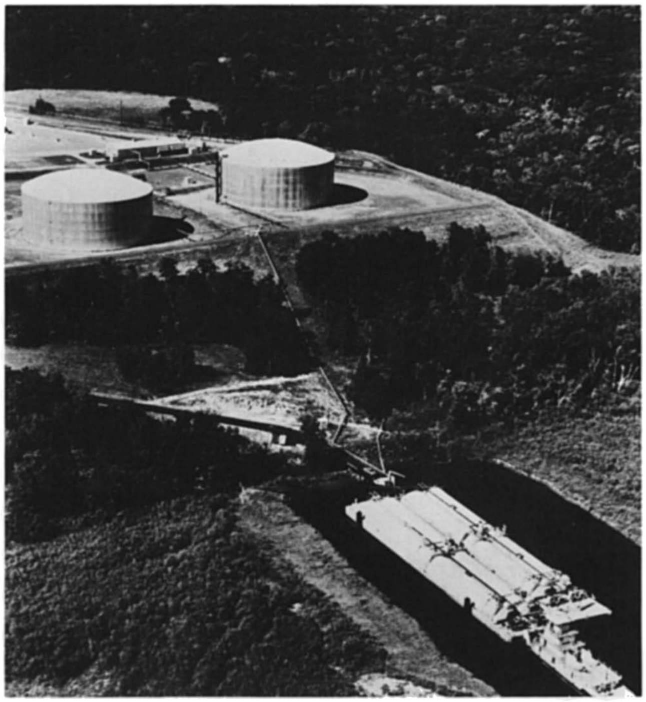


Figure 4. Ammonia Storage at Pine Bend, Minnesota served by barges. Photo courtesy of C. F. Industries.

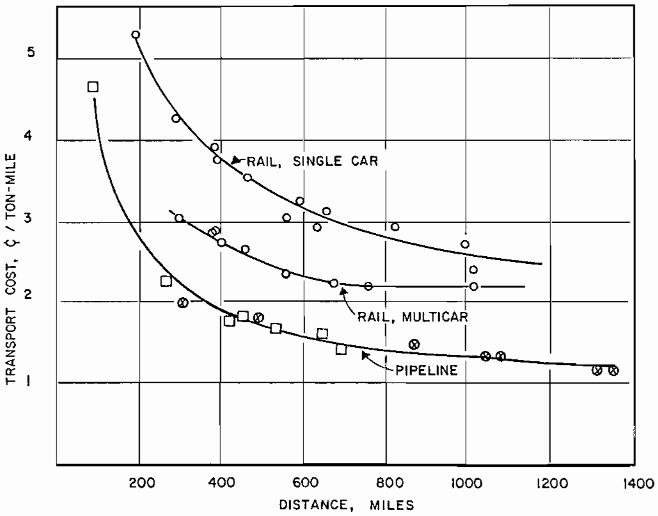


Figure 6. Pipeline and Rail Transportation Costs/Ton-Mile.

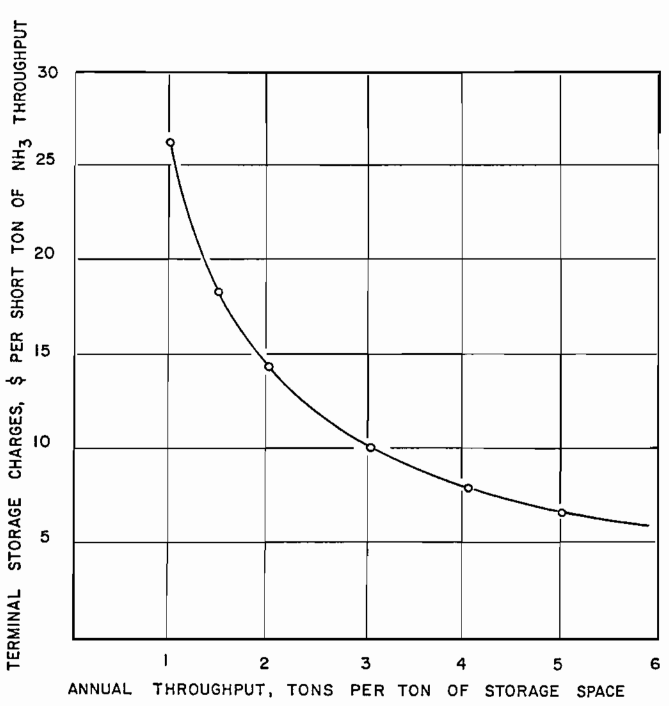


Figure 7. Terminal Storage Costs for Various Space:Throughput Ratios.

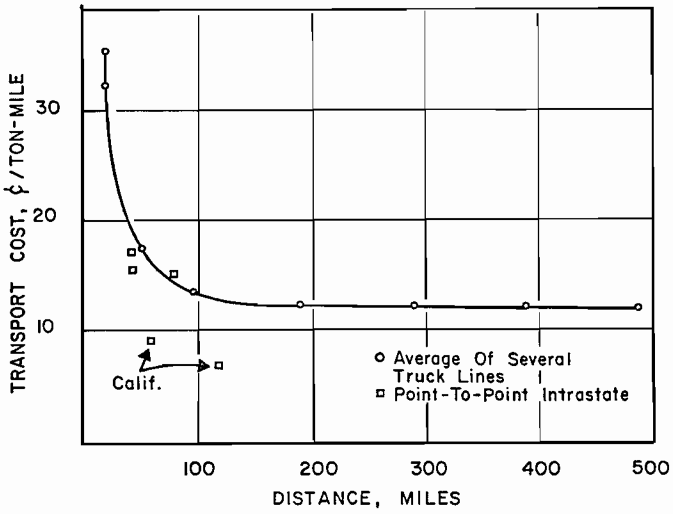


Figure 8. Truck Transportation Costs/Ton-Mile.

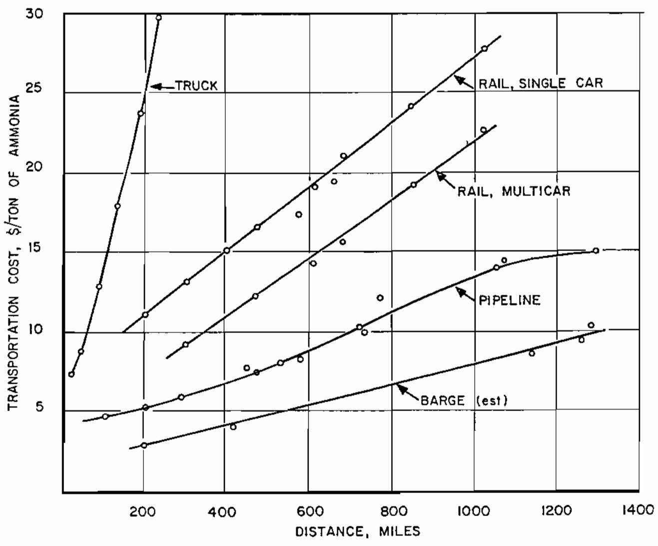


Figure 9. Comparison of Ammonia Transportation Costs by Barge, Pipeline, Rail, and Truck.

MODERATOR SPILLMAN: Thank you Travis. You have given us a throughly and most interesting description on "Transportation and Storage of Ammonia". (Applause)

Our next Speaker, Rodger C. Smith, has contributed many papers to the Round Table and was Chairman of the Round Table during 1977 and 1978. He was "Head of Fertilizer Research" with Eastern States Farmers' Exchange, since, merged into Agway until 1962, when he joined Amax Chemical Corporation, where he is Director of Market Development. Rodger has appeared on many Forums and authorized several chapters on "Fertilizer Technology", including one on "Potash Fertilizers" in the forth coming "United Nations Fertilizer Manual." Rodger has been a friend of our Round Table ever since its beginning and has attended all of our meetings except one. Rodger please. (Applause).

Potash Production

Rodger C. Smith

The technology of fertilizer manufacture is, as you know well, primarily one of chemical processing to produce agronomically useful mixtures or materials. Potash production, on the other hand, involves mining, refining, in addition to modification of particle size. It has been suggested that this round table have a glimpse of how potash deposits were formed, how potash is mined, refined and modified to the various particle sizes required in granulation, blending or other fertilizer manufacture.

Underground Mining

The mining of potash commenced in 1861 in the Stassfurt region of Germany. The investigations of the scientist, Liebig, into the mineral requirements of plant life led to the possibility of the use of potash salts as chemical fertilizers and the opening of the first mine at Stassfurt.

Commercial deposits, such as at Carlsbad, New Mexico, required the inflow of large amounts of sea water to a lagoon area were contained salts precipitated when the sea water reached about 100 times its original concentration. The order of precipitation based on solubility was calcium carbonate, calcium sulphate, sodium chloride followed by the highly soluble potassium and magnesium salts.

Minerals

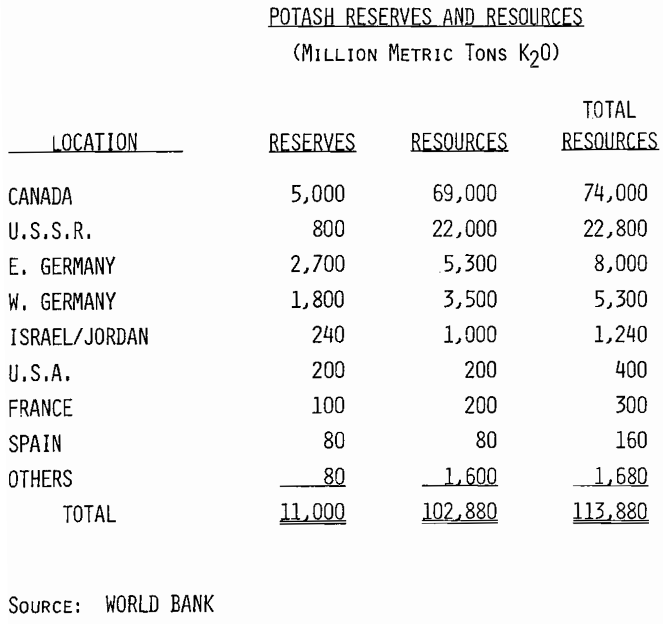
The three potash evaporate minerals of commercial importance are sylvinite, langbeinite and carnallite. Sylvinite, a mixture of potassium chloride and sodium chloride crystals, is the easiest to process and is mined in largest quantities. Sylvinite normally occurs in layers, underlain and overlain with sodium chloride as is the geology of the carlsbad and saskatchewan deposits. The sylvinite often occurs at more than one strata.

All North American mines producing muriate of potash recover sylvinite. Two mines in the Carlsbad area mine langbeinite.

Carnallite ($\mathrm{KMg\ Cl3.6H_2O}$) is more difficult to process but is refined in Europe, Israel and U.S.S.R. to recover muriate of potash.

Table Reserves (Slide 1)

World potash reserves are enormous and sufficient to meet requirements for many years to come.



POTASH RESERVES AND RESOURCES

(MILLION METRIC TONS K$_2$O)

LOCATION	RESERVES	RESOURCES	TOTAL RESOURCES
CANADA	5,000	69,000	74,000
U.S.S.R.	800	22,000	22,800
E. GERMANY	2,700	5,300	8,000
W. GERMANY	1,800	3,500	5,300
ISRAEL/JORDAN	240	1,000	1,240
U.S.A.	200	200	400
FRANCE	100	200	300
SPAIN	80	80	160
OTHERS	80	1,600	1,680
TOTAL	11,000	102,880	113,880

SOURCE: WORLD BANK

Slide 1

Enormous quantities of potash are present in Canada and the U.S.S.R., which together probably represent more than half the world reserves and about 80% of the world's resources. The remaining known reserves are distributed among the United States, Europe, Thailand, Congo and South America.

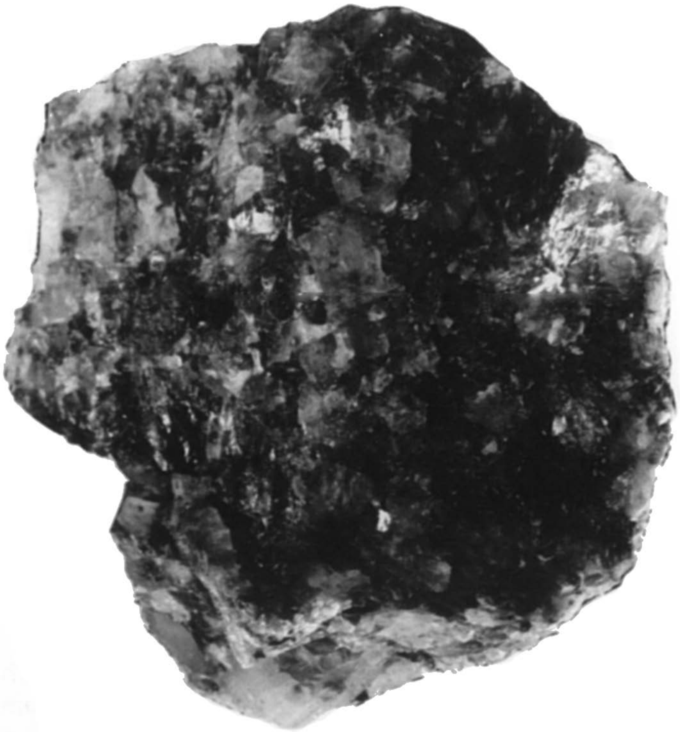
Potash Ore Nugget (Slide 2)

Potash is very largely extracted from underground deposits of sylvinite, which is primarily mixed crystals of potassium chloride and sodium chloride. Potash is also recovered in much lesser quantities from brines, i.e., the great Salt Lake and the Dead Sea, containing mixed salts including carnallite ($\mathrm{KCl \cdot MgCl_2 \cdot 6H_2O}$). Shaft and room and pillar mining is generally practiced underground. Long wall mining is used in limited instances.

Solution mining technology is well developed and is practiced on limited scale. The cost of energy required is the main deterrent to solution mining. Shaft mining is practiced when an underground ore body is less than about 3,000-3,500 feet from the surface. At greater depths solution mining is necessary.

Head Shaft Scene

Shaft mining: Shaft excavation and construction is generally conventional and costly. In Canada the Blairmore zone of high water pressure and unstable formations necessitated freezing in advance of excavation and tubbing. Similar difficulties were experienced in Yorkshire, England.



Slide 2

Room and Pillar Underground Scene

The economics of underground room and pillar mining is dependent considerably upon the thickness of the potash bearing ore and how level is the ore zone. A thin sylvinite or other potash bearing ore zone necessitates also mining sodium chloride above and/or below the sylvinite which dilutes the grade of ore that is elevated to the refinery. Equally difficult and expensive is a badly faulted mine, necessitating the excavation of undue debris in order to operate mobile equipment or to install belts. About half of the total ore is removed during the initial mining, depending upon mine depth, roof condition, etc. Secondary mining can increase the removal of ore to the 80-90% range after which the roof gradually settles.

Continuous Miner Scene

More recent installations use continuous mining machines instead of drilling and blasting, because of the capability of liberating up to five tons ore per minute, and with less possibility of roof collapse. Mechanical loaders gather the ore, whether freed by blasting or by continuous miners. Conveying from the mine face to the hoist shaft has traditionally been by rail cars.

Belt Haulage

Belt haulage is more economical and is rapidly replacing rails, especially as the distances increase from mine face to hoist shaft. Mine maintenance and other underground services are usually serviced from facilities located underground. Working conditions, including safety, temperature, freedom of harmful dust, services and mechanization are favorable in most potash mines.

Solution Mining

Solution mining involves complex phase chemistry as well as large amounts of increasingly expensive fuel to evaporate the brine unless solar ponds can be used. The main advantage of solution mining is ability to mine deposits without regard to overburden and at depths impossible by shaft mining. Drilling costs for identifying the ore zone as well as for production holes is high.

Brines

The recovery of potash from brines is practiced in only a few locations, most notably the Dead Sea where the net evaporation rate is exceptionally high. At both the Dead Sea and Great Salt Lake, brine is taken from that part of the "Lake" where retention has been longest and thus brine concentration the highest.

Flotation Cells

Let's talk about beneficiation and refining. Here an operator is observing the overflow of a flotation cell. The flotation method of refining is the most widely practiced and economical method of recovering sylvite (KCL) sylvinite, which as stated is a mixture of potassium chloride and sodium chloride crystals with some attendant clay slimes and other impurities. Flotation, as the name suggests, is a method of floating off either the potassium chloride or the sodium chloride. Potassium chloride is now believed to be universally floated off.

Flotation

The steps of flotation include the following:

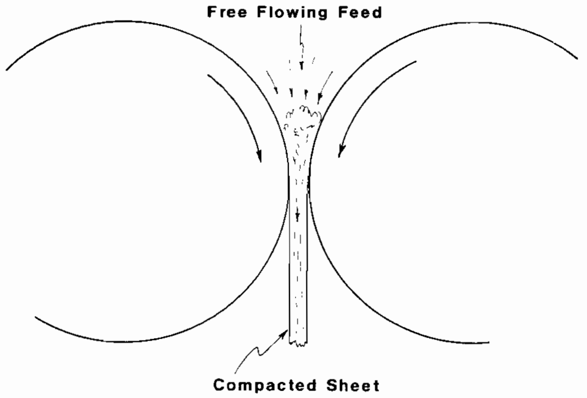
1. Crushing, classifying.
2. Adding a saturated brine of NACL and KCL producing a pulp.
3. Wet grinding the ore to a size that liberates the potash from the sodium chloride crystals.
4. Adding an amine to make the potash more hydrophobic, a blinder to depress slime flotation and an alcohol as a frothing agent.
5. Diluting with brine to 20-25% solids.
6. Introducing to a series of rougher flotation cells, providing agitation and the addition of air which adhere to the sylvite particles and cause them to tend to float to the surface. The sylvite float is raked off mechanically from the top of the flotation cells. This flotation process in the rougher cells is repeated, in usually five cells.
7. The flotation concentrate harvested from the top of the rougher cells contains a high percent of potash but also some sodium chloride. For that reason the harvested flotation concentrate is introduced to a "cleaner" flotation circuit which further refines the potash.
8. The potash is then dried either in rotary dryers or in fluid bed dryers.
9. The dried potash is then screened according to the sizes chosen to be marketed, i.e. special standard, standard, coarse, and in some cases also granular.

Compaction

Most producers supplying the bulk blend market, screen out their finer fractions of their composite product and compact it in equipment that produces a "board" of potash which is then broken and screened. The oversize is recycled for further degradation, and the fines recycled to compaction and the onsize particles coneyed to product bin or directly to hopper car. Both flotation and compaction involve considerable chemistry and mechanics. There is, however, substantial art to achieving high recoveries, good production rates and stable compacted granular product.

Compaction Rolls [Slide 3]

The compaction machine consists essentially of a set of two, powered, inward turning rolls. One roll has a fixed bearing, the other is floating in a slide arranged so that it can be forced toward the fixed roll by hydraulically actuated pistons acting on the bearing blocks. The material to be compacted is fed continuously into the nip of the rolls from above. Very high pressure can be exerted on the material as it is forced, or drawn, between the rolls where a momentary phase change to a plastic flow condition takes place. The crystals are fused together into an almost continuous sheet ejected beneath the rolls.



Slide 3

Photo White Potash

Flotation product muriate of potash analyzing typically 60.0-62.0% K_2O and usually reddish color because of presence of iron oxide is satisfactory for use in granulated or blended mixed fertilizers or for direct application. A recrystallized product as seen here is preferred by some in full liquid mixed fertilizers and for most industrial uses. A double refined potassium chloride is usually used in production of KOH, potassium hydroxide.

Equations [1] and [2]

Langbeinite ($K_2SO_4.2\ MgSO_4$) is separated from sylvinite and sodium chloride by selective washing, froth flotation or heavy media to obtain the product sulphate of potash — magnesia, potassium sulphate can then be produced by reacting one molecule of langbeinite with four molecules of muriate of potash. The reaction to produce potassium sulphate from langbeinite is as shown in these two equations:

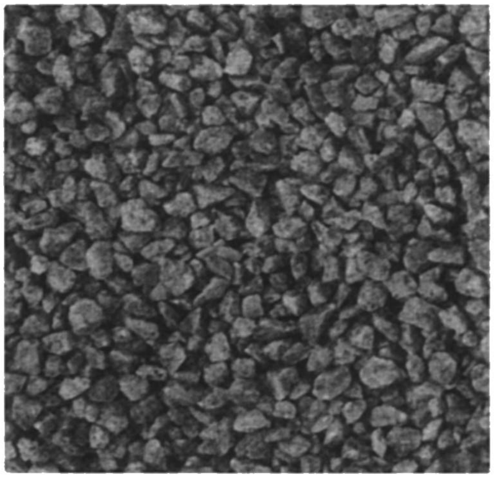
Photo Waste Pond

The beneficiation process incurs mine waste by-product sodium chloride brine which is usually pumped to a storage, constructed with earthen retaining wall, to gradually solidify as the entrained water evaporates.

Particle Size

During much of the history of potash production in Europe and North America, particle size was of little consequence, each company shipping for agricultural purposes the size range most easily produced, approximating what is now classified as "standard" grade.

The advent of "bulk blending" led to the need for "granular" materials. Coarse grade potash was originally introduced as an aid to granulation, and was first used and continues to be used to some extent in blends. Introduction of granular di-ammonium phosphate and other materials which were largely in the 6-14 Tyler mesh range led to the need for potash of similar particle size to avoid serious segregation of materials following mixing, i.e. during subsequent handling and spreading.



Slide 4

Photo Granular Potash [Slide 4]

Here is an example of granular potash. Gradually the potash industry, in North America especially, is increasing its compaction capacity to produce granular grade. Likewise blend plant owners are more generally recognizing the need for using potash of size similar to other granular materials in the mixture.

(1) $K_2SO_4\ .\ 2\ MgSO_4$ LANGBEINITE	$+ 4KCL \longrightarrow$ MUR. OF POTASH	$3K_2SO_4$ + POTASSIUM SULPHATE	$2MgCL_2$* MAGNESIUM CHLORIDE
(2) $2\ (K_2SO_4\ .\ 2\ MgSO_4)$ LANGBEINITE	$+ 2KCL \longrightarrow$ MUR OF POTASH	$3(K_2SO_4\ .\ MgSO_4)$ POTAS.MAGNESIUM SULPHATE	$+ MgCL_2$ MAG. CHLORIDE

*DISCARDED

Photo Granular Potash—DAP [Slide 5]

Which is demonstrated in this photo of a DAP and potash mixture. In Europe the West German plants have compaction units. The potash industry in the U.S.S.R. intends to increase the proportion of granular product to 75% of total output where only about 1.0 million tons per year were produced in 1977.

In the relatively short history of the potash industry, technology has developed to produce potash having specifications required for the various methods of mixed fertilizer manufacture and for industrial uses.

Thank you. (Applause)

Slide 5

MODERATOR SPILLMAN: Thank you Rodger. We appreciate your most interesting discussion on "Potash Production". (Applause)

It is 3:00 P.M. I just received word from Chairman Nielsson that Secretary of Agriculture, Robert Bergland, has just arrived at the hotel and will be ready in about five minutes to deliver his "Keynote Talk". Why don't we stretch our legs a bit? We will continue with the remainder of our afternoon's program immediately on completion of Secretary Bergland's Keynote Welcome.

Here they come. Frank has welcomed the Secretary and they are now coming up front. Everyone in the room gave lots of standing applause. It was a great honor for me to shake hands with the Secretary and thank him for taking part in "Our Program". Chairman Nielsson will now make the introduction.

Introduction Keynote Speaker
The Honorable Robert Bergland
U.S. Secretary of Agriculture

CHAIRMAN NIELSSON: You know that the Army takes Mississippi men, sends them up to New York and the Yankees cannot understand a word they are saying. Then, they send New Yorkers down to Mississippi, and they cannot understand the Yankee accent at all.

But, in reference to our guest, the President chose a farmer for his Secretary of Agriculture. This is so logical, it boggles the mind. Bob Bergland is the first farmer to serve as Secretary of Agriculture since Mr. Wickard in the Roosevelt days of 1940.

Mr. Bergland's farm consists of 600 acres, producing small grains and lawn seed. He has been Chairman of the Minnesota Agricultural Stabilization Conservation Service in 1961. In 1963, he moved to Washington to serve as Midwest Area Director for USDA's Agricultural Stabilization and Conservation Service. He was elected to the House of Representatives in 1970 and was re-elected in 1972, 1974 and 1976. In the House he was Chairman of the House Agricultural Committee on Conservation and Credit. He was a member of the Agricultural Committee Sub-Committee on Livestock and Grains and Dairy and Poultry. Before being made Secretary of Agriculture on December 20, 1976, he was a ranking Democratic Member of his two Sub-Committees on the House Small Business Committee, the Small Business Administration Legislation and Commodities and Services. He was a Congressional Advisor to the 17th Session of the F.A.O. Organization Conference in Rome in 1973 and he was a Delegate from the House of Representatives to the U.S. Conference on Trade and Development in Nairobi Kenya in 1976. The above remarks indicate that our guest has been around, he knows who is on first base, and he knows what the score is. So, a big welcome to the boy from the farm who made it good in the big city, our Secretary of Agriculture, the Honorable Bob Bergland. (Standing Applause).

The Honorable Bob Bergland's Speech.

Thank you very much, Frank, my distinguished friends. About 34 months ago I was home with my family in Northern Minnesota where we live and farm and have all my life; a place in which we have nine months of winter and three months of tough sweating; doing what every God-Fearing tax-paying patriot should be doing Sunday after church — watching Vikings football — when Jimmy Carter called and asked if I would consider taking a job in his just forming New Administration. I had just been elected to my fourth term in Congress, a high honor in itself, one which I was not about to cast aside lightly. I advised the then Governor that I needed to take this under some study. I went to a number of people, of course, including my wife first of all and my minister and then to my Dad. Dad is eight-five. Dad is a wise old man. I told Dad what was up, and he said that is the dumbest thing he ever heard in his life, in his own shy way. He said in spite of his advice, I would probably do as I was going to do anyhow, and in spite of his advice, I would probably take the job. He said, if you do, one thing don't you forget that no matter how hot the hen it takes 21 days to hatch an egg. I asked Dad, what kind of advice is that. Dad told me, there are certain biological limitations in this business. There are certain things that are going to happen in spite of Government or because of it. It was his experience in his lifetime in business and farming and other enterprises that there were the "Quick-Fix-Artists", who are going to propose a remedy for about everything that came along. In fact, there were some people he could name who had more solutions than there were problems. And that I must always resist the temptation to provide remedies or guidance or counsel to matters about which we had no control. And that it always took 21 days to hatch an egg. I thought that was sound advice and I have used that as one of the guiding principals in the 34 months we have been in this job.

I am told that I am going to be here until 4:00 o'clock. It's 6 minutes past three or there abouts. I have a few remarks I would like to bring to you to give you some measure of the world as we see it today, and then I would engage you in a discussion. There are microphones scattered here, and I am sure that there have been times in your life when you would like to take a shot at a Secretary of Agriculture. This is your chance. I just ask you to keep it verbal! I would like to hear from you. You may like to hear from me!

I do know this. You are a very, very vital live and important industry, which, from time to time, has either been vilified or ignored, but generally not understood. You are very much a part of a dynamic and changing world, and the demands upon you are going to be fierce, as they will be upon government and its many agencies and upon persons the world over. We need to be aware of limitations — that 21 days to hatch an egg, and other matters which we tend not to think about because, in government, at least, it is easier to engage in slogans that deal with symptoms and symbols, matter of substance. We, in the U.S.D.A. are trying to change all that. Some say 1928 was a good year. I know one thing, it is the year I was born, at a time when there was no such thing, really, as trade in agriculture or imported oil, at a time when there were two billion appetites in this world. During my lifetime practically everything important in the way of technological improvements in agriculture has taken place, been invented and been applied to the farm of the United States and much of the world. As a consequence of this technology, production in the land of the world has exploded mostly. Because of this technology and the resulting increases in fields, the two billion people that have come in my lifetime have been fed — some better and some worse. But, during my lifetime in these United States, the major farm problem, as defined by the people in the new world and elsewhere has been the so-called "burdensome surpluses". Having too much to eat was something of a drag, some people said as though having too little would be better. Again, slogans and symbols. Nonetheless, indeed the application of this technology in the farms of the United States, in my lifetime, has resulted in a productive explosion, the likes of which the world has never seen. So, we have a surplus of land because the bounty of that production could not be sold or given away at any price. We have resorted, for the most part, to land retirment schemes, soil bank, acreage allotments, marketing quotas, devices of all kinds all intended to do the same thing, to put land in reserve — a land bank, land which we, for the moment, did not need but someday might have to call upon. We invented food aid programs designed primarily to get rid of surpluses. And of that grew Public Law 400 — load rice on a boat, get it away from our shores. From thereon, we cared sort of, but not much. If the boat sank, we would send another. We invented the Food Stamp Program and the School Lunch Program, and so it goes on and on. Suddenly, six or seven years ago, we became aware of something that had not really thought much about — the Russian grain sale. Soviet Union had a bad crop and they entered the markets of the United States in a matter of a few days, purchased the world's reserves of wheat. Our price went up, and the next year, we had a bad crop. We suddenly paid attention to what had been taking place quietly and without much notice; namely we were engaged in trade the world over.

Then the Arab oil embargo struck, and the whole question came to center stage. Now we have been making changes in programs and policies to accommodate the dimensions of the real world. The impact of OPIC upon the economy of the United States is well documented. The rate of inflation in this country is largely determined by a group of persons over whom we have little or no control. There are some who would violate the 21 day rule, if they could. Turn the calendars back, maybe, and all will be well. Pure fantasy. In my judgement we need to look carefully at what is happening to this world and manage and guide our resources, public and private in such a way as to be able to accommodate this change. The world's population is still growing at the rate of 215,000 a day, but it is slowing down. With the slow-down in this population growth rate comes an increase in the per capita income. We are looking at of course, Cambodia with the tragedy reported there, but, beyond that there are perhaps 800 or so million people in this world who are too poor to buy anything from any producer, foreign or domestic. Instead of depending on charity to provide those persons with the where-with-all to expand themselves, our foreign policy under the present direction of President Carter is to go into those countries and teach those people how to build and run a better irrigation system, how to provide job opportunities in their own economy, is an infinitely better choice than charity. At the same time, develop trading positions and policies with the world which has brought about a significant change to our landscape. We no longer have land in reserve. Indeed in my lifetime we have paved over the equivalent of all the cropland in Ohio. At the rate we are going, we are going to pave over the equivalent of all the cropland in Indiana in this century. So, we need to examine the question of private rights and public interest. I own a square mile of land in Minnesota. The laws of my state enable me, entitle me, if I choose, to destroy that land. It's legal. We are now looking at the dimensions of limits in water. I have been out in West Texas. Many of you are from there, or service that territory. You know what is happening in the Oglala Resevoir from all the way from West Texas North to Wyoming. The draw down rate is twice the recharge rate. You don't have to be very smart to figure out what this means. Twenty-one day rule applies. The wringing of hands is an expensive luxury we can't long afford. We need to address the dimensions of water quality and water management in this country. Again like our land, a resource we have tended to take for granted. Then, to complicate matters, along comes the oil price increases and the impact it has on farming on the economy, your business and mine. Again, the 21 day rule applies.

We need, now, to look at ways and means of getting out from under the economic burdens and the political burdens imposed by the necessity of importing 60 billion dollars worth of oil each year and growing. We have established a new domestic policy in agriculture dealing with the question of exports. Time was when we depended on exports only when someone else's crop failed, but this year we will move 14 million tons of produce from the farms of the United States to markets abroad — a new all-time record high. The previous record was last year. Half of those exports will go to places like Europe, Canada, Japan — so-called Western Market economies. A third will go to the so-called developing world — mostly in Southeast Asia, Africa, Central and South Americas. The remainder, about one sixth goes to what we used to call Communist, but, now they have money, we call them centrally planned economies, now, the Soviet Union, People Republic of China, and their political allies. We are now looking at the dimensions of this trading policy. Ninety-five percent of these exports are paid for in cash, gold, convertable currency, not dependent on the facilities of P.O. 480 or some other active, international charity.

So, we are now looking at the global market as I think it should be, a common market. It means, therefore, that we will be pressing to buy and sell as a infinitely better choice than to build a barrier around ourselves and ignore the realities of a dynamic world.

That sort of policy is not without its problems, however, because it means that we do some importing, and it means we do some exporting. It means we put pressure on resources which heretofor had really been taken for granted. For every ton of corn we grow we have a net loss of two tons of top soil, using modern technology. Soil erosion is something that we are all against. It's like we are all against inflation and sin. Yet, we don't see it. It's not a dramatic windstorm that comes out of the Prairies of Western Kansas, or it's not erosion that gullies up the rolling countryside of West Tennessee. It's that quiet kind of leukemia. It will be the death of us. Yet, it goes unnoticed. It means, therefore, that we must focus our resources, our public facilities, and private enterprise in a joint venture, a joint effort, to mount an attempt, and sustain an attempt to deal with the reality of this increasingly dynamic world, recognizing the limits of our own resources.

It's fashionable for some to say, well, if we get the government out of our business, all would be well. That's another 21 day rule. It's more interesting than important. What we need to do is guide this government in a way that makes sense to deal with foreign political problems that you can't possibly cope with in private enterprise, where government can; to deal with the realities of drought and soil erosion and land policies in such a way as to make sense; to safeguard these resources to the extent they can be marshalled.

I am pleased to be here today with you. I know you have been talking about the fertilizer industry and technical problems associated with it. For 1980 there will be no set aside of any importance of any crop in the United States. We will have an increase of acreage planted to crops for growing international demand — something between 15 and 20 million acres above that which was committed this year. We have informed the leaders of the industry for several weeks that this decision was imminent so as to give you time to the best you can gear up for this additional demand, foreign and domestic. It is my hope that, as time goes on we can maintain this sort of liason so that, if you have problems in your vital industry that is so critical to the well-being of, not only the United States, by an increasingly hungry world, that we in government can do something about, please let me know. We in turn, will reciprocate if, indeed, there is something that we see coming that perhaps you may not be aware of but could do something about. Again, we like to be able to share these matters with you and see what we can do about harnessing the best and the brightest in public and private enterprise to attack some of these problems which transcend partisanship and transend our own roles, whereever and whatever they may be. So, with that, Mr. Chairman, I would like to spend the next half hour listening to you. If you have questions, I will do my best to answer. I can assure you, if I can't answer, I will tell you so. If you have advice to offer, I would like that too. We have two microphones in the aisles here. Who's first? (Applause)

Question and Answers To and From Our Honorable Secretary of Agriculture

QUESTION: Frank Achorn: With credit becoming difficult in all segments of the industry, ours and everyone else's, what assurance does a farmer have that he will be able to get farm credit? Will the price of money to the farmer become so exorbitant that we cannot grow the crops that we need to grow?

ANSWER: I don't know, for sure. I have talked with bankers, though, who have opinions about most matters. It seems as though the availability of credit will be assured. I have discussed this with the officials of the Federal Reserve System, who track agricultural credit needs and demands. I have talked with the leaders of the Farm Credit System that produce a big chunk of the farm credit now. It doesn't appear as though the supply of credit is in any kind of jeopardy. It does appear, though, that the cost is going to be higher than most of us would like. Now, we are re-examining the role of the Farmers Home Administration in all of this. It's sometimes believed that the small farmer is the one who's going to get hurt worse by the rising costs of credit. That's not true. We have about 7 million small farmers in these United States that don't depend much on the marketplace for anything, because they depend on a job in town — a good program. I have no fault with it. The ones who are probably going to get hurt the most are the types that were here in town to see me two years ago and were so anxious to come they came aboard their tractors — younger men and women, who have built a substantial enterprise largely on credit, and to whom rising costs of production become an overpowering burden. I have a farm I've had for thirty years, which Mom and I bought in 1950, and, because of inflation, we have a very handsome net worth. It isn't that I have earned it, but 100,000 of that we have earned and reinvested. The rest is inflation. Indeed, call it what we will, there are persons, 800,000 to a million or so, farming in this country that can cope with the rising cost of credit, because they have a financial base so secure and so strong. Indeed, the average debt to assets in this country is only 18% in agriculture. Now, there are some that are at 90%, and there are some, like me, almost zero — almost no debt. We make loans to persons who can get no credit elsewhere. We are limited by laws on how much we can lend per farm, of course, but, to the extent we can help those, we intend to. I have no problem — no, I shouldn't say that — I was going to say that I have no problem getting the necessary money. I shouldn't say that because I don't know what the demand is going to be. I may have problems, but we'll try. Okay? Another question, sir?

QUESTION: Lew Sullivan: My name is Lew Sullivan. I'm with Agrico Chemical Company, Tulsa, Oklahoma. You mentioned the 21 day rule, and it does appear that this country's going to be called upon to assume an ever-increasing role in supplying food to many other countries in the world. I remember another gentlemen saying some time ago that when you get the car up to the top of the hill, you don't take the motor out. The point I'm trying to make is that there is great concern about the decline in research — crop production and soil fertility research — at our land grant universities. I am wondering what your feelings are on that one, sir?

ANSWER: Agricultural research in the federal budget has been on a long, downhill slide since 1940, driven by the mistaken belief that we have "solved the farm problem." In that same period, we have seen state funded research hold its own even after accounting for inflation, but, during that same period, we have seen private research budgets explode. Private R &D budgets have more than made up for the flat performance of the federal research dollar. So, the total amount invested in agricultural research, marketing, production and development has, over the years, been increasing, largely because of private commitments. Many of you engaged in that. My view is that we ought not preempt private research and development with federal programs. My view, also, is that we ought not displace state university programs with federal activity.

There are 1,300 research budgets in the U.S.D.A. We use, under the direction of President Carter, the zero budgeting process as a management tool. Nothing, any longer, is taken for granted. In the course of our budget examination, we look at each of the 1,300 contracts. I have found that, in the first year we did this two years ago, there were many of these contracts that were obsolate. I cancelled them. Many contracts with state universities, in which the state and local taxpayers were putting up little or no money, the benefits of the enterprise were directed almost entirely to the economy or group of persons within that state. I cancelled those on the grounds that, if the local taxpayers didn't care, neither did I. I forced a complete examination of the federal role.

I can't talk about the '81 budget, because I'm not allowed to, but I can say, I think you will like it. What we are doing is examining very carefully those things which private enterprise cannot handle, looking at matters that are too expensive for state universities (one or more) to undertake, reserving some of these matters to an appropriate place in the federal research budget. I think we are going to be able to make a clear and convincing case that, for the reasons I have already cited — the land problems, the water problems, the fuel problems, and the world's market opportunities and all the rest — we are, by no means, out of the woods. We have demands coming at us that we have got to look at in a way that no one else can undertake. The miracle of genetic engineering is one which probably will provide us with yields beyond anything we contemplate in today's world of realism. These are things which we have not really come to grips with in a serious way, because we didn't need to. I mean, we had corn and wheat and soybeans and cotton coming out of our ears. Unfortunately, the federal decision process is tied to 12 month cycles, and that's too bad, but that's one of the realities of the business. I have no such thing as a 5 or 10 or 20 year budget. I have plans 5 years out, but only a 1 year budget. That's a limitation in the federal system that tends to inhibit our capacity to look ahead. I can assure you that we are aware of what you said, sir. The dimensions of your allegation are profound. First of all, your charge is true. Federal budgets have been taking a beating. I think we are on the way to turning this around. Yes, sir.

QUESTION: Rodger Smith: Secretary Bergland, my name is Rodger Smith. The previous speaker has the same point I was going to make. Let me comment that I have been on an industry committee that has worked with some of your immediate staff in trying to emphasize this point into developed programs between the fertilizer industry and the U.S. Department of Agriculture that would help to turn the tide and get more basic research. I think the only point I would like to add is that, as you pointed out, the fantastic developments in agriculture since 1928 have been partly as a result of the work done at the state universities and at Beltsville, in addition to what the machinery and pesticide people have done. I think we need to give every emphasis to this or else we won't have this balance of payments in the years to come.

ANSWER: Yes, sir. Your point's well taken. I don't think I need to comment because your assertion speaks for itself, and I agree with you, sir. Another one? Yes, sir.

QUESTION: I am Carlos Lago, American Cyanamid. My question is, I know that there are countries like Brazil that are trying to ferment corn for fuel, and it seems to me that the way we look at corn is just mainly as a food resource. If we were to look at corn as a fuel, we would be thinking about extra land for growing this crop. I would be thinking about some sort of incentive from the government to develop this. Are we heading in that direction? Do we have plans to face this problem?

ANSWER: Yes, sir, we do. We have studied the corn alcohol matter in great detail by the world's best scientists. There are two problems with it. One, the matter of economics. With the technology available today, and I stipulate that's today's state of the art, using $2.50 corn as a feed stock, using $105.00 a ton millers grain (which is its value in today's oil meal market), and using today's values for the other by-products, including corn germ and oils derived from various parts of the process, alcohol made from corn in today's economy would cost about $1.30 a gallon to produce. Now, even with gasoline at today's prices, the wholesale is about 72¢, and it just won't sell in today's economy. Now, we have a 40¢ a gallon federal subsidy on alcohol for motor fuel for highway purposes only, mind you. Keep that in mind. Some states have approved a state subsidy, so that in some states there's a dollar a gallon subsidy that goes into the enterprise, and then alcohol becomes competitive, provided you maintain that heavy presence. This is only for highway purposes.

The other problem with it is a matter of net fuel or energy gain. If you took the alcohol out of the ends of the spout and put it back in the boilers of the distilling process, you would wind up with a net loss. So, you have to have energy from some other source to run the distilling process — solar power, probably someday, coal power, most likely sooner; maybe other forms of energy. We are interested in our supporting financing research to see if there are other ways of converting fuels from these various residues and grains and the like without boiling it. We have contracts at University of Illinois, at Purdue, at Kansas State, and other places, looking at a whole range of ways of extracting usable energy from a number of these crops. We think waste crops are far more promising from an economic standpoint. We have animal wastes, corn husks, whey from the dairy industry, potato peelings and pulp, sugar cane residue and tons and tons of garbage, which we now bury or burn, that have within them certain reserves of energy, which we think can be converted to a liquid or gaseous fuel economically with today's technology. Part of the President's energy package pending in Congress would provide the financing mechanisms to undertake and underwrite some of these enterprises which, in today's markets, are admittedly a little risky. Banks are not sure about investing a hundred million dollars or more or less in something that's not been proven.

There's another dimension to this that we are examining at U.S.D.A. in addition to those I have mentioned — wood. We have about two billion acres of land in the United States that either is producing or is suitable for the production of wood, half of which is being used primarily as a feed stock for the paper industry for building material. We have never looked upon wood as an energy source in this country because we didn't need to. We are redirecting the research budget of U.S.D.A., particularly in the forest service area at our Madison Station and at University of Georgia and in other places, looking at the development and introduction of species of wood which can grow in our climates that are designed for one thing — improve the efficiency of gathering the energy from the sun and through the process of photosynthesis convert that to a fuel that we can use.

There's a billion acres of land in the United States which, in today's system, are not used for any commercial purpose whatsoever. We are now examining timber management in the context of solar farming. I don't know what this means for sure, because I am not a scientist. I know this. It's very probable that we will, in time, manage these lands in such a way as to plant them to species which are more efficient in gathering and converting sun's light on lands which are now of no value commercially. Undoubtedly, these plants are going to need to be fed, fed with fertilizers and fuel by the sun and around which new energy industries will arise. About that, I have no doubt. The only thing about which I am not sure is when this will come to pass. Again, I think it will depend on the state of the art and, again, it is terribly important that we fund the research capacity in public and private places to develop these resources, which we have really not thought much about. This oil business — we have just sort of taken for granted, like good health. I am not one that's prepared to spend much time wringing hands over OPIC. I think we need to get to the business of doing something about it. We can do something in our own country if we unleash the genius which is inherent and develop it. Yes, sir.

QUESTION: Walter Horn: Mr. Bergland, my name is Walter Horn. Regarding the sale of farmlands to foreign interests, what is your thinking on this? Any concern? Have you noted any effect on production from those lands?

ANSWER: About a year and a half ago, there was a worry that farmland is being purchased by foreigners, and it could become a national security problem. Congress passed a law which directed me to make a study of the matter we have almost completed. We had to go to the 3,000 county courthouses in these United States to get the information, because there's nobody who had to report to any federal agent. Any sale or transfer or lease of any property — these matters are governed by state laws. The search of courthouse records and the other kinds of things we did provided us with information not yet completely analyzed. So, what I am about to tell you is tentative. On the basis of what we now know, our estimates are that foreign ownership of land is less than ten million acres and probably less than five out of a total of 1.25 billion acres of privately held land in the United States. That represents a very, very small fraction of the total. The interesting thing is, much of this land has been owned for years and years. There are persons from other places in the world that have held land in the United States for more than 100 years. On the basis of what we now know, I do not believe that a threat to our national security does, indeed, exist. On the basis of what I now know, I would not recommend to the Congress that we pass a federal law to preempt the states on matters pertaining to who can sell what to whom. We will, though, give the information over to the states so that legislatures and governors can do with it as they choose consistant with the commerce clause of the Constitution.

We are looking at tax policy. I am examining another matter, which is purely federal, to see whether or not an investor from a foreign land has a tax advantage over an American investor in bidding for that land. There are 52, I think, tax treaties we now have with that many countries of the world. Tax reciprocity. To amend a tax treaty is no simple matter, and I am not sure we are going to recommend changes. At the moment, I do not regard this foreign land purchase problem to be a matter of any significance whatsoever to the United States as a whole and has had absolutely no measurable impact whatsoever on production. Yes, sir.

QUESTION: Jim Hart: Mr. Secretary, my name is Jim Hart from Kansas City. Transportation is absolutely essential to our industry. Recently, the Rock Islands had an extended strike. Prior to that, the Port of Duluth was on strike. A little earlier in your original comments, you alluded to the fact that if industry had any problems, you would like to know about it immediatley. What have you and our President, Mr. Carter, done to attempt to alleviate either one of those problems?

ANSWER: Well, I appointed a task force. That's the first thing you have to do in government. I got a good one — composed of ladies and gentlemen who come from the shipping, the carrier, the receiving, and other elements of the world of trade in agricultural produce movement, ladies and gentlemen who come from California handling perishables and others who are in the grain business, and the livestock business, and the fertilizer business, and others from various modes of the transport industry, to advise me on what, precisely, we ought to do about this. We are going to be making a report to the Congress, which is something that we always do too, in March. This probably will be a substantial and significant report, meaning no disrespect to others in government, because I have directed this task force to examine this question thoroughly and completely and with no preconceived notions, no limits, none whatsoever. It doesn't matter, well, it matters to me what the President says, of course, but I am not, in this case, bound by the provisions of the deregulation bill which has been submitted to the Congress. The task force has already discovered one thing which is no great discovery. We do not have a box car shortage in the United States at all — plenty of cars. We've got a problem with utilization. They run 15% of the time, and they stand 85%. Now, we need to look very carefully at why these cars are not being utilized.

I was out in Bondurant, Iowa recently at a substantial grain elevator, where they had the capacity to load and ship 55 carloads at a time. They load these things, hitch them up to power, and it goes on to Port of Houston, Texas for export. Takes 34 days round trip — 14 days running and 20 days standing — to load a train! Now, that's a problem. How, precisely, to increase utilization is something I don't yet have an answer for, but, if you do, we're all ears. The problem in the Rock Island is like we have with five or six other mid-western railroads. The I.C.C. calls it "cashlessness". I used to call it broke. They are not able to borrow money to invest in grades, tracks, equipment of any kind, electronic or otherwise. They're floundering. They have been for a long time. My guess is we're going to have to restructure the railroad industry. I have asked this committee to look at even the question of dependent communities in the context of branch line abandonment. I have no problem with abandoning a line that's a loser, if there's another mode available in the industry — trucks or barges or whatever. I am strongly in favor of generating competition between the trucks amd the railroads and the barge line operators. I think that produces the best in us. So, I, therefore, am in support of legislation which would abolish franchising and some of the arrangements and comforts and security provided by common carrier franchising and licensing. I am also aware of the potentially catastrophic effects upon the region of western Montana if the Milwaukee closes everything west of the Montana/North Dakota border. So, we are looking at it, again, from a dependent community standpoint. I am not one who thinks that a railroad should be kept just because it was always there, and it was laid out in the 1880's.

Our railroad network was laid out before anybody really thought about exports or imports. Now, we have an entirely different world. We need, in my judgment, to think about where is the tonnage going to go and come from as time goes on. Which is the most efficient mode? I don't think, for example, that we can long afford to ship lettuce from Salinas, California to New York by truck. I think there are better ways of doing it, and so we are urging alternatives — piggy-backing, roadrailers and a whole range of things, none of which is new exactly. We need to look at the railroads from a structural standpoint, because I don't think we can necessarily afford to have every town continue with railroad service they've been having in the past. I am of the view that the basic policy in this regard should be to use it or lose it, and that we find other ways of financing it perhaps. I don't know what all this might be. I am looking, for example, into the feasibility of creating a lending bank that could lend money to persons who want to buy out a portion of a railroad and operate their own. I am looking into the feasibility of restructuring railroads in the same way as we manage interstate highways; looking at the sense of running coal trains from Wyoming to Chicago through 1,200 small towns or grain trains from Kansas City to Houston, Texas through how many small towns, where they are not going to stop; looking into the feasibility of building a structure where we have those long distance, high speed lines running down the median strip of interstate highways leased back. Things like this, we need to examine carefully. Too much time has been spent complaining about the box car shortage and what we are going to do about it. That's the symptom of a much more important problem. We welcome your advice. Not today — it's too complicated to tend to in the few minutes we have. Any suggestions you might have, write to me or to Assistant Secretary Bobby Smith who heads up this whole agricultural railroad, truck and barge line study. Yes, sir.

QUESTION: My name is Ed White, I.M.C., Mundelein. I was told that a speaker from the Department of Agriculture advocated zero tillage at the World Food Conference in Argentina. This was advocated as a means of energy conservation. While it does conserve energy, on a per bushel basis or per ton, it's about the same as regular tillage and it does reduce the yield, the amount of grain available to feed the hungry. Is this now U.S.D.A. recommendations of policy?

ANSWER: It is not a U.S.D.A. recommendation. It is a matter which we are asking the state universities to study carefully. I don't know what the remedy might be, but I do know this. We cannot afford to lose two tons of topsoil with every ton of corn as a matter of public policy and get by with it in perpetuity. That won't go. We have soil losses running four to five tons per acre per year, but then the growing plant manufactures two and three tons. In spite of that, we wind up with a net loss. So, we are looking at that very carefully. What kinds of things can we do? I have been over in that soil type in west Tennessee, too, and I have seen what eight inches of rain can do on a 15° grade that has been planted with soybeans in the preceding year. I mean, it just won't go. Then, the question arises, what should the feds do about it. We are re-examining the A.C.P. cost sharing program to see whether this will do it. I don't think it will. I think it's a matter which is far more serious than just addressing it by trying to build incentives in programs and policies to encourage people to do what they should be doing anyhow. Frankly, I don't know the answer, but I do know that it's something that we have high on our list of priorities and agenda. Minimum tillage is only a practice which has been advocated successfully by some, and tried unsuccessfully by others. I think it's a practice which will fit in certain places under certain circumstances, but I do not recommend it as a cure-all.

I'm sorry, Frank, I am going to have to get on to another matter. I would prefer to stay here, but the 21 day rule applies again. Thank you very much. (Standing Applause)

CHAIRMAN NIELSSON: Thanks very much, Secretary Bergland for attending "Our 29th Annual Meeting". We appreciate your "Frank and Most Interesting Discussion and Answers to Our Questions." Moderator Spillman will take over the remainder of this afternoon program. (Applause)

MODERATOR SPILLMAN: Thank you, Frank.

Our final subject, "In Plant Energy Conservation", will be a "Panel Discussion." Our Panel Moderator Glen H. Wesenberg, really needs no introduction. He has appeared on "our programs" many times. Glen is Vice President of Process Engineering with Feeco International since 1955. He is a native of Wisconsin, is a graduate from Rivers Falls State College, River Falls, Wisconsin. He is a 1949 graduate with a B.S. Chemical Engineering degree from the University of Wisconsin and has contributed several papers to the Round Table. (Applause)

In-Plant Energy Conservation Panel

Russell C. Crom — Electrical
John L. Medbery — Mechanical
Robert E. Robinson — Fuel
***Glen H. Wesenberg — Process*
*** Panel Moderator*

MODERATOR WESENBERG: Good afternoon Ladies and Gentlemen. Our subject is the "In Plant Energy Conservation", and listening to some of the other presentations, the indication of concern is centainly very timely. We will h ave four presentations — Electrical — Mechnical — Fuel and Process. Some of the discussions will overlap in some of the "areas", however, the suggestions made are in an attempt to bring the attention to experiences of others and make suggestions for initiating or supplementing energy conservation programs. The present scope and trends provide some quantitative comparisons of various energy values with commonly known values.

After the four presentations we will have the question and answer period and we would like then, to have those in our audience give their suggestions and contribute with steps that they may have taken or are proven.

At this time I would like to introduce the speaker that was very receptive in 1976, and he has come back for an encore. He is a graduate of the University of Arkansas with a B.S. degree in "Electrical Engineering". He worked with Westinghouse for six years, and since 1955, has been with I.M.C. in various positions in the Headquarters and in the Field. He was a Production Manager in the nitrogen facility and the company Electrical Engineer. He travels extensively, does a lot of trouble shooting and advising. He has two patents in the mining mechanical area. He is now a Technical Consultant for the Fertilizer Group for I.M.C. I would like now to present Mr. Russ Crom. (Applause)

In-Plant Energy Conservation Electrical

Panelist Russell C. Crom

It is an honor to be on the same program as the Secretary of Agriculture, but it is sure a tough act to follow. Nevertheless, I join all of you in expressing appreciation to the Honorable Robert Bergland for being with us. I also want to express thanks to all of you who have remained in the audience because I know that you are truly interested in energy conservation or you would not be here.

For those of you who do not have telescopic eyesight, I am holding the cover of Cracked Magazine. It has a picture of frightened people in the center and the caption, "Don't look, it's too scary." It seems to me that this is the way we are with the energy situation. We are afraid to really look because it is too scary. What does a kid's magazine know about energy conservation? Let's look inside. Here we have a large photograph of an electrical switch which has "OFF" on both sides. No matter whether you flip it up or down it is off. Could we please turn off the lights. No, I am not going to show a bunch of slides — the projector takes electricity and this is an electrical energy conservation session. If you do not remember anything else I say today, remember this concept. If it uses electricity and you don't need it, turn it off.

In checking with this hotel I find that the lights behind this curtain and the side-lights cannot be turned off without calling an electrician. In checking our own plants we want to make sure that the operators have switches so that lights can be turned off.

Generally speaking, electricity is a necessary evil to the fertilizer industry. It is something we have to pay for and we can not get along without. Even if we were to completely wipe out the total cost of electricity in our fertilizer industry, it would have less than a 5% impact on the retail price. Considering the relatively small portion of the production cost of fertilizer, is it really worthwhile to spend our time in trying to conserve electricity? Let's do some simple arithmetic.

According to market reports, it is anticipated that 50 million product tons of fertilizer will be used in the United States next year. It is also estimated by TVA that each product ton requires about 168 KWH. Multiply these two figures together and we come up with 8.4 billion KWH. In this day and age with the folks over on Capitol Hill throwing billion dollar figures at us every day, we tend to become insensitive to big numbers. Remember the 8.4 billion was the total consumption. Obviously we can not get along without all of it, but what if we could save 10% of the 8.4 billion. This would give us 840 million KWH, which is still a big number. How big is it? Since we have all had the pleasure of waiting in a long line to get up to a gasoline station, let's convert KWH to gallons of gasoline.

To do this we should first recognize that the production of electricity is an inefficient process. The promoters of electrical heat will be quick to tell you that it is 100% efficient in the home, but they seldom mention the fact that the average utility efficiency is only about 30%. If you start with the raw energy into the power plant, by the time that it is finally delivered into usable electricity into the plant or the home, the losses are 70%. Considering the utility system at 30% efficiency, a conversion factor of 3412 BTU/KWH and 120,000 BTU per gallon, gives (if I have done my arithmetic correctly) 79.6 million gallons of gasoline. Recall that this is only 10% of the electricity used by the fertilizer industry. Now we are back to a number that is so big that it is beyond our comprehension. One way to look at it would be to say that if we put an EPA driver in one of these modern economy cars, that he would be able to make 14 round trips to the sun. This example is a bit far fetched, since Congress has not even appropriated money for a highway yet. More realistically it is possible that someone in this group has exceeded the 55 mile per hour speed limit. And possibly for this transgression, along with a few others, you may go to hell. Now if your first assignment in hell would be to get in your gas guzzler and drive at 75 miles an hour until you used the 79.6 million gallons of gasoline, it would take you 1800 years before you get your next assignment.

Some of you may be thinking that it would be ridiculous to burn gasoline in a power plant. You are right. It would be ridiculous to burn gasoline in a power plant. But it is even more ridiculous to burn natural gas in a power plant and we are doing that every day. In addition, we have many megawatts being generated by oil, in spite of the efforts to cut down on the use of oil and the oil imports.

For those of you who keep track of the big picture, you will recognize that 79.6 million gallons of gasoline is relatively small compared to the national energy problem. The point to be made is that even though it is small, if everyone does his part we will be able to get on top of the big problem. Euclid's axion, "The whole is equal to the sum of its parts," is as applicable to the energy situation as it is to geometry. When you look at individual cases, power bills will often be found to be significant. IMC has one operation where the power bill has exceeded $2 million per month. I submit that if we were not trying to minimize this expense that we would not be responsible people. We are doing something and I know that most of you are doing something. Let's look at some of the ways that we can go about saving 10% of our electrical energy utilization.

The first place to look is motors. One motor manufacturer, Gould, has had the guts to take the lead in developing high efficiency motors. I have a package of information distributed by Gould that is entitled, Electric Motor Efficiency Can Be Improved 10 to 12%. This is an excellent presentation and I commend it to you. If somebody had not turned the lights out maybe you could see this folder, but just to prove that we can get along without them, let me describe this to you. It is a blue folder and it is identified as Department of Energy Publication DOE—US 0003. Gould led, but GE, Westinghouse, Reliance and other manufacturers have followed suit. High efficiency motors cost more but they will give a return on our investment and at the same time save energy. At present costs, high efficiency motors will have a payback period running from three to five years. Smaller motors show greater improvement while larger motors have lesser improvement, but still the return on investment is there and the savings in electricity is real.

The DOE estimates that 76% of the industrial load in the United States is motors. So you can see if we save 10 to 12% in motor efficiency that we have gone a long way in reaching our 10% conservation goal. At this point we should not be deceived by following a mirage. A 10% reduction in motor efficiency does not equate to a 10% reduction in power used. With motors being the bulk of the load, here is where we have the greatest opportunity to save electricity. Mr. Wesenberg only gave me 15 minutes and it could easily all be spent on motors. Perhaps we can get back to more detail during the discussion period. I want to talk more about motor loading.

Now let's move on to lighting. The nicest thing that has happened to lighting in recent years is the high pressure sodium vapor lamp. As an example of what high pressure sodium can do, take a look at road lighting or area lighting. The old fashioned approach was to use a 400 watt mercury vapor light. The color quality of the mercury vapor is miserable but it was a substantial improvement over incandescent lighting. You can replace a 400 watt mercury vapor lamp with a 200 watt high pressure sodium lamp and have the same number of lumens output from the fixture. This is an example of a 50% savings and the color quality is better.

Improvements are not limited to area lighting. At this time I am not prepared to make a recommendation on office lighting, but General Electric, Westinghouse and Sylvania are all aggressively working to improve lighting. Working with one of these vendors, one of our purchasing agents decided to try an experiment. He selected a floor and with the emphasis on quality, started reducing the number of fluorescent tubes. He worked with the maintenance department on this project on evenings and week-ends and did not tell the people that they were part of an experiment. He reduced watts input by 1/3 and no one even noticed the difference. At the 1/2 level a change was noticed but he continued because people liked what he was doing. He now has two tubes per fixture where previously there were six. Here is a commendable example. Quality has replaced quantity. Power input has been reduced by a factor of two-thirds, colors are natural, glare has been almost eliminated and the ladies are illuminated to show their natural beauty!

Even without improvements in lighting it would be a simple matter to go through our plants and offices and cut out at least 10% of the lighting. Lighting is something, in my opinion, that has been greatly over-done. In the '30s any office or school that could afford 50 foot candles was considered to have good lighting. Not only that, we had no more eye troubles then we do now. In the war years of the '40s it was found that blackouts were tolerable and street lights were not needed. But in the '50s and '60s, along with the gas guzzling car, we became obsessed with high intensity lighting. Illuminating levels of 150 foot candles became a standard and along with it came glare problems. After you have reduced the lighting by 10%, don't forget that even these can be turned off. When the light is not needed, turn it off. It is true that bulb life is somewhat dependent on the number of starts. While there is discussion about bulb life and the number of starts, there is no argument about electrical consumption. If you turn the switch off, the light is not using any electricity.

The "turn it off" concept is not limited to lights. It is applicable to many items. As an example, an empty conveyor takes 30-40% of the full long current. Some operators may object to turning equipment off because of starting problems. In such cases maintenance would be a good investment.

In most plants the KWH usage per ton goes down with increasing throughput. This suggests that in the interest of electrical conservation that it would be best to schedule maximum production for a period followed by total shutdown for a day or two. Now before someone throttles me, let me quickly acknowledge that if you are on a rate structure that requires load factor control that this might be counter-productive. Also, some processes such as ammonia are not suited to this type of operation. It is something that would have to be studied in each case.

Electrical conservation efforts should include power factor correction. In the application of power factor correcting capacitors you want to get the most for your money. The greatest benefit is in conserving dollars spent for electricity. Because of the adverse effects of low power factor on generating equipment and transmission systems, utilities usually charge a penalty for poor power factor. It is not uncommon to find that capacitors will pay for themselves within a year or so. The main input comes by reducing the penalty and not because of a reduction of KWH's used. For this reason it is often better to invest in relatively large banks of capacitors rather than individual capacitors for each motor.

In earlier comments I mentioned that electrical heat is inefficient as far as raw energy consumption is concerned. So if there is any way that you can replace electrical heaters with process heat or heat from a boiler, it makes more sense to do it. Unfortunately, we must always consider capital and frequently you will find that electrical heating requires the least capital investment. But if we are going to conserve energy this philosopy needs to be questioned.

Transformers are not normally considered users of electricity. They are part of the distribution system and their efficiencies are generally very good. It is not uncommon to find transformers with efficiencies in the 98-99 percent range. However, if you consider that we are trying to save at least 10% on the losses, or save at least 10% of the kilowatts being used by every device, it becomes a realistic goal to save 10% of the transformer losses. Therefore, with a 98% efficiency transformer, the losses are only 2%. Then if we look at saving 10% of the 2%, this is only 2/10 of a percent. This is a possible achieved goal. And here again it is necessary to balance how much do we want to pay for the transformer against how much it will save. Recently I have had vendors call on me who are pushing high efficiency transformers. May & Christie is one. Compared to conventional dry type transformers, the cast coil transformer is an item that should be considered for new installations.

This brings us to the last item, which in this case is the least item. Losses in electrical wires are relatively small. However, in the design of new plants this is a factor that also offers the possibility of a 10% improvement.

So in reviewing, the ways that we can save electricity are with high efficiency motors, intelligent application of new lighting developments, proper application of power factor correcting capacitors, proper loading of motors, application of high efficiency transformers and adequate wiring. And most of all, if you don't need it, turn it off.

Thank you. (Applause)

MODERATOR WESENBERG: Thank you Russ. I guess we won't have to turn them back on just yet.

MODERATOR WESSENBERG: At this time, I would like to introduce to you a gentlemen who is a University of Minnesota graduate. He is well known to most of you. He has been on the program a number of times. Since 1952, he has been with I.M.C. He is currently the Director of Production of the Rainbow Division. I would like to introduce Mr. John Medbery. (Applause)

In-Plant Energy Conservation Mechanical

John L. Medbery

Good afternoon. The subject of my topic is "Inplant Energy Conservation - Mechanical". As I planned my presentation, it became apparent that the subject was much too broad to be treated properly in the ten minutes assigned. Accordingly, I have tailored my remarks to deal with a concept called methods improvement, a device which can be employed by anybody to seek out the most efficient way to accomplish a piece of work.

I plan to present a very simple example of how a methods improvement study can be used to save energy. The energy which is conserved is diesel fuel. The machine involved is the front end shovel loader, the most universally used, and misused, of all mechanical devices employed in manufacturing and shipping fertilizers.

Loaders come in all sizes. Some are fueled by gasoline, some by LPG, and some by diesel oil; however, they all consume energy. They are used in every one of the some 9,000 fertilizer plants in the U.S. today, including blending plants, fluid mixing plants, granulation plants or large nitrogen or phosphate complexes.

Any significant reduction in operating time or in cutting the distances traveled in the performance of a piece of work will save fuel. It will also cut manpower costs, maintenance expense, and possibly other energy costs too. I propose to show how this can be accomplished by using a simple methods improvement tool called the "process chart".

The process chart is a paper upon which is listed each step in the performance of a certain job. The time it takes to do each step is determined and where travel is involved, the distances are measured. A chart is prepared for the method currently in use. This is called "present method". After some thought, ways are seen to improve the manner of doing the job. Then another chart is prepared called the "proposed method", which incorporates the improvements.

Each step in the process is identified by a symbol on the chart. A circle represents an operation, the arrow symbolizes a transport step, the square is an inspection, the "D" represents a delay and the triangle is a storage step.

It is also necessary to prepare a flow diagram (Figure 1). This is a simple drawing showing the plant layout and depicting the actions required to accomplish a certain piece of work. In my example, we have a typical small bulk blend plant. Four raw materials are stored, but only two will be used.

The plant will mix two two-ton batches of 9-23-30 to fill a four-ton spreader order. Fortunately, the loader has a large bucket, or more travel would be required. The mixer and weigh hopper are sized for two-ton batches. Conveyors transfer the batch from the weigh hopper to the mixer and from the mixer to the truck.

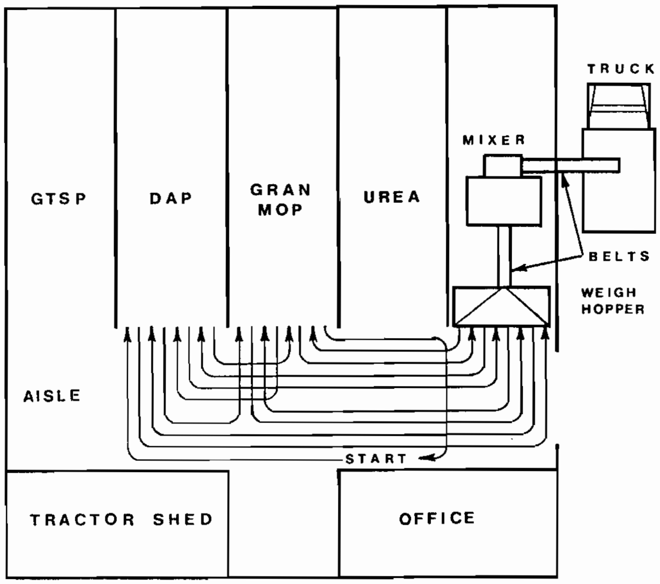
All batches must be made to weight and excess materials returned to the bins. The paths traveled by the loader are indicated by the lines with the arrow ends. The person making the study can re-enact the procedure and pace off the distances on the plant floor. After two two-ton batches have been made, we determine that the loader has traveled a total distance of 880 ft.

The sequence of steps is listed on the Process Chart, Present Method (Figure 2). Each step has been timed to the nearest one-tenth minute. The distance for each transport step is also recorded. The total elapsed time and total distance traveled is then determined.

It was decided that the operation could be made more efficient if a compartment hopper was provided over the scale hopper and an elevator be installed to fill the hopper via a swivel spout. The swivel spout and hopper gates would be controlled by the loader operator, therefore no more labor is needed. This is depicted on another flow diagram (Figure 3).

FLOW DIAGRAM
PRESENT METHOD

Figure 1

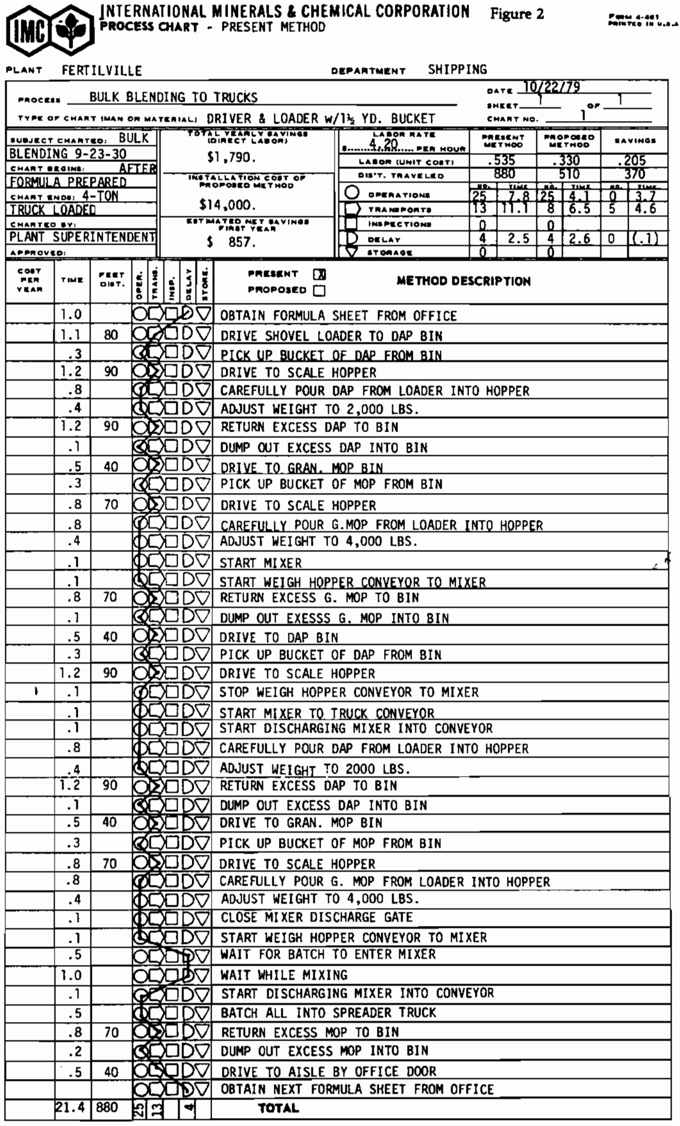


By eliminating the need to return excess materials to the bins, the number of transport steps is cut from 13 to 8 and the distance traveled is cut from 880 ft. to 510 ft.

The sequence of steps is listed on the Process Chart, Proposed Method (Figure 4). The total number of operations has been cut from 42 to 37. The time required to perform the job has been cut from 21.4 minutes to 13.2 minutes.

The savings have been itemized (Figure 5). They consist of savings in labor, fuel, maintenance and electric power and total almost 36 cents per ton. The energy savings amounts to over 10,000 BTU per ton.

A cost reduction report is prepared which describes both the present method and the proposed method (Figure 6). The costs are detailed and the economic feasibility of the investment in new equipment is determined. If the cost of labor and energy were to remain at current levels, this project would require 16 years to pay for itself. However, assuming a 10% per year inflation rate applying to both labor and energy, the return on investment is quite good and the pay-out will occur in about 8 years.



INTERNATIONAL MINERALS & CHEMICAL CORPORATION Figure 2
PROCESS CHART - PRESENT METHOD
FORM 4-461 PRINTED IN U.S.A.

PLANT FERTILVILLE DEPARTMENT SHIPPING

PROCESS BULK BLENDING TO TRUCKS
DATE 10/22/79
SHEET 1 OF 1
TYPE OF CHART (MAN OR MATERIAL) DRIVER & LOADER w/1½ YD. BUCKET
CHART NO. 1

SUBJECT CHARTED: BULK BLENDING 9-23-30
CHART BEGINS: AFTER FORMULA PREPARED
CHART ENDS: 4-TON TRUCK LOADED
CHARTED BY: PLANT SUPERINTENDENT
APPROVED:

TOTAL YEARLY SAVINGS (DIRECT LABOR) $1,790.
INSTALLATION COST OF PROPOSED METHOD $14,000.
ESTIMATED NET SAVINGS FIRST YEAR $ 857.

LABOR RATE $ 4.20 PER HOUR	PRESENT METHOD		PROPOSED METHOD		SAVINGS	
LABOR (UNIT COST)	.535		.330		.205	
DIS'T. TRAVELED	880		510		370	
	NO.	TIME	NO.	TIME	NO.	TIME
○ OPERATIONS	25	7.8	25	4.1	0	3.7
⇨ TRANSPORTS	13	11.1	8	6.5	5	4.6
□ INSPECTIONS	0		0			
D DELAY	4	2.5	4	2.6	0	(.1)
▽ STORAGE	0		0			

PRESENT ☒ PROPOSED ☐

COST PER YEAR	TIME	FEET DIST.	OPER.	TRANS.	INSP.	DELAY	STORE.	METHOD DESCRIPTION
	1.0							OBTAIN FORMULA SHEET FROM OFFICE
	1.1	80						DRIVE SHOVEL LOADER TO DAP BIN
	.3							PICK UP BUCKET OF DAP FROM BIN
	1.2	90						DRIVE TO SCALE HOPPER
	.8							CAREFULLY POUR DAP FROM LOADER INTO HOPPER
	.4							ADJUST WEIGHT TO 2,000 LBS.
	1.2	90						RETURN EXCESS DAP TO BIN
	.1							DUMP OUT EXCESS DAP INTO BIN
	.5	40						DRIVE TO GRAN. MOP BIN
	.3							PICK UP BUCKET OF MOP FROM BIN
	.8	70						DRIVE TO SCALE HOPPER
	.8							CAREFULLY POUR G.MOP FROM LOADER INTO HOPPER
	.4							ADJUST WEIGHT TO 4,000 LBS.
	.1							START MIXER
	.1							START WEIGH HOPPER CONVEYOR TO MIXER
	.8	70						RETURN EXCESS G. MOP TO BIN
	.1							DUMP OUT EXESSS G. MOP INTO BIN
	.5	40						DRIVE TO DAP BIN
	.3							PICK UP BUCKET OF DAP FROM BIN
	1.2	90						DRIVE TO SCALE HOPPER
	.1							STOP WEIGH HOPPER CONVEYOR TO MIXER
	.1							START MIXER TO TRUCK CONVEYOR
	.1							START DISCHARGING MIXER INTO CONVEYOR
	.8							CAREFULLY POUR DAP FROM LOADER INTO HOPPER
	.4							ADJUST WEIGHT TO 2000 LBS.
	1.2	90						RETURN EXCESS DAP TO BIN
	.1							DUMP OUT EXCESS DAP INTO BIN
	.5	40						DRIVE TO GRAN. MOP BIN
	.3							PICK UP BUCKET OF MOP FROM BIN
	.8	70						DRIVE TO SCALE HOPPER
	.8							CAREFULLY POUR G. MOP FROM LOADER INTO HOPPER
	.4							ADJUST WEIGHT TO 4,000 LBS.
	.1							CLOSE MIXER DISCHARGE GATE
	.1							START WEIGH HOPPER CONVEYOR TO MIXER
	.5							WAIT FOR BATCH TO ENTER MIXER
	1.0							WAIT WHILE MIXING
	.1							START DISCHARGING MIXER INTO CONVEYOR
	.5							BATCH ALL INTO SPREADER TRUCK
	.8	70						RETURN EXCESS MOP TO BIN
	.2							DUMP OUT EXCESS MOP INTO BIN
	.5	40						DRIVE TO AISLE BY OFFICE DOOR
								OBTAIN NEXT FORMULA SHEET FROM OFFICE
	21.4	880	25	13		4		TOTAL

Actually the two-component blend used in the example is one of the simplest to prepare. If three or four materials were used, the savings through use of the cluster hopper would increase and the pay-out would occur much sooner.

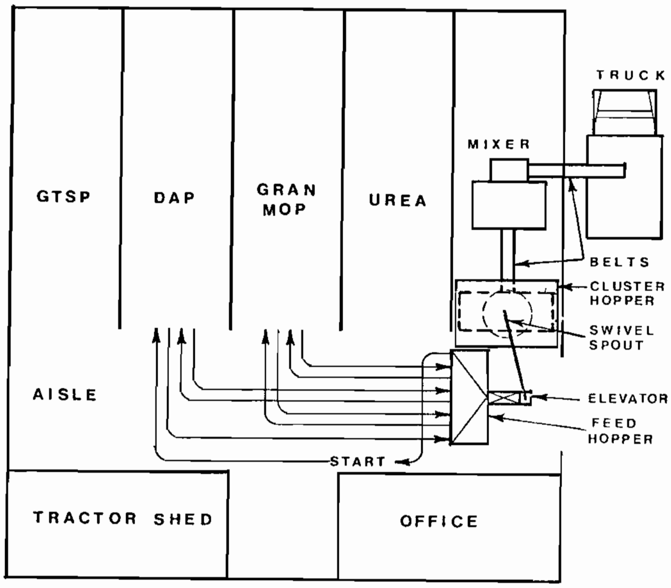
Please realize that the purpose of this paper was to present a tool, Methods Improvement, which can be used by almost anybody, but which can be used effectively to pinpoint and explore energy savings opportunities throughout the plant.

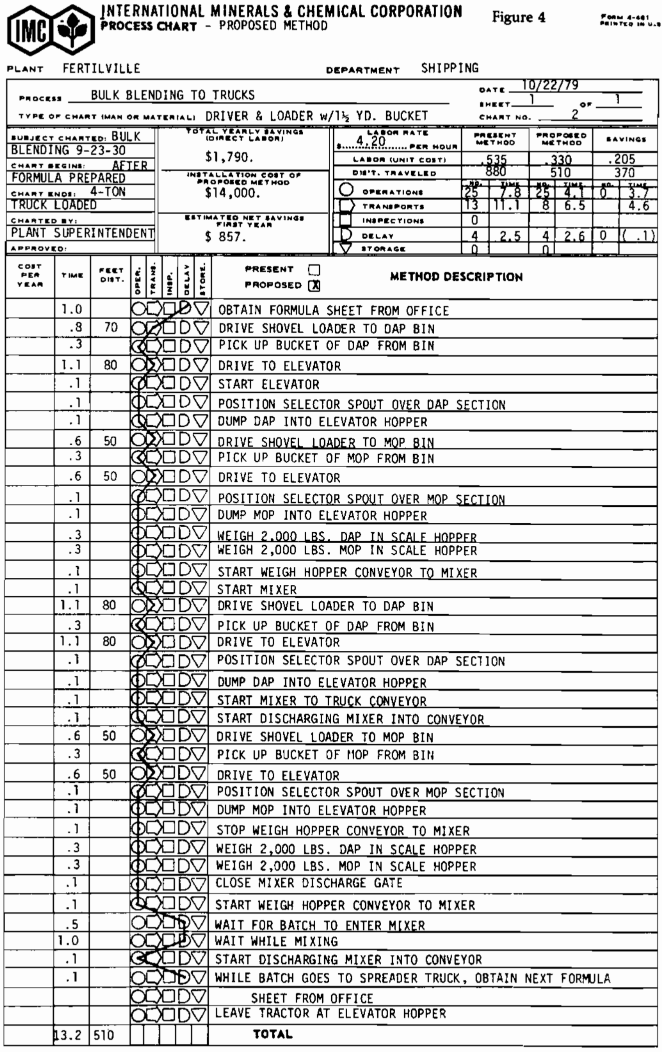
Other possibilities include —

- Use of gravity rather than machinery to accomplish mixing.
- Use of bulk holding hoppers for blended product to cut down on delays in filling orders and improving equipment utilization.
- Use of conveyors to bring bagged product to trucks directly from bagging machine, rather than through an intermediate warehouse involving forklift trucks and pallets.
- Spillage recovery with conveyors rather than with shovel loaders.

FLOW DIAGRAM NEW METHOD

Figure 3





INTERNATIONAL MINERALS & CHEMICAL CORPORATION Figure 4
PROCESS CHART - PROPOSED METHOD
FORM 4-461 PRINTED IN U.S.A.

PLANT FERTILVILLE DEPARTMENT SHIPPING

PROCESS BULK BLENDING TO TRUCKS
DATE 10/22/79
SHEET 1 OF 1
TYPE OF CHART (MAN OR MATERIAL) DRIVER & LOADER w/1½ YD. BUCKET
CHART NO. 2

SUBJECT CHARTED: BULK BLENDING 9-23-30
CHART BEGINS: AFTER FORMULA PREPARED
CHART ENDS: 4-TON TRUCK LOADED
CHARTED BY: PLANT SUPERINTENDENT
APPROVED:

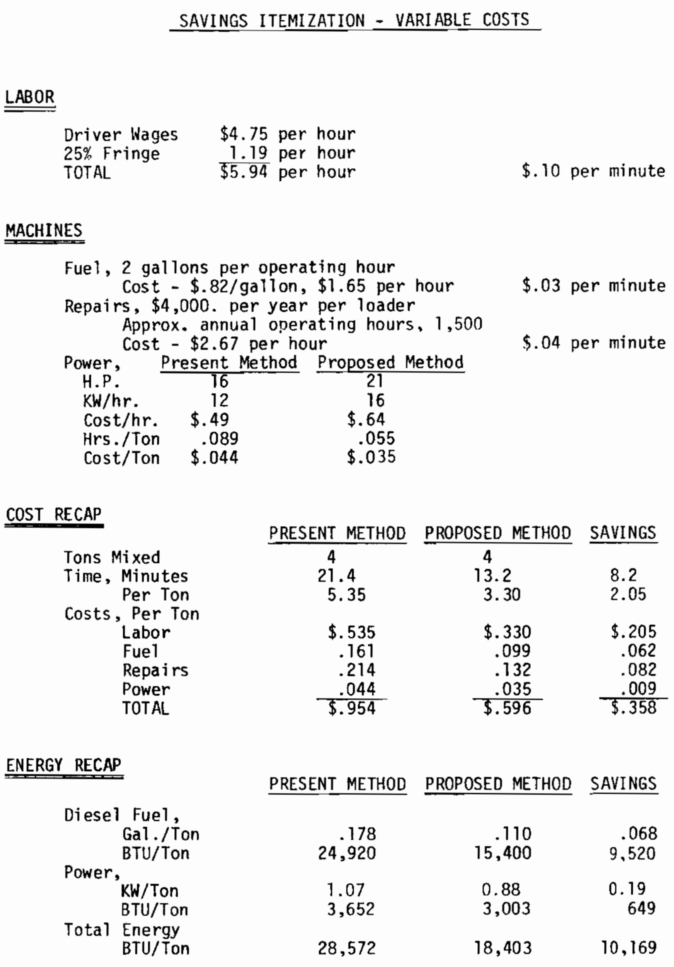
TOTAL YEARLY SAVINGS (DIRECT LABOR) $1,790.
INSTALLATION COST OF PROPOSED METHOD $14,000.
ESTIMATED NET SAVINGS FIRST YEAR $ 857.

LABOR RATE $ 4.20 PER HOUR	PRESENT METHOD		PROPOSED METHOD		SAVINGS	
LABOR (UNIT COST)	.535		.330		.205	
DIS'T. TRAVELED	880		510		370	
	NO.	TIME	NO.	TIME	NO.	TIME
○ OPERATIONS	25	7.8	25	4.1	0	3.7
⇨ TRANSPORTS	13	11.1	8	6.5		4.6
□ INSPECTIONS	0					
D DELAY	4	2.5	4	2.6	0	(.1)
▽ STORAGE	0		0			

PRESENT ☐ PROPOSED ☒

COST PER YEAR	TIME	FEET DIST.	OPER.	TRANS.	INSP.	DELAY	STORE.	METHOD DESCRIPTION
	1.0							OBTAIN FORMULA SHEET FROM OFFICE
	.8	70						DRIVE SHOVEL LOADER TO DAP BIN
	.3							PICK UP BUCKET OF DAP FROM BIN
	1.1	80						DRIVE TO ELEVATOR
	.1							START ELEVATOR
	.1							POSITION SELECTOR SPOUT OVER DAP SECTION
	.1							DUMP DAP INTO ELEVATOR HOPPER
	.6	50						DRIVE SHOVEL LOADER TO MOP BIN
	.3							PICK UP BUCKET OF MOP FROM BIN
	.6	50						DRIVE TO ELEVATOR
	.1							POSITION SELECTOR SPOUT OVER MOP SECTION
	.1							DUMP MOP INTO ELEVATOR HOPPER
	.3							WEIGH 2,000 LBS. DAP IN SCALE HOPPER
	.3							WEIGH 2,000 LBS. MOP IN SCALE HOPPER
	.1							START WEIGH HOPPER CONVEYOR TO MIXER
	.1							START MIXER
	1.1	80						DRIVE SHOVEL LOADER TO DAP BIN
	.3							PICK UP BUCKET OF DAP FROM BIN
	1.1	80						DRIVE TO ELEVATOR
	.1							POSITION SELECTOR SPOUT OVER DAP SECTION
	.1							DUMP DAP INTO ELEVATOR HOPPER
	.1							START MIXER TO TRUCK CONVEYOR
	.1							START DISCHARGING MIXER INTO CONVEYOR
	.6	50						DRIVE SHOVEL LOADER TO MOP BIN
	.3							PICK UP BUCKET OF MOP FROM BIN
	.6	50						DRIVE TO ELEVATOR
	.1							POSITION SELECTOR SPOUT OVER MOP SECTION
	.1							DUMP MOP INTO ELEVATOR HOPPER
	.1							STOP WEIGH HOPPER CONVEYOR TO MIXER
	.3							WEIGH 2,000 LBS. DAP IN SCALE HOPPER
	.3							WEIGH 2,000 LBS. MOP IN SCALE HOPPER
	.1							CLOSE MIXER DISCHARGE GATE
	.1							START WEIGH HOPPER CONVEYOR TO MIXER
	.5							WAIT FOR BATCH TO ENTER MIXER
	1.0							WAIT WHILE MIXING
	.1							START DISCHARGING MIXER INTO CONVEYOR
	.1							WHILE BATCH GOES TO SPREADER TRUCK, OBTAIN NEXT FORMULA
								SHEET FROM OFFICE
								LEAVE TRACTOR AT ELEVATOR HOPPER
	13.2	510						TOTAL

Figure 5



SAVINGS ITEMIZATION - VARIABLE COSTS

LABOR

Driver Wages	$4.75 per hour	
25% Fringe	1.19 per hour	
TOTAL	$5.94 per hour	$.10 per minute

MACHINES

Fuel, 2 gallons per operating hour
Cost - $.82/gallon, $1.65 per hour — $.03 per minute
Repairs, $4,000. per year per loader
Approx. annual operating hours, 1,500
Cost - $2.67 per hour — $.04 per minute

Power,	Present Method	Proposed Method
H.P.	16	21
KW/hr.	12	16
Cost/hr.	$.49	$.64
Hrs./Ton	.089	.055
Cost/Ton	$.044	$.035

COST RECAP

	PRESENT METHOD	PROPOSED METHOD	SAVINGS
Tons Mixed	4	4	
Time, Minutes	21.4	13.2	8.2
Per Ton	5.35	3.30	2.05
Costs, Per Ton			
Labor	$.535	$.330	$.205
Fuel	.161	.099	.062
Repairs	.214	.132	.082
Power	.044	.035	.009
TOTAL	$.954	$.596	$.358

ENERGY RECAP

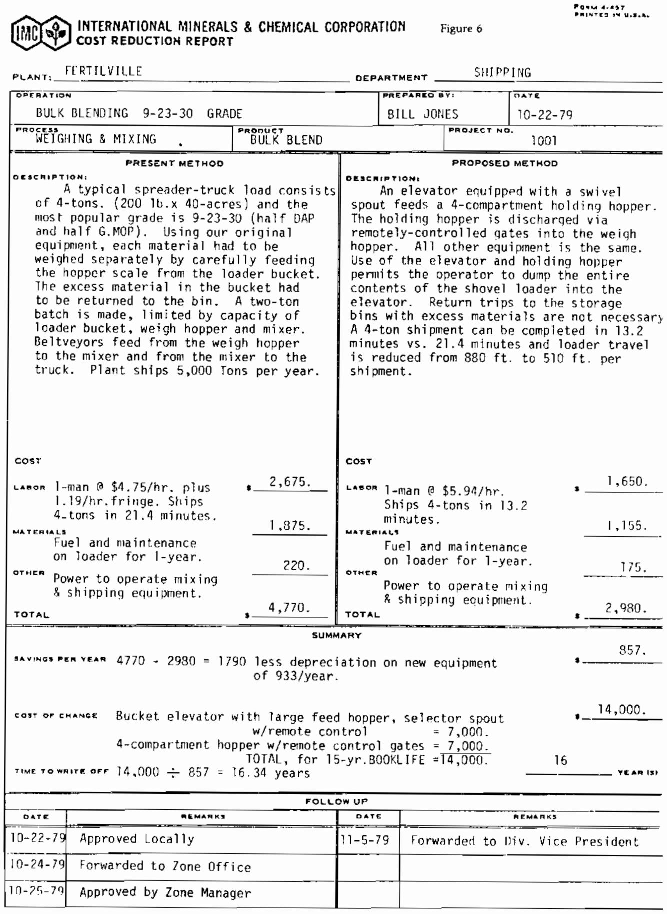
	PRESENT METHOD	PROPOSED METHOD	SAVINGS
Diesel Fuel,			
Gal./Ton	.178	.110	.068
BTU/Ton	24,920	15,400	9,520
Power,			
KW/Ton	1.07	0.88	0.19
BTU/Ton	3,652	3,003	649
Total Energy			
BTU/Ton	28,572	18,403	10,169

I hope that this brief presentation will be helpful to others concerned with effecting savings in energy or in improving efficiency in their operation.

Thank you. (Applause)

MODERATOR WESENBERG: Thank you John. That was very interesting. Our next discussion, "Fuel conservation" will be given by Bob Robinson. He is Vice President, Engineering, Edw. Renneberg and Sons Co., Baltimore, Md. He first participated in the Fertilizer Industry Round Table in 1955, and has been active in the design and manufacture of process machinery, for the Fertilizer Industry, for 33 years. He has a B.S. and M.S. degree from Georgia Tech and Johns Hopkins University respectively. He is a Registered Professional Engineer in the State of Maryland and Georgia. His special interests include mechanical design, thermal processing systems, engineering and controls. Bob please. (Applause)

Figure 6



FORM 4-457
PRINTED IN U.S.A.

INTERNATIONAL MINERALS & CHEMICAL CORPORATION
COST REDUCTION REPORT

PLANT: FERTILVILLE
DEPARTMENT SHIPPING

OPERATION BULK BLENDING 9-23-30 GRADE	PREPARED BY: BILL JONES	DATE 10-22-79
PROCESS WEIGHING & MIXING	PRODUCT BULK BLEND	PROJECT NO. 1001

PRESENT METHOD	PROPOSED METHOD
DESCRIPTION: A typical spreader-truck load consists of 4-tons. (200 lb.x 40-acres) and the most popular grade is 9-23-30 (half DAP and half G.MOP). Using our original equipment, each material had to be weighed separately by carefully feeding the hopper scale from the loader bucket. The excess material in the bucket had to be returned to the bin. A two-ton batch is made, limited by capacity of loader bucket, weigh hopper and mixer. Beltveyors feed from the weigh hopper to the mixer and from the mixer to the truck. Plant ships 5,000 Tons per year.	DESCRIPTION: An elevator equipped with a swivel spout feeds a 4-compartment holding hopper. The holding hopper is discharged via remotely-controlled gates into the weigh hopper. All other equipment is the same. Use of the elevator and holding hopper permits the operator to dump the entire contents of the shovel loader into the elevator. Return trips to the storage bins with excess materials are not necessary A 4-ton shipment can be completed in 13.2 minutes vs. 21.4 minutes and loader travel is reduced from 880 ft. to 510 ft. per shipment.

COST		COST	
LABOR 1-man @ $4.75/hr. plus 1.19/hr.fringe. Ships 4-tons in 21.4 minutes.	$ 2,675.	LABOR 1-man @ $5.94/hr. Ships 4-tons in 13.2 minutes.	$ 1,650.
MATERIALS Fuel and maintenance on loader for 1-year.	1,875.	MATERIALS Fuel and maintenance on loader for 1-year.	1,155.
OTHER Power to operate mixing & shipping equipment.	220.	OTHER Power to operate mixing & shipping equipment.	175.
TOTAL	$ 4,770.	TOTAL	$ 2,980.

SUMMARY

SAVINGS PER YEAR 4770 - 2980 = 1790 less depreciation on new equipment of 933/year. $ 857.

COST OF CHANGE Bucket elevator with large feed hopper, selector spout w/remote control = 7,000. $ 14,000.
4-compartment hopper w/remote control gates = 7,000.
TOTAL, for 15-yr.BOOKLIFE =14,000.

TIME TO WRITE OFF 14,000 ÷ 857 = 16.34 years 16 YEAR(S)

FOLLOW UP

DATE	REMARKS	DATE	REMARKS
10-22-79	Approved Locally	11-5-79	Forwarded to Div. Vice President
10-24-79	Forwarded to Zone Office		
10-25-79	Approved by Zone Manager		

In-Plant Energy Conservation Related To The Utilization Of Fuel

Robert E. Robinson

Contents: Abstract, Plant Energy Sources, Quantifications, A Checklist, Characteristics of Fuel, Basic Combustion Requirements, A Check List with Notes for Dryer Combustion Systems.

Abstract

Efficient utilization of fuels requires that a number of basic scientific principles be understood and applied. For existing plant operations and for new projects a simple check list is an effective tool with which an audit of fuel utilization practices can be initiated. Many steps are simple to investigate and implement on a "do it yourself" basis while others required careful systems study and analysis, including capital and operating cost comparisons. It is hoped that this paper will be useful in catalyzing beginnings for plant operators and designers.

Plant Energy Sources

We certainly think of fossil fuels as our primary energy sources: principally natural gas, fuel oils, and gasoline, lesser quantities of propane, acetylene, and other fuels are used for pilot flames, heating, cutting and welding, etc. Electricity is a converted energy form which is purchased, and occasionally forms of mechanical energy may be received and utilized in fluids under pressure or in motion. Chemical energy available from process reactions may provide recoverable heat, and waste streams may lend themselves to heat recovery and reuse.

Quantification

A wise first step in an audit would be a broad listing and quantification of energy purchases, uses, and losses, followed by dollar valuation. Logically, the larger items should be screened first for possible savings. Smaller items may well provide rewarding payback later, but usually the larger cost opportunities should be studied first. It is always necessary to compare a present cost with alternative costs on a fair basis, so it is customary to use financial mathematics to combine capital and operating costs into some comparable measure such as an annualized cost for some time period or a present value. Where changes are expected as in an inflationary economy anticipated future prices should be factored into the calculation. This of course introduces uncertainty and it is helpful if the measure can be presented with some idea of the probanle range and confidence level. A comparison often evaluates one fairly certain value against a different value with considerable uncertainty.

A Check List

The following list presents some places to look, more or less in a ranked order of decreasing importance:

1 Dryer combustion equipment
2 Steam generation equipment
3 Efficiency of process equipment
4 Insulation of thermal equipment
5 Losses in waste streams, such as stack losses
6 Electrical energy usage (to be treated by others)
7 Transportation energy (to be treated by others)
8 In-Plant flows and unnecessary materials handling

These broad categories are subject to a number ot corrective actions, including:

1 Minor operating adjustments (fine tuning)
2 Changes in process operating conditions or values
3 Changes in actual fuels or energy sources
4 Reduction of losses
5 Improvement in utilization of thermal energy (efficiency)
6 Reduction or elimination of unnecessary processing or handling
7 Recovery of energy in waste streams

Characteristic of Fuels

Fuels may be either essentially pure chemical compounds or mixtures. Propane, for example, is a single compound and has definite known properties. Natural gas may vary some in properties but is usually blended by the utility companies to provide a standard heat content. Although a mixture, it is usually of dependable consistency. Fuel oils are products obtained from refining crude oils, and are marketed in various grades. Fuel oils can be either paraffin or asphaltic based and often contain appreciable amounts of impurities. Heavy fuel oil, marketed in the U.S. on No. 6 or Bunker G, contains refinery bottoms or heavy residuals which require high flame temperature, adequate residence time,, and good atomization to burn. There is some ash residue from such fuels.

Coal is receiving increased attention. Coal is a mineral which occurs in widely varying composition and type, with wide variance in properties. The drying, sizing, cleaning, and preparation of coal for combustion is very important, and combustion equipment must be carefully engineered. Coal is essentially dirty and coal fired boilers are subject to continuous deposition of soot on the tubes. Blow down of boiler tubes is necessary several times each day.

Basic Combustion Requirements

Any fuel requires an adequate supply of oxygen (usually from atmospheric air), proper mixing and atomization, proper temperature, and sufficient time for completion of combustion. The function of the burner system is to deliver the fuel and air in proper proportions and condition, provide a means of ignition, monitor the continuous presence of the stable flame, control the firing rate, and safely shutdown upon a flame failure or when desired. The combustion chamber provides a place in which burning occurs. For heavy fuels radiation from incandescent refractory walls helps to supply heat to maintain a sufficiently high temperature to deliver complete combustion and smoke-free heated flue gases. Since dryers may be required to operate over a wide range of load, burners must provide sufficient turn-down to properly satisfy the required range of load.

A temperature control system regulates the burner firing rate to match the demand or load on the heated unit. Boilers usually have fixed firing rate burners which cycle on and off or high and low fire. Dryers usually are supplied with fully modulated burners so that the firing rate may vary continuously over the full operating range.

A Check List With Notes For Dryer Combustion Systems

1—Cleanliness

Check and clean oil filters, combustion air inlet filters, etc.
Clean atomizing nozzles.
Clean flame safety sensor (scanner) lenses.
Clean spark ignition electrodes.
Clean off all operating controls and linkages.
Clean temperature control sensors.

2—Temperatures

Be sure oil is supplied at proper temperatures and viscosity.

Check air heater exit gas temperature.

Check dryer inlet gas temperature. Note that cold air leakage into the dryer inlet lowers the drying gas temperature and if unwanted causes an entropy loss. A proper amount of secondary tempering drying air is normally mixed with combustion chamber exit gas to deliver a drying gas mixture to the dryer in proper amount at proper temperature.

Check dryer exit gas temperature. Higher than normal may indicate poor heat transfer in the dryer due to material build-up on the flights or excess air flow for the dryer load. Entropy relationships are such that the most efficient drying can usually be done by operating with the highest practical inlet gas temperature acceptable to the dryer itself and the material being dryed, coupled with a maximized temperature drop in the drying gases and a minimum acceptable exit gas temperature, which equates to a minimum stack loss. Exceptions may occur in systems where portions of the exit gas stream are to be recycled or put through heat recovery equipment or where moisture is to be removed in a condensing operation.

3—Atomization

Sludge and unstable viscosity of heavy oils can cause poor atomization which in turn can produce sparklers in the oil flame, smoky flame, accumulation of deposits on the burner tile, nozzles, combustion chamber floor and downstream gas duct walls and floors. A serious eventual consequence can be the breaking loose of a sizable piece of deposited carbon which may pass through the dryer as a glowing coal. Such coals have caused fires in bag type dust collectors, damage to rubber linings of scrubbers, and dust fires or explosions with combustible materials. Proper removal of sludge, proper temperature and viscosity control, and proper atomizing control is necessary to good, consistent and complete combustion.

4—Fuel Air Ratio

The exactly correct theoretical proportion of fuel and air for complete combustion is known as the stoichiometric ratio.

In practice, good stable flames are obtained with a modest excess of combustion air. The amount depends on burner characteristics as well as fuel, but too much excess air will lower the flame temperature and cause an entropy loss so that less of the gross heating value of the fuel can be utilized. Excessively fuel rich mixtures result in incomplete combustion, smoky flames, lower combustion chamber temperatures, and less efficient utilization of the heating value in the fuel. Where a temperature must be reduced after combustion, the secondary tempering air should be introduced so that the flame envelope is not disturbed and mixing occurs only after combustion is complete.

5—Preheating of Burner and / or Secondary Dryer Air

Whereever it is possible to utilize heated air for combustion or drying, the fuel requirement is reduced. It is possible to choose burner equipment to handle hot air, within limits, and provided that the air is clean. Such air can be heated by means of indirect heat exchangers. Secondary air can be obtained by recycling a limited portion of process exit gases provided that these gases are sufficiently clean and that necessary conditions of equilibrium are maintained. This means that moisture must be removed from the loop portion of the system at the same rate it is added as products of combustion and evaporation from drying. Oxygen content to support combustion must also be maintained at a minimum level.

6—Control of Drying Gas Flow

The traditional control system for fertilizer dryers has been use of exit gas temperature as a measured variable which has been controlled to a predetermined set point. Dryer characteristics and material properties remain sufficiently constant that a change in demand (dryer load) causes a drop in exit gas temperature. The control system acts to raise the burner setting which increases the dryer inlet temperature, which provides the needed increase in drying capacity, the new equilibrium condition being established with the same pre-set exit gas temperature.

Under certain conditions it may be advantageous to use a control system with a fixed dryer inlet gas temperature, using this parameter to control the burner, and a separate control to regulate gas flow through the dryer so that with increased load more air is used. This affords a more favorable entropy relationship at all times and maintains both inlet and exit gas temperatures close to optimum, keeping stack loss and radiation loss at minimums.

MODERATOR WESENBERG: Thank you Bob. We appreciate your valuable discussion. (Applause)

MODERATOR SPILLMAN: Glen Wesenberg will give us the final paper covering "In Plant Energy Conservation — Process." glen, please (Applause)

In-Plant Energy Conservation Process

Glen H. Wesenberg

At the World Fertilizer Conference in New York City, last month, Richard Freeman, director of TVA stated that from now to 1985, 17 million tons of new fertilizer is scheduled to go on stream. Of this total, 40% is scheduled for mideastern and Asian countries, 32% by Russia, very little for the rest of Europe and basically no new capacity for North America. New production locations are near abundant sources of economically available fuel for energy.

At the same conference, Mr. Ed Wheeler, President of the Fertilizer Institute, indicated that the fertilizer production cost has escalated 15 to 20% in one year, freight charges increased 19% and ocean shipping increased approximately 35%.

I am sure that by now we are all aware of the extensive shortages of or difficulties in obtaining commonly used fuels for processing, handling and distributing fertilizer materials. It appears that relief will be slow in obtaining these and new energy sources. Supply of natural gas is being depleted; American Petroleum Institute President Charles DiBona stated that there are 240 oil refineries in the United States and the likelihood of any significant increase in that number is bleak; because under today's regulatory climate, gaining approval to build a new refinery is nearly impossible.

(Nation's Business) publication reports that we have enormous deposit is of *heavy crude and oil sands* with reserves estimated in the United States and up to 300 billion barrels; Canada has more than 2 trillion barrels of heavy crude and oil sands in the province of Alberta alone; however, only about 10% of all petroleum products produced in the world in 1979 will be from heavy crude and oil sands. Although there has been no systematic exploration for heavy crude and oil sands over the years a recent release by Texaco-Raytheon and Badger indicate a new process for recovery of oil from shale using radio waves may provide commercial quantities by mid to late 1980's.

It is also reported that even if the United States adopted a crash program to develop its heavy oil resources, it would be approximately 8 to 10 years before the nation could begin using significant quantities of the end product.

National Coal Association President, Carl Bagge, recently stated, "given reasonable government policies and environmental regulations, we can mine all the coal America can build the hardware to consume".

Local, state and federal environmental regulations, and complex governmental pricing regulations together with the fact that huge sums of capital will be required for development tremendously retard the progress in these areas.

Solar energy and *wind source energy* are being studied and tried in many areas by many industries; however, a very small percent have been economically justifiable for process systems.

It takes approximately ten years to build a *nuclear power plant.* Safety refinements are required in existing plants, and it is questionable that Jane and Ralph will approve any new plants.

Without substantial easing of existing environmental laws the nation is likely to make very slow progress toward energy self-sufficiency.

Based on the above unpleasant indications, extensive steps in energy conservation will be a necessity for competitive existence in the fertilizer market.

Where do We Start — What Can We Do?

Every processing plant should have or start an *Energy Management Program.* The suggested *basic objectives* would be to:

A. Decrease consumption and losses of energy.
B. Use process energy whenever feasible and economical.
C. Use waste materials and by products for energy source where possible.
D. Change type of energy source if more efficient.

The first step in the program would be to have an *Energy Manager* to administer the action program. The following outline is suggested for the program.

I. Audit and analyze existing consumption to determine where the energy is going and how much is actually used — quantify use before attack.

II. *Start an Idea Bank* — The following sources are suggested for developing the *Idea Bank.*
  A. Participation from all personnel of your company. Use an *energy saving suggestion box* — give awards, publish names and ideas in company and/or local papers and provide either helmet stickers or pins for contributors. (One company uses a dollar sign on a light bulk — a good reminder, gets people conscious to save energy.)
  B. Government publications.
  C. Industry publications — especially those indicating proven action.
  D. Equipment manufacturers.
  E. Scheduled Round Table discussion.
  F. Review various lists of energy conservation suggestions.

III. Immediately initiate conservation measures that are low cost or can be done at no cost. Go through the checklists and you will find many simple ways of saving energy.

In heated or cooled areas such as control rooms, offices, lunchrooms, etc., if the walls have 1½ or more inches and the ceiling 6 or more inches of reliably installed insulation, either fiberglass or cellulose, it is doubtful that additional insulation would pay. However, a *vapor barrier* over *existing walls* and *sealing of leaks* will do more good. Glidden has a new paint that gives a good vapor barrier.

Plug up holes and cracks, fix leaks in energy consuming systems, insulate windows and doors, close off areas not necessarily used, build vestibules before each door frequently used which will be better than a storm door for stopping blasts of outside air from entering, *turn back thermostats* when rooms are not used, such as offices at night. Approximately 3% of energy can be saved per degree of cutback.

A University of Minnesota study shows that an average house during winter looses approximately 39.6% of heat through "holes", 33.4% through walls, ceilings and floors, and 27% through windows and doors. The above mentioned energy conservation areas are apprciable but minor compared to the extensive potentials for savings in the chemical processing areas of fertilizer manufacturing. A number of proven process energy conservation projects and systems have already been employed by the fertilizer industry, and others are under study. A few examples of these are as follows:

1. Approximately 25 *pipe cross reactors* have been installed to date where process reaction heat is used to reduce fuel requirements for drying material. Other contingent benefitsd are also realized. TVA in cooperation with various manufacturers have accumulated and presented various data pertaining to these reactors. Dave Salladay of TVA reports that about 700,000 tons of 13-13-13 were produced in 1978. If all of this were made conventionally about 200,000 BTU/ton of chemical heat would be released. The same grade made with a pipe cross reactor would release 500,000 BTU per hour of chemical heat and require no fossil fuel for drying. The fuel savings from this one grade would be 2.1 x 10″ BTUs. (210,000 Million BTU) Equivalent to 1,522,000 gallons of #2 fuel oil. Some grades give more savings and some less, or negligible, but it is worthwhile investigating the potentials.

2. A number of plants are using *cooling air for drying* — not only are there benefits from pre-heating the dryer air, but less pollution control equipment is required. With properly designed heat exchangers, it appears that additional energy savings can be realized by using the dryer exhaust air for additional pre-heating purposes. If ambient air enters the processing loop at 60°F., and exists to the atmosphere at 200°F., with a system using 86,000 pounds per hour of air (which would be a typical 20 TPH granulation plant) approximately 300,000 BTUs per hour would go to the atmosphere. When we consider that in the northern section of the United States, the average home would have a 100,000 BTU per hour maximum output heating unit; if only 1/3 of the 300,000 BTU/hour could be saved, it would be equivalent to operating the home unit at its maximum continuously when operating.

3. Considerable energy can be conserved from sulfuric acid plants. Gordon F. Palm & Associates, Inc., of Lakeland, Florida is doing considerable work in this area. Gordon states that modern sulfuric acid plants with proper energy conservation can generate up to *1.2 tons* of high pressure super heated steam per ton of 100% sulfuric acid produced.

With a high efficiency steam turbine, the steam from a 2000 ton per day sulfuric acid plant has a potential for generating *5000 to 6000 KW* on site, or of replacing of electric motor drives of *5500 to 6500 horsepower* by the use of steam turbines. There are many ways in which this potential power source can be used efficiently.

Gordon also stated that large potential savings can be realized in existing fertilizer complexes with sulfuric acid plants even when these plants are up to 20 years old; however, detailed evaluations would be required to determine the potential saving.

Other ways for the efficient use of ther additional high pressure superheated steam not used in the main turbine of the sulfuric acid plant include on-site electric power generation, high efficiency turbines to replace larger motor drives in equipment, such as water pumps, high horsepower fans, and the use of pre-heaters for granulation plants which can reduce oil consumption by 50% or more.

4. Other energy conservation measures such as heat recovery from contaminated or uncontaminated phosphoric acid evaporator condensate have been developed as well as many other recoveries of waste heat and energy now being discarded in phosphate chemical complex operations. Savings can run to several million dollars a year in a large complex, and return on investment after taxes can be, in some cases, less than one year, but generally less than 4 to 5 years.

5. Jet Propulsion Labs are working on a *Solar Powered Nitrogen Plant* which looks very promising provided ceramic receiver materials are developed to stand the high temperatures encountered. Personnel of the International Fertilizer Development Center are studying this project closely.

6. Any plants using *steam* or *hot water* for processing can usually conserve a considerable amount of energy.

Eliminating leaks should receive prompt attention. A hot water faucet loosing one drop per second wastes 2,304 gallons per year (19,200 lbs.). If the leak results from steam it becomes a considerable loss. Whatever low pressure steam is condensed by cooling water or air, roughly *1000 BTUs per pound* is wasted. For the one drop per second leak from steam amounts to over 19 million BTU. (Equivalent to 140 gallons of fuel oil wasted.) Improper operation and maintenance of tracing system can waste energy.

Tracing lines should not be used until necessary. They should be well insulated and traps should be used with all tracers. Preventative maintenance of traps, along with frequent checks to make sure they are *not blowing steam* will result in significant steam savings.

7. *Use of Insulation* — All steam and hot fired process lines and vessels where savings can be made should be well *insulated.* The higher the temperature differential the more important the insulation becomes. Heat losses from 1000 sq. ft. of bare surface can exceed 500,000 BTU/hour in an outside evaporator at a surface temperature of 200°F., with a moderate wind. (Equivalent to $13,200.00 in steam costs at $3.00/1000 pounds. One inch of insulation can reduce this cost by $1,500.00 per year. The most important variables for evaluating insulation requirements are:

- Initial cost of insulation
- Economic life of the insulation system
- Insulation thermal performance
- Current energy cost
- Energy-price inflation rate
- After-tax value of money.

8. *Miscellaneous*

a. Energy can be saved by minimizing transfer of materials from point to point. Peabody Coal Company made considerable savings in studying traffic patterns and *shortening repetitious routes of travel.*

b. *Drained crank case oil* diluted with regular diesel oil is being used *as diesel fuel.* The oil-fuel mixture, has a higher energy value than regular diesel fuel.

c. *Control Systems* — In reviewing the programs of twelve major companies not necessary in the fertilizer industry, but those having many similar situations and using similar principals, the largest savings resulted from *automatically controlling* and monitoring usage where possible — only using energy at *times necessary, minimizing peak consumption* of electrical supply and *not using energy in excess* of requirements.

The above energy conservation potentials are a few examples of projects successfully proven by various companies. I am sure each of you will find additional ways to conserve energy through your energy conservation programs.

Thomas Edison once said, "I shall make electric light so cheap that only the rich will be able to burn candles" — so he invented the first practical incandescent light and perfected the transmission of electric power. However, his most famous statement was, "Genius is 99% perspiration and 1% inspiration". Although we may not all become geniuses, we may need a little more of each ingredient to find ways of providing ample "cheap" energy and efficient usage. All of us must make a concentrated effort to sustain the leadership in the fertilizer industry of the world. Thank you. (Applause)

MODERATOR SPILLMAN: Thank you very much Glen. You as panel Leader, and Panelists Crom, Medbery, Robinson, gave most interesting, valuable discussions on possibilities, highlighting many suggestions for reducing "Energy Costs".

We are running a little late. If any questions Glen and his Panelists will be glad to have them.

Should you wish to talk to the Panelists later, they will be around until our Meeting has been completed Thursday. Please check the Bulletin Board for any messages.

Tomorrow morning our Meeting will start at 9 AM. Moderator Reynolds will appreciate those of you on the program, meet with him up front here, about 15 minutes before the meeting begins. Thank you, have a good evening. (Applause)

Wednesday, October 31, 1979

Morning Session
Moderators

Joseph E. Reynolds, Jr. — Herb C. MacKinnon

MODERATOR REYNOLDS: When we were planning this session, the discussions to be given this morning, came out of a Directors' Meeting back in March, keeping in the vein that our Round Table has been able to, over the years, of trying to bring pertinent subjects to the Industry.

The subject of "Suspension Fertilizers" was one that received a lot of attention and a lot of discussion. So, pretty soon we realized that we could not be satisfied with one paper, or two papers or three papers. We needed a half day. After much more discussion in the Board Meeting it was unanimously agreed that this should be done. So, today we are very fortunate that we can bring this one to you.

We have assembled our Speakers, for this Session from all over the United States. They are knowledgeable in this area "Suspension Fertilizers".

You received a supplement attached to your program as you signed in. We are going to have the first three subjects, then, there will be discussions by "the speakers and the audience". We will go on to the next four subjects, then permit more discussions. Finally we have the last subject and in the time that remains, we will be open for further discussions. We will have our speakers up here so that you can ask questions while the subjects discussed are fresh on your mind.

Our first speaker really needs no introduction, however he did provide me an opportunity to find out some of his background. I asked him to jot down the information. I received a five page epistle on Frank Achorn's background! There's one that's missing. His expertise of last evening, up in the lobby, with the "Love People", did not make it! We can add that later.

Frank is a graduate Chemical Engineer of the University of Louisville. He has been with T.V.A. for 30 years. His present assignment is "Senior Scientist" in the Process and Product Improvement Section, Division of Agricultural Development, at Muscle Shoals. As we all know, Frank has written many papers. He has appeared on many programs in the United States and around the world. He has traveled extensively. He is an honorary member of the National Fertilizer Solution Association. He is Vice Chairman of the Board of Directors of The Fertilizer Industry Round Table. I have tried to consolidate Frank's activities. I will now turn it over to Frank. (Applause)

Suspension Fertilizers—Up-Date 1979

Frank P. Achorn

Suspensions were among the first fertilizers used. Historical records show that the early Greeks used suspensions of sewage as fertilizer for their vegetable crops. During the past decade extraordinary growth has occurred in production and use of suspension mixtures. In 1969 only about 15 percent of the fluid fertilizers produced in the United States were suspensions. Recent statistics show that about two million tons of suspension mixtures have already been produced in 1979, and about 50 percent of all fluid mixtures are suspensions.

The term suspension fertilizer refers to a saturated solution in which small crystals of plant nutriets are suspended. Usually an attapulgite gelling clay, mined in southern Georgia, is used as a suspending agent. A sepiolite and sodium bentonite clay mined in the West also have been used as a gelling agent.

Producing suspensions has the following advantages:

1. Can be produced from economical sources of plant nutrients.

2. Produced in easily-operated plants of low-investment cost, usually with less labor per ton of product than required to produce other forms of mixed fertilizers.
3. Have high analysis plant nutrient contents, at least double those of solution mixtures.
4. Properly made suspensions are easy to transport and handle.
5. Can be uniformly broadcast with essentially none of the segregation problems that occur with bulk blends.
6. Excellent carriers of micronutrients to be uniformly applied.
7. Excellent carriers of pesticides.

The original purpose for making suspensions was to increase analysis of solution fertilizers, especially high potash grades. A comparison of plant nutrient concentrations of typical solution and suspension grades is tabulated below:

Ratio	Solution Grade	Suspension Grade
1:3:3	3-9-9	7-21-21
1:2:2	5-10-10	9-18-18
1:1:1	7-7-7	14-14-14
2:1:1	14-7-7	20-10-10
1:3:1	7-21-7	10-30-10

Use of Ammonium Polyphosphate Solution

In the late 1960's most suspensions were made from ammonium polyphosphate solution of 10-34-0 or 11-37-0 grade produced either from electric furnance or wet-process superphosphoric acid. Usually they were produced by cold mixing nitrogen solution (28-32% N), potash, and the ammonium polyphosphate solution. Attapulgite clay was and still is used as a gelling agent. Materials were mixed in conventional cold mixing equipment such as shown in Figure 1. These facilities were formerly used to produce solution mixtures (clear liquids). Usually the plant was equipped with small 3-inch lines and a small recirculation pump. Soon it was discovered that these lines and pumps were too small for fast production of suspension mixtures. The lines were converted to 5-inch size and the recirculation pump was replaced by one having a 5-inch discharge driven by a 50-hp motor. In converting the old plants to production of suspensions, it was found that most of the mixing was accomplished by recirculation of fluid through the pumps and tangentially to the walls of the mix tank.

Use of MAP and DAP

When shortage of materials for manufacture of fluids occurred in 1974, it was found that plants with large lines and recirculation pumps could convert solid materials such as monoammonium phosphate (MAP) and diammonium phosphate (DAP) to suspensions. This could be accomplished by adding an ammonia sparger to the tank when MAP was used. Although several designs have been used, one is relatively simple and works well. It is shown in Figure 2. This design is similar to that used for preneutralizers in DAP plants. It has two spargers hung independently of the mix tank. Ammonia is added through these spargers into the turbulent zone of fluid created by the conventional turbine agitator. The equipment, including the agitator, is simple in design and can be fabricated at local shops. Several companies fabricate lock-and-key plants that feature either high intensity agitators or fluid grinders. Most of these plants work well in converting granular phosphate materials to suspensions. Figure 3 depicts sketches of five of these plants.

In converting MAP to suspensions two important chemical factors must be considered.

1. Solubility of MAP in the fluid must be increased by adding ammonia. Chemical heat of reaction and increased solubility cause the granules of MAP to disintegrate if there is good recirculation of the material through the pump and back to the mix tank.
2. Enough ammonia should be added to the fluid so that the major crystaline phase is small diammonium phosphate crystals which usually cause less problems with clogging of nozzles of application equipment than do monoammonium phosphate crystals in the suspensions.

Figure 4 is a phase diagram of the ammonia-phosphoric acid system. These data show that as monoammonium phosphate is ammoniated from an $N:P_2°_5$ weight ratio of 0.20:1 to 0.307:1, there is about a four fold increase in solubility (from 30 lbs. of salt per 100 lbs. of water to 110 lbs. of salt per 100 lbs. of water) which causes the granules of MAP to disintegrate. However, at this ratio most crystals in suspensions are present as monoammonium phosphate. Figure 5 is a photograph taken through a microscope showing a comparison of the size and shape of monoammonium phosphate and diammonium phosphate crystals. The diamond-shaped diammonium phosphate crystals cause less problems with nozzle stoppage than do the long lumber-shaped monoammonium phosphate crystals. For this reason it is recommended that the degree of ammoniation of ammonium phosphate in suspension be increased to an $N:P_2O_5$ weight ratio of 0.333:1. At this degree of ammoniation all of the monoammonium phosphate is converted to diammonium phosphate.

The major finished phosphate fertilizer product sold in the world today is granular DAP. Therefore, it has become a readily available source of P_2O_5 for suspensions. Data in figure 4 shows that the solubility of diammonium phosphate is low. To increase this solubility, some phosphoric acid usually is added to adjust the $N:P_2O_5$ weight ratio to 0.333:1. In most instances excess phosphoric acid is added along with the appropriate amount of aqua or anhydrous ammonia to supply extra chemical heat to fluidize granules of DAP.

Most suspensions produced from MAP and DAP have unpredictable and, in most instances, poor prolonged storage characteristics. During storage, thick gels form in some mixtures making it very difficult to remove the materials from the storage tank and apply them. They also solidify in extremely cold weather. Therefore, suspension mixtures made from these materials should be applied soon after they are made. Small-scale tests have shown that a small amount of polyphosphate (15% of the total P_2O_5 in the product) improves the storage characteristics of suspensions produced from these solid materials. TVA is producing an experimental product, granular ammonium polyphosphate (APP), which contains 10-20% of its P_2O_5 as polyphosphate. Preliminary field storage results show that mixtures produced from APP have good storage characteristics over prolonged periods.

Use of Phosphoric Acid (54% P_2O_5)

About five years ago some companies began producing suspensions directly from phosphoric acid. Two general types of plants for this purpose are:

1. Those that produce mixtures for immediate application.
2. Those in which a phosphate base is produced, stored, and usually marketed through small mixing stations (satellites).

Figure 6 is a sketch of a typical plant of the first type. It is a plant of relatively low cost with a mix tank mounted on scales and equipped with a small turbine agitator and recirculation pump. A homemade cooler is mounted above the mix tank. Figure 7 is a sketch of a typical cooler of this type.

TVA has developed a three-stage ammoniation process for production of a 13-38-0 grade phosphate base suspension of excellent quality. Figure 8 is a flow diagram for this process. The first stage is a boiling reactor usually operated at about pH 5.0 and $N:P_2O_5$ ratio of 0.23:1. Magnesium, iron, and aluminum impurities are usually precipitated in a form that will avoid formation of gels during storage of the suspension. The second stage is operated at 200°F, pH 6, and $N:P_2O_5$ ratio of 0.30:1 to 0.33:1. Fluid from the second stage is rapidly cooled in an evaporative cooler. This rapid cooling results in formation of small crystals in the suspension. In the third stage, gelling clay and a small quantity of ammonia are added. The resulting 13-38-0 grade product is further cooled using a cooling coil. One company in the Midwest uses the process to produce a 12-35-0 grade. Two other firms are seriously investigating use of the process.

Future

Suspensions will continue to gain in popularity because mixtures can be produced from low cost materials in noncomplicated plants with minimum labor. Their production requires less energy per unit of plant food than that required bu other types of solid mixtures. They are particularly well suited for prescription mixing of NPK mixtures. Also, some scientists believe they are the best mixed fertilizer for use as carriers of micronutrients and pesticides.

Many new suspension materials such as nitrogen suspension (31-0-0-1.5% clay) and fluid clay (9% nitrogen as urea and 25% clay) are being introduced to further simplify production of suspension mixtures. Some operators have reported difficulty with excessive settling of phosphoric acid during transit and in storage. One commercial firm has developed a process for production of a stabilized phosphoric acid that will not settle during shipping or storage. This acid will be available in the near future.

Suspensions account for about 10 percent of the total mixtures. By 1989 it is expected that 30-40 percent of the total mixtures will be suspensions. (Applause)

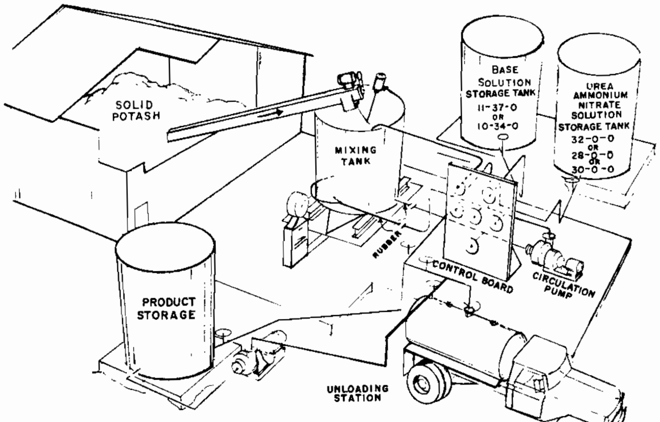


FIGURE I

COLD MIX PLANT FOR CLEAR LIQUIDS

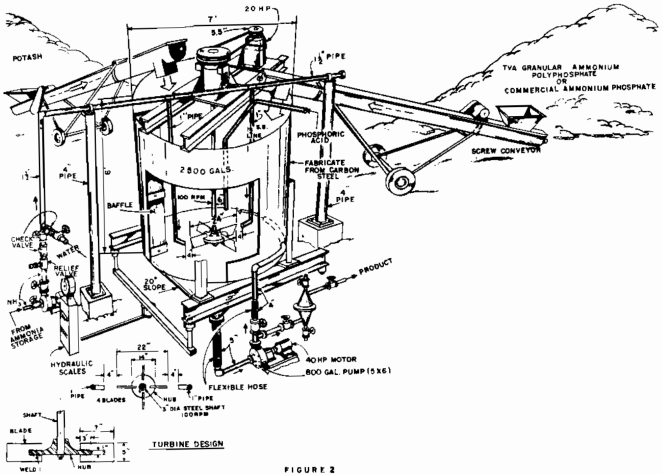


FIGURE 2

MIX TANK FOR PRODUCTION OF SUSPENSIONS FROM TVA GRANULAR APP OR COMMERCIAL GRANULAR AMMONIUM PHOSPHATES—12 TON BATCH

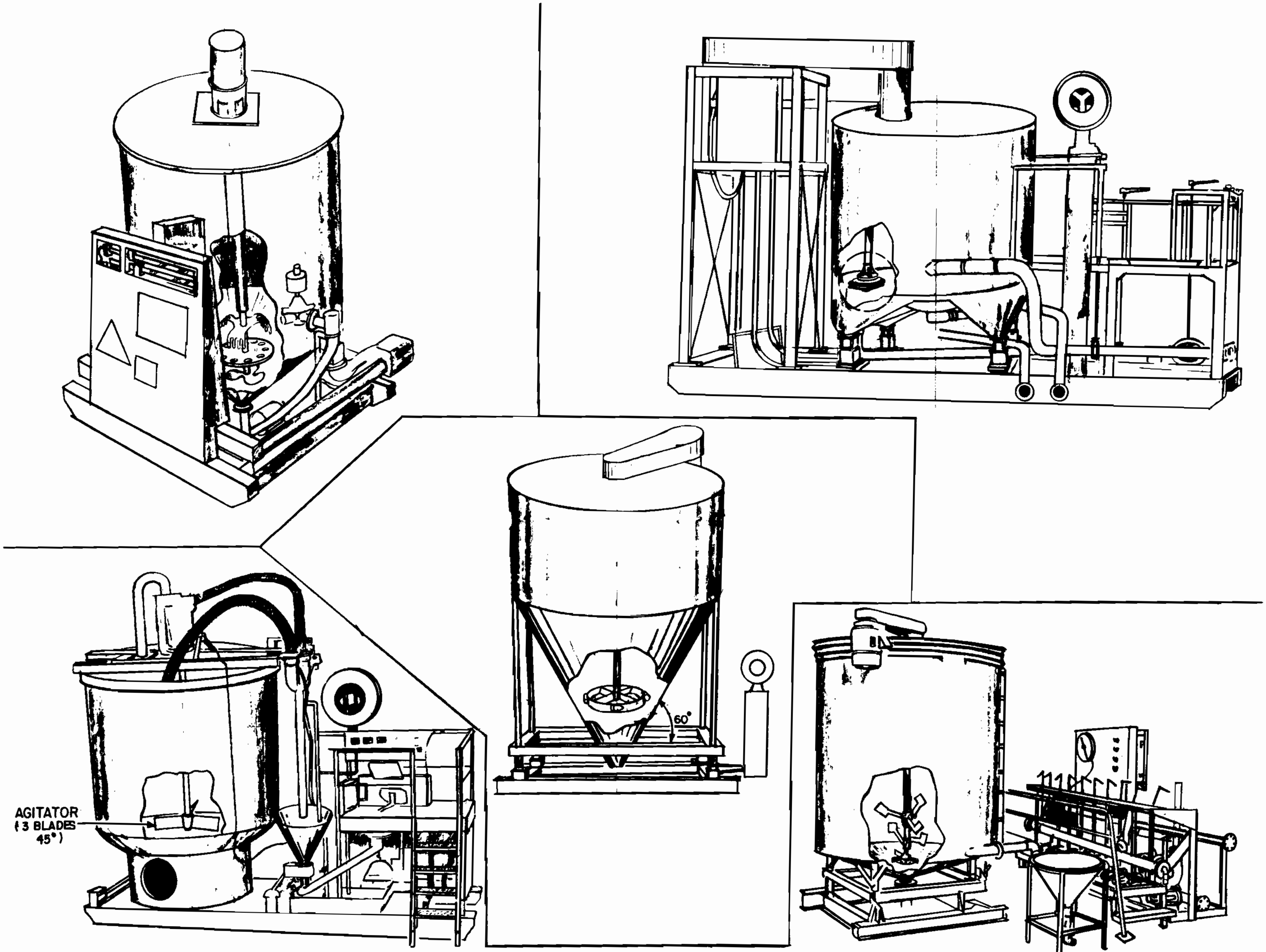


FIGURE 3
FIVE TYPES OF MIX TANKS FOR SUSPENSIONS

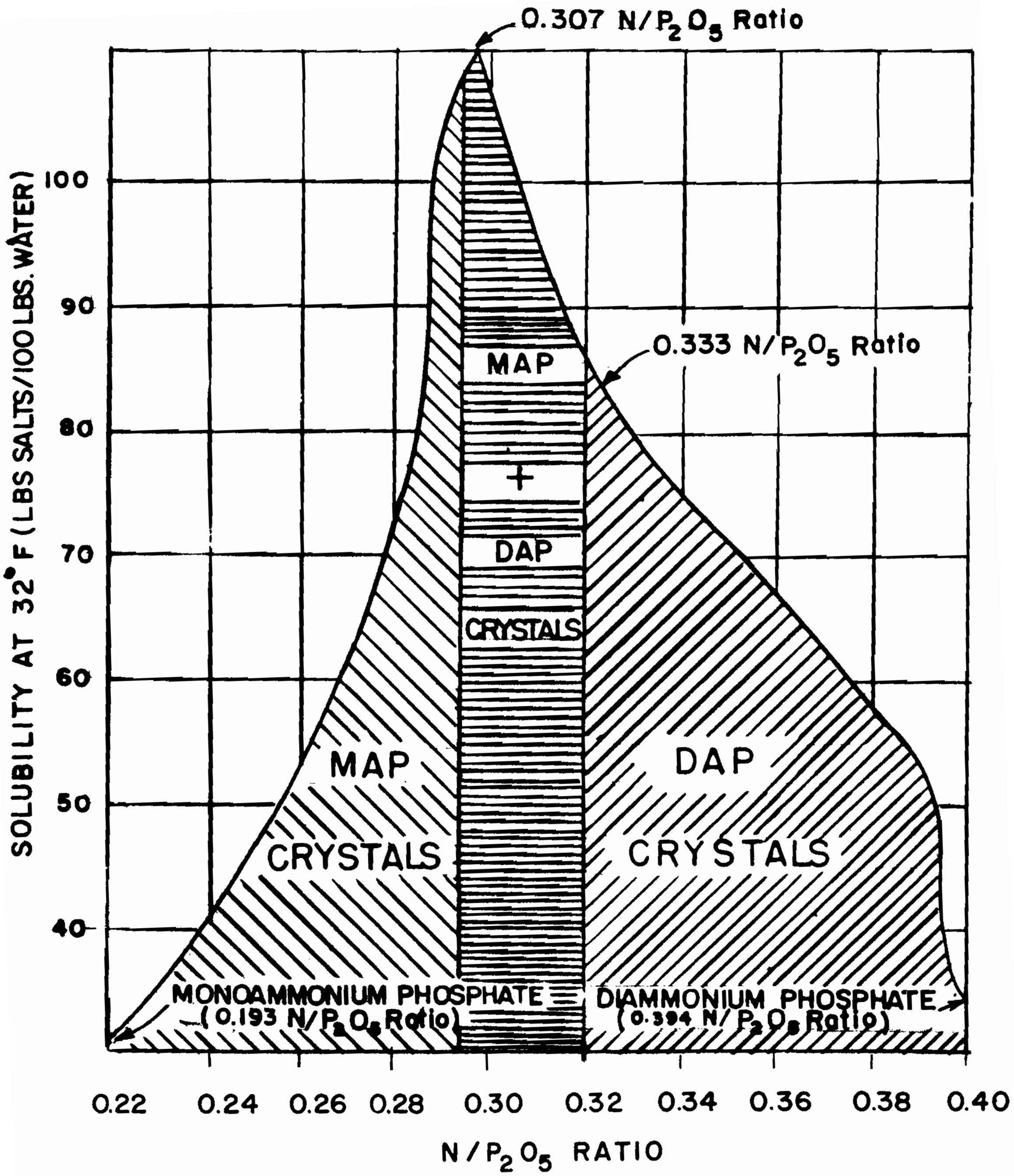
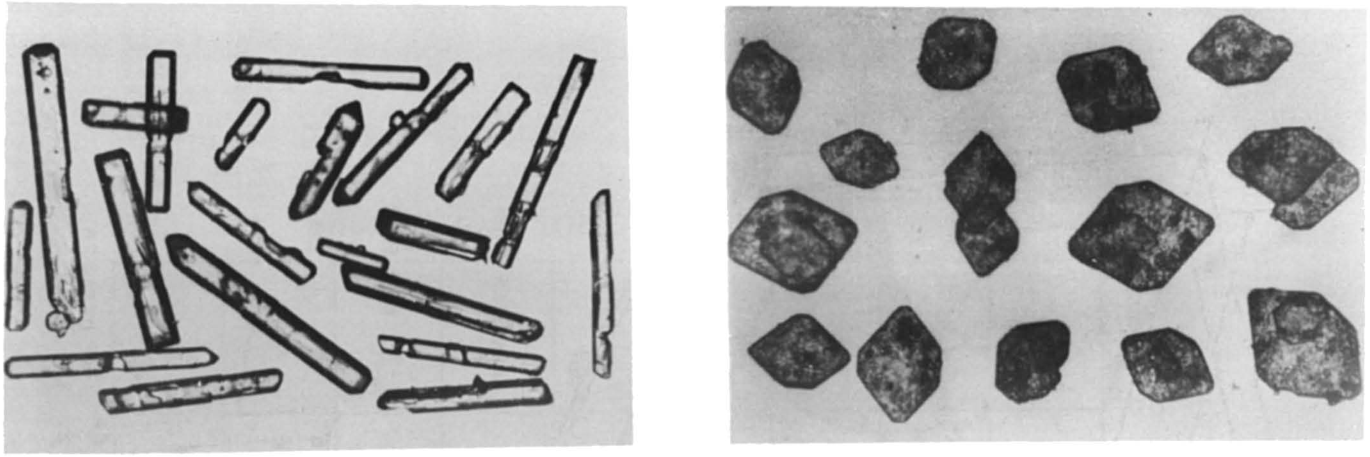


FIGURE 4

SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTION



MONOAMMONIUM PHOSPHATE **DIAMMONIUM PHOSPHATE**

FIGURE 5
MICROSCOPIC APPEARANCE OF MONOAMMONIUM PHOSPHATE AND DIAMMONIUM PHOSPHATE CRYSTALS

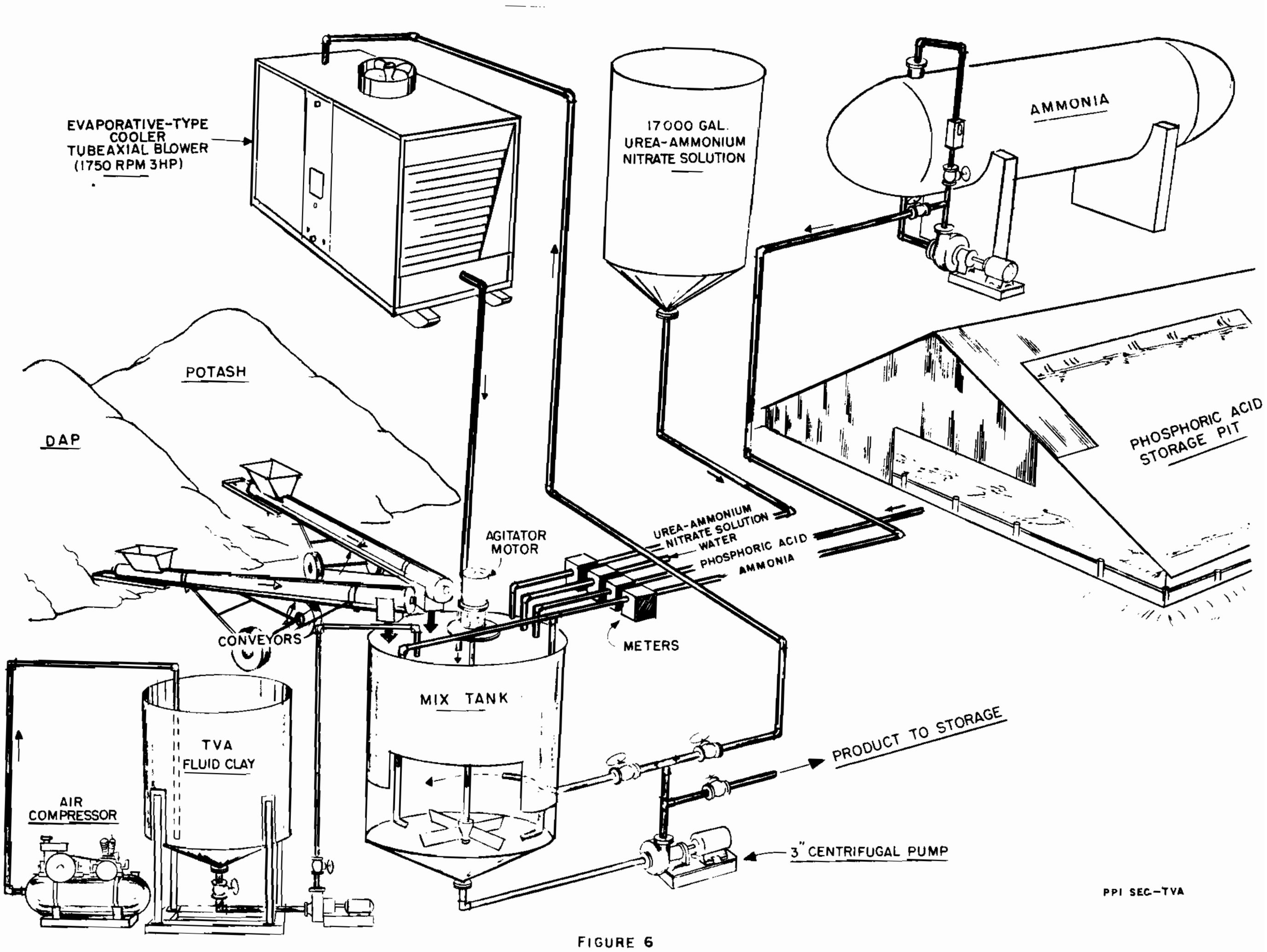


FIGURE 6
USE OF PHOSPHORIC ACID FOR NP AND NPK SUSPENSIONS

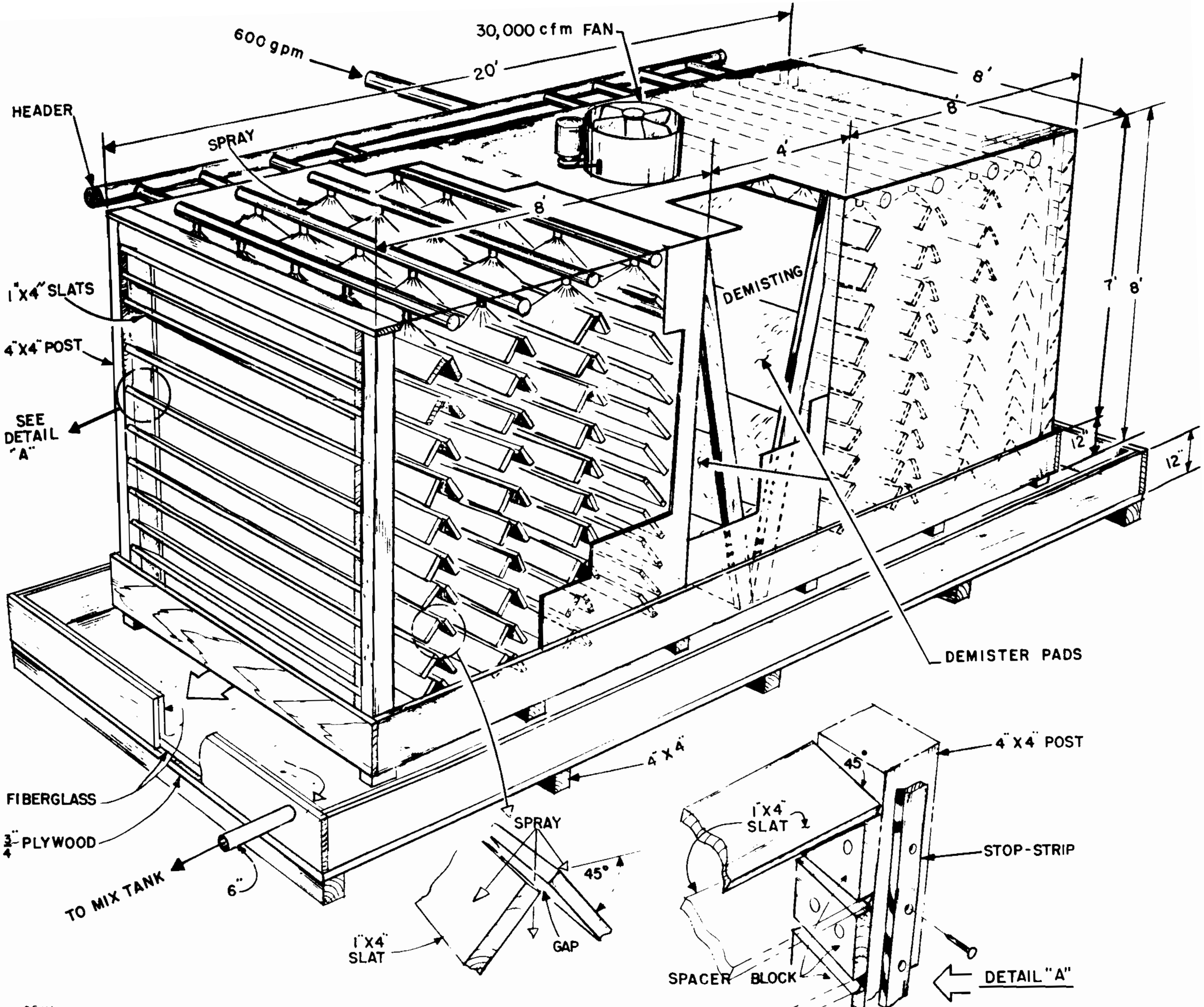


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FIGURE 7

SHOP-MADE EVAPORATIVE COOLER FOR SUSPENSIONS

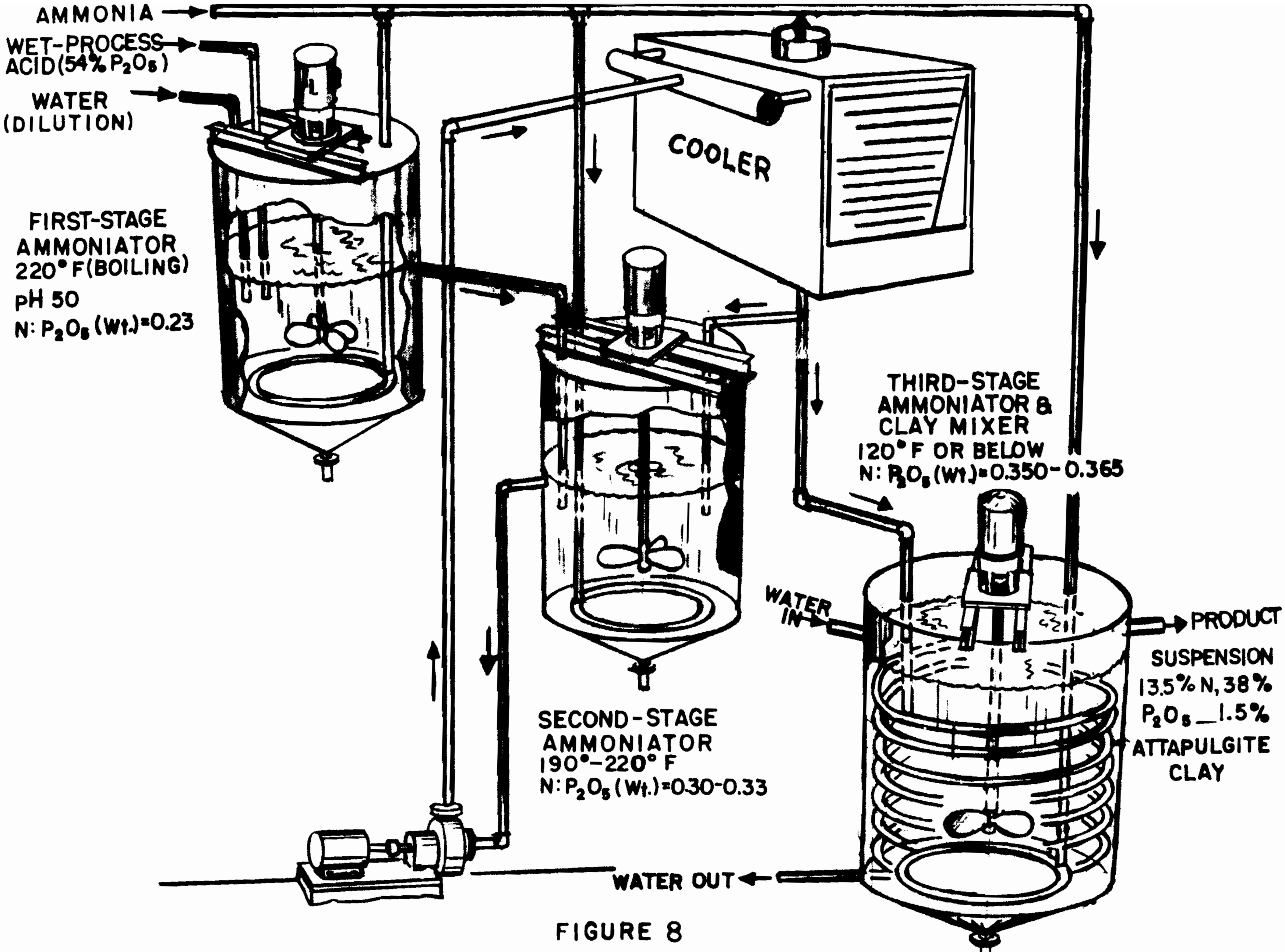


FIGURE 8

THREE STAGE CONTINUOUS AMMONIATION PROCESS FOR PRODUCTION OF 13-38-0 ORTHOPHOSPHATE SUSPENSION

MODERATOR REYNOLDS: Thank you Frank. (Applause)

Carrying on with our announced program on "Suspensions", Past, Present and Future, we are going to move into one of the areas that Frank referred to, the use of phosphoric acid.

Our next speaker will discuss the design of plants using phosphoric acid. Loren Hopwood is Vice President of MAPCO with the Indian Point Division in Athens, Illinois. He is in charge of equipment sales, fertilizer production and distribution. Loren graduated from the University of Illinois with a degree in general agriculture and went into farming. In 1954 he joined Kennedy Kincaid, who many of you know, and ventured into fluid fertilizers at Indian Point Farm Supply. Hopcaid Liquid Plant Food was the offspring of the venture and merged into MAPCO on January 1, 1968. Loren was, according to his background here, a basketball team and a cheerleader. He is depending on the next generation to supply the subs. So, I will turn you over to Loren.

Suspension Fertilizers Design Of Plants Using Phosphoric Acid

Loren E. Hopwood

Production of Suspension Fertilizer is quite similar to flying an airplane. All the "Book Learning" you can obtain will not replace the practical experience. I don't feel a person can define everything that is required to predict the outcome of producing suspension fertilizer until he has actually had the controls in his hand, any more than he could fly a plane until he has had the controls in his hand.

The design of a plant to produce suspension fertilizer from phosphoric acid is quite simple. Actually, all that is necessary in the design of nay plant is, [1] A mix vat, preferably of Type 316 Stainless Steel, into which predetermined amounts of raw materials are added; [2] a system to thoroughly wet all suspended solids; and [3] a pump to evacuate the suspension from the mix vat. The actual configuration of equipment involves knowing where you want to go, what will happen on the way, and how fast you want to go.

Phil Wrigby once stated "When two people think alike, one is not necessary". Frank Achorn and I could never be accused of "Thinking alike". In fact, we have some down-right heated discussions and each time I know I have gained knowledge in this business of fertilizer production.

I will cover the three areas I mentioned on configuration relating them to MAPCO's involvement in suspension.

I. "Where do you want to go" or what type of suspensions do we want to produce.
II. "What will happen on the way" or my understanding of suspensions and factors effecting their stability.
III. "How fast do we want to go" or the actual plant design and ingredient selection.

I. "Where do we want to go?"

The Indian Point Division of MAPCO operates two "Hot Mix" or acid neutralization plants. We have a franchise system of distribution which includes 25 additional Hot Mix Plants which we classify as Associate Producers. The Associate Producer will have a retail business plus a number of satellite dealers or cold mix plants. Totally we have 200 cold mix plants. The cold mix plant will have a mix unit and water supply plus storage for Nitrogen Solution, 10-34-0, and what we call a "heavy suspension" for a fluid source of Potash. Currently this "heavy suspension" is primarily 3-11-35, with some satellites using 5-15-30. This heavy suspension is so designated because we want 49 to 50 units of plant food as a potash base, it may be in storage for a prolonged period of time, and it is required to have enough suspending ability to enable the dealer to add Nitrogen and/or 10-34-0 and keep the resultant analysis stable enough for field application. This is where we want to go with most of our suspensions.

The Associate Producer will want to go to a lighter suspension for his retail business. The lighter material will contain less total plant food and be less viscous.

II. "What will happen on the way?"

I will give you my definition of a suspension so you will know the way I am thinking. It is simply "Undissolved solids suspended in a liquid". We have many apparent factors effecting the suspending ability. Technically speaking, I believe we only have three factors. The technical factors effecting suspending of solids in water, in my opinion, are:

A. Solubility of Compounds
B. Particle Size of Solids
C. Amount of Agitation

A. The solubility of compounds will effect:
    1. The specific gravity of the resultant liquid,
    2. the temperature versus viscosity relationship of resultant liquid,
    3. the amount of the compound that will dissolve before undissolved solids are present.

B. Particle Size of solids will effect:
    1. The rate at which the solid will migrate in the liquid,

2. the water required to wet the surface area of a given mass of solids.

C. The amount of agitation of a suspension effects:

1. The rate of fall-out of solids,
2. the flowability or thickening due to the thixotropic properties.

Experience is the best method to actually predict "What will happen on the way".

III. "How fast do we want to go?"

When we started applying fluid fertilizer 25 years ago and producing Hopcaid Liquid Plant Food, speed of production was not the limiting factor. A 50 ton day of production was in excess of sales. Our first year was something in the magnitude of 275 tons total. Times have changed but the desire of timely application of a quality product on a customer's field has not changed.

For a rule of thumb in the corn belt or where spring fertilizer movement is the largest percentage of the annual business, we should be equipped for a 10% day. This is not a 2.4 hour day but a day in which, with everything clicking together like clockwork, a good inventory of ingredients where we need them, and possibly a 24 hour day, 10% of our season's movement will move out of our plant. At our acid neutralizing plants, where we don't store retail analysis, this means 10% of our retail business or light suspensions, will have to be mixed *and* applied and 10% of our heavy suspensions will be transported away. With adequate storage the heavy suspension would not have to all be mixed that one day. I do suggest at least 5% of the season's requirements of heavy suspension storage at the hot mix plant. This equates down to production capabilities of 10% of the light suspensions plus 3% of the heavy suspensions.

Therefore, if the Associate Producer has 4000 ton of light suspension and 6000 ton of heavy suspension budgeted for the season, he should be capable of producing 400 ton of light suspension and 300 ton of heavy in a day's time. Normally, the heavy suspension rate is about 75% of that of light suspensions because we do not design to add dry as fast as we add liquids. Forty ton per hour of light suspension for 10 hours, which relates to 30 ton per hour of heavy suspension for 10 hours makes a 20 hour day, and is about as close as we should count on. With the number of plants we have, we can count on some inter-plant assistance if one plant goes down for a period of time.

This gets us down to our plant design. We design and fabricate all of our cold mix plants and nearly all of the hot mix plants, as well as design and fabricate 10-34-0 production facilities with durability, simplicity, and ease of maintenance in mind. We primarily use a 1750 gallon mix vat which will mix 8 ton of light suspension or 10 ton of heavy suspensions. Again, by equation, this means a batch every 12 minutes on light suspension and a batch every 20 minutes on heavy suspensions. We do use a scale for a weigh batch method introducing the raw material because of durability and relatively trouble free operation. A scale beam is used in most of the plants but for speed up on renovation, some have gone to a dial head or a digital read out. They may not be as durable, but they are time savers. Our feed plumbing to the pump is 4" or 6" to a 25 H.P. 4 x 3 S.S. pump with a 700 GPM at 60' head discharging into a 4" line. Our mixer is of our own design with a 10HP gear reducer and turbine type paddle to create an internal pumping action in the vat forming a vortex into which dry potash is dumped to be thoroughly wetted. Some of the older plants have a smaller mixer and a recycle stream aids in wetting the potash.

We are now down to the raw materials and why we have chosen what we use. To have a uniform suspension, which is very important in the heavy suspensions, we utilize ingredients that are the most uniform in impurities, solubility, and particle size.

Water, as the carrying agent, is the first to be added. If Nitrogen Solution is to be used it is next to be added. There is no Nitrogen Solution in the heavy suspensions. High Poly 10-34-0 is next on the formulation and is utilized to help sequester some of the impurities in the Wet Process Acid to inhibit the impurities forming an undissolved solid. Dry phosphate from MAP or DAP has been used and the heat of neutralizing the acid helps in dissolution. They will serve as a back-up source of P_2O_5 on light suspensions which are not stored and where a higher viscosity from the impurities is not too detrimental. They will not serve satisfactory in the heavy suspensions going into storage. Phosphoric Acid follows the 10-34-0 and usually does not make up more than 60% of the P_2O_5 and is followed immediately with Aqua Ammonia. Aqua Ammonia generates only about 75% as many BTU's reacted with phosphoric acid as does anhydrous ammonia and ammoniation is smoother and usually faster. We recommend testing each batch just after ammoniation with a bromo-thymol blue testing solution to assure us of proper Nitrogen/P_2O_5 ratio. A combination of MAP and DAP crystals in the ammoniated phosphates is the most soluble and we go a little to the DAP side or 1:3 ratio as the DAP crystals will not grow as large as MAP crystals. Prior to adding potash, we recommend liquid clay be added. A commercial liquid clay can be purchased, however, we have found it quite simple to disperse 1 part clay to 3 parts water with TSPP using a circulation pump, eductor and mix vat. The recommendation of liquid clay is based on more uniformity of particle size due to full dispersion of clay ahead of time and time is saved in not having to shear and gel the clay in the production cycle. After the clay, soluble potash, preferably with less than 15% retained by a Tyler 35 mesh screen, is added to the vortex of the fluid being mixed. As soon as the potash is weighed into the vat, if we have the 10HP mixer creating the vortex, we are ready to pump to storage. We utilize phosphoric acid as the primary source of P_2O_5 because of its relative consistant quality which results in high rate of production of a relative consistant quality of the finished product.

From the above, we have to consider the ingredients to be used as well as the physical equipment to arrive at the answer of "How fast do we want to go."

Yes, with my responsibilities of production and distribution which includes the design, production and selling the related equipment for 10-34-0 production facilities, suspension production and applicators, the challenge is still present for timely production and application of a quality product on a customer's field. (Applause)

MODERATOR REYNOLDS: Thank you Loren. We have gotton to "Step 2". Now we have some history and some production information. We have got it produced and we go on and store it, distribute and discuss some application features.

Our next speaker, Mark Cornelius, comes from Odon, Indiana. He has formed his company there called Cornelius Farm Supply. He has a farm background. His father and his brother operate a large farm in the cash grain area of Indiana. He is one of the new breed. He graduated from high school in 1970, spent two years in the Marines, returned to the family farm, became very restless and wanted a little more action. He went into sales. He went into the chemical business. Then, he ventured into fluids. In 1977, he went into a fluid blend plant, added his newest equipment, installed a full line of fluids, based on soil tests and yields. In 1979 he expanded further into satellites. He has a group organization with between 17 and 20 people. He's had a lot of help along the way, he tells us. We are looking forward to Mark coming up here and telling us all about the storage, distribution and application. (Applause)

Storage Distribution and Application

Mark Cornelius

Cornelius Farm Supply at Odon, Indiana, is in business to distribute fertilizers and chemicals to growers in southwest central Indiana.

It is a young and growing business, formed in 1977 because there was opportunity for better fertilizer and crop programs for farmers in this area to improve their production and profits.

With due respect to Secretary Bergland, we Indiana Hoosiers think that Earl Butz was the only Secretary of Agriculture this country ever had. We lost Secretary Butz in 1976, and without profitable crop production and fertilization programs, all of us in agri business are going to lose our butts!

At Cornelius Farm Supply, we have dedicated ourselves to serving our customers through programs that will improve their production and profits. We are equally dedicated to performing our distribution and service activities at a profit. We are convinced that profitable customers will assure profits for Cornelius Farm Supply.

Winston Churchhill once said, "It is a socialist idea that making profits is a vice; I consider the real vice is in making losses."

The terrible pressures on profits from today's spiralling costs make profitable fertilizer distribution a real challenge. We selected Fluid Blend suspension fertilizers because we felt that this system of fertilizer distribution offered the superior handling advantages and flexibility of liquids at costs competitive with dry fertilizers.

Fluid Blends are suspension fertilizers in which the total phosphate source is derived from MAP. The common nitrogen materials such as nitrogen solution and ammonia are used for supplemental nitrogen sources and either soluble or fine standard potash is the potash source. Using these common fertilizer materials in a suspension fluid fertilizer eliminates the premium costs of more refined phosphate materials normally associated with liquid solution fertilizers. Flexibility is maintained for prescription formulation and incorporation of chemicals and micronutrients in uniform mixes.

Our distribution objective is the efficient service of our customers with plant nutrient programs, specific to their crop yield objectives. Recommendations are developed from soil analysis, crop history, leaf analysis, and yield objectives. We provide custom application for plow-down fertilization and for chemical application. The broadcast program for corn will compliment a customer's row application of starter fertilizer and micronutrient mixes with seeding.

Productive use of distribution and application equipment is essential to efficient and profitable customer service and crop results.

Suspension fertilizers may be defined as: Fluid Mixtures of Solid and Liquid Materials in which the Solids Do Not Settle Rapidly and which Can Be Readily Redispersed to a Uniform Mixture with Simple Mixing.

Since suspensions are formed by dispersing solids into liquids to form homogenous fluids, efficient handling systems and techniques must recognize the handling characteristics of both.

Cone bottom tanks are the preferred design for storage of Fluid Blend suspension. The sloped bottom reflects the typical design for gravity movement of solids; the tank and piping systems reflect fluid design requirements.

Since some compression of the suspended solid materials is expected in most suspension products, storage tank design should encompass effective means for simple remixing of the product. This remixing is most easily accomplished by positive recirculation of the product through piping for tangential entry into the storage tank at one or more levels depending on the tank capacity, tank dimensions, and product agitation requirements.

Storage of base grade materials such as 10-30-0, and 3-10-30 for cold-blend mixing as product is shipped can improve distribution efficiency. Finished products for starter programs, or for transfer to secondary distribution locations may also be effectively stored in cone-bottomed tanks. Optimum tank size is about 25,000 to 30,000 gallon capacity. This size tank will store about 180 tons of base or finished product, and the tank height is still within the limits of efficient pump operation. These tanks are arranged in clusters to minimize the piping requirements.

The weight and viscosity of Fluid Blend suspensions requires large pipe diameters and large capacity pumps to reduce friction losses and achieve efficient product transfer. Typical systems will include 4″ to 6″ piping with 5″ x 4″ or 6″ x 5″ centrifugal pumps. The 4″ pumps will transfer at about 600 gpm and the 6″ will transfer at about 1,000 gpm.

Additional productive efficiency can be achieved through use of gravity drop-loading tank systems. A series of cone-bottomed tanks typically of 1500 to 3200 gallon capacity are supported on an overhead rack system. Loadout is through a 6″ valve. Product is prepared to specific orders prior to shipment and held in designated tanks.

The transport equipment is pulled under the tank rack and top-loaded by the driver. The gravity feed through the 6″ valve will loadout 1600 gallons in about two minutes.

To prevent mixing of orders, tanks should be color-coded or otherwise marked for simple but accurate identification.

The overhead loading rack tanks should have a steep cone bottom of about 50° and large 6″ bottom outlets. Additional flexibility can be achieved if piping is arranged for product reclaim from these tanks.

Typical operations will include both overhead loadout systems and a loading rack for pump loadout direct from the mixing unit or from large storage tanks. It is inefficient to use the mixer pump for loadout from storage; therefore, a separate loadout pump should be used.

There are many types of nurse and transport equipment. This is an area where improved design by equipment manufacturers can vastly improve productivity. The drop tanks previously mentioned provide for rapid and efficient loading. Loading platforms should be mounted permanently on the transport equipment for safety and efficienty. The size of trnsport should be determined by distribution logistic factors:

> the ton-mile transport distance; the use requirements at destination; and the product properties.

The transport should be fitted with pump recirculation sparger systems.

The product will settle or compact from vibration of highway transport and efficient remixing is required at destination before use.

Loadout efficiency can be improved by adequate communication between the loadout rack and the billing office or dispatcher. Color coding or other identification of loads is effective at the loadout rack. It is also helpful to color code the transfer lines from the mixer to the loadout tanks.

Nurse equipment should be fitted with 3″ outlets and piping for efficient handling. Horizontal tanks require a trough bottom and sparger recirculation is desirable. Poly sphere and poly cone tanks are very popular for nursing equipment. These can be easily recirculated by bottom suction and top-return. Transfer may be through the pump system on the applicator or by a pump on the nurse vehicle.

Nurse equipment and pumping systems should be designed to efficiently serve the application equipment, and minimize idle application time. Forward scheduling of application services is difficult but can really pay off in improved customer service and productive use of equipment.

Transfer time from nurse equipment using a 3″ centrifugal pump typical to high capacity floater equipment can easily run 15 to 20 minutes. At 20 minutes, productivity efficiency of the applicator and operator is 67%. If this time can be cut in half productive efficiency will increase to 83.5%, an improvement of 25%.

Transfer efficiency can be improved through use of larger transports and larger capacity pumps. Use of large transports to nurse application equipment will provide for more efficient application but the idle time will be traded off to the expensive transport.

Larger size transfer pumps and hoses can also improve transfer efficiency but lugging and connecting a 4″ transfer hose is a man-killing effort.

Like nurse equipment, applicators come in all shapes and sizes. Suspension fertilizers are most easily handled through centrifugal pumps of at least 3 x 3″ size. Suspensions with solids of less than 20 mesh particle size can be handled very well in piston-type pumps. Larger pumps and piping diameters will provide greater flexibility and efficiency. It is well to maintain large diameter plumbing as much as possible to reduce friction loss in the fluid lines. Rather than reducing the plumbing diameter at the pump discharge, friction loss can be reduced by reducing at the nozzles or at the boom. Sparger recirculation should be included in all application systems.

Row application is satisfactorily handled in corn planters equipped with squeeze pumps or 2" piston type pumps with products formulated to specific qualities for this type of application. Lower viscosities are desired and crystals, and solid particles in excess of 20 mesh cannot be tolerated.

Fluid Blend suspensions are particularly effective in broadcast applications. Distribution is uniform and even application of the homogeneous mixture of major plant nutrients, secondary nutrients, micro-nutrients, and chemicals is easily and effeciently accomplished.

Agronomic prescriptions are easily and effectively met. Soil compaction is reduced and efficiency improved through one-shot application of all fertilizers and chemicals. Dusting and wasteful uneven distribution is eliminated, assuring productive crop yields.

Efficient and effective service of our customers with high quality products, homogeneously mixed into precise agronomic formulations, and uniformly applied provide the best assurance I know of for optimizing profitability for my customers. We are convinced that our continued efforts to promote our customers profitability will provide the profit necessary to the continued growth and success of our Cornelius Farm Supply.

MODERATOR REYNOLDS: Thank you, Mark. I am going to ask Frank Achorn, Loren Hopwood and Mark Cornelious to come up to the head table for discussions. Do we have some questions for these gentlemen?

Questions and Answers

Moderator Reynolds

QUESTION: My name is Juhani Poukari from Kemira-Or-Finland. I would like to know what the freezing properties are? At which temperatures are the substances frozen? What happens when you heat them up again?

ANSWER—FRANK ACHORN: You are talking about 13-38-0? It unthaws difficult. What we recommend, if your are going to store 11-38-0, that it contain at least 10% Poly-Phosphate (For Winter Storage) that it be deluted to a 37% P_2O_5 grade, and that it be air sparged in the storage tank once a day. One reason, we recommend air spraging of suspensions is that if you allow the material to remain quiescent on the side wall of the tank, it tends to grow big crystals. If you air-sparge it once a day, you break up the material and keep the large crystals from growing on the walls of the tank. We have photographs to show that. The other advantage to air-sparging, once a day, is to make sure that you do not have the separation into two distinct layers. In this instance a clear layer on the top and a suspended layer on the bottom. That clear layer at the top is a saturated polution with no crystals on it. Therefore, it is an excellent medium for the growth of big crystals if it appears; and it will. I do not care what anybody says. It will appear in 99% of the suspensions.

QUESTION FROM THE AUDIENCE: Primarily most of your suspensions are getting 60% of your P_2O_5 from acid. Have you gone beyond that?

ANSWER—FRANK ACHORN: Yes we have on the lighter weight suspensions. On the heavy weight suspensions, that is about all that we can neutralize, because we feel that we should use some "Polys" as a heat sink, and on the 3-11-35, 60% P_2O_5 using "Aqua-Ammonia". I would cut down to less than 50% if you used Anhydrous Ammonia.

QUESTION—HAROLD BLENKHORN: Mr. Hopwood you mentioned that you use a combination of Ortho-Acid and Polyphosphate. Do you use, as your source of Poly, Super Acids or do you purchase 10-34-0 made from Super Acids?

ANSWER—LOREN HOPWOOD: We produce 10-34-0 ourselves, so we are using 10-34-0 produced from Super Acids. We had been using on our production of 3-11-35, 2% dry clay. T.V.A. says you cannot get that much dry clay in there. The way we were introducing that was ahead of ammoniation. The acid, itself, plus the extreme heat we give during ammoniation, reduces the suspending ability of the clay and we are using 2%. Now, then, if we went into using Liquid Clay, we wait and put that in just ahead of the potash. It is in the hot liquid for a short period of time but soon cools down. We are using just half as much actual clay. The economics, around $3500 to $4000 will provide the equipment that is necessary to produce the liquid clay, whether you are using bagged clay or bulk clay as the primary source of clay. We are using just half as much clay as we were. The TSPP adds a little cost. I think it is about 40% less cost to use liquid clay. This saving will help pay for the equipment to liquify the clay.

QUESTION— FRANK NIELSSON: Now, my company happens to be in the potash business. Years ago, I used to do a little bit of troubleshooting on suspensions. I just wanted to see what they do about adding potash, because one of our plants had a satellite customer who was making what you would call a heavy suspension; let us say 3-10-10. He noticed that when he used our special standard potash, the fine stuff, that he had a hell of a job bringing it back in if it settled out. If he used tech ag-white potash, the single crystallized material, it came back very well. We are wondering why the difference, because, essentially, they look about the same, one is red, one is white. We asked our man in Carlsbad to take a look at it. He came out with the fact that ag-white is much more uniform in particle size, whereas the special standard has a much wider range of particle sizes. He said that was why the ag-white would go back into suspension after it had settled out. I am just wondering, what kind of potash do you use generally, and have you noticed any difference using, say, a special standard compared to an ag-white?

ANSWER—MARK CORNELIUS: All I can tell you is, from our experience, we have used just about every kind of potash, I guess. We have tried the fine standard. We have tried standard and soluable. This coming year, soluable is all I am using. We use lower rates primarily. I think if a guy was in a situation where he used high rates with total N P and K applications, he could use any product he wanted to use. He would be using larger nozzles. As far as coming back into suspension, we have found the soluable to be the easiest product to use.

ANSWER—FRANK ACHORN: I would like to add to that just a little bit, Mark. I mentioned that we want the soluable potash, maybe the red would work also if it would not retain more than 15% of the material in a 35 mesh screen. In fact, the Farm Chemical Magazine, which are out on the table, has a story in there on segregation of various size solids. Even when you get a car of soluable potash in, even the little coarser particles will roll to the outside of the pile, leaving the finer particles in the middle. Sometimes, we will have a batch, if you are picking up the potash from the edge of the pile, that does not suspend that particle size as well as that that comes from the middle of the pile.

BILL ADAMS—ALLIED CHEMICAL CORP.: I would like to ask Mark a question. I think he said that 80% of the fertilizer was suspension type. Am I correct on that?

ANSWER: MARK CORNELIUS: That is correct, at my plant.

QUESTION—BILL ADAMS, Allied Chemical: Is it applied on top of the ground, under the ground, or on what basis?

ANSWER—MARK CORNELIUS: Well, normally, an inch to the side and two inches below, two and two, something in that area.

QUESTION—FROM THE AUDIENCE: Are you doing any screening of your material going into the mix tank? All materials, that is.

ANSWER—MARK CORNELIUS: Definitely. It is screened. The dry material goes across a shaker screen before it goes into overhead hoppers, which charge the mixer. Then, it goes through a larger mesh screen, I think about an eighth inch, then, again, through another strainer screen that goes into the floater or reverse vehicle or transport or whatever.

QUESTION FROM THE AUDIENCE: Are you using any kind of lump breaker or tailing mill type thing where you go in prior to your mix tank? Did I understand correctly that you are screening before you go to your mix tank?

ANSWER—MARK CORNELIOUS: The dry product.

ANSWER FROM FLOOR: Yes.

MARK CORNELIOUS: Yes. It does have a shaker screen that all the product flows thru.

QUESTION FROM THE AUDIENCE: Have you some kind of breaker there or pulverizer type?

ANSWER—MARK CORNELIOUS: It has a vibrator on it.

QUESTION FROM THE AUDIENCE: You do not have anything that actually breaks in part particle size if they are to big?

ANSWER—MARK CORNELIOUS: If big lumps are in there, it is not going to go through. We do not have a lump breaker. We just scoop it off. This is another reason that we went back to soluble potash. In other words, if we get any lumps in the stuff, the shaker screen will break them up, whereas, in the fine standard and other grades of potash materials, the lumps are a lot harder, and they do not breakup as easily.

QUESTION FROM THE AUDIENCE: If you got them in your mix tank, they will stay there. In other words, you will have it in the bottom of your tank when you load out. Now you are speaking of larger pipes and bigger pumps. What rate can you manufacture suspensions on that type of thing?

ANSWER—FRANK ACHORN: Generally about 20 minutes per batch.

QUESTION: What size bath?

ANSWER—FRANK ACHORN: We use 5 inch recirculation lines, 5 inch discharge pump.

QUESTION FROM AUDIENCE: What capacity have you got? We cannot make over ten tons an hour on a Suspension.

ANSWER—FRANK ACHORN: They make two ten-ton batches per hour, put it that way.

QUESTION FROM AUDIENCE: In other words, about twenty tons hourly?

FRANK ACHORN: At least that.

QUESTION FROM THE AUDIENCE: How about DAP? Is there any maximum amount you can use in a ton mixture, as far as weights are concerned?

ANSWER—FRANK ACHORN: Generally, using MAP, we found the best grade to use is 11-30-30 as a base material. That is about the highest P_2O_5 we use.

QUESTION FROM THE AUDIENCE: Are you using any solid DAP in making suspensions?

ANSWER—FRANK ACHORN: Oh, yes, solid DAP is used to make suspensions.

QUESTION FROM THE AUDIENCE: Is there any maximum amount used to make suspensions?

ANSWER—FRANK ACHORN: We generally produce 11-30-30 grade in which 70% of the P_2O_5 is supplied by DAP and 30% by acid.

MODERATOR REYNOLDS: We are going to have to cut the questions. We are running a little bit tight. I want to thank the speakers. We'll have a chance to get back at them later on, hopefully, at the end. I am going to turn the program over to Herb MacKinnon who is going to moderate the next four speakers. (Applause)

MODERATOR HERB MACKINNON: Thank you, Joe and speakers. We are going to move right along with the program now with additional panel discussions. The first speaker will be Robert Dixon of Farm Service, Inc. in Hokie, Arkansas. Bob is 36 years old, married with four children. He has a B.S. in math, engineering and agriculture and a M.S. from L.S.U. in agricultural economics. He has been active in the Arkansas Plant Food Society, is a past board member. He is presently Secretary of the Arkansas State Plant Board. He has been employed by Farm Service, Inc. as a General Manager for 11 years. Farm Service, Inc. is a diversified farm supply business in northeast Arkansas. This supply business under his management, has changed from a half million annual sales and 13 employees in 1968, when he joined them, to sales of over 14 million with 90 employees this year. He has been in the suspension fertilizer business for two years, and he is going to speak to you on marketing and distribution of suspension fertilizers. Bob.

Marketing of Suspensions

Robert Dixon

Five years ago I would not have thought it possible for me to be talking about the merchandising and marketing of suspension fertilizer, but times change and we try to change with them.

In the twelve years I have been in the fertilizer business we have always looked at liquid fertilizer as an alternative to dry fertilizer. I never thought we could justify the move to liquid. At first, I decided that liquid would not last. It was a "here today and gone tomorrow" product. In our area we could not see any benefits to our farmers over dry. But the introduction of suspensions and the production of better handling and manufacturing equipment for higher analysis fertilizer made us interested in pursuing liquid suspensions. Also, I found that my most aggressive farmers were asking about liquids.

Two years ago we made the move into suspensions by purchasing a Bard and Bard liquid plant. This investment of company capital was treated as any other investment. We have a preset procedure for deciding on capital investments. This justification procedure is also used as the first step in our 4 prong marketing and merchandising system. These four steps are:

1. Evaluation and information gathering
2. Formulation of a plan
3. Taking the offensive and implementing the plan
4. Following through after the sale

We spent one a half years reading, talking to suspension dealers, and visiting with personnel from equipment manufacturers and TVA. We visited 22 different dealers trying to find out what they thought and how they handled their product. This was my search for information to judge the feasibility of suspensions. I have found suspension to be as good as an investment of company capital as we have ever made. But more important, suspension fertilizer is the best alternative for the farmers. This makes the long run situation secure and makes suspensions a "sellable product".

I have always felt that a good salesman cannot sell a product if it is not a quality product and one that will benefit his customer. This is the beauty of suspensions. We don't have to "sell" this product — we only present it. We kept this in mind when we developed our marketing plan. My major concern was to make the farmer knowledgeable of suspensions. We knew if we could do this, he would buy the product. We set out to slowly and methocically give the farmer the knowledge we had gained in the previous one and one-half years. A time frame was set for starting in August and having completed all plans before the start of the next season.

I have a "hangup" on how information or advertising is presented to farmers. I have seen major chemical companies waste thousands of dollars in advertising money trying to reach the farmer. Then, I have seen others spend half the money and be ten times more effective. I'm sure you all have seen the chemical advertisement that shows the farmer in coveralls, driving an old dilapidated truck, backed up to a 1920 vintage warehouse, buying chemicals that are being rolled out on a two wheel cart. Or right in the middle of your favorite TV show you've seen all kinds of animals prowling across your screen roaring out the name of some chemical. In my opinion, advertising money spent this way is pure economic waste. They not only turned off the *commercial farmer* when they depicted him as using horse collars, but they stepped on my toe when they showed the dealers warehouse. Today we have forklifts running out of steel warehouses placing pallets of expensive chemical on new pickups for one of the most innovative and aggressive businessmen in the U.S. And this is the same farmer that *wants* to buy suspensions. And this is the commercial farmer that we made plans to inform about suspensions.

But before we started our offensive to inform the farmer, we informed all of our employees. These employees have all attended fertility short courses. We used slide presentations of dealer installations we had visited and used as detailed production information as we could obtain. All key personnel were expected to be able to discuss suspensions intelligently. This included knowledge of mole ratios, suspending agents, liquidity curves and many other technical aspects. We want to *talk up* to our famers, not *down* to them.

Several years ago I had a nightmare. I dreamed that I was standing on the big long porch of a farmer's house trying to sell products to the man inside. I was not invited in and had to talk through a big screened window.

The farmer sat and rocked in his chair, drank coffee, and it was obvious he did not pay any attention to what I had to say and was not interested in what I had to sell. Since that night I have been looking for the *key* to that farmer's door. I want that farmer to listen to me as we have coffee together in his living room. I have found that the *key* to his door is *confidence.* It is given only after long hard hours of work and it can be destroyed very quickly by a few thoughtless words. For this reason, our offensive to "sell" suspension fertilizer was of a no pressure, "take it if it works for you" type. It was factual and straight forward.

We started with informal contact where we explained to our customer what we were going to do. We used direct mail in an attempt to inform about our new product. Then, we followed with a series of 13 farmer meetings. These meetings were organized along product lines of milo, rice, and soybeans within each trade area. Each meeting was organized with three guide lines:

1. Never allow over an hour and 15 minutes of presentation after the farmer has been served the best dinner we can arrange.
2. Have highly informative information from one or two commodity specialists.
3. Have at least 30 minute presentation on what suspensions were and how they fit in with a given crop.

These meetings were our main thrust. They were our main efforts to present — present, not sell. We concentrated on the quality of our equipment and the main advantages of suspensions like weed and feed, service, even spread pattern, uniform application of micro-nutrients and the ease of applying micro-nutrients.

We tried not to say words like unique, different, better than, or impressive when making reference to suspensions. These are the building blocks for short run programs and we want to build a long run situation. Our main objective was to take the farmer through the same decision making process that we had gone through. And have him reach the same conclusion — suspensions are for me.

Like any good golfer knows — you cannot make an initial drive from the tee without thinking about the "follow through". Our "follow through" is a continuous process. More than anything else it is one of problem evaluation and problem solving. Items like:

a. How do we always remember to get the Treflan out of the booms before we start on a milo field, or,
b. How to prevent stopped up nozzles or getting to the wrong field, or,
c. How do we keep the farmers thinking suspensions — and so on

Every year we wash our laundry and hang it on the line so that the farmers can see we want to start clean. We, like anyone, make mistakes, but when we do, we admit it and correct it.

Essentially, the follow through is to keep the business you have and to prevent the loss of business. I have always felt that farmers quit doing business with a dealer for three reasons:

1. The dealer made a mistake that he did not correct, or
2. The dealer lost contact with the farmer, or
3. The dealer did not have the information or product the farmer desired

The best marketing program is to do it right while maintaining contact and providing the products, service, and information the customer desires. (Applause)

MODERATOR HERB MACKINNON: Thank you very much, Bob. Some of us were discussing the program last night, preparing for this morning. Somebody said that nothing happens until a sale is made. I think Bob is very much pointing that out this morning. Somebody else added a comment, nothing happens until a sale is made and collected for. I think that relates to some of the other comments this morning.

Our next speaker is Jim Westfall of Ohio Soil Service Inc. at Mechanicsburg, Ohio. Jim has been with Ohio Soil Service since 1956. He has a B.S. degree in agriculture from Ohio State University. He served in many capacities with Ohio Soil Service and is presently Vice President. He also is Senior Vice President of the Ohio Grain, Feed and Fertilizer Association. He is past President of the Ohio Pesticide Institution. He is a farmer and is active in the Marysville, Ohio Kiwanis Club. Jim will also speak to us this morning on merchandising and marketing of suspension fertilizers. Jim.

Merchandising and Marketing Suspension Fertilizers

James D. Westfall

There is nothing I dislike more than some self appointed authority on an ego trip speaking on "How I do this or that".

Yet, I have been asked to share my experiences with you in marketing and merchandising Fluid Blends. Since my only base of authority is our experience at Ohio Soil Service, Inc., I must, therefore, speak on "How we do it".

Background History

First, please understand that although we have been marketing fertilizers for more than twenty-five years, our Fluid Blend experience dates back only one year. I am hardly an authority, let alone an expert, even though I am far enough from home to qualify.

Ohio Soil Service, Inc. (OSSI) is a wholly owned subsidiary of the Ohio Grain Company, an old established grain and feed firm.

The combined companies operate three grain elevators, (one a large sub-terminal) a feed manufacturing plant, six fertilizer outlets and a seed processing facility.

The fertilizer operations offer the customary service; dry bulk blend, clear liquids, UAN solutions, anhydrous ammonia, seeds, chemicals, and fluid blends.

Nearly 75% of our dry blends and 100% of our fluid blends are custom applied. We own very little custom application or transportation equipment, choosing instead to contract with independent operators for this work.

We became interested in fluid blends three or four years ago. Right or wrong, I saw suspensions, offering our farmers some distinct advantages, while giving us a new, unique, marketing tool.

Local environmental concerns caused a year's delay but we finally opened for business in September of 1978.

The Agrico designed plant has a thirty TPH production capacity. It has 3200 tons of dry storage and 1000 tons of liquid raw material storage and 650 tons of finished product storage.

Service Logistics

We service all of our suspension business from the Mechanicsburg "Mother" plant.

Finished product is shipped directly to the field in nearly all cases. We have looked at a satellite plant program, especially for the two branches furthest from the "mother" plant. Even though this is nearly 25 miles distance, I am not sure we can justify the additional investment if we can do a good job of scheduling trucks to keep the floaters busy every where.

We can currently put up to five floaters on suspension work. I say up to, because we can, and do, jockey between liquid and dry as seasonal demand requires.

I am not sure the color of your flotation equipment matters much, but we are using four Big A's and one floater.

Frankly, neither machine has worked to our satisfaction with fluid blends without extensive modification. Things like bigger pumps and lines were found necessary.

We try to keep the Big A's in the field and working by nursing each rig, with two semi-tankers and one tractor. Quite often this is not enough, especially with high rates and/or long hauls.

Some customers went as high as 1200 pounds per acre last spring, so a 25 ton load only does 41 acres. If you are shooting for 350 acres a day, this means eight or nine truck loads, and you just can't do it with two trailers and one tractor.

Our system works fine for 500-600 pound rates and 10-12 mile hauls. You stretch either one much and you are in trouble.

Merchandising and Marketing Programs

There is a saying often heard at our sales meetings, "at Ohio Soil Service, everyone sells". Although this is not always true, it sure sounds good at a sales meeting — and it really does point out our philosophy about selling.

We have tried several methods, but at present, we have one full time agronomist whose major responsibility is to sell. He has primary responsibility for some 80-100 key accounts at four branch locations. At the present his accounts are 800 acres or more in size.

In addition to servicing larger accounts, the sales agronomist is responsible for new key account development, training and education grower meetings, and fertilizer and chemical test plots.

Our branch managers are expected to devote time to outside sales, prospect development, follow up, meetings, etc.

The branch manager has primary responsibility for marketing at his branch, and is expected to use the agronomist to the fullest advantage.

OSSI has historically relied heavily on technical service rather than price to help sell our products.

Our technical service program includes the basic soil test (free) written recommendations for N-P-K, seeds, chemicals, and management factors.

We insist on follwow up sales calls, field inspections, post-harvest evaluation, and prompt complaint investigation.

Each branch maintains a complete customer file on all key accounts and many smaller ones. These include soil test results, recommendations, purchase and use history, field maps and evaluations.

Many in season orders are placed as "give me what Kirk recommended on field 21", and we take it from there.

We have also offered a formal "Scouting program" on a limited basis for the past two years. This program is co-sponsored by the Cooperative Extension Service. The University trains and supplies the scout.

This year it was a young lady who did a super job on nearly 2000 acres.

The charge is $3.00 per acre for weekly visits which start just before planting and run to maturity. The program is about break even for us.

Advertising and Promotion Program

Our intention to enter the fluid blend market was announced with the usual glowing press releases. The zoning and environmental battle that followed provided more press coverage than we really wanted, so our progress, or lack of it, was a much publicised fact.

We kicked things off with an Open House at both the new fluid blend plant and Ohio Grain's newly remodeled grain elevator. The Grand Opening featured plant tours, supplier displays, and of course, free food.

We use limited newspaper advertising. Our advertising is on a seasonal basis and we stress the benefits of fluid blends.

Our most successful promotions have been small grower meetings held at each branch to introduce fluid blends. Each hosted 15 to 20 growers. They discussed and compared product features and comparisons, economic comparisons, fluid blend benefits, etc.

We try to keep our grower meetings low key and highly educational.

Follow up calls should be made within a week or two to nail down good prospects.

Other promotions we used were:

1. The production of our own fluid blend sales manual
2. Demonstration plots and field days
3. Sales incentives for new fluid blend business. Both cash and trips were offered.

Fluid Blend Economics

I have saved the most important point for last in this discussion — Economics are what this game is all about.

Fluid blends have some definite pluses and some real minuses.

First the Pluses:

1. It is no secret that suspensions formulated on the MAP program are competitive in cost with dry blends. In fact, you can formulate some grades at less cost. It also means you are formulating at considerably less cost than clear liquids. You get the option of competiting with dry blends, on an even basis, or clear liquids, and holding more margins.
2. Fluid blends are worth more, and the farmer will pay more than for dry blends. Our customer will pay three to four dollars per acre more for uniform application of a homogenous mixture. We are getting 5 to 10% more margin from fluid blends than dry blends at the present time.
3. Farmers really like the "one trip over the field concept". Fewer applications help offset the increased cost, reduce compaction and save time. Our customers recognize what their time is worth in the planting season.

What about the minus factors:

1. We found we cannot on standard grade potash to give us the product we want, so we have gone to Kalium's fine grade. This costs more than expected.
2. Fluid blends cost more to transport and spread than we expected and substantially more than dry blends. Lower analysts, higher per acre rates, and a high percentage mixed with herbicides, all tend to slow you down and increase costs. The state of the application equipment art has not kept pace with product technology. Pumps are too small — lines are too small — trucks too small — everything is too slow!
3. Already the MAP suppliers are trying to kill the goose that laid the golden egg. The differential between DAP and MAP has increased from $5 to $10. This obviously hurts MAP fluid blend formulation. They may find we can use DAP and spent acid if this spread continues.

I certainly don't want to conclude on a sour note, so I finish by saying we are generally pleased with our fluid blend operation.

Increased margins and good customer acceptance seems to point to a profitable operation.

Ask me again in five years! (Applause)

MODERATOR MACKINNON: Jim, thank you very much for an excellent presentation.

Our next speaker is Jack Zorn. Jack is married, has two daughters, was born and raised in Florida, Alabama, and graduated from Marion Military Institute and the University of Alabama. After serving a tour of duty in the Army as an infantry officer, he joined Monsanto Chemical Company. He left Monsanto in 1971, after ten years, to form Zorn Brothers Inc. with his two brothers. He is a member of the Board of Directors of The Fertilizer Institute and the Alabama Soil Fertility Society. He is past chairman of The Fertilizer Institute Retail Committee. Jack told me this morning that he has been in the liquid fertilizer business three years in Florida. Jack. (Applause)

Fluid Lime and Micronutrients With Suspension Fertilizers

C. Jack Zorn

My presentation this afternoon consists of two parts — Suspension Lime and Micronutrients, and how these products are incorporated into a suspension fertilizer marketing program. I will briefly describe for you the evolvement of these products into our overall marketing program.

Zorn Brothers, Inc. is located in South Alabama in a predominately sandy loam soil area. Our primary crops are soybeans, peanuts and corn double cropped with rye, ryegrass, or wheat in the winter months. We are a broad based Agri-Business with three operating divisions: Plant Food, Grain, and Fertilizer Systems. For today's presentation I am wearing the Plant Food Division Hat.

Part I — Fluid Lime

Why Fluid Lime? The basic catalyst behind all new products that are introduced into the market place is need creating demand — Fluid Lime is no exception.

We work with farmers through a very in-depth crop planning and total crop production program. We sell him many commodity items which are molded into a proprietary program. Maintaining soil Ph is certainly one of five more critical items in the program.

Our entree into the production and marketing of Fluid Lime was one of Agronomic necessity. Many customers were applying a ton of Standard Grade Granular AG Lime each year and not building their Ph levels. As stated previously, we are dealing with sandy loam soils. The annual rainfall is in the area of 55 inches and much of this soil will receive 150# N per acre each year and produce two crops.

Why Fluid Lime?

1. Good quality Granular Limestone not available when it is needed.
2. Adequate Ph response not obtained with Granular Ag Lime. Quicker response with Fluid Lime.
3. Better quality control with Fluid Lime program.
4. More uniform application.
5. Greater flexibility of application in combination with other products.
   a. Applied with Clover, Millet and small grains.
   b. Applied with N, K_2O, M_gO and Sulfur.
6. Can be applied in the rain with flotation equipment.
7. Greater efficiency of fluid fertilizer equipment.

Agronomics of Fluid Lime

I have very carefully kept up with most of the many articles, papers, reports, discussions and studies, both objective and subjective on this subject. Views are, to say the least, extremely varied. I have also kept very careful farmer records where Fluid Lime has been applied to our customers' soil during the past three years. This is the data I take seriously. This is the data that we base the decision on as to whether we should retain or delete a product program from our operation. To date, after three years, this data is impressive, the demand for the product is good, and we will continue to sell Fluid Lime.

The Alabama Lime Law is a good one. It states that 50% of Dry Ag Lime should pass 60 mesh, and of at least 90% $CaCo_3$. We interpret this to deliver to the soil half of that on as effective material, based on the $CaCO_3$. The Fluid Lime Law states that the material must be of 50% concentration, 44% $CaCO_3$ and 100% pass 100 mesh.

Soil Recommendations

Our basic recommendation is 2000 pounds Fluid Lime per acre where 2000 pounds Ag Lime is recommended.

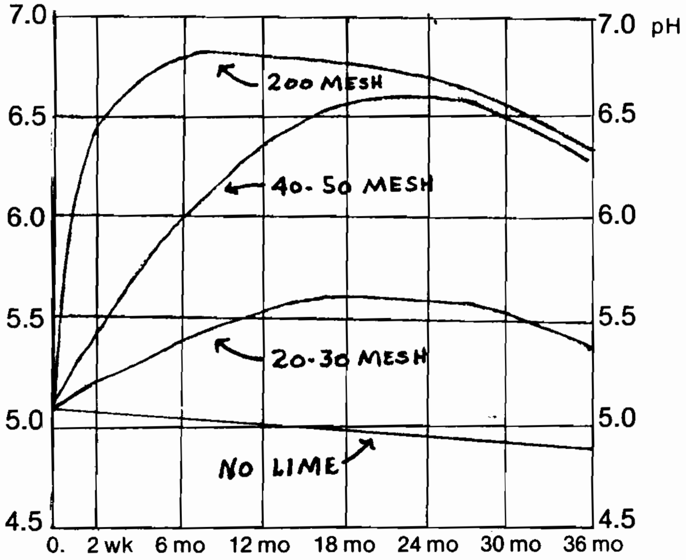
We compete with Tag Quality Dry Ag Lime.

In most cases, the farmer feels that he is getting far greater response on the 1:1 recommendation, therefore he will generally tend to use less actual Lime from Fluid than from Dry.

Why?

1. The product we use is 70% - 325, 100% - 200, mixed 50/50 with water and 30 lbs. dry Attapulgus Clay per ton.
2. It is of Tag Quality.
3. It is applied evenly.
4. Ph response is quicker.

Of the many charts you have seen, let's look again at thee and then simulate a fourth.



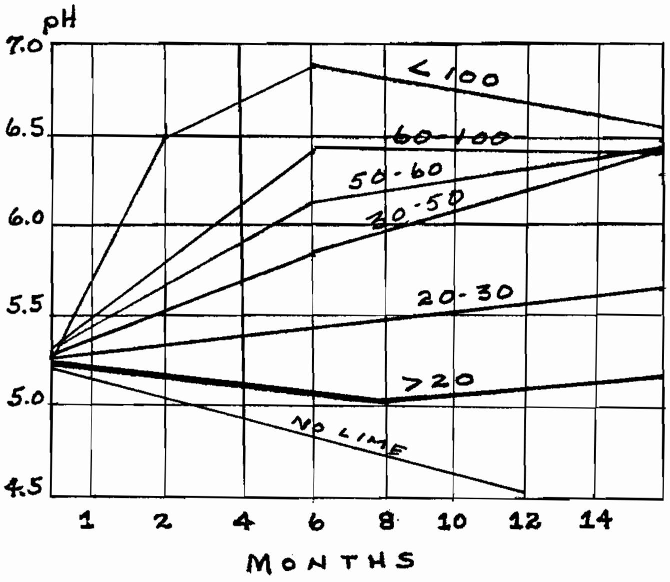
1.

Chart from Jerry Hakenson's Paper "Use of Lime in Suspensions"

Efficiency of Liming Materials Depends on Particle Size

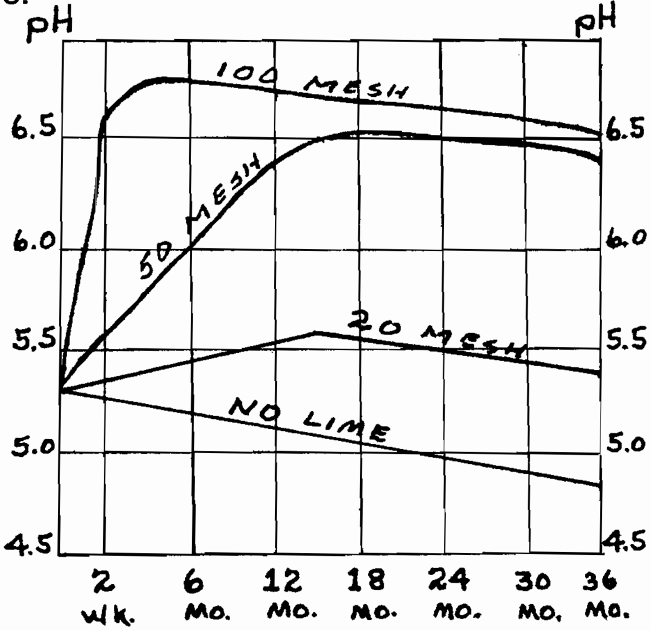
Chart from John Peifer Goldkist Limestone Study

2.



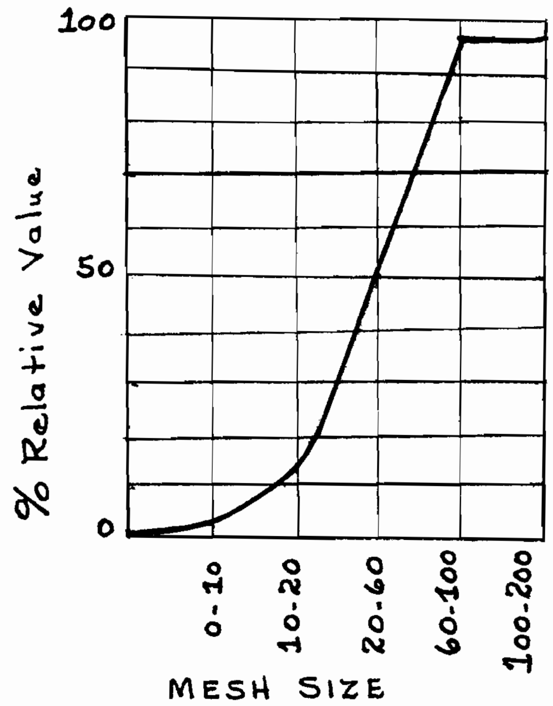
Dr. Fred Adams, Auburn

3.



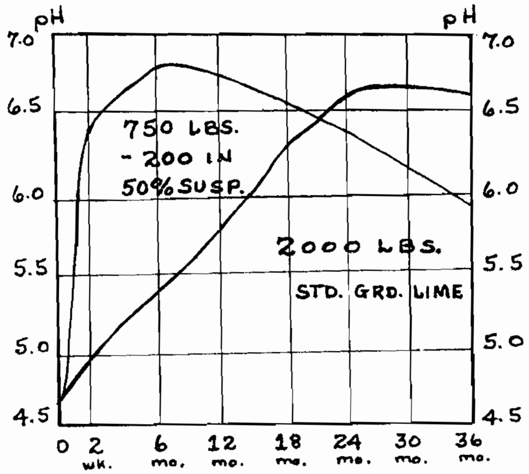
Dr. Fred Adams, Auburn, Most Recent Chart

4.



? Simulated Chart

5.



TIME is DOLLARS to the Farmer. He weighs quick pH vs. longevity as an investment.

Summary

Based on the first three authenticated charts and the fourth simulated chart, one can only conclude that there is a vast difference of opinion as to the true effectiveness of the various size liming materials.

As I look at the reality of the situation — the farmer who buys the products, farms for profit, and pays his bills — it leads me to believe that somewhat less 200 to 325 mesh Lime applied in a good quality suspension may prove on certain soil types to be of greater value to the farmer than standard grade Dry Ag Lime.

Fluid Lime does not have application to every retail operation, the greatest limiting factor being supply. To have a quality and effective product we must have quality Lime Flour (100 mesh to 325 mesh) as a raw material. This product must be made into a quality suspension, transported and applied at the correct rate per acre in a uniform manner. If all this criteria is met, you will most assuredly meet the basic fundamental marketing test — that of providing value to the customer for the dollars he is paying now.

I feel that a quality Fluid Lime program has great value in many retail operations. I challenge the Fertilizer Industry as well as the Agricultural Academic Community to initiate studies to determine objectivety:

1. Dollar value of uniform application Suspended High Quality Fluid Lime.
2. True effectiveness of 60 mesh Limestone vs. 100, 200, 325 mesh material.
3. Procedures to stabilize,manufacture, and apply numerous Limestone and Cement By-Products, many with astronomical neutralizing power.

Manufacturing Fluid Lime

We have used three basic methods:

1. Dump Lime Flour into fertilizer bin, transport with front end loader, auger into Fert-O-Batcher.
2. Blow into 10,000 gallon horizontal tank from pneumatic truck. Predetermined amounts of clay and water in tank when truck discharges.

   Horizontal tank equipped with three equally spaced 12" x 12" propellers. Center propellers pushing down (Dry Lime Flour enters above center propeller). Two end propellers pushing up.
3. Blow into 25,000 gallon recirculation tank, equipped with 6"x6" pump with 40 h.p. motor.

Option number three has proven to be by far the most efficient of the methods used to date.

Part II — Micronutrients in Suspension Fertilizers

Micronutrients in Suspension Fertilizers offer us a wide range of flexibility only limited by our knowledge of our products and ability to use Clay and other gelling agents.

Products that Zorn Brothers has used:

1. Chelates
2. Sulfate Powders
3. Elemental Powders
4. Suspended Elementals

Since making the transition from a Dry Bulk Blend Operation to a Suspension Fertilizer Program our Micronutrient Program has followed product priority as listed above.

For the past year we have moved exclusively toward number four, suspended micronutrients. The ability to manufacture powders in suspension has been made possible as the result of a product developed by our Fertilizer Systems Division. The product is ZAP GEL. Basically, one pound of ZAP GEL will suspend micronutrient or fertilizer materials equivalent to twenty pounds of Dry Clay. We will produce a number of ZAP GEL variations. These various products will have incorporated into them proper and balanced ratios of suspending and wetting agents to fit the various micronutrient of fertilizer formulations. Technical letters as to formulation and mixing procedure is also a very important part of the program.

Through the program a suspension fertilizer dealer will have the option of preparing his suspended micronutrients as a Premix similar to the way he would handle 10-30-0 or 4-12-24 Base Grades. By so doing he prepares his Micronutrient Bases when he does not have the pressure of the customer, therefore speeding up his manufacturing operation during the heat of battle.

Another option the Southeastern dealer has is to simply buy the suspended product from Zorn Brothers and not have the labor involvement of double handling the bags. To date we are prepared to ship the following products:

PRODUCT	END USE
ZAP GEL	Suspending agent for fertilizer and/or Fluid Lime
ZAP GEL-S	Suspending agent for 50% Flowable Sulfur
ZAP GEL-M	Suspending Agent for 50% Suspended Magnesium
ZAP MAGNUM-25	Suspended 25% M_g0
ZAP FLOWABLE SULFUR	50% Suspended Sulfur
ZAP SUSPENDED ZINC	40% Suspended Zinc
ZAP SUSPENDED MANGANESE	30% Suspended Manganese.

With this concept and this beginning family of products I see great transportation and labor savings and a new era of micronutrients in suspended fertilizer. (Applause)

MODERATOR MACKINNON: Thank you very much, Jack. I think you met the challenge of encompassing a really broad subject, compacting the information and getting it across to us very effectively.

Our next speaker is Jack Whitmore. Jack is President of Whitmore Fertilizer Company, Inc., located in DeWitt, Arkansas. He is a native of Arkansas. He was born in a small farming town in eastern Arkansas, St. Charles, where he now resides. He began his business in cotton-ginning. He owns and operates a cotton gin. He started that business in 1950 and stayed in it until the county lost all the cotton acreage in 1972. He entered into the dry blending fertilizer business in 1962 and is still engaged in this business. He began building a liquid suspension plant in 1978, completing it this past Spring in May. Jack is going to talk to us about why he chose suspension fertilizers as an addition to his product line. Jack (Applause)

Why I Added Suspension Fertilizer To My Product Line

Jack C. Whitmore

To make a presentation on a subject such as Suspension Fertilizer seems almost meaningless unless you have an understanding of the needs of our customers and the history of our company. Only in this way can you best understand and appreciate our need and desire to add, not only suspension fertilizer, but any other forms of advanced technology that will enhance the prestige of our firm, and motivate the leaders of our local farm community.

Our fertilizer plant is located in DeWitt, Arkansas, which is near the center of one of the oldest and largest rice producing areas in the United States. Our crops are virtually all rice and soybeans, with a one year rice and two year soybean rotation.

My company had it's beginning in the year 1962 as a simple dry blend operation. In 1975, we began thinking about suspension fertilizer, and for the next three years, we used much of our off season time in making a feasibility study to determine such factors as (1) market potential (2) Availability of products for fluids (3) Plant expansion for additional inventory, and (4) Financing additional investments. All of this information was necessary to make a final decision on the wisdom of adding fluid fertilizers to our present program. In the spring of 1978, we elected to add suspension fertilizer to our product line, and as soon as our season ended in that year, we began our planning and building program. In the spring of 1979, our plant was completed and we began operating.

In my judgement, suspension fertilizer has seven major advantages in the area that we work, and among the farmers whom we serve. The basis of this presentation will be to expound on these advantages.

(1) *Suspension fertilizer provides a better mixture of NPK.* I know of no one in the fertilizer industry who has operated a bulk blending *dry* plant who would deny that seperation of particles is not only likely, but extremely commonplace. The differences of weight and particle size are major contributors to this seperation. The lack of uniformity of product makes it almost impossible to formulate an accurate mix from the blender — to maintain a uniform mix in transit, and to spread an even mix from the distributor. In contrast, to my knowledge, practically every reputable liquid suspension plant will mix a uniform mixture of NPK with a reasonable shelf life, and a satisfactory spreading quality — providing the equipment is designed for suspension, and provided the plant operator and distributor driver has an understanding of the nature of their product.

(2) *Suspension fertilizer provides a better mixture of the fertilizer — chemical combination.* For many years, the majority of our dry mixed fertilizer has been applied as a fertilizer — chemical combination. Our introduction to this process was done through injecting a herbicide into our dry blender as the fertilizer was being mixed. This impregnation is used universally among dry blenders over the country, and has served a useful purpose. We have learned, however, from test plots and first hand experience that the impregnation system does not give us the grass control that we had formerly received with chemical and water. Even though our farmers accepted the fact that this practice of impregnation was inferior to their original way of applying the chemical-water combination, they continued this practice because, (1) It eliminated the need for water and water tanks, 2) It eliminated the need for a chemical applicator, and (3) Most importantly, it speeded up their soybean planting by saving them one trip over the field.

Since we have been mixing herbicides with suspension fertilizer, we have not seen any signs of weakness in our grass control, and in our judgement, we feel that this practice is every bit as good as the chemical applied with water. We have detected one peculiar characteristic of herbicides impregnated with fertilizer. We have found that chemically impregnated fertilizer does not give as good a grass control with low analysis fertilizer as it does on the higher analysis. We must conclude from this that the dolomite limestone used as filler does not serve as a good carrier for herbicide. The point here, is that the suspension fertilizer is more adaptable to mixing with chemicals under any condition, and most definitely has an advantage on low analysis fertilizers.

(3) *Suspension fertilizer provides a better mixture of the fertilizer — micronutrient combination.* Our rice -soybean rotation over the past many years has had a gradual effect upon reducing the fertility of our soils in Arkansas County. We have literally been mining the soils, not only in NPK, but minor elements, as well. The results of this practice is that we are now having to apply larger amounts of fertilizer, and are now beginning to see serious deficiencies in Zinc, Sulphur, and Boron. You can readily see that the formulating of high rates of NPK with low rates sof micronutrients and secondary elements becomes as critical in mixing and spreading as the fertilizer-chemical combination that I have just covered. The problem is then compounded when you consider that many of our farmers are now ordering high rates of NPK, low rates of Zinc, Sulphur and Boron, and two additional chemicals to be mixed and applied in one application. A typical order of this type would be a 12-36-72 with 10# Zinc, 15# Sulphur, 2½# Boron, 1½ pints treflan or prowl, and 3/4# sencor or lexone. Please keep in mind that this is all one mixture and is meant to all come out the back end of the spreader truck together. I can't overemphasize the fact that when you lay this material on the ground, it is extremely important that your spread pattern be near-perfect. We have not had the capability of mixing this prescription mixture and applying it evenly and uniformly with granular or prilled fertilizer. We have every confidence to believe that we are doing it right with our suspension facility.

(4) *Suspension fertilizer provides a much better spray pattern.* The spread pattern of fertilizer is always important, but our thinking is that some crops are more critical than others. For instance, we occasionally see one of our farmers miss a complete swathe across a rice field when he is applying anhydrous ammonia pre-

plant. Keep in mind that rice is always planted broadcast or drilled. The number of acres that are missed with NH3 can easily cost him twenty five to thirty bushels per acre. At todays prices, that would be roughly one hundred fifty dollars per acre. Now, he has reduced his yield by one hundred fifty dollars per acre simply because he did not get the fertilizer where it belonged. I think all of us would agree that this is a costly error.

We try to perform many services for our growers but there are three services that we think stand high above the rest. (1) To mix a quality product, giving him exactly what his soil tests recommend. (2) To deliver this product to his field on time, (3) To give him the exact mixture of fertilizer and chemicals on the ground that was originally mixed in the tank, by prompt delivery and precision spreading.

(5) *Suspension fertilizer possesses agronomic advantages for the grower.* I cannot furnish you documented evidence that suspension fertilizer is superior agronomically to dry fertilizer. This was not one of the major reasons that we added fluid fertilizer to our program. My observation, based upon one years experience, plus many visits, discussions, and studies of test plots done by liquid blenders with many more years of experience in fluids, causes me to believe that crop response and uptake is definitely better from a liquid source of fertilizer, particularly considering the nitrogen-phosphate relationship of MAP. I am hopeful that our state extension department and private consulting services can furnish additional information on this subject in the future.

(6) *Suspension fertilizer provides economic benefits for the blender.* We feel that there are two reasons why we should enjoy an economic advantage with suspension fertilizer as opposed to dry. This has nothing to do with gaining new business or proselyting on our competitors. The first reason is that we are able to enjoy a better margin of profit on liquid than we can on dry. The very nature of storing, mixing, and applying suspension requires a greater profit to justify the investment. We have no assurance that we will not have as much competition with liquids as we have in the past with dry, but I must confess, I have no real worry of this happening in our area. Suspension fertilizer is a complicated, sophisticated business, requiring a tremendous investment and demanding a lengthy time for return on this investment. To be successful, it takes a commitment. It is not for everyone. I think that I can safely predict that many will fail. It takes better management, better personnel, better financing, better equipment, and most importantly, a keener, and more inquisitive mind to stay on top of the problems, and to take advantage of the opportunities. I don't believe we have scratched the surface of what we can do with suspensions.

The second economic advantage that we enjoy from suspension is that we have to sell more fertilizer in a liquid form to get the same nutritional values. A few years ago, our biggest seller was two hundred pounds of 0-26-26 in a dry form. For this same customer today, we have to sell him nearly three hundred pounds of 6-18-18 to give him the total nutrients required for his phosphate - potash requirements. This, as you can see is a fifty percent increase in fertilizer sales.

(7) *Psychological benefits to both grower and blender.* The psychological effect that suspension fertilizer has had upon our business is perhaps the greatest advantage that we have realized. I have been extremely impressed with the people whom I have met traveling over six states studying liquid fertilizer. There seems to be an enthusiasm, an excitement that I don't find among *dry* blenders in this business. I think perhaps it was there at one time, but the disillusioning days of the 60's, when the oil companies invaded this field, seems to have taken its toll on our morale. Even among our growers, I notice that the ones who are playing with suspension on their farms are the ones who are excited about farming, and feel that it has a future. They are looking for something new and better, and you know, I think they'll find it. They are saying to us, "Why can't I grow two hundred bushel rice, and seventy five bushel soybeans?" They are not asking for 200# of 0-24-24 now just because this is what their Dad has been using for twenty five years. They are now asking for a 16-48-96, or something comparable, with 10# Zinc, and 15# Sulphur. They are now going to the doctor, and when he prescribes penicillin, they don't want aspirin as a substitute.

I personally am excited about suspension fertilizer. In our company, we are enjoying the new association of other fluid blenders who are equally enthusiastic. We are offering a motivational tool to our growers who are seeking new ways to break through the barriers that have restrained them for so long. We are challenging our personnel to improve their learning abilities and techniques in their respective jobs, whether it be bookkeeper or plant manager. I'm personally excited about suspension fertilizer because it is another tool — another challenge in one of the most interesting professions that I cam imagine — the world of agri-business. (Applause)

MODERATOR MACKINNON: Thank you very much. Joe Reynolds, back to you.

Thank you, Herb. We are going to move along. I had indicated some discussion at this point in time, but I think we are going to proceed and then see how we come out on time at the other end.

Our speakers have performed in a way that brought us up-to-date concerning suspensions. I think they have attracted your attention. We have come from the past up to the present. Now, we are going to do a little star-gazing here for the future.

Richard Farst is with us today. He is President of Blank's Agri Service in Marion, Ohio. He is a graduate of Ohio State. He is past President of the Ohio Agricultural Chemical Association. He is the current treasurer of the Ohio Fertilizer and Pesticide Association. He is past Vice President of the N.F.S.A., and he is currently President of the National Fertilizer Solutions Association. So, Richard, we will turn it over to you and see where we go from there. (Applause)

Future of Suspensions

Richard Farst

Thank you very much, Joe. I know you guys have been sitting here a long time. I told Joe last night that I don't make speeches, I just get up and talk to friends of the Fertilizer Industry. So, I will make it short and sweet.

It's obvious what the future of the Suspension Business is. You have just heard it from the "Quality People" that are in this business. I think that we owe the guys that preceeded me a great round of applause for the job that they have done this morning. (Applause) There's no question in my mind that, with this kind of capable people in this industry, the future is really bright.

What is the future? Gentlemen, I think "Suspension Liquid Fertilizer" is your future. No question in my mind. Frank, it's your underestimate in 1989 40-50%. Suspensions will be above that. I have been noted to be positive in my attitude. Fellows, if suspensions are not above that, I am going to starve to death. I have been in the fertilizer business for 19 years.

My company is 26 years old. We have never sold a pound of dry fertilizer, and we never will. "Suspensions and Liquids" are my only job and my only future. I think that is a very bright future from my standpoint, and it is obviously quite bright from the country's standpoint with what the fellows have said ahead of us.

You know, I think that those of us in the room can guide this future even more rapidly. In the past, we know that certain companies (granted, for their own obvious benefits) have pushed people into suspensions. I had a company do this to me back in 1966. Now, a lot of you guys have been in the business 1, 2, or 3 years. I have been shoveling our tanks, that I made mistakes, a lot longer than those fellows. Frank, you've been there. We started a little jug, thank goodness, and made it on the bench, but it's a lot of fun and a lot of hard work. We have made a lot of progress. The promotion of Suspension Fertilizers has been great in the past. I think we are really just starting to see what it really can do for us. Now, it is really an opportunity and a pleasure to be here with you fellows today and winding up the month of October.

I have had the distinct pleasure of being in the states of Washington, Idaho, Oregon, Texas, Michigan and Canada, all this month, speaking about my favorite subject "Liquid Fertilizer." To round it up, with such a distinguished group as before me today, is really an honor. I do appreciate it very much, Joe. I think what you fellows in the room, representing major manufacturers of raw materials and equipment, have done and are going to do for Suspenions, we are really on the threshold. Somebody mentioned earlier that we are really just in the beginning. I think that is quite true in Suspensions, although some of us have got a lot of gray hairs playing with Suspensions.

The promotion of this product by the raw material suppliers and now by manufacturers of equipment to manufacture the product and application equipment and, yes, I don't want to forget the Association I represent, the N.F.S.A. We feel we have had a great deal to do, in the past, with the promotion of Suspensions and you haven't seen anything yet.

An on-going program with the N.F.S.A. is education. No question in the future, you will be seeing more and more education not only the agronomics, as Jack mentioned here. I believe it, too, Jack, and I have proof across my set of scales to prove agronomic advantages of suspensions over drys.

We are going to have training programs through the N.F.S.A., in the years to come, not only along the lines of agronomic advantages, manufacturing, application, so that we, as fertilizer dealers, can do just what these fellows ahead of me have said, "Not only make the product properly, but distribute it properly." I agree 100%, Frank, that we have the equipment to do it with, but that doesn't mean it is going to get done, because we, as dealers, have got to calibrate and have got to train our people. Jack and I were talking about this earlier this morning. If we don't train our people properly, we can show a slide just like Mark had other "strips all over the field." That is not the problem of the product or the equipment. It is the problem of dealers.

What's the future? Well, I think the future's really great. I think it is going to be greater as the days go on, because more and more people are going to hear the word we just heard this morning. They re going to go out and disseminate this information. So, we can look for a lot of promotion, not only from the suppliers, but from us at the N.F.S.A. We can improve technology. Frank touched on that this morning. Bud and Frank disagree, and disagreement leads to better technology and more study, so that there is agreement. There's no question, we are an infant Industry in the "Suspension Business". If you listened to most of these guys, 3 or 4 or 5 years is all they have been in it. The real emphasis has only been on it for a short period of time. So, there is no question about it. There will be further technology developed which will, again, increase the uses of Suspensions.

I think that we cannot over-emphasize the importance of what you fellows play in the raw material supply. I am pretty stuck in my ways, and Frank said I could say anything I wanted to up here, and Joe agreed with him, I am 100% a liquid man. I believe in phos acid, 10-34-0, and there's a lot of people just like me. The future of Suspensions has a lot to do with the raw materials. Frank touched on it that we are going to be looking at some and more "Phos Acid". The total economics are to bring it in as "Phosphoric Acid" and use it that way, rather than going to dry and back to a liquid. So, therefore, the major manufacturing companies that produce the raw materials that we use have a very distinct hand in the future of "Suspensions" on what takes place in the development in the future and what is made available here to us domestically. The real reason, and these guys, Mark touched on it, Jack just summed it up beautifully that "The Suspensions Future" is great, is one simple reason, as far as I'm concerned, and it is entitled "Profits".

Now, in Ohio, the Governor so states "profit is not a dirty word." I think we started right out this morning saying that very thing. If it is a sin, then I am going to be a sinner, because I am going to make a profit. That is what I'm in business for, and I'm going to make my farmer a profit, because that is what he is in business for. Even though I got a lot of gray hairs in this business, I have a lot of them to go yet. I have got kids to educate. So, I am going to be here for a good many years to come.

The only way I am going to be here is to produce my farmer a better product and more profit for the same input cost or less per bushel raised. That is the reason my business has been successful, and that is the reason that the suspension business and the liquid business is growing like it is today. Profits are the key. Profits are the key for him, but profits are the key for us.

These other fellows have touched on it. Jim made it very clear. He can make a better mark-up on "Suspension Fertilizers" than he can on his dry blend. I can make a better profit than my dry blend competition down the road. I can offer more services, because I can make a better profit. Because of those services, I can increase those profits. To me, that's the name of the game fellows. If there is a future, the future's got a lot of advantages that we have heard about, but, number one, it is going to produce all of us a better return on that investment. I really think that that is the real key to what we are looking at in the '80's and the '90's to come, because with double digit inflation, we have got to have more money to cover all of our costs. We have got to have better health. There's no question about it. To do the job we are going to do, we have got to have better men on those machines. We are going to pay them more money. There is only one place where that is going to come from, and that is the profits from what we dealers derive from the products we are selling. Suspensions hold a real key to that.

So, as I star gaze, there's no question in my mind. Fifty to sixty percent of the total business in the next ten years is going to come from the "Liquid Industry". Beyond that, I don't know. I think the statement that Jack just made, that it's not for everybody, and that is for sure. It's not as easy as what we stood up here and talked about. There is a lot of hard work in making "Suspension Fertilizers", and we deserve more profits because of it. But, the future is there for all the reasons we pointed out this morning on what the advantages are, and lastly, but surely not least, there's more profit for you and for me.

It has a great opportunity to come here, representing the National Fertilizer Solution Association. We appreciate this opportunity and thank you very much.

MODERATOR REYNOLDS: Thank you, Richard. You have been a very attentive audience; however, I do want to thank the members of the panel. They have done a tremendous job. I feel very fortunate to have been associated with this group. I guess I was real lucky selecting you. I think you have done a tremendous job. We do have time for, maybe, a couple of questions, as we had promised earlier. It has been a long morning. You have been very, very good. Maybe we should adjourn this session. We come back at 1:30. Perhaps you can see some of these speakers outside. Thanks again. We will see you this afternoon. (Applause)

Wednesday, October 31, 1979

Afternoon Session
Moderators

Walter J. Sackett, Jr. — D. O. Walstad

MODERATOR SACKETT: Our first speaker is Harold G. Walkup of T.V.A.

Harold was born and reared on a crop and livestock farm in York County, Nebraska. He was educated in the Public Schools of that County. He received a Bachelor of Science Degree in Agronomy, from the University of Nebraska. Following a tour of duty in the Europene Theatre, during World War II, he obtained a Master's Degree in Agricultural Economics from Washington State University and was employed there from 1947 to 1955 teaching Market Research. From 1955 to the present time he has been employed by T.V.A. to supervise and conduct fertilizer marketing research. He has made and published studies of the cost of doing business in Bulk Blending Anhydrous Ammonia, Nitrogen Solutions and Mixed Fluid Fertilizers. He has conducted studies of various types of delivery and application systems. In 1969 he was the recipient of the Honorary Membership Award of the Natural Fertilizer Association. He has been the leader of T.V.A. Fertilizer Study Teams to Afghanistan, South Viet Nam, Nigeria and Bangladesh. In 1968 he was appointed Head, Economics and Marketing Research Section, Test and Development Branch of T.V.A.'s Division of Agricultural Development, which is his present position. Ladies and Gentlemen, I give you Harold Walkup. (Applause)

Alternative Fertilizer Distribution Systems

Harold G. Walkup

Anyone acquainted with the fertilizer industry is aware of the variety of products and services it offers. This stimulus to agricultural productivity has grown from a regional trickle, prior to World War II, to a flood reaching nearly every type of agriculture in the nation. In total tons of material the industry annually exceeds 50 million; in tons of nutrients it exceeds 20 million; and farmer annual outlays for these inputs to the agricultural production process exceeds $6 billion. In addition, industry provides numerous associated services that are of a considerable magnitude but go largely unrecorded in reliable statistics.

While the fertilizer industry has achieved a high level of performance in providing inputs to agriculture, its product mix continues to expand. During the 1970's through 1978, tonnage distributed increased over 20 percent, while plant nutrient consumption increased over 28 percent—reflecting in part an increase in plant nutrient content of all products from 42 to 45.1 percent.

This paper will discuss the fertilizer materials and the handling, mixing, delivery, and application systems employed to deliver the yield-increasing package of practices.

Specifically, the paper will: (1) identify and examine the identifiable systems currently existing; (2) estimate their relative contribution to getting the marketing job done; (3) consider their principal roles at the farm level; and (4) consider their outlook for the future in terms of emerging conditions both within and outside of agriculture.

Considering Fertilizer Systems

A system, according to the dictionary, is "a group of interacting, interrelated, or interdependent elements forming or regarded as forming a collective entity." In most cases, among fertilizer systems, the generally recognized systems pertain to the chemical and/or physical characteristics of the fertilizer(s) involved and their handling. For our purposes, each system will be defined as (1) containing a certain product or class of products, (2) involving typical storage and handling at the retail level, and (3) using typical delivery (nursing) and application equipment.

To assist in gaining perspective relative to specific systems, let us first examine some broader aspects of fertilizer distribution at the local level. In general there are two types of products — fluid and dry. Fluid products account for 32 percent and dry products 68 percent of fertilizer products used on farms. The use of fluid products is growing at a somewhat higher rate than for dry products.

Another classification of fertilizer products is method of application — either applied directly (unmixed) or as mixtures. Considered in those terms, direct application constitutes 53 percent and mixtures 47 percent of total tonnage. However, in terms of plant nutrients, direct application materials account for a somewhat higher percentage because of their higher average plant nutrient content (Table 1).

TABLE 1. Fertilizer Use in the United States by Principal Categories and Types of Products Relative to Total and Plant Nutrient Tonnage, and Percent Distribution, 1978.

	Tonnage			Plant Nutrients			
Nitrogen Direct	Total	Percent of Total	Subgroup Percent	Total	Percent	Subgroup Percent	Average Analysis Percent
Nitrogen Solution	5,481,864	11.5	30.5	1,589,740	7.7	20.9	29.0
Anhydrous Ammonia	4,538,157	9.5	25.2	3,721,289	18.1	49.0	82.0
Ammonium Nitrate	2,448,824	5.1	13.6	820,356	4.0	10.8	33.5
Urea	1,935,720	4.1	10.8	880,753	4.3	11.6	45.5
Ammonium Sulfate	899,339	1.9	5.0	187,962	0.9	2.5	20.9
Aqua Ammonia	576,281	1.2	3.2	115,256	0.5	1.5	20.0
Other N	2,101,455	4.4	11.7	284,025	1.4	3.7	13.5
Subtotal	17,981,640	37.7	100.0	7,599,381	36.9	100.0	42.3
Phosphate Direct							
Concentrated Super	1,076,454	2.3	45.0	487,634	2.4	64.5	45.3
Ammonium Phosphate	657,686	1.4	27.5	179,494	0.9	23.8	27.3
Other P_2O_5	657,816	1.4	27.5	88,064	0.4	11.7	13.4
Subtotal	2,391,956	5.1	100.0	755,697	3.7	100.0	31.6
Potash Direct							
Potassium Chloride	4,295,417	9.0	84.4	2,590,401	12.6	96.0	60.3
Other K_2O	796,491	1.7	15.6	106,759	0.5	4.0	13.4
Subtotal	5,091,908	10.7	100.0	2,697,160	13.1	100.0	53.0
Mixtures							
Bulk Blends*	8,382,851	17.6	37.9	3,986,800	19.4	41.8	47.6
Bulk Granular*	4,245,860	8.9	19.2	1,783,261	8.6	18.7	42.0
Fluids	3,976,600	8.4	18.0	1,371,740	6.7	14.4	34.5
Bagged Granular*	3,919,255	8.2	17.7	1,646,087	8.0	17.2	42.0
Bagged Blends*	1,596,734	3.4	7.2	759,391	3.6	7.9	47.6
Subtotal	22,121,300	46.5	100.0	9,547,279	46.3	100.0	43.2
Total	47,586,804	100.0		20,599,517	100.0		43.3

*Estimated.

Among direct application nitrogen materials, nitrogen solutions rank first in tonnage of materials followed by anhydrous ammonia. However, due to the higher content of anhydrous ammonia it is the dominant source of directly applied nitrogen. These two are followed by ammonium nitrate and urea which now rank about equally. In total, direct applied nitrogen amounts to nearly 38 percent of the tonnage of all materials and 37 percent of total plant nutrients.

In contrast with direct applied nitrogen, direct applied P_2O_5 amounts to only 5.1 percent of total tonnage applied and only 3.7 of total plant nutrients.

Direct applied potash has become a significant portion of all potash applied and now represents nearly 11 percent of all materials and over 13 percent of plant nutrients applied.

Among the five classes of mixtures, bulk blends constitute nearly 18 percent of materials and over 19 percent of the plant nutrients applied. Bulk granular, fluid, and bagged granular mixtures each represent over 8 percent of total tonnage and, combined, account for over 23 percent of plant nutrient consumption.

TABLE 2. GROWTH IN PLANT NUTRIENT USE IN TOTAL, IN MIXTURES, AND IN STRAIGHT MATERIALS IN THE UNITED STATES, 1970-78.

	1970-78 PERCENT INCREASE
Total plant nutrients	28.2
Total N	33.7
Total P_2O_5	11.5
Total K_2O	37.0
N in mixtures	22.4
P_2O_5 in mixtures	17.1
K_2O in mixtures	6.2
N in straight materials	37.7
P_2O_5 " "	8.6
K_2O " "	96.6

TABLE 3. GROWTH IN THE USE OF FERTILIZERS IN TOTAL AND IN THE VARIOUS FORMS IN WHICH THEY ARE USED IN THE UNITED STATES, 1970-78.

	1970-78 Percent Increase
Total Materials	20.2
Total direct application materials	36.1
Dry bulk direct application materials	58.0
Dry bagged direct application materials	-39.7
Fluid direct application materials	47.9
Total mixtures	5.5
Dry bulk mixtures	38.4
Dry bagged mixtures	-37.8
Fluid mixtures	56.5

TABLE 4. GROWTH IN THE USE OF INDIVIDUAL DIRECT APPLICATION FERTILIZER MATERIALS IN THE UNITED STATES, 1970-78.

		1970-78 Percent Change
Total direct application materials		36.1
Ammonium nitrate	(10.2)[1]	-13.9
Anhydrous ammonia	(18.9)	30.8
Aqua ammonia	(2.4)	-17.8
Nitrogen solutions	(22.9)	69.0
Urea	(8.1)	262.8
Ammonium sulfate	(3.8)	15.0
Sodium nitrate	(0.3)	-26.7
Ordinary superphosphate	(0.4)	-65.9
Concentrate superphosphate	(4.5)	-10.6
Ammoniated phosphates	(2.7)	2.1
Secondary and micronutrients	(7.8)	44.7
Potassium chloride	(18.0)	97.3
Total	(100.0)	

[1] Amounts within parentheses indicate percentage each is of the total direct application materials.

TABLE 5. SYSTEMS OF FERTILIZER DISTRIBUTION AT THE RETAIL LEVEL IN THE U.S.

	1978	
	Percent Tonnage	Percent Plant Nutrients
(1) Bulk Straight Solids[1]	29.1	26.7
(2) Bulk Blends	17.6	19.4
(3) Nitrogen Solutions[2]	14.9	8.9
(4) Anhydrous Ammonia	9.5	18.1
(5) Bulk Granular Mixtures	8.9	8.6
(6) Bagged Granular Mixtures	8.2	8.0
(7) True Solution Mixtures	4.8	3.3
(8) Suspension Mixtures	3.6	3.4
(9) Bagged Blends	3.4	3.6
Total	100.0	100.0

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[1] Includes ammonium nitrate, urea, ammonium sulfate, some undesignated "other nitrogen," all direct phosphate, and all direct potash.

[2] Includes aqua ammonia, some undesignated "other nitrogen," and urea-ammonium nitrate solution.

TABLE 6. MATERIALS USED IN THE PRINCIPAL FERTILIZER DISTRIBUTION AND APPLICATION SYSTEMS.

	Bulk Straight Solids	Bulk Blends	Nitrogen Solutions	Anhydrous Ammonia	Bulk Granular Mixtures	Bagged Granular Mixtures	True Solution Mixtures	Suspension Mixtures	Bagged Blends
Anhydrous ammonia			X	X	X	X	X	X	
Ammonium nitrate	X	X	X				X	X	X
Urea	X	X	X				X	X	X
Nitrogen solutions (non-pressure)			X		X	X	X	X	
Nitrogen solutions (pressure)					X	X	X	X	
Aqua ammonia			X				X	X	
Ammonium sulfate	X	X			X	X		X	X
Sodium nitrate	X	X			X	X		X	X
Diammonium phosphate	X	X			X	X		X	X
Monoammonium phosphate	X	X			X	X		X	X
10-34-0							X	X	
11-37-0							X	X	
Phosphoric acid					X	X	X	X	
Sulfuric acid					X	X		X	
Ordinary superphosphate	X	X			X	X		X	X
Concentrated superphosphate	X	X			X	X		X	X
Potassium chloride (granular)	X	X							X
Potassium chloride (standard)					X	X		X	
Potassium chloride (soluble)					X	X	X	X	
Potassium sulfate	X	X			X	X		X	X
Ammonium thiosulfate							X	X	
Micronutrients		X			X	X		X	X
Pesticides		X	X		X	X	X	X	X
Jelling clay								X	

TABLE 7. THE PRINCIPAL DISTRIBUTION SYSTEMS IN OPERATION IN THE UNITED STATES AND THE PRINCIPAL METHODS OF APPLICATION THEY SERVE.

System of Distribution	Bulk Application of Straight Material			Bulk Application of Complete Mixtures	Starter	Side Dress	Weed & Feed	With Insecticide	With Minor Elements	Gravity Irrigation	Center Pivot Irrigation	Aerial Application	Foliar Applicati
	N	P_2O_5	K_2O										
Bulk straight solids	X	X	X			X						X	
Bulk blends				X	X		X		X			X	
Nitrogen solutions	X					X	X				X		
Anhydrous ammonia	X					X				X			
Bulk granular mixtures				X	X		X	X	X	X		X	
Bagged granular mixtures				X	X		X	X	X	X		X	
True solution mixtures				X	X		X	X	X	X	X		X
Suspension mixtures				X			X	X	X	X	X		
Bagged blends				X	X		X					X	

Nutrient Consumption Up During 70's

To determine the directions the industry appears to be headed regarding types and classes of fertilizer and their use, it is helpful to briefly review what has been happening during 1970-1978—the latest available statistics (Table 2). Total plant nutrient consumption have increased 28.2 percent. Both nitrogen and potash consumption have increased relatively more than average for all nutrients, while P_2O_5 consumption has increased by only about one-third the average. In general, plant nutrient application as mixtures has not kept pace with the overall rate of increase, with nitrogen increasing at about 80 percent, P_2O_5 at about 60 percent, and K_2O at about 22 percent of the overall rate of increase. In contrast, the application of straight nitrogen materials increased about one-third, and K_2O nearly three and one-half times the overall rate of increase, whereas, straight materials applied P_2O_5 increased only one-third the overall rate of increase.

Let's also identify trends that have been occurring during the eight-year period in total materials and the principal forms in which they have been marketed (Table 3). Total material consumption increased 20.2 percent. Tonnages of direct application materials, however, increased at a rate of over 1.75 times the overall rate. Within the direct application category, dry bulk direct application materials consumption increased at nearly three times the overall rate. The use of bagged direct application materials declined by nearly 40 percent. Fluid direct application materials increased nearly 2.5 times the overall rate.

Total mixture applied, in contrast to direct applied materials, increased at only one-fourth the rate of overall increase in consumption of all fertilizer materials. Dry bulk materials consumption expanded at twice the overall rate of growth in materials use. Fluid mixture use increased over 2.5 times the overall rate of growth. The relatively low overall rate of growth in use of mixtures is principally associated with the 37.8 percent reduction in the use of bagged mixtures. It is interesting to consider the shifts in use of direct application materials (Table 4). Whereas, overall the direct application of materials increased 36.1 percent, these increases were confined to anhydrous ammonia, nitrogen solutions, urea, ammonium sulfate, ammoniated phosphates, secondary and micronutrients, and potassium chloride. Decreases occurred in use of ammonia nitrate, aqua ammonia, sodium nitrate, ordinary superphosphate, and concentrated superphosphates. Nitrogen solutions, anhydrous ammonia, potassium chloride, and ammonium nitrate now constitute nearly 70 percent of all direct application materials.

Nine Systems Identified

There are about nine systems at the local level. Each is characterized by its capability to use materials and/or has certain limitations on the use of materials. The equipment for local handling, storing, mixing (for mixing systems), delivery and nursing, and application is well prescribed. These systems are shown in Table 5 with their contribution to the percentage distribution of total tonnage and plant nutrients. Materials used for direct application or as ingredients for mixtures are shown in Table 6.

There can be little doubt that the "lion's share" of the total tonnage as well as nutrients tonnage is applied as straight solid materials. Twenty-nine percent of the total tonnage and nearly 27 percent of the plant nutrients are applied in this form. Most are applied through bulk blending outlets.

The second most important system for distributing fertilizers is bulk blending which prepares its formulations with straight granular materials. This system accounts for 17.6 percent of the tonnage and 19.4 percent of the plant nutrients. Since it is also the primary outlet for straight dry materials, it appears bulk blenders distribute 46.7 percent of the tonnage of materials and 46.1 percent of the plant nutrients.

The third most important system in terms of total tonnage is the nitrogen solution system which handles nearly 15 percent of the tonnage of materials, 8.9 percent of the plant nutrients, and over 23 percent of direct applied nitrogen. The principal product used in this system is urea-ammonium nitrate solution. It is available in 28, 30, or 32 percent nitrogen concentrations. This system provides a versatile product for direct application and in preparing fluid mixtures.

Although in fourth position with 9.5 percent in total tonnage, the anhydrous ammonia system provides over 18 percent of all plant nutrients and nearly 50 percent of the direct applied nitrogen. This system is unusual in that nearly all of the anhydrous ammonia is farmer applied. Usually, the material is made available in the retailer's nurse tank, which also doubles as the applicator tank, and is applied by the farmer through an applicaor owned by the retail outlet.

The bulk granular mixture and the bagged granular mixture systems when considered together provide over 17 percent of the total tonnage and about the same percentage of total plant nutrients. About 25 years ago, the chemically-mixed granular fertilizer system, distributed primarily in bags, was the principal fertilizer manufacturing and distribution system. It was particularly adept, and still is, at using industrial byproducts, e.g., as spent sulfuric acid, and byproduct ammonium sulfate in its mixing processes. It is also an excellent system for incorporating secondary and micronutrients and some pesticides, with the three primary plant nutrients. The method of mixing assures that the mixtures will be homogeneous. Bagged granular mixtures are usually applied by farmers using their own fertilizer spreaders and through farmers' planters as starter application.

Fluid System Growing

The most recent addition to the variety of fertilizer systems available to agriculture is the fluid system consisting of two subsystems— true solutions and suspensions. Together, they account for 8.4 percent of the total tonnage and 6.7 percent of the plant nutrients. Principal ingredients of these systems are wet process phosphoric acid and anhydrous ammonia which are used to make base grades, e.g., 10-34-0, 11-33-0, and 8-24-0. However, dry ammonium phosphates, e.g., 11-55-0 and 11-32-0 are also being produced and increasingly being used in the fluid fertilizer industry due in large part to their economy in shipping. Also, they utilize large quantities of urea-ammonium nitrate solution and soluble potash in their manufacture.

Probably one of the most rapidly growing subsystems is that designated as "suspensions." All liquid materials and most solid materials can be utilized in their production and their plant nutrient content compares favorably with dry blends. Suspensions depend on the solubility of ingredients, the right crystalline structure of components, and a jelling clay to hold solid particles in suspension. Handling and application equipment usually requires that they be custom applied. A strong point for the system is that it can be added to many existing dry fertilizer businesses with only a moderate outlay. Many of the dry materials previously used can be included in the formulations for suspension mixtures, and the system provides for easy and homogeneous incorporation of minor elements and most pesticides for simultaneous application.

For a fertilizer system to be of service to agriculture it must meet the needs that exist in the market area. The systems and principal market needs they serve are shown in Table 7.

Considering The Systems

Bulk blends which are distributed through approximately 6,000 blending plants provide the principal route for the application of straight solid fertilizers and for mixtures. The advantage of the system is its nearly unlimited flexibility to efficiently provide any number of desired mixtures. Usually, addition of filler can be eliminated or reduced. Conventional truck spreaders, high flotation spreaders, and all types of towed dry bulk spreaders can be used. Blends are used also in aerial application.

The distribution of straight solids appears to be an important element in the bulk blender's business. Of growing importance has been the straight application of potassium chloride on soils with a high exchange capacity so that the application of potash need not be done every year. Economy moves of this kind will probably grow in view of the much higher prices for gasoline and diesel fuel.

Bagged blends are usually packaged during the winter season in anticipation of their sales as starter fertilizer for planters having dry materials starter attachments. With adequate time for blending, small quantities of micronutrients and pesticides can be incorporated, and a homogeneous mixture that will remain properly mixed can be fairly assured. Some lawn and garden fertilizers also are prepared in the bagged blending system.

Another system of straight nitrogen distribution and application is urea-ammonium nitrate solutions. As with anhydrous ammonia, part of the versatility lies in UAN solution's usefulness in the manufacture of fluid fertilizers—both true solutions and suspensions. However, for direct application UAN solutions are easy and safe to handle and are frequently used to incorporate herbicides in the so-called "weed and feed" program provided by retail fertilizer outlets. UAN solutions are popular side dressing materials, and are increasingly being applied through center-pivot irrigation systems to provide a continuous supply of nitrogen to crops.

Anhydrous ammonia is effective for use in bulk application and for side dressing. Too frequently the season during which it is used is short. Also, it must be injected into the soil, thereby, requiring more power than any other system. However, anhydrous ammonia is less costly per pound of nitrogen than any other product, and its nurse and application equipment is long lived. The use of the nurse tank as the applicator tank has done much to preserve the economic usefulness of this system. As fuel costs escalate, ammonia application in conjunction with other tillage operations such as plowing, discing, and chisel plowing will become more popular.

Bulk and bagged granular mixtures are prepared in about 100 plant distributing products a radius of up to 150 miles. These plants use reactive chemial materials in their formulation so that the heat and other conditions created are conducive to preparing a desirable granular product. The granulation system provides the means for incorporating low-cost materials, small quantities of micronutrients and other additives with a high degree of assurance that a homogeneous mix is achieved and that it will be maintained. Bulk granular fertilizers are used in commercial farming much as bulk blended fertilizers are used except that the ratio and grade variability is more limited. Bagged granular mixtures are used on many small farms, on high value crops where homogeneous mixing and uniform application is desired, and for starter application. Lawn and garden fertilizers are prepared in the granulation system and bagged for packaged retail sale.

The true solution system is highly dependent on receiving an assured supply of high quality phosphoric acid, i.e., acid not containing impurities that will cause precipitates to form during ammoniation. True solutions are applied by farmers as well as by custom applicators. Solutions are advantageous in starter applications due to their reliability of application.

Suspension fertilizers appear to be a hybrid between solids and true solutions. They contain both solids and dissolved ingredients. In addition to using phosphoric acid containing impurities, suspensions formulations now frequently contain materials such as diammonium phosphate, monoammonium phosphate, ammonium sulfate, triple superphosphate—as well as the more conventional fluid materials, e.g., urea ammonium nitrate solution, 10-34-0 and 11-33-0. Suspensions also contain a jelling clay of up to 2 percent concentration to help suspend small solid crystals. Suspension grades can be made that will contain up to one-third more plant nutrients than is possible with true solutions. However, present technology confines the application of suspension fertilizers largely to custom applicators.

Outlook For The Systems

In view of existing conditions within the fertilizer industry and agriculture, what appears to be the outlook for each of the systems?

Bulk straight solids. This system of distribution, which is associated with bulk blending operations, appears to offer an economical and efficient means of supplying individual plant nutrients where they alone are needed. It can utilize any and all of the equipment for receiving, storing, handling, delivering, and applying solid materials usually associated with a bulk blending or bulk granular retailing installation. It has potential for growth in the application of slow-release solid materials, and for potash which can be applied for crop use of a several-year period. As with all solid materials, the efficiency of this system could be enhanced by improving the transfer of materials from nurse vehicles to high-capacity application vehicles so that idle time of the applicators is minimized

Bulk blends. This system will continue to find favor in the market place due to its versatility and efficiency in preparing small batches to meet particular requirements of individual fields. Its usefulness will be enhanced if improvements can be developed in the incorporation and homogeneous mixing of minor elements and pesticides. Operators will need to concentrate on securing, developing, and maintaining complete mixing of the primary nutrient materials through mixing materials of uniform-sized particles; on proper adjustment and operation of applicators to assure uniform application of all ingredients of their blends; and in improved transfer of blends from nurse to high-capacity application equipment.

Nitrogen solutions. This system appears to have a bright future with regard to urea-ammonia nitrate solution in view of its versatility in use both within mixing plants and in straight application. It seems likely that pesticides increasingly will be incorporated in the product and simultaneously applied. Also, its use as well as that of aqua ammonia may prove increasingly more economical, relative to anhydrous ammonia. Also, as more and more center-pivot irrigation systems are installed and operated, this system would appear to offer advantages for nitrogen application.

Anhydrous ammonia. The prospects for this system appear good if economies in application are forthcoming such as simultaneous application with other tillage practices. Although anhydrous ammonia usually offers the least costly nitrogen material relative to its plant nutrient content, its application is more costly than that required by any other system. Converting the ammonia to aqua to capture application economies might be in order in some situations.

Bulk granular mixtures. This system is dependent on the availability of industrial byproducts in the vicinity of these plants. The recent development of the pipe cross reactor to replace the pre-neutralizer and to eliminate the drier has enhanced the basic economies of this system in its production. We can expect more of the product to go the bulk rather than the bagged route as retail outlets and farmers continue to mechanize fertilizer handling and application. It will continue to provide a considerable quantity of dry product in which farmers will have a high degree of confidence in the homogeneity of the mixture.

Ragged granular mixtures. This system, which uses essentially the same products as the bulk granular mixture system, is expected to continue to decline in importance relative to the general expansion of the fertilizer industry. However, it will continue to fill the need for high-quality products for uses such as starter applications where bagged fertilizer is still a handy way to handle the material, where assured homogeneity of product is desired, and when small quantities are needed for farmers to apply themselves.

True solution mixtures. This system appears to have a bright future for starter and center-pivot irrigation system application and for incorporating pesticides easily into homogeneous mixtures. Its future is quite dependent on the continued availability of adequate quantities of high-quality phosphoric acid. Recent developments in pipe reactors to economically increase the polyphosphate content of intermediate product has enhanced this system's prospects.

Suspension mixtures. This system appears to have a bright future in view of its raw material versatility, in its ability to incorporate micronutrients and pesticides homogeneously, and in its ability to formulate small batches economically to meet specific field requirements. It is disadvantaged to some degree because it does not provide product considered suitable for application by farmers, but only by custom service. It is usually considered inadvisable to prepare product for application in advance of the season and intermediates must be agitated in storage to maintain the suspension properly. A principal advantage of the system is its ability to formulate relatively high analysis mixtures of a fluid type from almost all available materials.

Bagged blends. This system will probably decline relative to the growth of the industry in general. Special attention will need to be given to preparing homogeneous mixtures and avoiding resegregation. However, for starter applications and where small quantities are to be applied bulk spread by farmers, this system will continue to serve the need.

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MODERATOR SACKETT: Thank you Harold. (Applause)

Our next speaker, David G. Salladay, is a Chemical Engineer, Process and Products Improvement Section, T.V.A., has worked in areas of Process Design, Corrosion Control, Air Pollution, Control Plant Start-ups and Energy Conservation. He has a B.S. in Chemical Engineering from the University of Tennessee, has industrial experience with Freeport Sulphur in Louisiana and Amoco Chemicals Corporation in Alabama. Since coming to T.V.A. 5 years ago he has authored and co-authored 15 papers. Mr. Salladay is an associate member of Sigma Xi National Research Honorary. David will speak on "Quality Control in N.P.K. Granulation Plants".

Improving Quality and Grade Control In NPKS Granulation Plants

David G. Salladay — Carl A. Cole, Jr.
and
Jeffery L. Greenhill
Presented by David G. Salladay

Granular homogeneous fertilizers continue to be a significant portion of fertilizer production in the United States. TVA estimates 1978 U.S. production at 1.5 million tons of monoammonium phosphate (MAP), 8.5 million tons of diammonium phosphate (DAP), and 8.5 million tons of homogeneous granular NPKS fertilizers. These NPKS homogeneous fertilizers have several advantages inherent in their production and use. They can be produced from damaged, distressed, or off-size dry materials. Byproduct sulfuric and phosphoric acids can also be used with economical ammonia, particularly if granulation plants are equipped with pipe-cross reactors. Sulfur is easily included in this fertilizer production method. Homogeneous NPKS fertilizers can be bagged with fewer grade penalties than bagged bulk blends. Also, micronutrients can be readily incorporated in these homogeneous granules. Lastly, as minimum-till cultivation practices increase to conserve energy, homogeneous NPKS fertilizers containing MAP and ammonium sulfate can be put into the rows without fear of germination injury to seeds that would be caused by DAP and urea (1, 2, 3).

This paper will summarize changes taking place in "regional" granulation plants and discuss quality improvement of current grades. While previous papers have emphasized energy conservation aspects of the pipe-cross reactor and melt granulation, little has been said about another major advantage of the process-improved product quality.

Raw Materials in Current Grades

The five most popular homogeneous NPK grades, in decreasing order of production, are 6-24-24, 10-10-10, 13-13-13, 5-10-15, 10-20-20, and 12-12-12 (4). As less sulfur dioxide is emitted from stacks and rained into the soil, agronomic requirements for sulfur are increasing, and grades that specifically identify the sulfur content are becoming more common. Examples are 16-20-0-14S, 15-15-15-8S, 16-8-8-17S, 32-16-0-3.6S, and 12-48-0-4S. TVA expects use of sulfuric acid in regional granulation plants to increase. These regional plants are well suited to receive byproduct acid from petrochemical and manufacturing operations, sour gas cleanup, or stack gas desulfurization at coal-burning electric generating plants. Use of such acids with anhydrous ammonia yields not only economical raw material costs, but contributes to hard, homogeneous, dry granules. In general, TVA has found in its field work that use of more acids and ammonia has greatly improved the quality of 1:1:1:XS ratio fertilizers. Recently, demand for wet-process orthophosphoric acid by these plants has far exceeded supply.

In the area of nitrogen sources TVA observes less dependency on nitrogen solutions (ammonia-ammonium nitrate solution) and powdered materials and more use of prilled urea and granular ammonium nitrate. Use of such prilled or granulated raw materials tends to result in less in-plant dust and better grade control.

Although plants using melt-type granulation with pipe-cross reactors are in general improving their product quality, some plants are obtaining very poor results. In some cases, use of large quantities of bulk-blend raw materials, granular TSP and DAP, with small amounts of ammoniating solution and acid is resulting in nonhomogeneous, virtually ungranulated NPK products. Although satisfactory conventional granulation can be accomplished with appropriate raw materials and adequate liquid phase and chemical heat, in some instances, granulators are merely steaming or wetting down bulk blends.

Trends In Plant Equipment

The type of plant discussed in this paper is referred to as a regional NPKS granulation plant. In general these plants have production capacities of 25 to 35 tons per hour with recycle throughout capacities of 50 to 70 tons per hour. Equipment in these plants typically consists of 8-ft diameter by 16-ft long TVA-type ammoniator-granulators, rotary dryers and coolers approximately 8 ft by 60 ft long; screens, oversize crushers, and conveyors. A typical plant is shown in Figure 1.

Over the past few years equipment changes have been made in these plants. About one-third of them now use a TVA pipe-cross reactor, normally 5 or 6 inches in diameter. The current design sketch for this reactor is shown in Figure 2. More granulators are equipped with rubber liners instead of oscillating scraper bars. The trend has been to streamline operation of the granular, leaving it less crowded with support members and spargers. This trend has improved overall operation of the granular with fewer large chunks of oversize being formed. Air flow through these ammoniators has more than doubled in recent years. Plants originally designed with air flows of 4,000 to 5,000 acfm, now use 10,000 to 12,000 acfm. This increased air flow is necessary because the ammoniator-granulator is now also functioning as a dryer. Fertilizer material discharged from the granulator contains about 2 to 2½ percent moisture rather than 5 to 6 percent obtained in conventional granulation. A water balance for an ammoniator-granulator is shown in Figure 3 (5).

In these regional plants good air pollution control has been obtained with both wet scrubbers and bag filters. The current mode of operation with the pipe-cross reactor in which phosphoric acid is ammoniated to MAP results in almost negligible fluorine emissions from the plant. Recently, inclining the pipe-cross reactor up 5° to the discharge end has greatly reduced ammonia losses from the granular. The major pollution control consideration in one of these plants today is particulates discharged from the dryer and cooler cyclones. In recent field tests TVA has learned to minimize in-plant dust by careful placement of the liquid feeds to the granulator bed and the pipe-cross reactor. These subjects are discussed in greater detail in a later section of this paper.

Grade Control

Several interrelated areas of operation affect grade control. The first is the basic equipment used to feed raw materials to the granulator, while the second is the metering equipment. The third and fourth areas are the analytical procedures and personnel operating the equipment. With a great percentage of liquid raw material used in NPKS granulation, adequately sized, reliable equipment is essential. This includes adequately sized lines and properly sized pumps that can deliver the fluids to the pipe-cross reactor at about 60 psig. With phosphoric acid, it is also advisable to sparge the storage tank so that a portion of the sludge in the acid is always being fed to the granulator. A typical sparger design is shown in Figure 4. Other equipment that can greatly affect the overall operation and grade control includes the recycle control, weigh hoppers, and volumetric feeding belts. Field experience continues to show that some type of recycle control such as shown in Figure 5 is essential to proper operation. Obviously, all of this equipment should be kept in good repair.

Magnetic flow meters are used in most granulation plants to measure the flow of phosphoric and sulfuric acids; armored rotameters with magnetic readouts or turbine meters are used for anhydrous ammonia. In some instances in the field TVA has encountered plant startups in which old inaccurate meters were used. Attempts to start the plant had almost catastrophic results with the bed of the granulator oscillating from a bone-dry, dusty condition to one of soup pouring over the dam. With the large quantities of acid and ammonia being used in formulations, good metering equipment is essential. Metering was not as critical in the past using conventional granulation with large quantities of dry materials and steam.

Another area which can greatly influence grade control is the effect of personnel on the operation. Proper training of personnel in the importance of monitoring granulation is essential for good operation. It is crucial that granulator operators understand the importance of periodically checking the pH of granules discharging from the ammoniator-granulator, water flow rates to the pipe-cross reactor and the bed of the granulator, and temperatures of the pipe-cross reactor reactor melt and granulator discharge. Also, it is very helpful if plant operators have some understanding of the basic ammonium phosphate solubility curve shown in Figure 6 (6). Although they may not fully understand all aspects of it, good granulator operators do have a general idea about solubility relationships. It is also important that the control room in the plant be supplied with a properly calibrated and maintained pH meter. With little experience, operators will soon learn exactly what pH, usually in the range of 4.0-5.5, should be maintained for each of their formulations. Good operators check pH of the granulator discharge product about every 30 minutes. They also know, in addition to the amount of each raw material in their formulations. how much water should be injected into the pipe and sprayed onto the bed. And, they will learn what temperatures should be maintained in the pipe and the bed for each grade produced. In recent field work TVA found granulation plants operated more like basic petrochemical facilities. So, these regional granulation plants are much better instrumented and more closely monitored than they have been in the past. Although there is still a certain degree of art in production of homogeneous NPKS fertilizers, more of the process is continually being quantified into engineering terms.

Plant Test Results

Several plant tests have been conducted to study effects of operating variables on in-plant dust, product crushing strength, degradation, and storability.

Crushing Strength and Degradition of 5-20-20-7S-Micronutrients

Tests have been conducted to study the effect of various proportioning of the phosphoric acid and its ammonia between the granulator bed and the pipe-cross reactor, and the effect of product pH on the quality of a 5-20-207S grade containing micronutrients. The granulation plant was essentially like the typical plant already discussed with a couple of noteworthy exceptions. Air flow through the granulator was low—about 5,500 acfm—and there is only five feet of bed between the pipe-cross reactor discharge and the weir.

Results of these tests are shown in Table 1. For comparison, data on physical properties of common fertilizer materials are included in Table 2; these data were obtained by personnel in the Applied Research Branch at the National Fertilizer Development Center (NFDC). Test results indicate that lower product pH gives a harder granule, while phosphoric acid on the bed of the granulator makes a rounder granule. Future tests are planned with pH at 3.5 and acid on the bed. Also, this plant will be equipped with an additional blower on the ammoniator-granulator and the pipe-cross reactor will be moved toward the feed end of the bed.

15-15-15-8S

Production of a 15-15-15-8S grade using a pipe-cross reactor was recently tested to determine if the quality could be improved over that of the conventionally granulated grade. The granules had not been as homogeneous or hard as desired when granulated with the following conventional formulation:

15-15-15-8S

New material	lbs/ton
448 ammoniating solution	225
Ammonium sulfate (21% N)	460
DAP, 18-46-0	650
Potassium chloride (60% K_2O)	492
Sulfuric acid (66° Be.)	180
Clay	15

There was also a desire to avoid using clay conditioner with the 15-15-15-8S grade if possible. Results of two plant tests using ammonium nitrate and urea for supplemental nitrogen are shown in Table 4.

In both tests, all liquid raw materials were fed through the pipe-cross reactor, which is 6 inches in diameter and contains a 4-inch stainless steel sleeve (Figure 7). Earlier tests with part of the liquids fed onto the bed of the granulator were not early as successful. In both tests, product from the cooler discharged to the storage bin at a high temperature. In test 1 this temperature was 130°, while in test 2 it averaged 148°F. These high temperatures were undoubtedly the cause of some of the resulting pile set, and could easily be reduced by using a fluid bed cooler, such as shown in Figure 8, to further cool the product. Both formulations granulated easily. Screen analyses shown in Table 4 indicate the effect of testing urea immediately after ammonium nitrate. The 9-percent fines shown in the results of test TVA-PC-9 are a result of screen blinding. In both tests, moisture content of the product was quite low—0.5 to 0.6%. Limited storage data indicate that probably the 15-15-15-8S containing urea can be produced, stored, and used without clay conditioner. One-month bagged storage tests at NFDC show less bag set and lumping for 15-15-15-8S containing urea than for the clay-conditioned coventional product. The clay-conditioned material had a heavy bag set, and after dropping from a height of 3 feet, contained 11 percent light lumps. The 15-15-15-8S containing urea had only a medium bag set and contained only 2 percent light lumps after dropping. Crushing strength of all three 15-15-15-grade products was in the same range—6 to 7.3 lbs for a —7 +8-mesh granule.

Dust Control During 13-13-13-11S Production

Recently, granulation tests were conducted in a North Carolina plant to study the effect of operating variables in the pipe-cross reactor ammoniator-granulator on dust production in the dryer and cooler. Results are summarized in Tables 4, 5, and 6. In all tests, a 13-13-13-11S grade was produced at 27½ tons per hour using a 4½-inch diameter pipe-cross reactor. As noted in Table 5, the variables included a 5,800-acfm air flow in tests A and B, which was about doubled to 11,200 in tests C and D. In tests A and C all of the ammonia, phosphoric acid, and sulfuric acid in the formulation were fed to the pipe-cross reactor. In test B a portion of the anhydrous ammonia and phosphoric acid was fed to the bed, while in test D only a small portion of the phosphoric acid was sparged into the bed. In Table 4 the large differences in the amount of dust not captured by the cyclone during these four tests are evident. It appears that inadequate air for drying granules in the ammoniator-granulator was a major contributor to the dust produced in the dryer and cooler. It also appears that the dust load from the dryer and cooler can be further reduced by putting a small portion of the phosphoric acid into the granulator bed as shown in test D. Obviously, if the dust load to the scrubber from the dryer and cooler cyclones can be cut by a factor of almost five, the plant will operate better with far less scrubber problems. Also, as Table 4 indicates, about one-half ton less dust has to be recycled to the granulator in test D.

Table 6 shows the particle size distribution for the dryer and cooler cyclone dust recovered during these 13-13-13-11S production tests. Whereas in Table 4 results of the two runs for each condition were averaged, in Table 6 data for each run are tabulated. Most of the material captured by the dryer cyclones was in the —20 +80 Tyler mesh size range (or subproduct size). However, about 20 to 40 percent of the material captured in the cooler cyclones was product size. From data in these tables it is apparent that particularly in the case of test D, very little dust of small particle size was produced.

In tests with this grade at another plant, considerably more dust was formed. While about 1½ to 2 tons per hour of dust was formed in these tests, summarized in Tables 4, 5, and 6, a very similar plant making 13-13-13-11S at 22 tons/hr had cyclone dust loads of 4 to 5½ tons per hour. Much of this difference is attributed to inadequate sweep air in the ammoniator-granulator and a very short bed.

Samples of 13-13-13-11S grade products from all of these tests were quite similar. Their size distribution was about 12% +6 mesh, 85% —6 +16 mesh, and 3% —16 mesh. Moisture contents were 0.85 to 1.04%, and degradation was 1.0 to 1.6%. Crushing strengths of —7 +8-mesh granules ranged from 4 to 6 pounds in all tests, with samples B and C slightly stronger than samples A and D. In one-month bagged storage tests, samples A and D were better than samples B and C. Medium strength bag set resulted in no lumps after dropping once from a height of three feet.

Conclusions

Test work in these regional granulation plants has identified the following relationships. Product crushing strength, degradation, homogeneity, and storability are effected by the following operating parameters in the ammoniator-granulator:

(1) weight of the pipe-cross reactor (PCR) above the granulator bed
(2) air flow through the ammoniator-granulator
(3) distance downstream from the PCR discharge to the end of the granulator bed
(4) split of the phosphoric acid and its ammonia between the PCR and the bed
(5) pH of the product for each grade
(6) use of sleeves in the PCR discharge to adjust heat flux
(7) 5° upward tilt of the PCR to the discharge end
(8) temperature of the PCR melt
(9) temperature of the granules discharging from the granulator
(10) moisture of the granules discharging from the granulator

Although more investigation of these relationships is needed, these plants can now be operated to obtain improved product quality.

Summary

Over the last five years an interesting number of regional NPKS granulation plants have implemented melt granulation technology via the TVA pipe-cross reactor. Most of these plants are well instrumented and closely operated by knowledgeable personnel. As a result of this trend, good quality, hard, homogeneous, easily stored, NPKS granular materials are being produced.

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Table 1

Plant Tests 5-20-20-7S
TVA Pipe-Cross Reactor, 4" Diameter
Production Rate 28 tons/hour
March 12, 1979

Basic Formulation, lb/ton product

Raw Materials	
Pipe-Cross Reactor	
Ammonia (82% N)	109
Phosphoric acid (54% P_2O_5)	600
Sulfuric acid (60° Be)	115
Ammoniator-Granulator	
Ammonia (82% N)	14
Ammonium sulfate (21% N)	90
Normal superphosphate (17.9% P_2O_5)	46
Concentrated superphosphate (46% P_2O_5)	169
Potassium chloride (60% K_2O)	550
Potassium magnesium sulfate (22% K_2O)	365
Micronutrients	95

Physical Properties

Test Conditions	Crushing Strength, lbs	% Degradation
Basic Formulation, All phosphoric acid to PCR, product pH 3.5	6.9	2.75
30% phosphoric acid and its ammonia to the bed product pH 4.6	4.8	1.66

Table 2

Selected Physical Properties
Fertilizer Materials

	*Crushing Strength	% Degradation
Ammonium nitrate	2.5-4.0	4.6
Urea prills	2.0-3.0	19.7
Granular urea	4.5-7.0	2.0
Pan granulated urea	3.0-5.5	1.7
DAP	6.5-11.5	0.7
Concentrated superphosphate	3.0-8.0	0.7
Normal superphosphate	4.0-7.0	-
Potassium chloride	7.5-10.0	3.3

*Crushing strength in pounds for a specific size granule. Crushing strength below 3 pounds indicates weak granule.

Table 3

Plant Tests 15-15-15-8S grade
TVA Pipe-Cross Reactor 6" Diameter, 4" S.S. Sleeve
Granulation Plant, Ohio

Test No.	TVA-PC-7	TVA-PC-9
Operating time, hrs	2	2
Production rate, tons/hour	22	25
Formulation, lbs/ton product		
Raw Materials		
Pipe-Cross Reactor (PCR)		
Ammonia (82% N)	86	92
Phosphoric acid (54% P_2O_5)	459	502
Sulfuric acid (66° Be)	75	75
Water	22	70
Ammoniator-Granulator		
Ammonium nitrate (prilled, 34% N)	285	-
Granular urea (46% N)	-	147
Ammonium sulfate (21% N)	547	704
DAP, 18-46-0	125	75
Potassium chloride (60% K_2O)	492	492
Operating Conditions		
Temperature, °F		
Product from granulator	205	203
Product from dryer	188	192
Product from cooler	130	148
Melt from pipe-cross reactor	297	271
pH of product from granulator	5.3	5.3
Heat flux (PCR sleeve 4" diam.) Btu/hr/in^2	387,400	470,200
Total heat, Btu/ton	221,200	236,300
Recycle rate, lbs recycle/lb product	1.0	1.7
Chemical Analysis, % of Total		
N	14.5	14.5
P_2O_5	15.7	14.9
K_2O	15.7	15.6
% H_2O	0.6	0.5
Screen Analysis		
+5	0.93	0.54
-5+6	8.63	4.72
-6+8	34.29	29.22
-8+12	29.20	28.77
-12+20	24.87	27.00
-20	2.01	9.05

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[a] Screens blinding due to ammonium nitrate from previous tests combined with urea

Table 4

Dust Loadings on Dryer and Cooler Cyclones
13-13-13-11S, Pipe-Cross Reactor Production Tests
Granulation Plant, North Carolina
June 26-28, 1979

Test	Dryer (lb/hr) Inlet	Dryer (lb/hr) Outlet	% Recovery	Cooler (lb/hr) Inlet	Cooler (lb/hr) Outlet	% Recovery	Scrubber Sump Loading lb/hr
A	1125	225	80	2900	235	92	460
B	1145	220	81	2440	265	89	485
C	930	155	84	2490	35	98	190
D	755	35	95	2310	60	97	95

Table 5

Operating Conditions for Dust Load Tests
27.5 tons per hour 13-13-13-11S
4-1/2" Diameter Pipe-Cross Reactor
Granulation Plant, North Carolina
June 26-28, 1979

Formulation, lb/ton product	Test Number A	B	C	D
Raw Materials				
Pipe-Cross Reactor				
Anhydrous ammonia (82% N)	185	155	185	170
Phosphoric acid (54%)	496	347	496	427
Sulfuric acid (78%)	400	400	400	384
Ammoniator-Granulator				
Anhydrous ammonia (82% N)	-	30	-	-
Ammonium sulfate (21% N)	549	549	549	600
Phosphoric acid (54%)	-	149	-	75
Potassium chloride	447	447	447	447
Sand	97	97	97	67
Air Flow Rate Ammoniator-Granulator, ACFM	5800	5800	11,200	11,200

Table 6
Particle Size Distributions
Dryer and Cooler Cyclone Recoveries
13-13-13 Production Tests, PCR
Granulation Plant, North Carolina
June 26-28, 1979

Sample	A1D[a]	A1C	A2D	A2C	B1D	B1C	B2D	B2C	C1D	C1C	C2D	C2C	D1D	D1C	D2D	D2C
Screen analysis Tyler, mesh, %																
+10	.1	5.1	.2	3.9	.1	2.8	.1	2.8	.02	2.6	0.4	2.0	.07	1.8	0.9	3.1
-10 +20	10.2	31.5	.3	39.8	.1	21.8	.2	27.9	.1	27.6	0.3	31.1	.1	23.9	0.5	41.0
-20 +35	9.1	36.5	29.2	41.4	8.1	34.3	16.3	37.0	10.9	33.39	20.0	37.0	12.2	44.0	21.0	34.3
-35 +42	12.9	3.2	13.5	3.7	5.8	5.0	8.9	4.5	9.6	3.7	10.5	3.7	10.3	3.5	10.4	2.6
-42 +60	51.5	5.5	35.4	5.3	57.8	17.8	40.7	18.3	46.8	9.2	39.3	5.3	47.0	10.2	42.0	3.2
-60 +80	14.9	11.1	20.1	5.4	23.4	15.6	26.0	8.9	27.0	19.3	23.9	15.2	22.0	12.8	21.1	11.4
-80 +100	1.1	1.9	1.1	.4	4.3	1.8	5.5	.4	5.0	3.5	3.8	3.9	4.2	1.8	3.2	1.8
-100 +150	.1	1.3	.1	.03	.3	0.7	1.7	.03	.5	.6	1.3	1.2	2.7	1.1	0.6	1.8
-150 +200	.02	1.5	Trace	.02	.04	0.1	.3	.03	.03	.1	0.4	.5	1.2	.4	0.2	0.7
-200	.02	2.3	Trace	-	.03	0.07	.07	.03	.02	.01	0.1	.03	.1	.3	0.1	0.1
Total	99.94	99.9	99.9	99.95	99.97	99.97	99.77	99.89	99.97	100.0	100.0	99.93	99.87	99.8	99.9	100.0

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[a] First letter in sample designation is the test during which sample was taken. The number, 1 or 2, refers to either the first or second part of the test. The last letter, D or C, refers to either the dryer or cooler cyclone recovery.

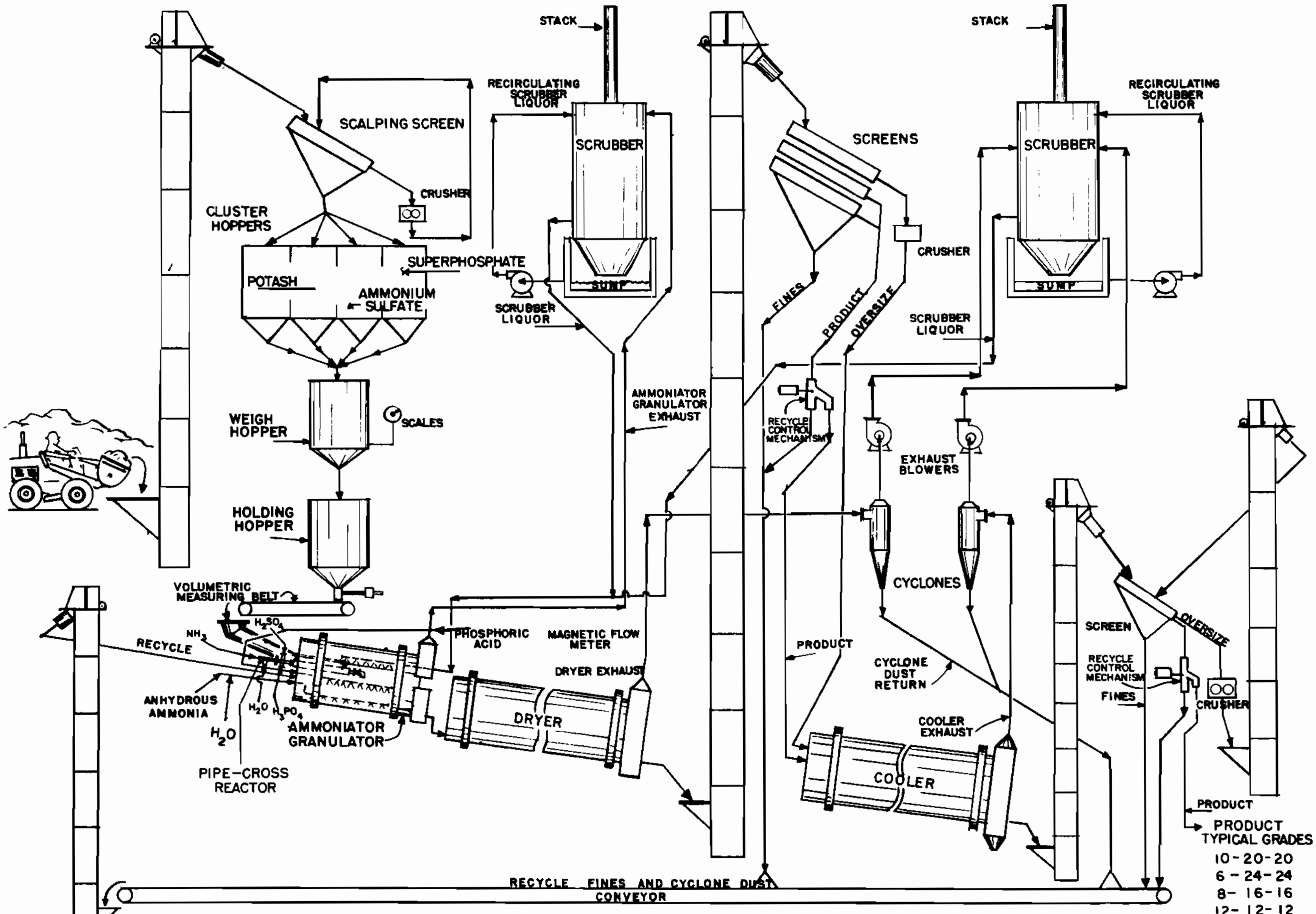
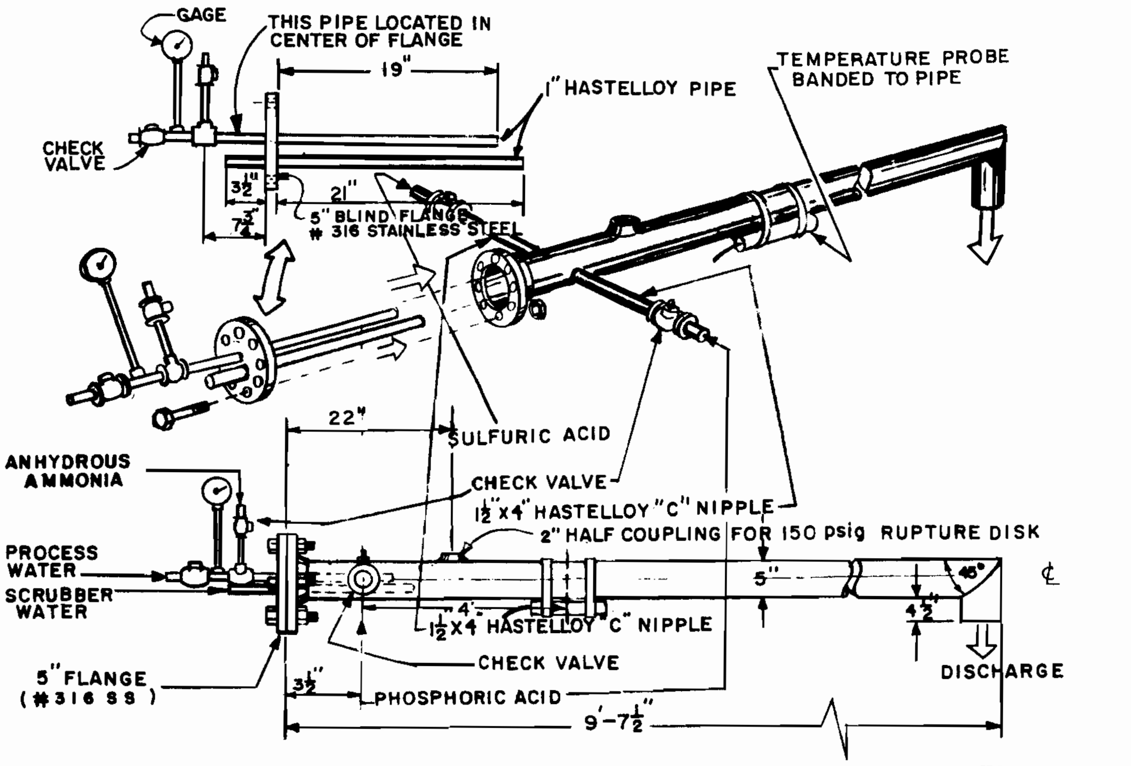


FIGURE I
AMMONIATION-GRANULATION PLANT WITH PIPE-CROSS REACTOR

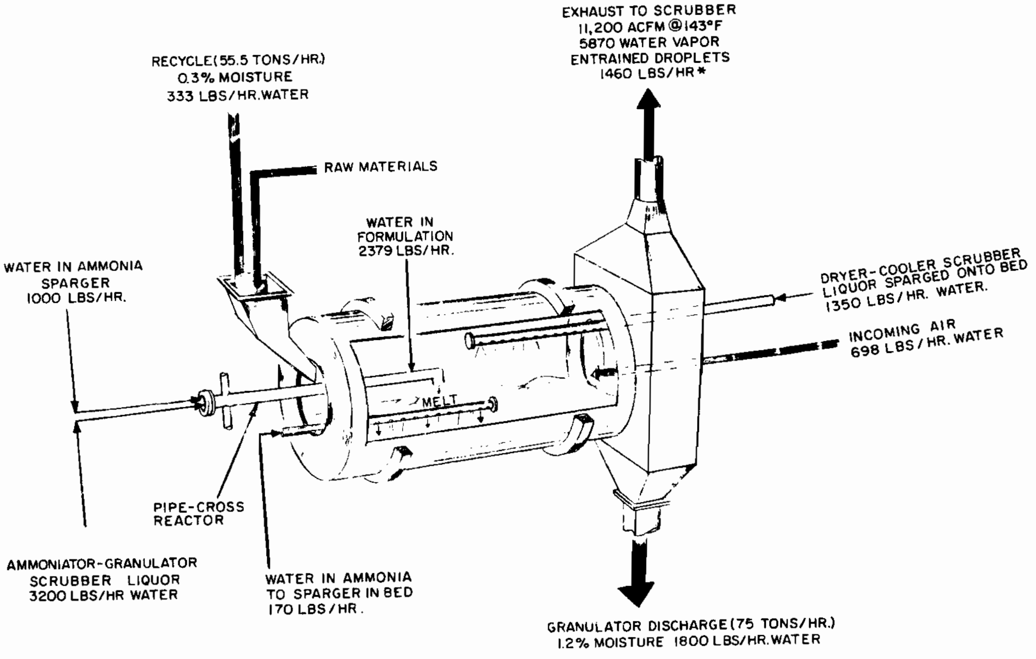
PRODUCT
TYPICAL GRADES
10-20-20
6-24-24
8-16-16
12-12-12
8-24-24
16-8-8



NOTE:
ALL HASTELLOY C-276

FIGURE 2

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



NOTE:
*CALCULATED FOR CLOSURE OF BALANCE. EMISSION TEST INDICATED THAT ACTUAL WATER CONTENT WAS 25.9% ADDITIONAL WATER AS ENTRAINED DROPLETS (1522 LBS/HR.)

FIGURE 3

MATERIAL BALANCE-WATER, AMMONIATOR GRANULATOR
PRODUCTION RATE 19.5 TONS/HR 12-12-12

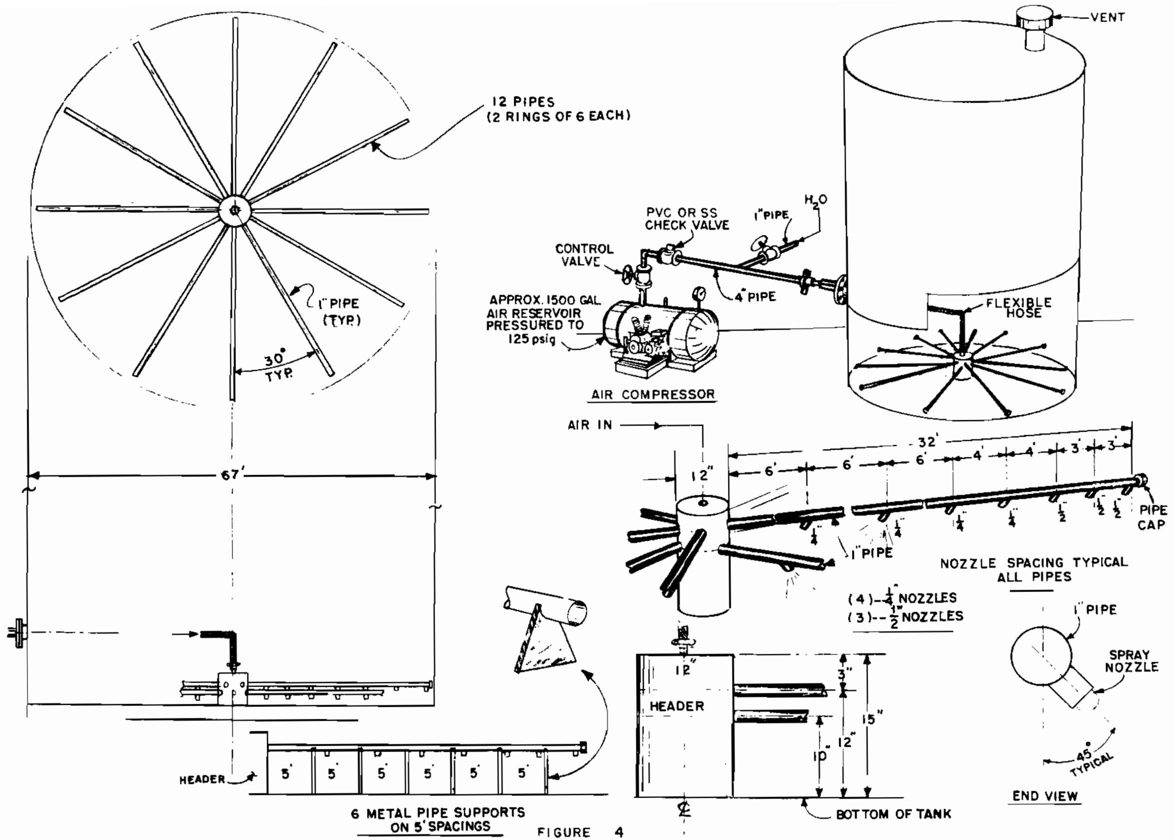


FIGURE 4
AIR SPARGER
FOR LARGE STORAGE TANKS (67' DIAMETER)

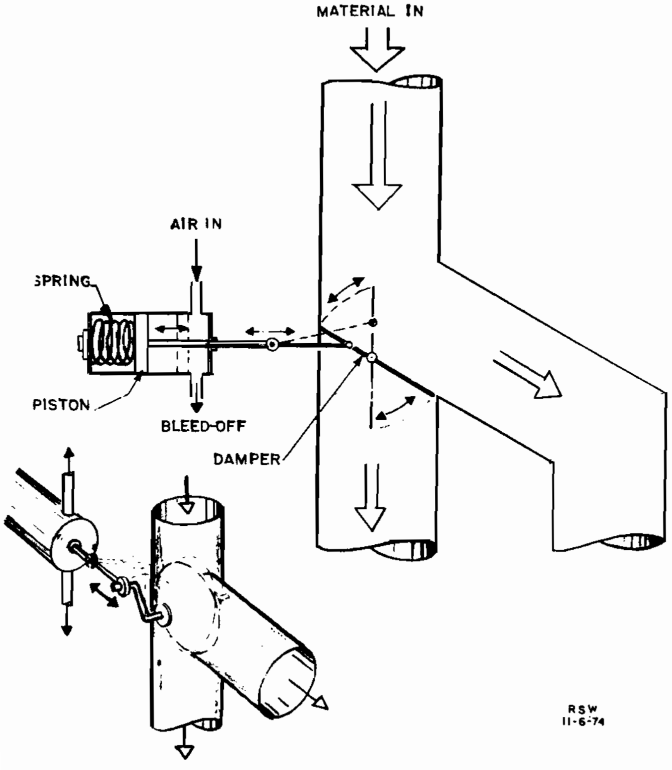


FIGURE 5
RECYCLE CONTROL MECHANISM

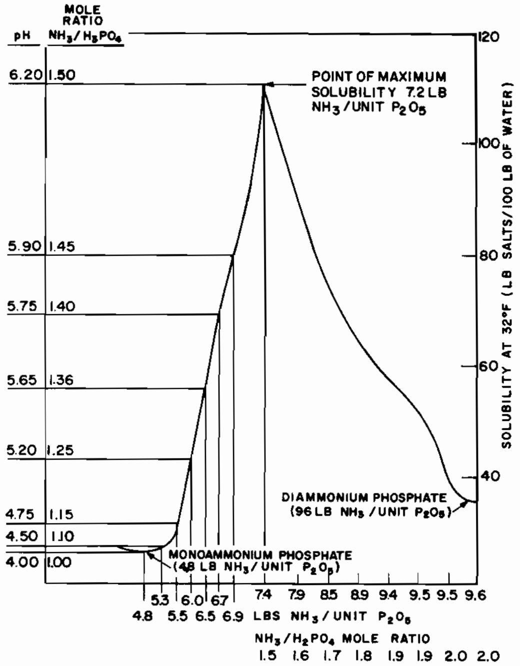


FIGURE 6
SATURATED AMMONIUM PHOSPHATE SOLUTIONS SOLUBILITY, pH, MOLE RATIO, AND POUNDS OF AMMONIA/UNIT OF P_2O_5

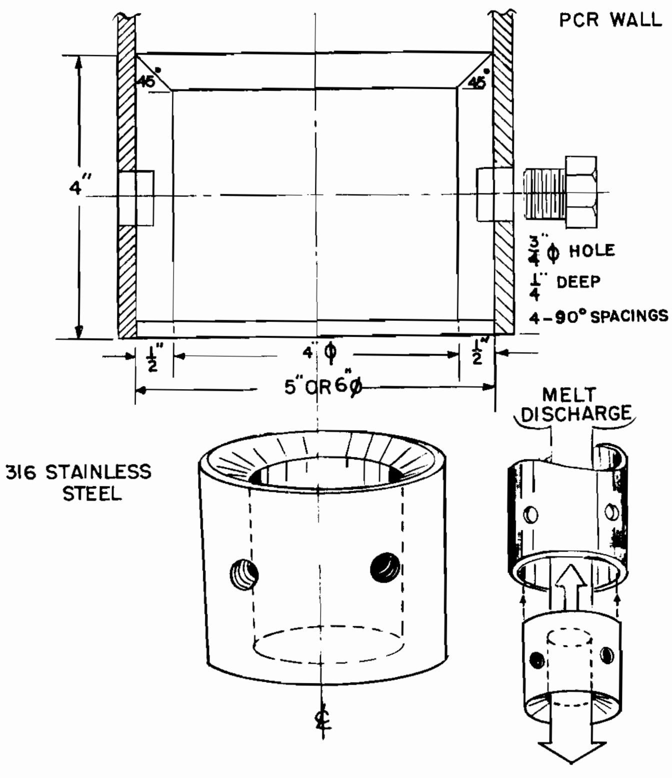


FIGURE 7
DISCHARGE NOZZLE FOR 5" OR 6" PCR.

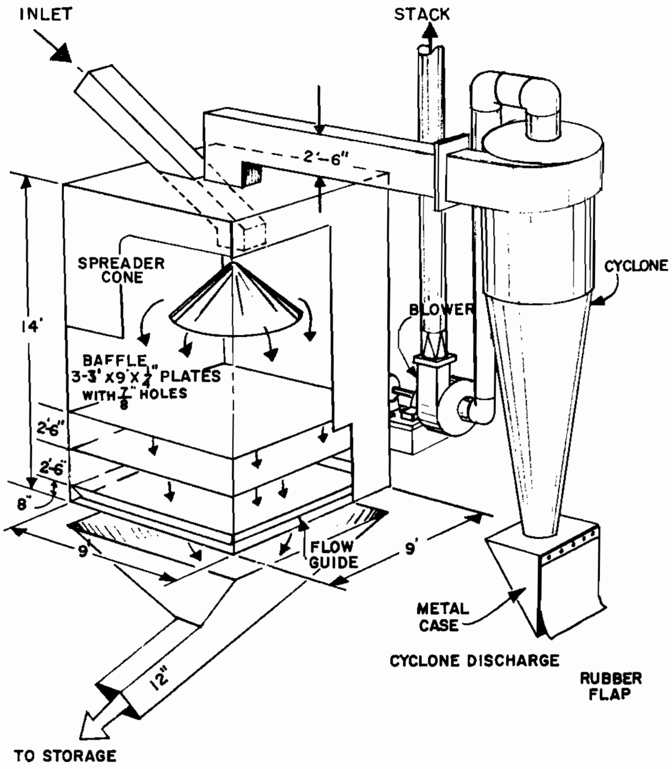


FIGURE 8
FLUID BED COOLER

MODERATOR SACKETT; Thank you, David, for an excellent presentation.

Our next speaker is Issac McCamy of T.V.A. Mr. McCamy is in the Process Engineering Branch of the T.V.A. He has a degree in Chemical Engineering from Auburn University. From 1941 to 1942, he was with the Metallurgical Laboratory, T.C.I., Fairfield, Alabama. He was in the Chemical Warfare Service, Edgewood and Huntsville Arsenals from 1942 to 1945. He has been with T.V.A. from 1945 to the present time with varied fertilizer experience in crystallization, fluids and granulation. He has spent about 20 years on various granulation processes. He has authored and co-authored many publications during the past 25 years. (Applause)

TVA's Experience With The Production Of Granular NP And NPK Fertilizers Containing Urea

I. W. McCamy, M. M. Norton
and
B. R. Parker
Presented By I. W. McCamy

TVA has been engaged in research and development programs to demonstrate the use of urea as a supplemental nitrogen source for the production of granular fertilizers for about 20 years. In 1964, during TVA's Fifth Demonstration of Fertilizer Technology, a process was demonstrated for production of a granular urea-ammonium phosphate fertilizer based on diammonium phosphate with the addition of urea to supply supplemental nitrogen. This process is now being used successfully in several large commercial operations in India, Spain, and other parts of the world. Typical grades produced are 28-28-0, 35-14-0, and 19-19-19. Other processes using nongranular monoammonium phosphate as the basic source of phosphate and urea as the source of supplemental nitrogen have been quite successful in commercial operations for many years.

TVA has also demonstrated the use of urea in combination with both single and triple superphosphate to produce granular NP and NPK fertilizers. The presence of urea in these products makes drying difficult because low mositure contents are required for satisfactory storage and high temperatures cannot be used without melting the product. Products require drying to about 1% moisture or less, and many of them require a conditioning agent to ensure satisfactory storage properties. Because of the drying problems associated with these products, TVA's recent research and development program have been concentrated on melt processes which require little or no drying.

In December 1973, after about 10 years of pilot-plant development work, TVA began operation of a modified melt granulation plant having a capacity of about 400 tons per day of 28-28-0 or about 300 tons per day of 35-17-0 urea-ammonium phosphate fertilizers [1, 2, 3]. This unit has now been in production about 6 years and its operation is routine. A flow-sheet of this unit is shown in Figure 1. Typical operating conditions and data for each of these grades of urea-ammonium phosphate are given in Table I. (Figure 1)

During TVA's Tenth Demonstration of Fertilizer Technology in 1974, another melt granulation process for the production of NPK granular fertilizers containing urea was shown to the fertilizer industry[4]. A flowsheet of the process equipment is shown in Figure 2. This process utilized equipment normally found in a typical granulation plant, such as a drum granulator and a preneutralizer. A pipe reactor was used to produce an ammonia phosphate melt and the urea and potassium chloride were added as solids to the recycle stream. Urea was incorporated in the granules better when microprills or crushed regular prills were used. Operating conditions and typical data for 19-19-19, 12-24-24, and 15-30-15 grades are shown in Table II. When producing these grades, all of the P_2O_5 was furnished by wet-process merchant-grade (54% P_2O_5) phosphoric acid. The acid was ammoniated in two stages, first in a preneutralizer tank (a typical commercial-scale tank is shown in Fig. 3) and then in a pipe reactor installed to discharge into the drum granulator (see Fig. 4). The heat of reaction obtained was sufficient to evaporate all the free water and a part of the chemical water in the feed acid, thus converting a part of the orthophosphoric P_2O_5 to the polyphosphate form as shown by the following equation:

$$2H_3PO_4 \xrightarrow{\text{heat}} H_4P_2O_7 + H_2O$$

No dryer is required in the process, so there can be significant savings in investment and operating costs as well as energy requirements. The dryer is also a major source of particulate emission, so its elimination affords a conmsiderable savings in costs and energy for pollution control equipment. (Figures 2, 3, 4)

In 1974 TVA, in cooperation with the Missouri Farmers Association at their fertilizer plant in Palmyra, Missouri, began experimental tests of a modified pipe reactor in which sulfuric acid was added in addition to phosphoric acid and ammonia. This reactor, which is known as the pipe-cross reactor, is now utilized by commercial companies throughout the world for production of granular fertilizers[5, 6, 7, 8]. In late 1974 TVA began a pilot-plant developmental program utilizing the pipe-cross reactor. A flowsheet showing the pilot-plant equipment is shown in Figure 5. TVA has used this process in pilot-plant tests to produce several NP and NPK grades of granular fertilizer containing urea, such as 33-11-0, 32-16-0, 20-10-10, 17-17-17, and 15-15-15. Typical operating conditions and data for each of these grades are given in Table III. Not all of these grades were successfully produced without some supplemental drying. Drying was required for the 32-16-0 grade because higher granulator moistures were required to agglomerate the solid feeds. Overall granulation was good for the 33-11-0 and 15-15-15 grades, but some difficulties were encountered in producing homogeneous granules of the other grades. (Figure 5)

With sufficient experience in operating techniques, it is possible to produce good quality NP and NPK granular fertilizers using urea as a supplemental nitrogen source[9, 10, 11, 12]. It must be remembered that mixtures of urea and ammonia nitrate are very hygroscopic and should be kept separated both in the manufacturing and storage areas.

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11. "New Developments in Fertilizer Technology," Tennessee Valley Authority Belletin Y-136. (12th Demonstration, October 1978, Muscle Shoals, Alabama)

12. "Studies of Granulation of Compound Fertilizers Containing Urea—A Literature Review," Tennessee Valley Authority Bulletin Y-108. (October 1976)

TABLE I

Typical Operating Data for Melt Production and Granulation, TVA Demonstration Plant

Nominal grade	28-28-0	35-17-0
Production rate, tons/h	18	13
Urea		
75% solution		
Temp, °F	200	202
Feed rate (100% basis), tons/h	8	8
Melt to pug mill		
Temp, °F	285	290
Concentration, %	99	99
Ammonium polyphosphate		
Melt to pug mill, tons/h	9	4
Temp, °F		
Phosphoric acid	130	-
Spray-reactor product	266	255
Pipe-reactor melt	422	412
pH		
Spray-reactor product	1.5	1.7
Pipe-reactor melt	3.4	4.1
Granulation		
Recycle		
Temp, °F	140	-
Ratio, lb/lb product	4.5	4.5
Granulator product		
Temp, °F	178	172
Screen analysis (Tyler), %		
+6 mesh	14	-
-6 +10 mesh	42	-
-10 +16 mesh	29	-
-16 mesh	15	-
Product		
Chemical analysis, %		
Total N	28.7	35.5
Total P_2O_5	28.6	17.0
Available P_2O_5	28.6	-
Orthophosphate P_2O_5	23.2	11.4
Polyphosphate, % of total P_2O_5	18.9	32.9
H_2O (Karl Fischer)	1.0	0.8
Biuret	0.5	-
pH	4.9	-
Screen analysis (Tyler), %		
+6 mesh	2	1
-6 +8 mesh	28	22
-8 +10 mesh	52	53
-10 +12 mesh	10	20
-12 +16 mesh	7	3
-16 mesh	1	1

TABLE II

Formulations and Operating Conditions for Production of NP and NPK Fertilizers by Pipe-Reactor/Drum-Granulator Process

Nominal grade	19-19-19	12-24-24	15-30-15
Formulation, lb/ton of product			
Ammonia (gaseous)			
To preneutralizer	36	46	57
To pipe reactor	60	75	94
To drum	22	29	36
Total	118	150	187
Wet-process phosphoric acid (54% P_2O_5)	704	889	1111
Urea (46% N)	615	252	317
Potassium chloride (60% K_2O)	633	800	500
Preneutralizer			
Acid preheat temp, °F	210	180	200
Slurry temp, °F	293	290	282
$NH_3:H_3PO_4$ mole ratio	0.4	0.4	0.4
Pipe reactor			
Melt temp, °F	432	440	435
Melt analysis, %			
Total N	11.8	11.6	12.2
Total P_2O_5	57.8	58.0	57.2
Polyphosphate, as a % of total P_2O_5	20	21	21
Drum granulator			
Recycle ratio, lb/lb product	1.7	2.3	3.3
Product temp, °F	172	178	175
Moisture content, % AOAC (vacuum desiccation)	1.2	1.2	1.0
Screen analysis (Tyler), % retained			
6 mesh	4	33	22
8 mesh	14	62	40
10 mesh	35	84	58
12 mesh	52	91	68
16 mesh	83	97	83
Ammonia evolution, % of total feed	4	3	6
$NH_3:H_3PO_4$ mole ratio	1.3	1.3	1.4
Onsize (-6 +12 mesh) product analysis, %			
Total N	20.3	13.4	14.5
Total P_2O_5	20.1	25.1	29.6
K_2O[a]	19.8	24.3	18.6
Percent of total P_2O_5 as			
Polyphosphate	27	23	20
Water soluble	94	99	100
Available	99	100	100
Moisture (AOAC vacuum desiccation)	1.1	1.2	0.9

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[a] K_2O content high because sampling took place about 4 hours after changing from 12-24-24 grade.

TABLE III

Formulations and Typical Operating Conditions for Production of NP and NPK Fertilizers

Using the Pipe-Cross Reactor and Drum-Granulation Process

Nominal grade	33-11-0[a]	33-11-0[b]	33-11-0[c]	33-11-0[d]	17-17-17	20-10-10	32-16-0	15-15-15
Test No.	PCU-30	PCU-38	PCU-43	PCU-45	PCHA-8	PCHA-6	PCU-73	PCX-93
Length of test, h	5.1	5.8	5.5	5.0	5.4	6.0	4.5	5.7
Nominal production rate, ton/h	0.5	0.5	0.5	0.5	0.75	0.75	0.6	0.6
Formulation, lb/ton of product								
Ammonia								
To pipe-cross reactor	96[f]	136[f]	96[f]	96[f]	161[e]	144[e]	111[f]	146[f]
To granulator[f]	21	29	27	27	-	-	32	29
Ammonium sulfate (20.7% N)	165	-	-	-	-	601	-	340
Wet-process phosphoric acid (54% P_2O_5)								
To pipe-cross reactor	411	411	411	411	630	370	570	562
To granulator	-	-	-	-	-	-	-	-
Sulfuric acid to pipe-cross reactor (92% H_2SO_4)	200	200	200	200	250	300	200	320
Urea (46% N)	1217	1183	1259	1259	448	340	1150	207
Pipe-cross reactor								
Phosphoric acid feed temperature, °F	152	153	155	155	155	160	133	133
Equivalent acid concentration, % P_2O_5	40	41	47	39	50	44	47.9	42.6
Ammonia feed temperature, °F	Ambient				22	20	Ambient	
Melt temperature, °F	269	278	276	264	290	240	387	327
Melt analysis, %								
Total N	11.3	16.8	37.0	13.0	15.0	16.4	12.7	11.2
Total P_2O_5	26.6	13.2	10.5	30.8	35.4	28.0	27.0	31.2
NH_3:H_3PO_4 mole ratio	0.46	1.46	-	0.67	0.84	1.0	0.64	0.72
Drum granulator								
Recycle ratio, lb/lb product	3.8	3.9	3.6	3.5	3.8	3.4	2.8	3.3
Discharge temperature, °F	170	179	175	186	166	158	179	183
Moisture (AOAC), %	1.2	1.3	1.0	1.3	1.1	0.9	0.9	0.9
Screen analysis (Tyler), %								
+6 mesh	23.5	12.1	10.7	7.1	12.3	10.0	5.7	10.0
-6 +10 mesh	31.9	49.8	34.5	45.0	36.6	32.2	47.3	57.6
-10 +16 mesh	29.6	27.4	31.7	37.4	33.8	32.2	28.8	26.1
-16 mesh	15.0	10.7	23.1	10.5	17.3	25.6	18.2	6.3
NH_3 evolution, as % of total NH_3 feed	5.2	21.2	17.2	7.0	16.9	11.2	4.0	4.2
pH of granulator product	6.2	6.6	6.9	6.5	5.8	5.2	5.7	5.2
Onsize product								
Total N	33.9	34.6	36.4	35.6	17.4	19.8	31.5	15.5
Total P_2O_5	11.5	12.3	11.9	11.9	17.5	10.4	17.9	14.8
SO_3	14.0	10.3	8.5	8.6	14.1	29.0	10.0	20.6
As % of total P_2O_5								
Polyphosphate	10.9	5.7	10.9	11.8	10.6	16.8	5.9	1.4
Water soluble P_2O_5	91.3	93.5	92.4	94.1	90.6	92.8	92.7	96.6
Available P_2O_5	97.4	100	100	100	100	100	100	100
Moisture (AOAC)	0.8	1.4	0.8	0.9	1.1	0.9	1.0	1.2

---

[a] Five percent sulfur; ammonium sulfate added to bed; monoammonium phosphate mole ratio formulation.
[b] Three percent sulfur; diammonium phosphate mole ratio formulation.
[c] Three percent sulfur; urea added to the pipe-cross; monoammonium phosphate mole ratio formulation.
[d] Three percent sulfur; monoammonium phosphate mole ratio formulation.
[e] Liquid ammonia.
[f] Gaseous ammonia.

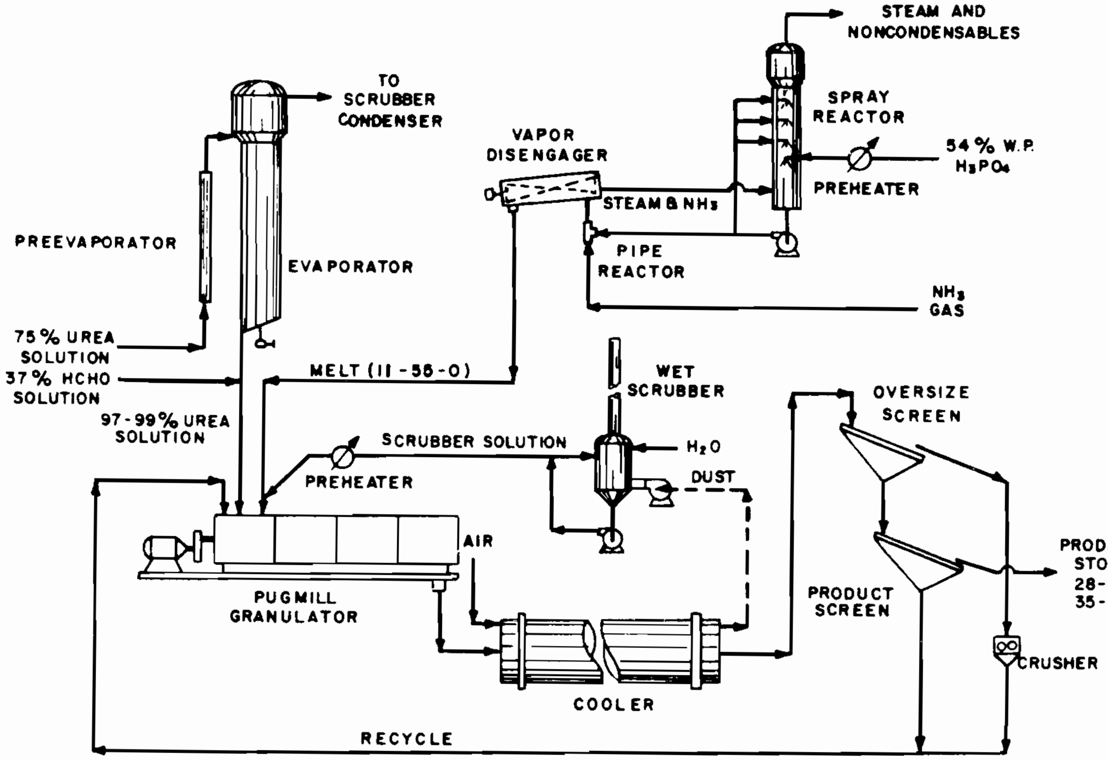


FIGURE 1

Pipe-Reactor/Pugmill Process

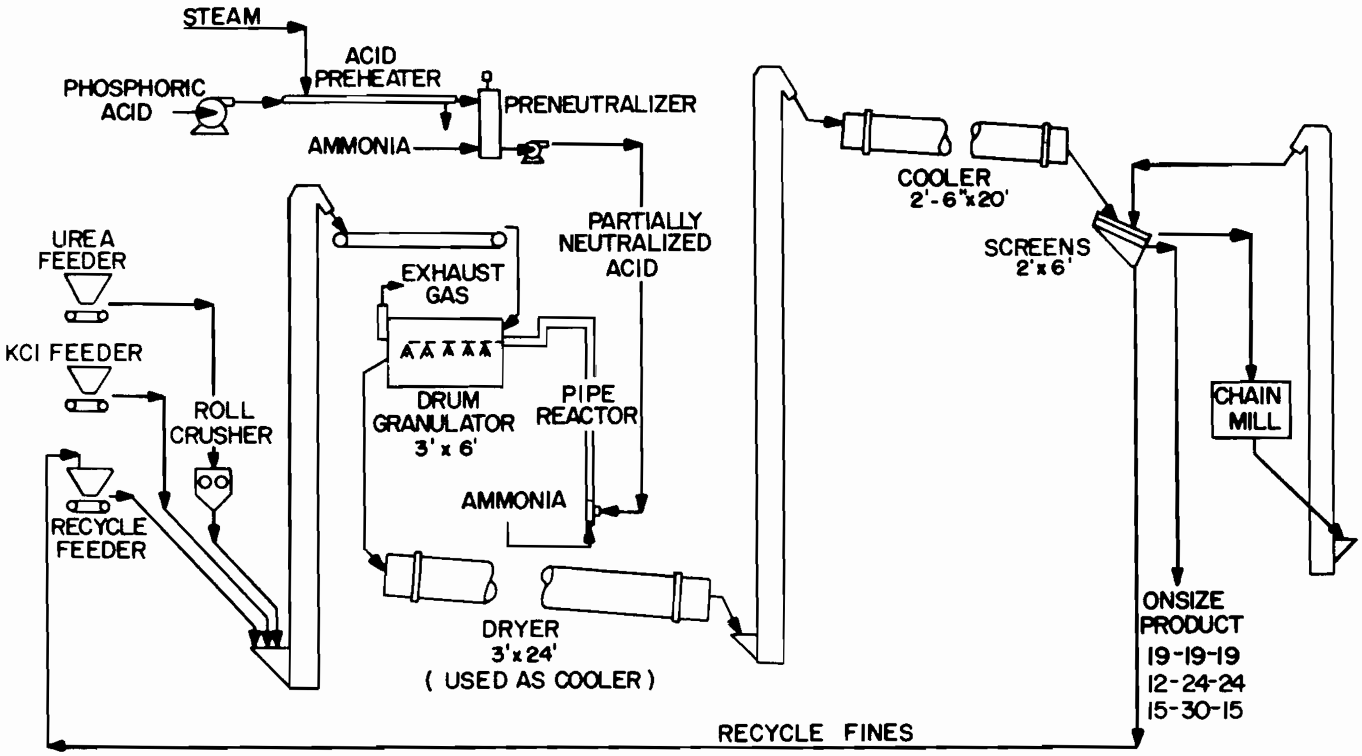


FIGURE 2

Pipe-Reactor/Drum-Granulator Process with a Preneutralizer

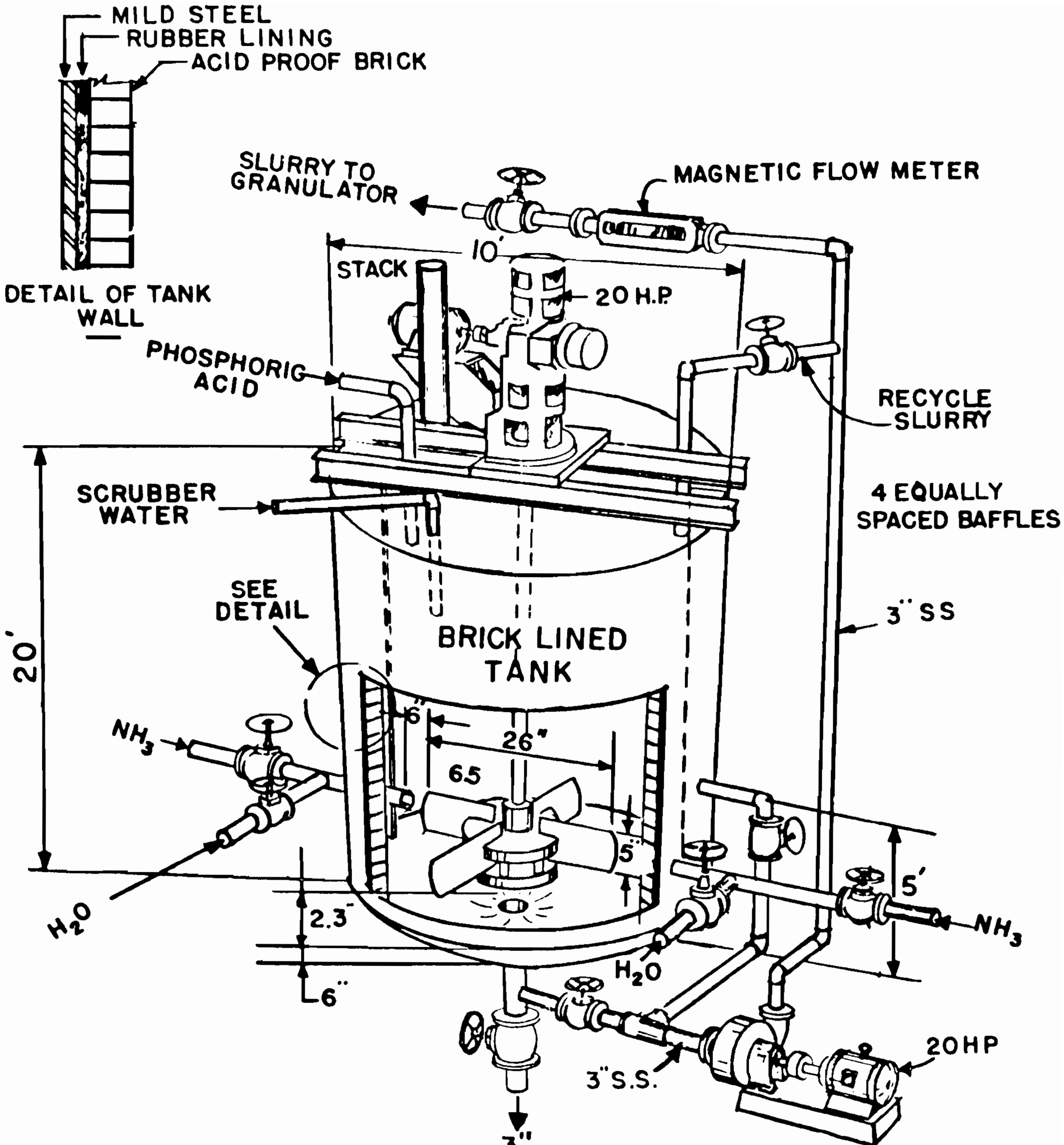


FIGURE 3

Typical Preneutralizer Tank

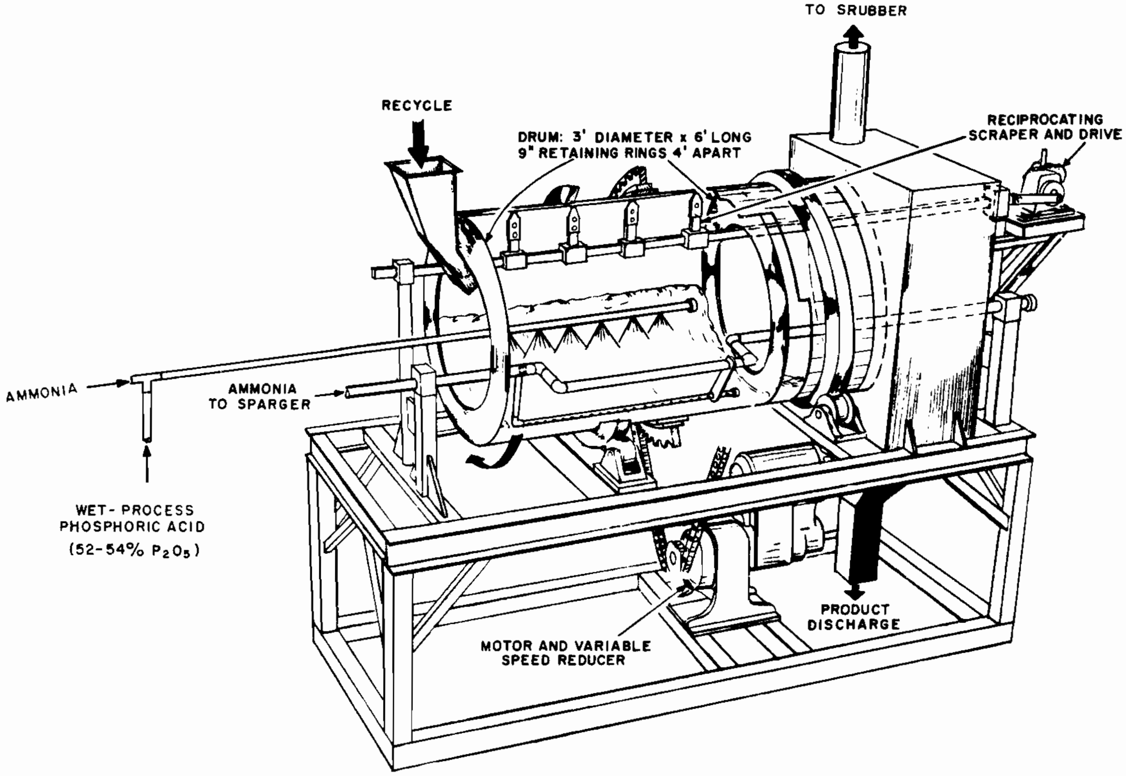


FIGURE 4

Sketch of Pipe Reactor and Rotary Drum Granulator

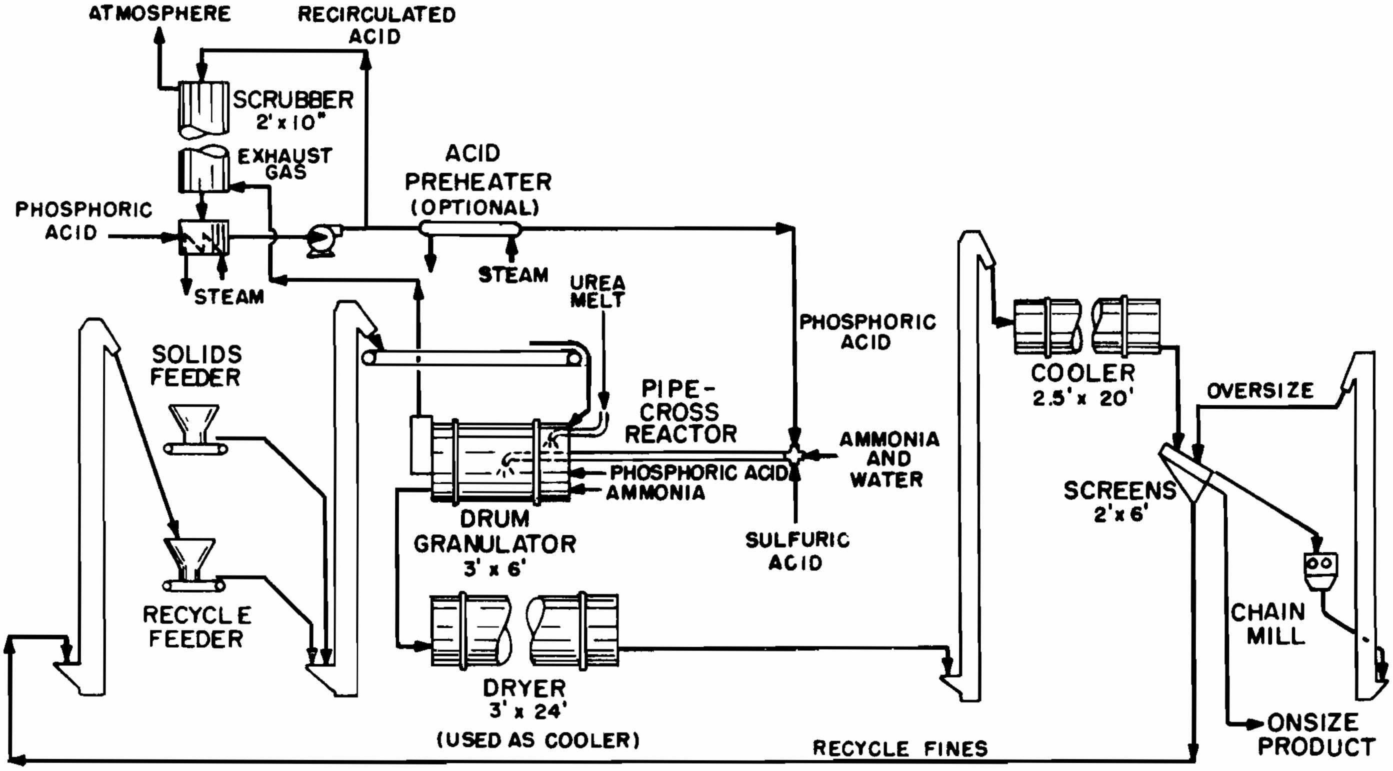


FIGURE 5

Pipe-Cross Reactor/Drum-Granulator Process

MODERATOR SACKETT: Thank you Mr. McCamy. (Applause)

Our next discussion "Grade Control in Bulk Blend Plants" will be in two parts. First Part No. 1 by Dr. David L. Terry and Part No. 2 by Herbert L. Balay.

Dr. Terry will give us Part 1. Dr. Terry is the Assistant Director and Co-Cordinator of the Fertilizer Program at the University of Kentucky. He received his B.S. in Agriculture from Kentucky in 1958 and his M.S. in Agronomy from Kentucky in 1961 and his Ph.D. in Soil Science from North Carolina in 1968. Dr. Terry is also a member of Alpha Zeta Phi Eta Sigma, Gamma Sigma Delta, American Society of Agronomy, Soil Science Society of America, Associate of American Plant Food Control Officicals, Associate of Southern Feed Fertilizers and Pesticide Officials. He is the author or co-author of 11 research papers in the Fertilizer field. Dr. Terry, please. (Applause)

Grade Control In Bulk Blend Plants
Part One

D. L. Terry

Grade control or more appropriately "quality control" in a bulk blend fertilizer plant is of interest not only to the manufacturers but also to regulatory officials. Both parties are interested for some of the same and for different reasons. Both want to see the farmer receive the full guaranteed value of his purchase and both are interested from a compliance standpoint. In addition, the manufacture is concerned that, while meeting the minimum guarantee, he is not inadvertently giving away product because of poor control of his manufacturing process.

I want to dicuss fertilizer quality control from there aspects:

(1) the role of the fertilizer control official in fertilizer quality,
(2) effects of a quality assistance program on fertilizer quality, and
(3) the particle size problem.

A fertilizer regulatory program has at least three main objectives: (1) consumer protection, (2) industry protection, and (3) fertilizer quality. I would like to discuss at this point the latter objective. That fertilizer quality should be stated as an objective of a regulatory program may not receive unanimous support from all regulatory officials; However, I believe it is a very important aspect of a good program. I am not referring to the aspect of a regulatory program where quality results indirectly because of penalities for poor quality but where the control takes an active role in providing assistance to the manufacturers.

Shortly after the role of the fertilizer control official in fertilizer quality, I came to Kentucky in 1974 as Coordinator of the Fertilizer Regulatory Program, it became obvious that we had a quality problem with blended fertilizers. Further investigation revealed that there was a general lack of training and understanding among the industry, especially the small independent blender, concerning how to make quality blends. In the summer of 1976 the Division of Regulatory Services of the University of Kentucky, in cooperation with the Kentucky Fertilizer and Agricultural Chemical Association, held a series of workshops for Kentucky fertilizer blenders on quality control in blending plants. We also held a similar series of workshops in 1978. These workshops formed the basis of a quality assistance program which reflects our conception of the role the fertilizer control official should assume in fertilizer quality. The following is a discussion of our program as it has developed so far.

There are at least four parts to the program, which are: (1) identify and describe the quality program, (2) enlist the support of the state industry, (3) provide a program based on up-to-date information and geared to the understanding of the plant manager and his crew, and (4) have a follow-up program to evaluate your efforts and to continue to emphasize the program.

Identify the Problem

The regulatory agency is in the best position to identify and describe the quality problem by looking carefully at the samples taken of the products offered for sale in the state. The samples should be identified as to whether they are a blended or an ammoniated-granulated product, bag or bulk, liquid or dry, mixture or material, custom mixed or blended to standard grade, etc. We found in Kentucky in 1975 that the deficiency rate for bulk blended fertilizers was about twice that of ammoniated-granulated products, thus, our program was directed at bulk blenders.

Support By The Industry

Support of the program by the state fertilizer industry is crucial to its success and can usually be obtained by working with the state fertilizer industry organization. We are fortunate in Kentucky to have a very active organization, the Kentucky Fertilizer and Agricultural Chemicals Association, and they worked with us in setting up the workshops and in encouraging and enlisting the support of the Kentucky fertilizer industry, especially the bulk fertilizer blenders. Such a program is voluntary and it takes some promotion and maybe some encouragement from the regulatory agency to make the manufacturer want to participate.

Up-To-Date Information

For the program to be acceptable to the participants it must provide information that is up-to-date and be presented in a fashion that is understandable to the plant manager and his crew. It is important that the information be presented so that even the front-end loader operator can understand it and that not only problems are discussed, but also solutions are presented and discussed.

We enlisted the assistance of TVA personnel who provided the expertise on quality control in bulk blending. Other sources of expertise might be the industry itself through TFI, or the Association of American Plant Food Control Officials (AAPFCO).

The Good Manufacturing Practices Committee of AAPFCO is working with TFI on a format and program materials for workshops similar to the ones we held in Kentucky. When finished, the package would be available to any state for adaptation to their specific situation.

Evaluation

There should be a follow-up the year following the program, such as, evaluating the sample defficiency rate of those companies attending, asking the inspectors to start discussing with the plant personnel some of the points covered in the workshops and instituting, on a voluntary basis, a program of evaluating the overall operation of a plant. The overall evaluation of a blend plant should include items such as storage facilities, mixing equipment, labeling, formulation and mixing procedures, inter-plant communication, employee training, house-keeping, etc. We, in Kentucky, are still developing our plant evaluation program and do not have any experience with it yet; however, some of its characteristics as we visuallize them are:

(1) it will be voluntary,
(2) it will include a limited number of free chemical analyses of samples taken by plant personnel,
(3) the company must agree to make any reasonable changes and/or improvements in their operation as suggested by the evaluation, and
(4) there will be some kind of recognition, such as a certificate or plaque for those companies with high achievement.

I want to stress that it will be voluntary, with the sole purpose of assisting the company with its quality control program. Those companies participating will not receive any special considerations otherwise in the enforcement of the regulatory program.

Quality Assistance Program

I would like now to look at the effects of those workshops on the deficiency rate of the regulatory fertilizer samples. I will compare the rates the year before and the year following each workshop.

In 1975-76, the year before our first workshop, the overall deficiency rate was 37% (Fig. 1). Deficiency rate is defined as the percent of official samples having one or more N, P, or K deficiencies under the analytical tolerances currently in effect in Kentucky. In 1976-77, the year following the workshop, the overall deficiency rate was 33%, which is a significant decrease. We think this is an indication of how our industry will respond to a quality assistance program. By providing the information on what the problems are in manufacturing blended fertilizers and on what to do about it, the companies apparently put the information into practice.

A comparison of deficiency rates befoire and after the 1976 workshops for the categories of bagged, bulk, and liquid showed us that the deficiency rates for bag and bulk decreased while that for liquids increased (Fig. 2).

Table 1

Deficiency Rates Before and After the 1976 Workshops by Form of Distribution

Form	Deficiency Rate, %	
	1975-76	1976-77
Bag	34	33
Bulk	45	35
Liquid	21	27
All	37	33

The main decrease was observed in the "bulk" category where most of our blends are found.

The other categorization we make is the type of manufacture, that is, ammoniation-granulation (manufactured), blended (to grade), materials, and custom-mixed blends. The comparisons for these categories are in Table 2 (Fig. 2).

Table 2

Deficiency Rates Before and After the 1976 Workshops by Type of Manufacturing Process.

Type	Deficiency Rates, %	
	1975-76	1976-77
Mnfr.	25	22
Blend (Grades)	50	46
Materials	4	5
Custom-Mixes (Blend)	52	40
All	37	33

These data give us more insight into where the problem was and where the major improvement was effected. Blended grades and custom mixed blends are the problems and are where our emphasis was placed. Custom-mixes showed the main decrease followed by the blended to grade category, which is what we were aiming for.

The same kinds of data foar the 1978 workshops are shown in Tables 3 and 4 (Fig. 1 & 2).

Table 3

Deficiency Rate Before and After the 1978 Workshops by Form of Distribution.

Form	Deficiency Rate, %	
	1977-78	1978-79
Bag	33	30
Bulk	36	35
Liquid	42	37
All	35	32

Table 4

Deficiency Rates Before and After the 1978 Workshops by Type of manufacturing Process.

Type	Deficiency Rate, %	
	1977-78	1978-79
Mnfr.	25	22
Blend (Grades)	44	39
Materials	7	6
Custom-Mixes (Bland)	40	38
All	35	32

The decrease following the 1978 workshops was not as large as for 1976 but there was a decrease across all categories. This indicates that progress is being made and that our quality assistance program is still having an effect.

In 1976-77 the largest decrease in deficiencies was in the custom mix category; however, in 1978-79 the category with the largest decrease was the blended grades. This could be partly due to the assistance provided to specific companies with quality problems. As part of our follow-up to the workshops, we will go by request to a specific plant and evaluate various aspects of their operation, such as to be reported by Mr. Balay. We have had success in improving quality control in several plants that blend-to-grade which probably is partly reflected in the improvement in the blended grade category. Our quality assistance programs have apparently eliminated or reduced most of the "easily" solved problems. Any further improvement in fertilizer quality will probably be slower and will involve a continued, concerted effort by the industry and the regulatory officials.

Particle Size Problem

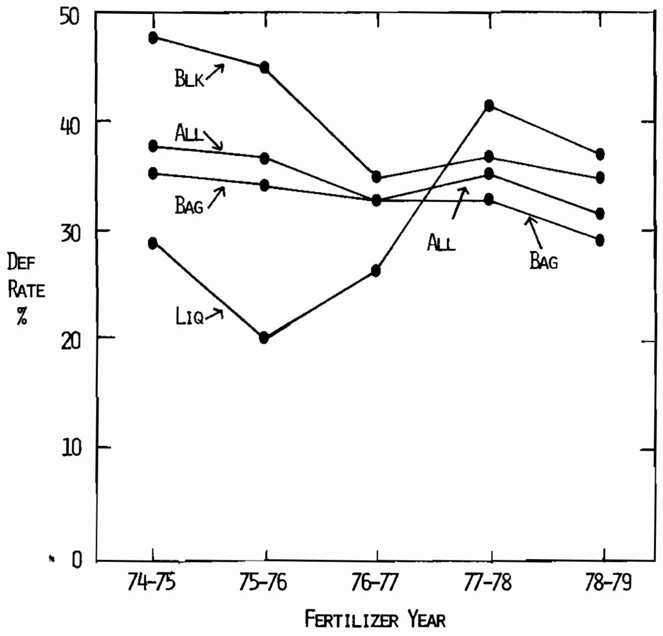
The most prevalent and aggravating problem in the fertilizer blending industry is unequal particle size distributions of the materials used in blending. An illustration of this problem is shown in Figures 3 and 4. These data were obtained by selecting samples of materials that had been collected by our inspectors during the 1978-79 fertilizer year. They are probably representative of the materials in general use in Kentucky. TVA has indicated that when there is a divergence of 20 or more percentage points between the cumulative particle size distributions of blending materials, a segregating blend will result.[1] The data in Figure 3 show that segregation would be a problem using diammonium phosphate (DAP), ammonium nitrate (AN), and muriate of potash (MP) which are common blending materials. On the number 8 mesh sieve there is a divergence of 58 points between MP and DAP, 24 points between MP and AN and 34 points between AN and DAP. A blend made from these three materials would segregate severely, causing problems with off-grade analysis. The data in Figure 4 show variation in particle distributions between lots of the same materials. The two AN lots varied 43 points on the number 10 sieve while the sulfate of potash (SP) lots varied almost 70 points on the number 18 sieve.

REFERENCES

1. Hoffmeister, George. *Quality Control in Bulk Blending Plants.* Proceedings of TVA Fertilizer Bulk Blending conference. August 1973. (TVA pub. Z-49).

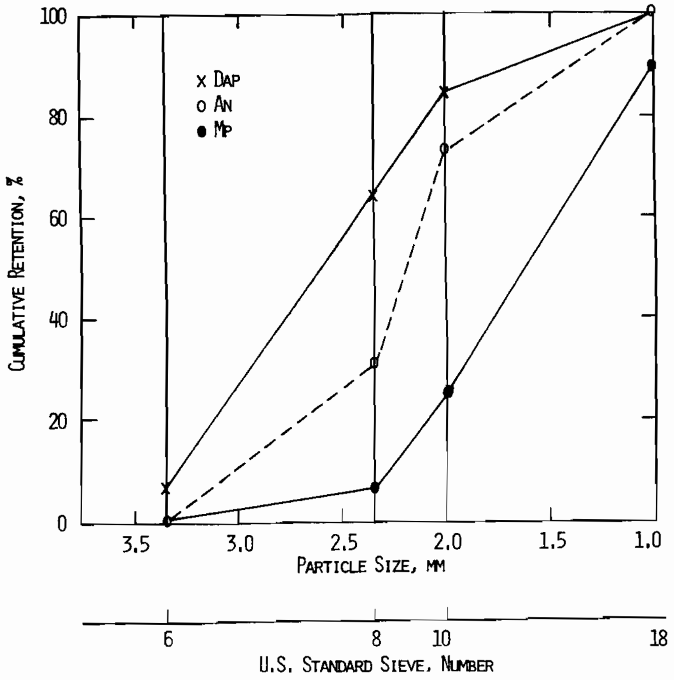
These data point out that the industry has a long way to go before particle size compatibility between the blend materials is achieved. There has been progress with the advent of granular urea and muriate of potash but we still have a long way to go. I challenge the industry to give serious consideration to initiating a program for standardizing the particle sizes of the various blend materials. I think it would be better for you to do it than to have some regulatory agency require you to do it.

In conclusion I would like to emphasize that grade control is and will continue to be a problem in the blend fertilizer industry. It is not a simple problem and its solution must come from a coordinated approach by both the industry and the regulatory officials. We feel in Kentucky that one avenue of approach is through an educational effort promoted by both the industry and the regulatory agency. It's working in Kentucky.



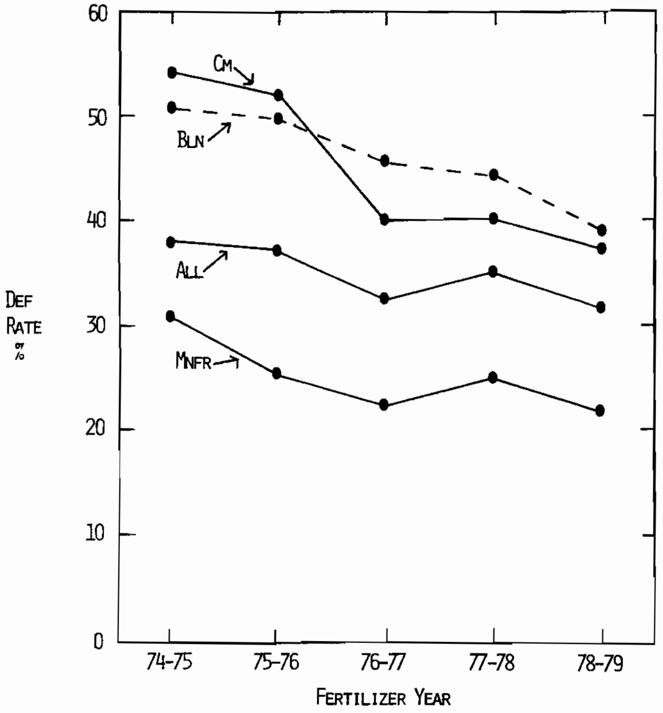
Slide A

Fertilizer sample deficiency rates in Kentucky from 1974-1979 by form of distribution.



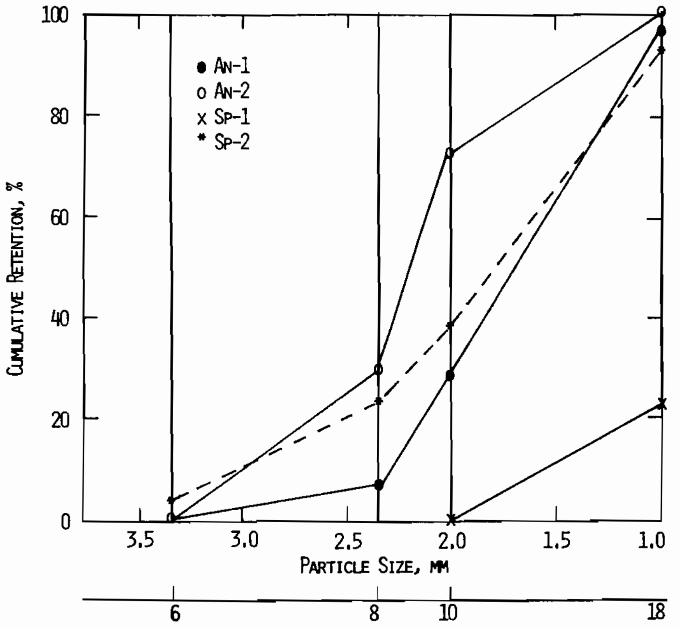
Slide C

Cumulative sieve analyses of diammonium phosphate (DAP), ammonium nitrate (AN), and muriate of potash (MP).



Slide B

Fertilizer sample deficiency rates in Kentucky from 1974-1979 by type of manufacture.



Slide D

Cumulative sieve analyses of two lots of ammonium nitrate (AN) and sulfate of potash (SP).

MODERATOR WALTER SACKETT: Thank you Dr. Terry. Our next speaker will be Hubert L. (Bud) Balay, T.V.A. Field Chemical Engineer. Bud is a graduate Chemical Engineer of the University of Arkansas. He worked 12 years with Spencer Chemical Company and he has been with T.V.A. for 14 years. Bud will continue on with Part 2 of our subject of "Grade Control in Bulk Blend Plants."

Grade Control In Bulk Blend Plants
Part Two
Hubert L. Balay

In 1962, George Hoffmeister of TVA, in a paper presented at the Round Table, showed conclusively that mismatch of particle size and coning as a result of mishandling are major contributors to segregation in bulk blends. Coning causes deficiencies by making it almost impossible to obtain a representative sample, even if the average formulation is correct. Since 1962 the Process and Product Improvement Section of TVA has used the information developed by Hoffmeister to assist bulk blend plants all over the world to achieve better grade control. The "egg crate" dividers developed by Hoffmeister have been effective in preventing segregation, or unmixing of blended material, in bagging and holding hoppers by preventing coning; however, this device will not remix fertilizer that has not been properly mixed or which has become "unmixed" during handling. This is especially true in plants where raw materials of unmatched particle size are used. Filler is a major source of unmatched particles in many plants because properly sized filler is difficult to obtain.

Results from a typical plant in the Southeast clearly show how deficient samples can be obtained from a well formulated grade. Table 1 shows the chemical analysis of raw materials used in a nominal 6-12-12 grade. A contributor to the problem which recently seems to occur more frequently is shown in the chemical analysis of the diammonium phosphate; the nitrogen content is a little low. Other raw materials used are slightly over analysis. The formulation is shown in Table 2; however, the actual grade formulated was 5.96-12.11-12.04, not 6-12-12. A 1-ton batch of the nominal 6-12-12 grade was prepared and samples were obtained from every seventh bag starting with bag No. 5 using a slotted single-tube trier with solid cone tip and AOAC procedures. It was thought that starting with bag No. 5 would eliminate variances caused by handling at the beginning of the batch. Chemical analyses of these samples are shown in Table 3. As the raw materials fell from the cluster hopper into the weigh hopper in assembling the batch, samples were obtained by cutting the stream of raw materials with a TFI stream sampling cup having a long handle. Cumulative screen analyses of the raw materials are shown in Table 4; a plot of cumulative screen analyses is shown in Figure 1. An unusual characteristic of these raw materials is the almost equal size distribution of the urea and potash. Limestone filler usually is smaller than the other raw materials.

Laboratory tests, along with practical experiments, show that if the maximum variation in cumulative screen analyses of raw materials is 10 percent or less, variation in analysis is minimal; if the variation in screen analyses is as much as 20 percent, severe segregation will occur. From this it can be assumed that the pounds of urea and potash in each bag would be close to the formulated amount while there would be severe variation in the diammonium phosphate and limestone.

To test this assumption each chemical analysis shown in Table 3 was formulated using the original raw materials. Pounds obtained for each formula were then compared to pounds per ton das originally calculated. For example, a formula for a 4.8-10.4-11.6 grade (analysis from sample No. 1, Table 3) was calculated and compared to the intended formulation shown in Table 2. A sample calculation is shown in Table 5. Comparison of the sample calculation to the actual formulation shows that the material in the bag was short 70 pounds of diammonium phosphate per ton, 22 pounds of urea per ton, 16 pounds of potash per ton, and contained an excess 108 pounds of limestone per ton. Similar calculations were made for each of the analyses shown in Table 3 and results are plotted as pounds above or below the calculated amount for each sample. Results are shown in Figure 2.

Urea and potash are fairly evenly distributed throughout the samples and are fairly close to the actual amount formulated, while limestone and potash vary widely between the first and fifth bags. Also, except for the fifth bag, potash varies almost directly with urea. It can be concluded that if the limestone and diammonium phosphate had been in the 10 percent range in the cumulative screen analyses chart, all of the analyses would have been much closer to the calculated grade and would probably have been within tolerance specified by state regulations. If sampling had been exact, it would be expected that when using this method of analysis, the pounds of each ingredient above the zero line would be equal to the pounds below the zero line; however, pounds above and below the line are not equal, probably because of mixing, weighing, sampling, riffling, and analytical error.

Similar data for a second plant are shown in Tables 6, 7, 8, 9, and 10 and Figures 3 and 4. Cumulative screen analyses for the raw materials are less closely matched than those of the previous example. In this plant urea is the largest material used and limestone, as almost always, is the smallest. Diammonium phosphate and potash are the two most closely matched materials. Although they are not as perfectly matched as the urea and potash in the first example, they always fall within the 10 percent range. When the pounds over and above the formulated amount are plotted in Figure 4, the match between the two most closely sized materials, diammonium phosphate and potash, is better than for the other ingredients. Potash exhibits an orientation around the zero line very similar to that seen in example 1. Although diammonium phosphate is high in the first three samples, it returns to the zero line on the fourth sample and generally follows variation of the potash after the fourth sample. Again, if limestone and urea had fallen within the 10 percent range, it is likely that orientation of the whole sample would have been around the zero line and the sample would have been acceptable, except for the first few bags. The excess diammonium phosphate in the first three samples can probably be explained by incomplete mixing or by segregation caused by the bagging machine.

It has been shown that some plants stay close to formulated analysis while others do not. Having properly sized materials is important in staying on analysis. This is especially important in plants that bag bulk blends because there is more opportunity for control officials to sample bagged blends and also further opportunity for segregation to occur in bags due to segregation in the bagging machine and in handling after the bags are filled. If properly-sized raw materials cannot be obtained, even-spreading of fertilizer in bins so that cones do not occur will minimize variation in cumulative screen analyses. Also, installation of properly designed dividers in bagging bins and holding hoppers and even-spreading of fertilizer as trucks are filled will help to solve the problem and give the farmer an on-analysis blend.

TABLE 1

CHEMICAL ANALYSIS OF RAW MATERIALS

Material	% N	% P_2O_5	% K_2O
Diammonium phosphate	17.8	46.4	0
Urea	46.4	0	0
Potash	0	0	60.2

TABLE 2

CALCULATED FORMULA FOR 6-12-12[1]

Raw Material	lb/ton Product
Diammonium phosphate (18-46-0)	522
Urea (46-0-0)	57
Potash (0-0-60)	400
Limestone (granular)	1021
Total	2000

1. Actual analysis 5.96-12.11-12.04 based on chemical analysis of raw materials.

TABLE 3

CHEMICAL ANALYSIS OF BAG SAMPLES

Grade: 6-12-12

Sample No.	% N	% P_2O_5	% K_2O
1	4.8	10.4	11.6
2	4.7	10.1	11.8
3	4.8	10.6	11.4
4	6.2	12.8	12.4
5	5.8	12.4	11.8
Average	5.3	11.2	11.8
Standard Deviation	0.69	1.24	0.37

TABLE 4

CUMULATIVE SCREEN ANALYSIS OF RAW MATERIALS USED

Raw Material	Mesh Size[1]						
	+7	+8	+9	+10	+14	+20	-20
Diammonium phosphate	5.0	29.7	63.4	86.5	97.5	99.9	100
Urea	26.3	61.0	85.0	94.5	97.6	100	-
Potash	28.4	62.6	84.6	93.6	97.6	100	-
Limestone (granular)	11.6	28.8	44.4	59.9	84.1	99.9	100

1. Tyler standard screen - scale seives.

TABLE 5

SAMPLE CALCULATION OF ACTUAL FORMULA FROM CHEMICAL ANALYSIS OF SAMPLE

Bag Sample No. 1, Intended Grade 6-12-12, Chemical Analysis 4.8-10.4-11.6

Raw Material	Chemical Analysis	lb/ton[1] Product	lb/ton as Calculated	Pounds Over or Under Calculated Amount
Diammonium phosphate	17.8-46.4-0	452	522	- 70
Urea	46.4-0-0	35	57	- 22
Potash	0-0-60.2	384	400	- 16
Limestone	0-0-0	1129	1021	+108

1. Pounds required to give chemical analysis.

TABLE 6

CHEMICAL ANALYSIS OF RAW MATERIAL

	% N	% P_2O_5	% K_2O
Diammonium phosphate	17.30	46.11	0
Urea	42.77[1]	0	0
Potash	0	0	59.99

1. Urea apparently contaminated.

TABLE 7

CALCULATED FORMULA FOR 14.13-15.03-15.00[1]

Raw Material	lb/ton Product
Diammonium phosphate (17.30-46.11-0)	652
Urea (42.77-0-0)	397
Potash (0-0-59.99)	500
Limestone (granular)	451

[1] Grade was to have been 15-15-15, but urea was off analysis.

TABLE 8

CHEMICAL ANALYSIS OF BAG SAMPLES

Grade: 14.13-15.03-15.00

Sample No.	% N	% P_2O_5	% K_2O
1	15.09	17.96	13.77
2	15.72	17.48	14.75
3	15.19	16.80	14.20
4	12.39	15.05	15.00
5	14.59	15.61	15.77
6	14.33	16.18	15.52
7	13.22	15.36	14.20
8	12.66	15.96	15.30
9	12.78	15.45	14.95
10	12.02	15.01	14.50
11	12.53	15.70	15.90
12	12.22	15.33	15.35
13	12.63	15.46	14.35
14	13.41	15.50	15.47
Average	13.48	15.92	14.93
Standard deviation	1.248	0.896	0.65

TABLE 9

CUMULATIVE SCREEN ANALYSIS OF RAW MATERIALS USED

	Mesh Size[1]						
Raw Material	+6	+8	+10	+12	+14	+20	-20
Diammonium phosphate	2.2	19.1	59.8	74.2	85.6	98.0	100.0
Urea	1.3	40.9	94.9	98.1	99.1	99.5	100.0
Potash	6.4	23.4	52.0	64.6	76.8	90.1	100.0
Limestone (granular)	1.1	11.3	37.0	52.2	67.0	89.4	100.0

[1] Tyler standard screen - scale seives

TABLE 10

CALCULATION OF ACTUAL FORMULA FROM CHEMICAL ANALYSIS OF SAMPLE

Mixer Sample No. 1, Intended Grade 14.13-15.03-15.00,
Chemical Analysis 16.05-17.63-14.10

Raw Material	Chemical Analysis	lb/ton Product	lb/ton as Calculated	Pounds Over or Under Calculated Amount
Diammonium phosphate	17.3-46.1-0	765	652	+113
Urea	42.77-0-0	441	397	+ 44
Potash	0-0-60	471	500	- 29
Limestone (granular)		323	451	+128
Total		2000	2000	

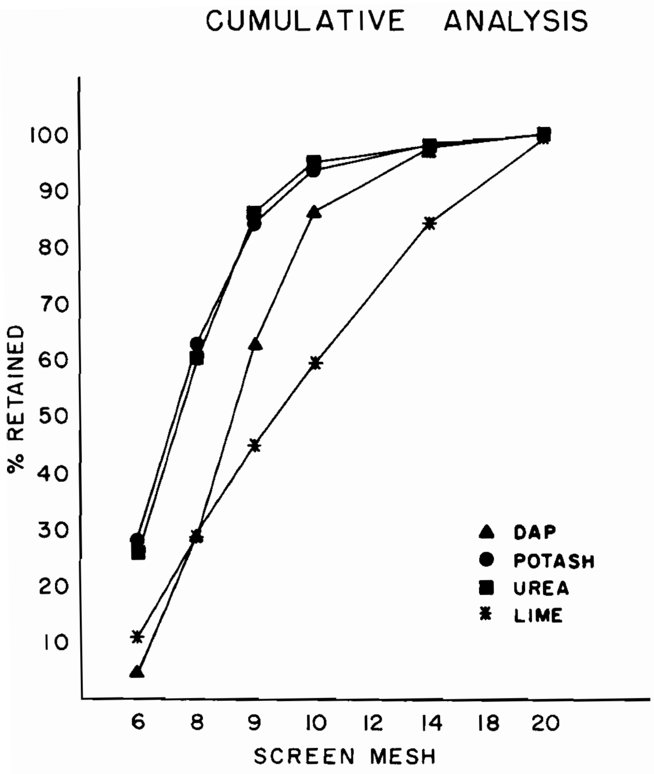


Figure 1

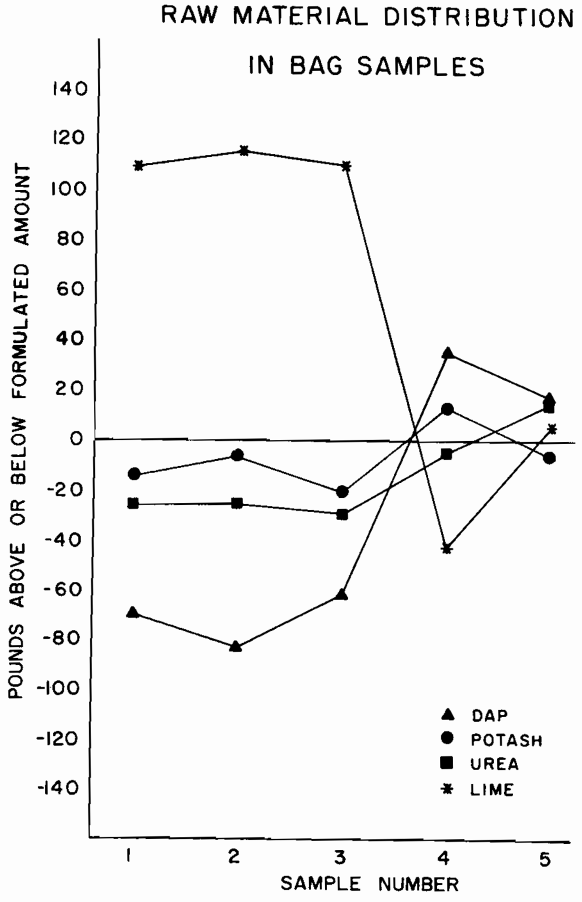


Figure 2

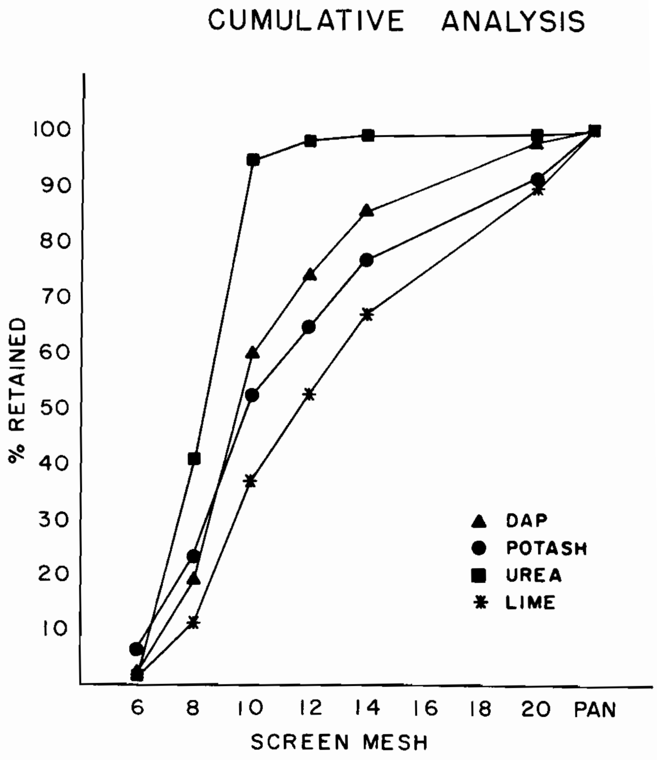


Figure 3

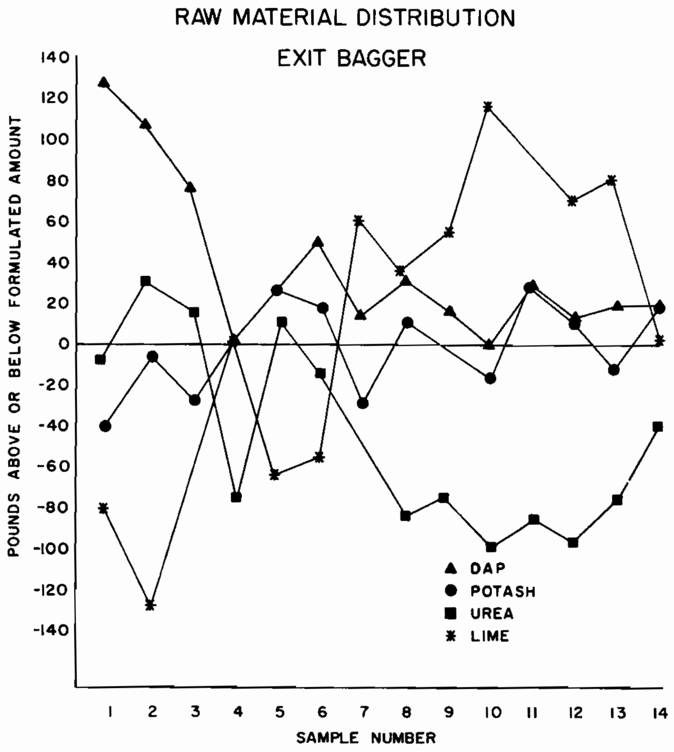


Figure 4

MODERATOR SACKETT: Thank you Messrs. McCamy (Part 1) and Balay (Part 2) for those interesting discussions and your usual concise professional job.

Our next Speaker is Karl Johnson. Karl is Vice-President Environmental Programs, The Fertilizer Institute, Washington, D.C. His major responsibilities are in a program area of great importance to the Fertilizer Industry — environmental regulations affecting manufacturing plants. Before coming to T.F.I. in 1975, Karl worked for the U.S. Environmental Protection Agency in its office of enforcement where he helped to implement the nation-wide industrial waste water permit system. A graduate of Iowa State University with a B.S. in Chemical Engineering Karl's work experience also included positions with Dupont and Atlantic Research Corporation. Karl will give us an update on Environmental Regulations.

Update on Environmental Regulations

Karl T. Johnson

Lest you had fears that a talk with the title "Update on Environmental Regulations" would not take up the allotted time on the program, let me reasure you that the facts are such that the problem is the other way around — how to select only a few items to cover in the allotted time so as to not overwhelm the speaker or the audience.

By recent tally there are at least seventeen federal laws on the books incorporating environmental and product safety and handling provisions which impact the chemical industry. The five major environmental laws are the ones we can enumerate easily: Clean Air Act, Clean Water Act, Toxic Substances Control Act, Safe Drinking Water Act and Resource Conservation and Recovery Act. Under each of these five the U.S. Environmental Protection Agency (EPA) is busy preparing regulations or policies which effect some segment of the fertilizer industry. As if status quo weren't enough, the Congress is heavily embroiled in an additional effort — namely, the "Superfund" legislation.

Today I will limit my remarks to a few actions which are of particular interest to the fertilizer industry.

Clean Air Act

The Clean Air Act Amendments of 1977 are expected to bear fruit in the form of standards of performance for emissions from new plants which produce ammonia, ammonium sulfate, ammonium nitrate, urea, potash and process phosphate rock. The EPA administrator published his findings on August 21, 1979, that these sources and 53 others were major air pollution sources and thus will be considered for New Source Emission Standards. Work on the standards is underway on all of the above except ammonia plants and possibly potash. The reason for the question on potash is that the standards development effort for potash as a separate category has not begun and we have indication that the EPA will drop it, provided states having potash facilities do not object. Dropping would be based on the low growth projection for this industry in the U.S. TFI promoted this idea at the public hearing on the priority listing. However, a draft report was circulated for the non-metalic mineral processing category, which took the approach of controlling certain processing operations such as crushing, grinding, and conveying which are common to several mineral industries. Potash was included in the draft document as one of the effected industries. EPA is considering withdrawal of potash from this category but has not made a firm decision as yet.

Engineering and economic impact studies, including on-site testing, are underway for ammonium nitrate and urea plants. In fact, testing is completed and EPA is now projecting draft documents to be ready about March of 1980. Proposed standards would follow in about 6 months. The agency is looking only at the solids forming processes — in other words, granulation and prilling — with the view of establishing standards for particulates. A side issue in this development effort is the need to prepare a new test method for sampling of particulate emissions from prill towers. The EPA Method 5 has proven to be unsuitable for sampling most towers. Therefore, modifications are being considered.

Particulate Emissions Standards for ammonium sulfate processes are scheduled for proposal in December of 1980. These would cover both the synthetic and byproduct (coke and caprolactam) manufacture of ammonium sulfate.

Proposed rules which would establish particulate emissions standards for phosphate rock plants were published September 21, 1979. sources covered are calciners, dryers, grinders and ground rock storage and handling. EPA has apparently based the standards on removal efficiencies achievable with baghouses and which they say are achievable with scrubbers — provided you operate with a 25-27 inch pressure drop. The high temperature and moisture conditions present at the outlet of calciners and dryers and the fact that no one in the industry uses a baghouse for these operations, has not deterred EPA from "technology transfer." The proposed standards are 0.04 pounds per ton for dryers, 0.11 pounds per ton for calciners and 0.012 pounds per ton for grinders. A 0% opacity standard is proposed for these three sources plus ground rock handling and storage systems. Moreover, continuous monitoring systems for opacity are required for all cases where baghouses are used. If a scrubber is selected, then continuous monitoring of a pressure drop across the scrubber will be required. Preliminary industry assessment is that the mass standards may be achievable but they are certainly not sustainable on a continuous basis, and the 0% opacity requirement is both unreasonable and unnecessary. A thirty day extension of the comment period until December 26, 1979 has been granted upon request of The Fertilizer Institute. The challenge is now before the industry to come through with solid data showing EPA's proposal to be ill-conceived.

Since work has not begun on ammonia plant emissions we cannot say with certainty what paramenters will be subject to control. However, estimated hydrocarbon emissions were used in placing ammonia plants on the priority list.

EPA efforts effecting ambient air quality standards which bear watching as possible signals of future tightening on fertilizer process emissions is that associated with revision of the ambient air quality criteria documents. Review drafts have been made available for sulphur oxides, particulates, and nitrogen oxides. Significant changes in the criteria would lead to changes in the ambient air quality standards followed by pressure to tighten individual source emmission standards. Review and revision of the criteria documents and ambient standards, if needed, is now required to be per on a five year cycle.

A bright spot of interest to those planning new nitric and sulphuric acid plants is that EPA had concluded that no change is necessary in the New Source Standard for these categories. Review of all New Source Standards is to be performed every four years as a result of 1977 Amendments to the Clean Air Act.

Even though emission standards for certain new sources are not changing, this does not necessarily mean that you can rely on current control technology to install in your new plant. Other considerations may dictate use of more extensive abatement technology. For example, if the new plant is to be placed in a clean air area, i.e., one meeting the ambient air quality standards, you may be limited by the incremental amount of air pollutants (particulates or SO_2) permitted in such clean air areas under the Prevention of Significant Deterioration (PSD) rules. Plants planned for non-attainment areas would be subject to use of best technology and have to find a source of emission offsets as well, either within their own complex or by agreeing to abate your neighbors' emissions.

Clean Water Act

Turning to the Clean Water Act we find most people struggling to get a reporting mechanism set up to handle potential spills of hazardous substances in to the waters of the United States. This has been brought about by the September 28 effectivity date of the Section 311 Hazardous Substances spill Regulations. After a success court challenge by industrial groups, including The Fertilizer Institute, to clarify the relationship of Section 311 with regard to the Discharge Permit Program, the Regulations were issued in August and require reporting of spills of certain reportable quantities of 299 substances listed as hazardous. The reportable quantities of most interest to the fertilizer manufacturers are 100 pounds for ammonia, 1,000 pounds for nitric acid and sulfuric acid and 5,000 pounds for phosphoric acid. The "person in charge" of a facility from which a discharge is made must report any discharge equal to or greater than the reportable quantity of the designated hazardous substance occurring in any twenty-four hour period, "as soon as he has knowledge" of the discharge. Failure to report is a criminal offense carrying a potential fine of $10,000 and/or one year of imprisonment. Moreover, the Coast Guard is required to assess a civil penalty of up to $5,000 for each discharge of a hazardous substance. Costs for clean-up is a responsibility of the spilling party. Certain exemptions from reporting under Section 311 are possible. A temporary exclusion from reporting is available to common carriers until the EPA and DOT publish regulations effective for them. Discharges by private or contract carriers are currently subject to the regulations, however. There are three exclusions from the requirements that a NPDES permit holder may excercise. First, any discharge of a hazardous substance is subject only to the NPDES program whether or not it complies with the permit limitations, unless the discharge is non-complying as a result of a spill. However, under a second exclusion, process and treatment spills may be subject only to NPDES if the nature and source of the potential spills are reported in the permit application. Lastly, a hazardous substance spill may be excluded from 311 if the plant demonstrates in its permit application that sufficient treatment capacity is available to handle a potential spill.

Revisions to the NPDES rules this past year will add two more programs to the alphabet soup, namely, BMP and SPCC. Best Management Practices (BMP) are intended to be applied wherever toxic or hazardous substances are handled in facilities ancillary to the manufacturing operations. A BMP Guidance Document is under preparation and is expected to be published in about three months. Requirements for BMP's will be enforced sixty days following that publication. A BMP will be required with the renewal of NPDES Permits. The EMP is seen by EPA as basically a documentation of general practices the industry already performs. The Spill Prevention control and Counter measures Plan (SPCC) is oriented toward construction or engineering requirements and must be certified by a professional engineer. A BMP will likely require an SPCC for affected materials.

In a move reportedly to streamline and consolidate various permit program regulations EPA has proposed to integrate requirements and procedures of the 1) Hazardous Waste management Program-RCRA 2) The Underground Injection Control Program under

Safe Drinking Water Act 3) The NPDES and Section 404 Dredge and Fill Program under the Clean Water Act and 4) Certain Regulations related to the Clean Air Act. Industry assessment of these proposed regulations is that EPA is merely compiling various permit programs rather than simplifying procedures. In fact, EPA actions likely will add confusion and delays to current programs rather than cut red tape. Some of the key criticisms of the proposal are that the permit consolidation is only offered at government option, not industry, and a five year review cycle is imposed upon permits under RCPA and Underground Injection Control that under current rules would be for the lifetime of the facility.

An item which I believe should be of particular concern to the nitrogen producing industry is the attempt of EPA to list ammonia as a toxic water pollutant. This proposal had reached the administrators desk over a month ago, but has since rebounded to an Associate Assistant Administrator level for resolution of differences within EPA. If adopted, however, this would result in EPA having to re-evaluate the best available technology (BAT) effluent standards for ammonia in nitrogen plant wastewater discharges. It would take away the possible option, now available, to get relief on an economic basis or on a showing of a lack of environmental necessity. Furthermore, no extension in meeting the BAT-1984 deadlines would be allowed. It would place the fertilizer industry into a so-called Group 1 category of point sources which significantly increases the effluent monitoring requirements for purposes of your discharge permits. Beyond these features it has potential for more stringent receiving water quality standards which could end up being the deciding factor on how much can be discharged by an individual plant.

Resource Conservation Recovery Act

For nearly a year now we have been playing a waiting game for final regulations on Hazardous Waste Management to be issued under Subtitle C of RCRA. The December 31, 1979 court ordered deadline is not going to be met according to EPA administrator, Doug Costle. April 1980 has been set as a time for issuance of a basic "core" of regulations. The agency is also expected to re-propose some major portions of the Section 3001 and 3004 regulations dealing with identification of hazardous waste and the management of them, respectively. You will no doubt recall that last December EPA proposed that by-product gypsum from phosphoric acid manufacturing and over-burden and slimes from phosphate rock mining would be classified as a "hazardous waste" and placed into a Special Waste category. Certain interim rules would apply while EPA studies these categories to determine appropriate management practices. We are hopeful that EPA will postpone any regulation of these operations until the study is complete.

Study of phosphate mining has been kicked off and is expected to take 26 months for extensive testing, observations and analysis at several mine sites. A companion study of the chemical processing operations has been delayed for approximately six months while the EPA re-groups its statement of work and goes out for a re-bid for the performance of the study. Additionally, a study of non-hazardous waste is under way presently which is taking a look at fertilizer operations, both nitrogen and phosphate.

Superfund

I would like to wrap up this talk with a few words about "Superfund" or "Ultrafund", whichever you prefer. I doubt that anyone has not heard about this legislation being worked on in congress, which would tax industry for the clean-up of spills and abandoned waste disposal sites, but let us review a little history on the subject. You will probably recall that under Section 311 of the Clean Water Act amendments of 1972, there was authorized a $35 million fund to be appropriated from public funds. This fund was to be available for the Government to use in the instant clean-up of oil and hazardous substances spills into waters of the United States. The fund was to be replenished from refunds of the clean-up costs from the guilty parties. Oil spill regulations did get published but the hazardous waste component did not come out until this year, as I mentioned earlier. Congress has, so far, appropriated only fifteen million of the thirty-five. The EPA has concluded that even the 35 million dollar fund would not be adequate to handle the response necessary for the number and quantity of oil spills alone. Hence, an effort to get a Superfund for oil spills was mounted in Congress a few years ago. It has not passed as yet. Into this scenario was placed the discovery of an increasing problem with disposal of chemical wastes, e.g., Valley of the Drums. RCRA was passed in 1976 with the promise of a mechanism to control waste disposal in the future, but did not address the abandoned disposal sites. With a lack of funds and manpower, EPA has proposed to expand the Superfund concept to cover abandoned sites and spills of oil and hazardous substances. The administration i.e., EPA, approach to get the funds is to tax crude oil, petro-chemical feedstocks, such as methane, and certain inorganic chemicals. 1.6 billion dollars was to be raised before pausing to see what good had been accomplished. The single industry most heavily hit in this approach was the fertilizer industry, with its contribution being 40-60 million dollars per year raised by the tax on sulfuric acid, nitric acid, ammonia, ammonium nitrate, and phosphoric acid. In addition to tax, the law would apply joint, several and strict liability to all those who cause or contribute to a spill. This would open everyone in the production/distribution chain to suit for damage claims from spills. We contend that Fertilizer has been unfairly hit as EPA has been unable to show where the fertilizer industry has contributed to the abandoned waste site problem. The spill history EPA has shown is almost totally transportation-related, i.e., when we do not have control over the product.

We believe the mood of Congress is such that passage of some form of legislation is likely. Timing is a big question and form another. There could be separate laws for abandonded sites and spills or a single comprehensive one as EPA has promoted. Funding could range from total industry tax to total public fund. We believe we have gotten the attention of the subcommittee drafting the legislation as to the inequitable impact on fertilizer, and ultimately food. We are working hard to keep their attention as the law is marked up for final passage. (Applause)

MODERATOR SACKETT: Thank you Karl Johnson for your up to date, valuable discussion. (Applause)

We shall now go to the Safety Discussions to be handled by Moderator Daniel Walstad.

Dan Walstad grew up in Minneapolis where he attended the University of Minnesota and received a degree of Bachelor of Chemical Engineering. After being with the Tennessee Valley Authority in Alabama a number of years he joined American Cyanamid Co. in 1958. He is presently a Production Engineer in Cyanamid's Plant Food Division at Wayne, New Jersey and has responsibility for Operation and Planning for Fertilizer Facilities. He is a member of the Board of the Fertilizer Round Table. It is a pleasure to turn over the dais to Dan Walstad.

MODERATOR WALSTAD: Thank you Walter. We turn our attention to a different area now.

The next four speaker "Safety Panel," will describe the kind of incidents that we hope "none of you" ever see. They cover chemical spills, oil spill, derailment and chemical fire. Should this happen to you, as Karl Malden says in his famous TV commercial "what do you do?" I think these speakers have the experience in this type of incident where they can help you a great deal. So, without further ado, we will introduce the speakers. There are four of them. Then, we would like to have you hold all of your questions until after all of the speakers are finished and we will bring them up onto the dais here.

We start with Richard Fox, who is from Remington, Indiana. He is a native of that state and is a graduate of the South Bend School of Business. He is now General Manager with the Farmers Cooperative Company there, a company that does apparantly 18 million dollars worth of business. He is currently President of Indiana Grain and Feed Dealers North-West and Vice President of the Indiana Plant Food and Agricultural Chemical Association.

Safety—Directed to N.P.K. Plants 10-34-0 Spill

Panelist: Richard Fox

Cause

Early Friday AM, January 28, 1977, a blizzard blew into Northern Illinois-Indiana and Ohio without warning. This winter storm consisted of snow, 35 mile per hour winds with gusts up to 55 mph and temperature dropping to 25 degrees below zero. The chill factor was 50-55 below zero. This was the first storm of this degree in over 40 years for our area. The storm lasted until noon Saturday. Needless to say, all roads and streets were impossible for any form of transportation except snowmobiles.

Our plant manager was the first employee that was able to get to our plant late Sunday evening. During inspection of the plant, be found that the 1" plastic sight gauge on one 30,000 gallon upright steel tank had been broken off during the storm, releasing the contents (10-34-0) of the tank. The sight gauge valve had not been turned to the off position and locked after filling the tank earlier in the week. After checking all of the other tanks, he found that this was the only tank that had not been secured.

Action

Our plant is located on the last side of Goodland, Indiana, on the South side of the railroad track and less than 300 feet from a county ditch that drains into the Kankekee River 7 miles North of town. The land that our plant is located on slopes towards the ditch. the ground was frozen with a heavy accumulation of snow, however, it was very evident that some of the material was already in the stream. The plant manager notified me immediately. We were unable to contact any one by phone until Monday morning. However, we dammed the stream with a load of crushed stone and baled straw after breaking the ice with a back-hoe. We also used crushed mill stone to form a dyke between the tank and the ditch, to contain surface run-off. We then pumped what we were able to under the existing conditions.

Monday morning, when phone service was restored I informed the Indiana Stream Pollution Control Board, The E.P.A. Board and the local Conservation Office and the State Board of Health and Safety. I reported what action we had taken and asked for instructions. Because of the severe weather and road conditions, the representative of the Indiana Stream Pollution Control Board was not able to make an inspection until Tuesday. He took several samples of the water in the ditch at various locations where he was able to get to during the 7 mile course to the outlet at the river. He found some evidence of contamination at each stop, however, the level was very low. He observed no dead fish downstream from where the ditch entered into the river.

We had contacted the manufacturer of the product for a chemical analysis of the 10-34-0, which we gave to the inspector, with the name and phone number of the person that he could contact about any question that he may have in regards to the material. The Inspector made two more trips, of a follow-up nature, before completing his report. He authorized us to clean up the dam that we had constructed the following week.

Prevented Procedure

(a) Be sure all tanks have locking valves and locks are in place and are locked when not in use.
(b) Dealer should keep emergency tank repair kit of numerous soft wooden plugs (cone shape) in sizes from ½" diameter at head to 6", epoxy patching compound, or metal screws on hand to plug holes in containers.
(c) Soil dykes around storage area are most economical. Calculate total storage capacity of largest tank and be sure dyked area is large enough to hold contents plus 2" of rainfall.
(d) If tanks are close to buildings, railroad, etc., properly sealed concrete block, or walls may be necessary on one side of confinement area.
(c) Soil type in storage area should be checked. Your local S.C.S. agent can help you if you don't know.
(f) Install drain pipe and valve to drain excess water during rainy periods.
(g) Dealers in local communities should plan "Emergency help each other" storage procedure. Your best ally in this situation is your competition.
(Applause)

MODERATOR WALSTAD: Thank you Mr. Fox for those excellent suggestions.

Our next speaker William Askins is a Co-Worker to me at American Cyamamid. He is currently Supervisor of Environmental Compliance in Environmental Protection Department of American Cyanamid Company. During his eleven year career, in the field of Environmental Engineering, Bill has worked as a consultant on a variety of Environmental Projects for Industry, Municipalities, and Governmental Agencies, and for the last six years has served on the Corporate Environmental Staff of Cyamamid on projects both in the United States and abroad. Bill holds a master of Science Degree in Sanitary Engineering from the University of California in Berkeley and a Bachler of Science Degree in civil engineering from Newark College of Engineering and is the author of several papers dealing with the topic of Advanced Waste Water Treatment. Bill please. (Applause)

Spilled Oil — A Case History

William Askins

The story I'm going to tell you today will probably sound familar to many of you because it deals with a topic that has appeared often in the newspapers in recent times. Some of you may even have been personally involved in a similar mishap and subsequent cleanup effort. Although the story doesn't deal with the fertilizer industry per se, certainly many of you deal with oil as a fuel on a day-to-day basis, and, the lessons learned from a spill experience, much like the one I will relate, have wide application to virtually *any* stored chemical that can be spilled.

To tell the story properly, I'm going to give you some background so that you can more fully appreciate the difficulties we encountered; I'm going to relate the chronology of events; I'm going to describe the cleanup and monitoring efforts; I'm going to show you the system that was installed to contain any possible future spillage; and I'm going to present some principles that are of broad general interest.

The oil spill occurred at a small plant of the American Cyanamid Company. The plant is a manufacturing facility which operates on a three shift, five day per week, 24 hours per day basis. About 200 people are employed at the plant.

The plant is located in an industrial park which is built on fill material between two abandoned coal strip mining operations. The surrounding area contains many old anthracite coal mines, both surface and underground, and is littered with spoil banks, sink holes, water filled pits, and other remnants of the coal mining industry. The region is considered by the state regulatory agency to be environmentally non-sensitive* because of the damage already done by past mining activities and because of the continued pollution caused by large quantities of acid mine drainage.

The plant uses No. 2 fuel oil to fire its boiler, and the oil is stored in an above ground, horizontal, 30,000 gallon tank. The tank rests on concrete saddles*, and the tank bottom is about three feet above grade. The tank was diked with an earth/rock mixture, and the dike was provided with a drain valve.

The tank and its valving, gauges, and peripheral piping were inspected by plant personnel on a once per shift basis. Valves on the tank were checked by hand to insure that they were closed.

With that background in mind, I'll now describe the actual events that occurred just before, during, and after the spill. On the afternoon of Friday, March 10, 1978, the tank, diking, and valves on the tank were checked as usual, and a reading of the gauge on the end of the tank indicated that 62% of the contents remained. Everything appeared to be normal.

At 2:00 a.m. on Saturday, March 11th, a check of the gauge showed a reading, of what appeared to the person checking it, to be between 50% and 60% remaining oil. However, the needle on the gauge has a back end that extends past the center of the gauge and the person read the wrong end of the needle. In reality, the gauge read approximately 3% remaining. This error in reading was later attributed to the person *expecting* a reading of approximately 60%, and in the dark mistaking one end of the needle for the other.

At 2:45 a.m. the same day, the level dropped below the boiler feed line, and the boiler stopped. Operating personnel traced the system from the burner all the way back to the tank, suspecting that water in the oil had frozen and caused a blockage in the lines. However, when the tank area was checked, the last of the oil was heard gurgling out of the tank. On closer inspection it was found that a 1 inch gate valve that was used periodically to drain water and sludge from the bottom of the tank was partly open, and the oil had drained out through the valve.

Plant personnel removed the valve and replaced it. The apparently faulty valve was then checked for flaws, but none were found. It was never conclusively determined how the valve could be open and yet not be detected when it was checked the previous afternoon. It was theorized that water had frozen in the valve body, and the gate could not fully close. later, the ice melted allowing the oil to flow out of the tank.

The plant people estimated that some 18,000 gallons of No. 2 oil were lost, and they thought the oil was captured in the dike. Later, checking the diked area more closely however, (and remember, the spill occurred at night with about two feet of snow on the ground), it was found that some of the oil was outside the dike. The snow in an area of about 100 square feet just north of the tank was stained with oil. A still larger area was uncovered where oil had run under the snow.

A front end loader was brought in to scoop up the snow/oil/ground mixture, and the mixture was put back inside the dike after the drain valve was closed. About 70 tons of sand were brought into the plant site and placed over the area that had been cleared by the front end loader so that more oil could be soaked up. The sand/oil mixture was later disposed of at a state-approved land fill with the state's concurrence. That same day, a Saturday, the plant people called the State Regulatory Agency but could only get an answering service. A verbal accounting of the spill was given to the answering service, and the plant people were told that someone would get back to them on Monday. Incidentally, the state has since changed its system for handling emergency calls because of this event, and a person from the agency can now be reached at anytime.

A representative of the regulatory agency did call back that Monday to review the events that had occurred. The agency representative was satisfied with the way the incident had been handled by the plant, and no further contact was made between the two parties for a two week period. The plant did not do any further cleanup work for that time period.

On Thursday, March 30th, nineteen days after the spill occurred, a regulatory agency representative visited the site, explaining that he had a mistaken impression that the spill had been fully cleaned up. He and the plant people inspected the spill site and the surrounding area, and in checking samples of surface water runoff, found oil in the samples. It was clear then that the actions taken by the plant, although proper in the agency's opinion, allowed only a portion of the spilled oil to be recovered, the task now was to define the cause and extent of the oil's migration and to recover as much of the oil as possible. The agency representative pointed out that although the area has low environmental sensitivity, the large size of the spill warranted further action.

It was at this point that corporate environmental personnel became involved in the situation. A more thorough inspection was made of the plant and the surrounding area, and it was found that some of the oil had travelled approximately a quarter of a mile to an abandoned coal stripping pit. This was the furthest point from the spill site at which oil was to be detected

It was obvious from the inspection that more information about the area was needed, and further meetings were held with the regulatory agency to bring them up-to-date and to gather information on the soils and geologic formations underlying the plant and the surrounding area. A plan of action was then developed by the plant and approved by the agency. The plan consisted of three phases, all of which were subsequently implemented.

Phase 1 consisted of the construction of an interceptor trench on the plant property and a collection pond downstream from the trench. A boom was placed across the collection pond exit, and the trench was partially lined with plastic. The coal stripping pit was thought to be a good final collection pond because it appeared to hold water fairly well. All parts of the oil intercept system were to be checked periodically, and collected oil was to be removed for reclamation.

Phase 2 consisted of drilling of monitoring wells in areas down gradient of the spill site. The wells were to be sampled periodically for oil contamination, and more wells were to be installed if the ground water contamination was extensive.

Phase 3 consisted of the writing of a spill control plan and installation of positive spill control features. Well, the plan was instituted, but not all of the elements worked out as expected. The interceptor trench/collection pond combination collected very little oil. The coal stripping pit that was thought to be fairly water tight, was not, and the day that the plant had targeted for cleanup of oil in the pit, the pit was completely empty. Leaves that lined the pit, however, *were* soaked with oil, and the leaves and oil were removed from the pit. Subsequent soil sampling in the bottom of the pit revealed that the oil had not penetrated past the leaf covering.

The well drilling did not proceed quite as intended either. The driller discovered that the plant was built on fill material that was placed over bedrock, and the rock was very close to the surface in most spots. There was considerable discussion between the State's representative and the corporate representative, both of whom have geological backgrounds, over how and where to drill the wells. It was finally decided that the wells should go somewhat into the rock, but not through it. There was fear that drilling through the rock might allow oil to migrate to an aquifer below the rock stratum and contaminate that drinking water source.

Three monitoring wells were finally drilled on April 20 and 21. The first hole is 3.5 feet to bedrock and 8 feet into the rock. The second hole is only 2 feet to bedrock and 4.5 feet into the rock. The third hole is 4.5 feet to the bedrock plus 5.0 feet into the rock. In addition, many hand augered holes were dug, but only the hole directly under the diked area showed any significant quantity of oil.

The three drilled wells were monitored for some time and, in fact, wells #1 and #3 continue to be checked. Well #2 has been removed from service. Varying quantities of oil, depending on rainfall, continue to be found in well #1, and none is found in well #3. It has been estimated by the plant personnel that only a very small portion of the spilled oil, aside from that recovered and disposed of in the first few days after the spill, has been accounted for.

Where, then, did the oil go? Remember, I mentioned that this was old coal mining country and the area has many remains of that industry. It has been theorized, after close examination of all the facts gathered by the plant, that the oil traveled through the relatively pervious dike around the tank and the earth beneath the tank and that it followed down-gradient along the bedrock formation which is close to the surface. The oil which remained beneath the ground probably remains pooled in depressions in the rock, and the oil which emerged on the surface apparently has degraded.

Luckily, none of the drinking water wells in the area were affected by the spill (continuing analyses of the water from these wells has proven this point). Also luckily, the area is environmentally non-sensitive — the destruction of the environment and the continuing effects of coal mining in the region minimized the impact that was caused by the spill.

Nevertheless, more damage *could* have been done, and the plant, motivated by this experience and the lessons learned during the cleanup, took steps to prevent a recurrence.

It was decided to leave the tank in place and to build positive spill containment around the tank. A concrete box was built under and around the tank with a capacity large enough to hold the entire tank's contents plus an extra allowance for rainwater. The dike-drain valve is chained and locked closed as are the drain valves on the tank itself. Lighting has been installed at the tank location. A ramp has been provided for the delivery trucks, and the filling area is concrete with a slope into the diked area — any leakage from the fill hose or truck connection would flow into the diked area. A watchman's station has been provided so that a permanent record is obtained of tank inspection frequency, and an administrative procedure has been instituted for checking the tank.

A sump was built inside the dike to allow recovery of spilled oil. The plant personnel are fairly sure that such an event will not occur again.

It's obvious from what I have described to you that the plant people acted in an expeditious and forthright manner and that the regulatory agency endorsed those actions. Those factors plus some lucky circumstances prevented any significant deleterious effects.

I'd like to leave you with some thoughts — items that have application across the board in the storage and handling of chemicals.

1. Administrative controls, as well as positive engineering controls, such as impervious containment, are required to insure that if and when a spill does occur, the spilled material will be contained. And that's not just applicable to oil — it could be almost any liquid chemical. *And* there's a side benefit — the oil, or other substance, may be recoverable.
2. A spill control plan should be written for virtually any sized facility, even if the law doesn't require it. Responsibilities of *all* plant personnel should be included, and the plan should be reviewed with plant personnel from time to time. This plan should include reporting procedures, both inside and outside the plant.
3. Credibility with the regulatory agencies is *very* important. In the case I cited, the plant had to pay a fine for the spill, but it was minimal because the regulatory agency recognized the cooperative attitude and the efforts expended by the plant personnel. In other words, work *with* the agency.
4. Don't pre-judge readings on gauges and charts. Take the readings first, then see what they mean.
5. Have people with a given background in your plant talk to regulatory agency people of similar background. This philosophy proved to be of significant value in planning efforts between the two parties in the example cited.

6. Quick action, such as that expended by the people in my example, is needed in responding to a spill situation to minimize impacts.

Just one final note — spill cleanup is costly. It has been estimated by the plant that the spill cleanup efforts cost approximately $20,000. This figure does not include the value of the lost oil, nor the value of lost production because the boiler was shut down. The number could very well have been much higher. At another company location, a chemical spill occurred at almost the same time as the one I just described. The total bill for cleanup including construction of an extensive spill control system was nearly one million dollars! So my message is clear — spend your money *now* in a well engineered, well thought out spill control system so that damage from the spill never occurs, and the subsequent cleanup efforts, exposure to penalties under the law, and other headaches caused by a spill also never occur.

Thank you. (Applause)

MODERATOR WALSTAD: Thank you, Bill, for a very interesting talk and a helpful one.

I believe most of you know our next speaker — he's with the Fertilizer Institute — Jim Massie. He has been involved with safety programs and material for The Fertilizer Institute, and, recently, the middle of this month, he has been advanced to a different position. So, he said right now, he is wearing two hats and is kept very busy. He is leaving his job in the safety and materials program and is going to work in the transportation regulation area for The Fertilizer Institute. Of course, he lives here, in Fairfax, Virginia. He originally came from Missouri, yet he went to Oklahoma State to get his Bachelors Degree in mechanical engineering. I now turn the platform over to Jim Massie. (Applause)

Crestview, Florida Train Derailment

James D. Massie

I. *Introduction*

The U.S. fertilizer industry produces, imports and transports tremendous amounts of material. We manufacture an estimated 56 million tons and transport 100 million tons of product. We provide the American farmer 50 million tons of material and the U.S. economy $1.28 billion in export trade.

Several of the key products either utilized directly as fertilizer or utilized to manufacture fertilizers are classified as hazardous materials or hazardous substances. Five key products classified as both hazardous materials and hazardous substances are:

Product	Production ton/yr.*	Imports ton/yr.*	Total ton/yr.
Anhydrous Ammonia	17,005	1,516	18,521
Ammonium Nitrate	7,325	300	7,625
Phosphoric Acid (P_2O_5)	9,554	56	9,610
Sulfuric Acid	39,825	300	40,125
Nitric Acid	8,048	8	8,056

* thousand short tons

The distinction between a hazardous material and a hazardous substance is not definitive. A hazardous material is the Department of Transportation's (DOT) nomenclature for chemicals that pose a risk if spilled when transported. The hazardous substance is a chemical classified by the Environmental Protection Agency (EPA) as posing a risk to the environment or public if discharged.

The Department of Transportation regulates the transport of hazardous materials. Basically, the DOT imposes rules governing the vehicle and operator. However, the movement of a hazardous material can require additional vehicle markings, shipping papers and vehicle safeguards by the DOT. Violation of the rules for transporting hazardous materials can result in fines up to $10,000 per violation.

In the event of an accident involving a hazardous material present transportation rules require the carrier (rail, truck, etc.) to notify DOT of any incident involving a hazardous material resulting in:

1. fatality
2. hospitalization
3. damages exceeding $5,000

Incidents should be reported to DOT at (202) 426-1830.

Apparently these rules will be modified shortly as a result of a rulemaking procedure completed April 23, 1979. When the rules are promulgated as proposed by DOT & EPA the spillage of a hazardous substance (to be marked on the shipping papers) and it is being transported in a quantity greater than the newly defined reportable quantity requires immediate notification of the U.S. Coast Guard, National Response Center, (800/424-8802). Please note that these new reporting proposals are in addition to the present requirements and that they have yet to be promulgated.

Material	Reportable Quantity
Anhydrous Ammonia	100 lbs.
Nitric Acid	1,000 lbs.
Phosphoric Acid	5,000 lbs.
Sulfuric Acid	1,000 lbs.

The Environmental Protection Agency's jurisdiction over the spillage of a hazardous substance results when a spillage or discharge event threatens the public and/or the environment. EPA's concern and resultant interest is the protection of the environment and the public. EPA can be and often is involved in transportation accidents involving the spillage of hazardous substances. This involvement normally is due to the potential danger posed to surface and underground waters.

If you discharge a product classified as a hazardous substance from your facility in a quantity equal to or greater than the reportable quantity you must report the spill within 24 hours to EPA. Failure to report the spillage to EPA is a criminal offense carring a potential fine of $10,00 and/or one year imprisonment.

II. Chemtrec

Because of regulation and the tremendous growth in the chemical industry, CHEMTREC, an emergency assistance group, was formed within the confines of the Chemical Manufacturing Association (CMA), formerly MCA. CHEMTREC, specifically is a 24-hour information center. If you spill a hazardous material CHEMTREC'S operators will provide you "basic" product safety information and will attempt to provide product experts if required.

CHEMTREC has been in operation for approximately ten years and the service of providing on site emergency forces product information has proved valuable. However, in no way should you confuse the telephone information provided by CHEMTREC with on site assistance. CHEMTREC provides only data collection and dissemination, it does not provide technical people at the site of a spill.

Our experience with CHEMTREC and transportation accidents have surfaced two areas requiring additional effort: First, time is the most significant factor affecting proper emergency response. Second, technical assistance at the spill site is essential.

CMA recognizes that "time" is a major factor affecting the response and the corresponding corrective action implemented. Thus, CMA is undertaking a modernization of CHEMTREC to provide faster data input, collection and dissemination. The new system will be implemented in phases, and when finally operative, CHEMTREC will include:

1. Hard copy data link with carriers, chemical companies and emergency forces.
2. Conference call capability to link the on site forces with product experts.
3. Data link with the carriers to permit rapid accident reporting and transportation information.

Many instances involving the spillage of hazardous material do not need on site technical personnel, however, for the incidents which require such expertise, the on site technical assistance is required immediately.

The requirement for prompt on site personnel poses a special problem to the fertilizer industry due to our diversified marketing and manufacturing structure. TFI's Board of Directors recognizes a need for industry expertise at the scene of an accident. To alleviate the problem the Board has instigated work which would provide one fertilzer company a mechanism to utilize personnel from another company if an accident required on site assistance and the company involved in the accident could not realistically provide the necessary immediate technical help.

The work on this project should be completed shortly. If there is interest in such a program, implementation would start in early 1980.

III. Ammonia Spill Study

The fertilizer industry is fortunate that several actions have been initiated by The Fertilizer Institute's Board of Directors. Among the most noteworthy programs is the Ammonia Spill Study. This Study will involve the spilling of approximately 4-ton and 80-ton quantities of anhydrous ammonia on land and water. Data collected during the tests will be utilized to determine the behavior of anhydrous ammonia when spilled. This information in turn can and will be utilized to determine the siting of new ammonia plants and storage tanks. The Study will soon enter the test phase and if the present schedule can be adhered to, the Study's final report will be available in the third quarter of 1980.

The ammonia Spill Study is divided into three parts: Phase I is the experimental design of the test; Phase II is the purchase, calibration and installation of the equipment and Phase III is the actual spillage of ammoni and report preparation. Phase I was completed in December of 1978. Phase II is presently underway and will be completed prior to mid November. Phase III will begin in 1980.

In Phase III, the first test will be a spill of 1500-gallons of refrigerated anhydrous ammonia on water. Weather permitting, this is scheduled prior to December 15, 1979. Upon completion of the 1st test, there will be a 3-4 week period for data analysis.

The first 80-ton spill will be followed by a similar 3-4 week break for data analysis to insure accurate and appropriate information is being recorded.

Crestview Rail Derailment.

For today's program I have been asked to additionally review the April 8, 1979 Crestview, Fl. derailment in which 12 cars of anhydrous ammonia were involved.

On April 8, 1979 29 cars of a 114 car Louisville and Nashville Railroad Company, train derailed while crossing the Yellow River in the panhandle of Florida (between Milligan and Crestview, Fl.). Twelve of the 29 derailed cars contained anhydrous ammonia and 26 of the 29 contained hazardous materials. The remaining hazardous material cars contained acetone, methyl alcohol chlorine and carbolic acid. Upon derailment one ammonia tank car ruptured, apparently from the damage inflicted to the structure during the course of the accident. A fire began immediately after the derailment and twelve cars were either burned or consumed by the fire. The resulting fire apparently caused a second car of anhydrous ammonia to rupture about 20 minutes after the derailment. The incident forced 4,500 residents to evacuate their homes, injured 14 people and resulted in $1.25 million in property damage.

This type of derailment, requiring evacuation of residents and involving numerous hazardous materials, is not uncommon. However, the quantity of hazardous material and the fire presented unusual technical and logistic problems. As a result decision making was severely slowed.

Shortly after the incident occurred, local, state and federal officials were joined by product experts and railroad representatives. All totaled there were more than 10 groups present to provide clean-up, evacuation and environment protection advice. the sheer mass of technical expertise available to the harried coordinating officials caused utter confusion and resulted in technically incorrect news releases, public over reaction concerning to the chemicals involved and unnecessary delays with the clean-up of the accident.

In review of the Crestview accident several points become quite clear regarding major hazardous material accidents:

1. There is a tremendous need for coordination of the on-scene emergency and clean-up forces.
2. Information released to the public must be prompt and correct.
3. The response must balance both economic, social and environmental concerns.
4. Prompt positive action must be taken by the on site forces.

Crestview was a major train derailment, and unfortunately the fertilizer industry was significantly involved. The industry's poor public image resulting from this incident will soon vanish because we were lucky, no one was fatally injured. tomorrow will hold, without a doubt, another Crestview. Unless we recognize the need to take action now, the problems present at Crestview will surface again. Next time we may not be as fortunate.

Recommendations

There have been several train derailments of fertilizers classified as hazardous materials. I believe that the number of these incidents will not be greatly reduced in the future as our farmers continually demand greater amounts of fertilizer in ever shorter periods of time. It behooves every fertilizer manufacturer to assess the products he handles. If you transport or store hazardous materials the spillage of this material requires prompt and proper treatment. Do not neglect minor leaks and spills. Incidents of this nature can result in fines that would affect even the most profitable companies.

In closing, I recommend that you analyze the potential of the regulations mentioned herein. Additionally, I advise you to determine how your company will respond if you are involved in the spillage of a hazardous material. (Applause)

MODERATOR WALSTAD: Thank you, Jim. (Applause)

Tom Howe is in the enviable position of being our last speaker on the program today. Many of you know him. He is on the Board of Directors of The Fertilizer Industry Round Table. He has been at these meetings a number of years. He's the third generation in a family-owned business in Minneapolis, Minnesota — Howe, Inc. He is a graduate of Augsburg College and has been involved in the programs of this group before. Several years ago, he gave a paper on "Use of Super Phosphoric Acid in a Granulation Plant". I will now ask him to tell us his experiences with the fire in his plant. Tom. (Applause)

Agricultural Chemical Fire In A Fertilizer Plant

Tom Howe

The purpose of this paper is to tell you of our experiences relating to a fire that occurred at Howe, Inc. In doing this I hope to create an awareness of the possible hazards and identify their implications to you as a fertilizer plant operator. Following my presentation, I will answer any questions you may have.

Introduction

Howe, Inc., is a fertilizer manufacturer and agricultural chemical distributor. We have an ammoniation-granulation plant, blend plant and warehouse facilities. My grandfather built the original plant in Brooklyn Center, Minnesota, in 1946, and it was a welcome addition to the area's agricultural community. This location was convenient because it is on the railroad, near the Mississippi River, and in the area of the rural customers who have traditionally relied on Howe, Inc., as a supplier.

To accommodate returning servicemen after World War II, Brooklyn Center traded its rural land for urban development and became a residential community. This change in the surrounding neighbors isolated Howe, Inc., and created problems because of the inherent differences in land use. It also magnified the potential hazards of a fertilizer plant.

Fire

On a very cold January 6, 1979, a fire started in the southeast corner of a metal chemical warehouse, shop and vehicle garage. The fire spread fast and there was heavy smoke and flame pouring out the front door when the first fire truck arrived. Mutual Aid was called immediately. The other local communities supported the Brooklyn Center Fire Department with their equipment and men.

The spectacle of a city fire with black clouds of smoke gave opportunity for the Media, as well as curious neighbors, to view and talk about our fire. Large balls of fire shot into the air as the gas tanks on the trucks erupted. The chemical containers could be heard popping as the heat built up.

Fire fighters applied approximately 300,000-600,000 gallons of water to the blaze. This water, now contaminated with pesticides—primarily atrazine and Lasso—ran across the yard into a dry creek bed adjacent to the plant.

In the case of a potential pesticide emergency, a response team made up of the State Agencies is notified, which trips a series of phone calls notifying the proper people. Among those people notified was Chemtrec— a National organization that provides assistance for such situations.

Government Involvement Crew

Shortly after the fire representatives from various governmental agencies began calling on us. Each agency had various departments and complement of staff. As the days passed, the number of involved and overlapping government agencies grew.

The main agencies were the Department of Agricultural, the Pollution Control Agency, and the Health Department.

Other interested organizations and agencies were EPA, OSHA, product suppliers, City of Minneapolis, City of Brooklyn Center, Soo Line Railroad, Hennepin County, Department of Natural Resources, Coast Guard, U.S. Treasury Department, because of the explosives on site, University of Minnesota (various departments), State Executive Council, News Media, and others.

The number of people and agencies involved confused the situation. In the words of one official who was quoted in the paper, "What seemed right one day wasn't right the next."

There was a "stop sale" placed on the chemicals in the fire and on the fertilizer that was in other buildings which were not affected by the fire. This was removed after an appeal. Since the fire we have had two OSHA inspections, one involving the State Health Department which tested our employees' blood for chemical poisoning. We were ordered not to drive trucks across the yard where the water had frozen so the tires wouldn't spread the chemical to other areas. An embargo was placed on all incoming railroad traffic to the plant. This was also removed in a short period of time, and a 24-hour police watch was placed around the plant.

Cleanup and Disposal Created Controversy

The key problem was disposal. Under State definition the soil, snow, and ice that were contaminated with the fire water, as well as the building debris laced with spilled chemicals, were considered hazardous waste materials. There is no hazardous waste disposal site in Minnesota. Disposal options and their costs were like two people on a teeter-totter. Risk goes down, cost goes up.

The three State Agencies assumed the most critical attitude toward the chemical-laden debris. Many statements made by officials were speculation and overreaction. The Media carried these statements and developed news stories that seemed designed to create fear and apprehension.

These scare tactics worked and the State was a victim of its own overreaction and speculation. Many disposal attempts were blocked by alarmed people and harum-scarum public hearings. Each disposal attempt increased the number of local governments and agencies involved and further confused the issue.

The last of the material was finally moved the latter part of March, three months after the fire. The Health Department is still concerned about the ground water. Three six-inch wells have been installed and are continuing to pump the ground water into sanitary sewer 24 hours a day.

A direct aftereffect of the fire was the dying of 17 neighboring lawns which had been contaminated with atrazine. This occurred either from the fumes during the fire, and became apparent in the spring as the grass became active, or by delayed and incomplete cleanup conducted by the State, which allowed contaminated soil to blow across the road to adjacent yards.

Governmental Agencies Reviewed Problems

This fire was the spark of a procedure review between our State Agencies. It also gave rise to many seminars conducted on pesticide and fertilizer fires. This open discussion brought out a number of problems relating to the handling of a pesticide fire. Three of the most important are discussed.

1. *The first problem* was the use of great quantities of water without providing a means of containment. The water that was used to stop the fire spread pesticides and fertilizer off the asphalted area into a creek bed. This created the bulk of the problem with relation to ground water contamination and cleanup.

Solution: The appraoch should have had an emphasis on pollution avoidance. Fire-fighting techniques are far advanced from simply pouring water on top of a fire. Preplanning is extremely important. Each situation is different and each fire is unique. The National Fire Academy is conducting seminars on Pesticide Fires and Spill Control. After our fire both the Minnesota Plant Food and Chemical Association and the National Agricultural Chemical Association have published Preplanning Guidelines for Agricultural Pesticide and Fertilizer Facilities. (Howe, Inc., happens to be on the cover of the N.A.C.A. booklet). The preplan should include the company, the insurance company, and the responding emergency department.

2. *The second problem* was the lack of coordination between State Agencies.

Each assorted agency was making its own statements without responsibility. Officials made announcements that were intended to cause alarm and frustration. (Examples: "This may cause death" — "It will wipe out the Mississippi River" — "Children can't play in snow" — Hazardous Signs Placed Around the Plant — 24 hr. Police Patrol.) The intent was to scare citizens and create fear.

The solution would be to have one person as the spokesperson, issuing all public statements. That individual's statements should be moderate and factual, which would have been better guidance for the public.

3. *The third problem* was that the State did not pursue the proper method of disposal because it was a politically sensitive issue.

Solution: A predetermined lead agency should be appointed and given authority. Action should be prompt and firm. Immediate action is necessary before the Media kills or delays the action. This agency also has to have the proper funding to implement the proper action.

Aftermath Implications

Along with State Government dealing with the disposal of our fire remains, we had the local municipality dealing with Howe, Inc. Their purpose was the prevention of this type of accident from reoccurring.

Eight Thousand Dollars was authorized to conduct a study of Howe, Inc., and report what hazards are present by having a fertilizer plant and chemical distributor within the City of Brooklyn Center. this study was done by Eugene A. Hickok & Associates, a professional engineering consultant.

This report combined all fertilizer products and agricultural chemicals and dealt with them as similar products. This improper classification of chemicals by lumping them in one broad group made the report inaccurate. It attempted to show the hazards of fertilizer by identifying its decomposition. The purpose was to show the extreme hazardous reaction that might take place with these materials. Ammonium sulphate, for example, is characterized in the Hickok Report as "emitting toxic fumes of sulfur oxide upon decomposition." In actuality, ammonium sulphate is used as a fire retardant. Only after total release of ammonia resulting in sulfuric acid formation and heating to decomposition at 1500°F could oxides of sulfur be released. Ammonium sulfate is used as a fire retardant on, for example, cellulose insulation materials.

The Report was difficult to deal with. Before receiving the Report the City and the Press declared the Hickok Report as an expert evaluation of our industry. The city had authorized the money and the Report painted the picture of many potentially hazardous situations. This led to development of recommendations for regulating all chemical storage facilities. Their recommendations called for a clay lining to be put beneath the Howe plant to protect the ground water, clay-lined retaining basin to collect all 500,000 gallons of water run off in the event another fire would occur, and a ground water monitoring system.

Other areas given attention were:

1. Diking of above-ground liquid storage.
2. Curbing and drainage patterns to control direction of runoff.
3. Sulfuric and phosphoric acid fire and emergency plans.
4. Nitrogen solution storage and potential hazards
5. The use of and care of explosives in loosening caked fertilizer materials.
6. Ammonium nitrate handling and storage.
7. Agricultural chemical storage with attention on toxicity and flammability.
8. The possibility that in the presence of a fire the mixture of various fertilizer materials and agricultural chemicals may present a new and more potentially hazardous situation.

Lessons Learned

The long lasting effects of a dramatic fire go well beyond the actual fire. The lessons learned from any accident are costly. Basic points that can be stated with regard to emergency situations include the following:

1. Read and review your insurance policies. Find out what is actually insured and what you are self insuring. Remember that debris removal, cleanup and environmental considerations can be more expensive than the actual physical damage. Diking can reduce the cost

of digging up a foot or so of soil, cleaning up the chemical debris, and disposing of the contaminated materials. With a little planning a manager or owner can create his own insurance policy.

2. Update your emergency information and accident preplans. They get old very quickly. Have technical data information sheets available for each product handled. The potential of ground water contamination is a major concern. To save time find out the depth of the water table, direction of ground-water flow and locations of nearby wells. In an emergency this is important when digging an area for diking. One of the best methods of minimizing a spill is to have absorbent materials available at the plant to contain the spread, such as ground corncobs, clay or even soil. When formulating preplans, know what to anticipate. The real key is prevention.

3. Educate your employees, community, and city as to who you are and how essential your business is. No matter how safe the chemicals you handle might be, after an emergency situation they are put into a single group— Hazardous Waste. Public relations and goodwill within the community and city are necessary to avoid overreaction.

Inform your employees about what they are handling and how to act in emergencies. Product education programs for all employees who handle chemicals can prevent turning a simple spill into a much more costly and dangerous accident than necessary. Have protective gear available for employees and insist that they wear it. You can make people conscious of the need to curtail spills through fire prevention information, establishment of safety procedures and observation of good driving habits, but you can't prevent them entirely. Therefore, you must also be prepared to establish measures to minimize the consequences if and when a spill occurs.

A written procedure is necessary. If a procedure is not readily available as a reference, employees will be forced to cope with a situation with which they may not be familiar. Not all people think clearly in an emergency, but if something is written down, it should help keep confusion to a minimum. It provides a margin of safety that assumes an accident will be handled correctly.

4. In an emergency situation understand that you will be on your own. The State tends to do everything it can to make an example of the situation. Everyone is overconscious of the implications of becoming involved. People are careful that anything that is said might imply liability.

Summary

The implication of our fire will be around for many years. There are still many open-ended problems that remain.

1. We have been denied rebuilding our chemical warehouse by the local City council—this is in the Courts.
2. Brooklyn Center has a new ordinance regulating storage of pesticides and storage facilities.
3. Brooklyn Center has discontinued permits issued for explosives used to loosen certain fertilizer materials.
4. Brooklyn Center has an ordinance designed to phase out any nuisance aspects of our fertilizer plant. This is in the Courts.
5. Lawsuit: State of Minnesota v. Howe, Inc., to recover cleanup costs.
6. Lawsuit: Area neighbors v. Howe, Inc., relating to damaged lawns.
7. Lawsuit: Howe, Inc., v. Insurance Co., to determine amount of coverage.

I think it is a fair statement to say our standard of living is directly tied to the responsible use of chemicals. The greater presence of chemicals means there will be occasional accidents in the form of spills and fires. We as an industry either collectively or individually must look at these possibilities and deal with them. Given the opportunity government will deal with them for you.

From our fire I have learned the fire is not out when the last flame is gone. It is not over until the last bureaucrat has left. (Applause)

MODERATOR WALSTAD: Thank you for your thorough report. (Applause)

I will ask our Speakers covering the 4 phase discussion report to come to the dais. Messrs. Richard Fox — 10-34-0 Spill, William Askins — Spilled Oil, James D. Massey — Train Derailment and Tom Howe — Fire in Fertilizer Plant.

Our thanks to all of you. We will now have questions.

QUESTION—FROM AUDIENCE: When you store ammonium nitrate, the temperature can rise spontaneously in that pile. Do you measure that temperature.

ANSWER—TOM HOWE:We do not measure the temperature. It is stored in a well-ventilated building, stored separately from organic chemicals, but we do not measure the temperature in the pile. Also, we do not manufacture ammonium nitrate. We store it and use it in a blend operation.

QUESTION—LIAM O'CLEIRIGH: My name is Liam O'Cleirigh from Nitrigen Eireann Teoranta in Ireland. I am particularly interested in the ammonia spill, because it is a coincidence that, for the first time last Friday, ammonia was moved by rail in Ireland by our company. The spill couldn't have come at a worse time for us, because, not only do we have the advantage of learning from others, but out environmental lobbyists have the advantage of learning from yours. I have a number of questions I would like to address to Mr. Massie. We don't have any regulations, as such, being the only major chemical company in the country. We are faced with the writing of the regulations ourselves, together with the transport company. We are going to limit the transport trains to ammonia. That is, they will be dedicated to anhydrous ammonia service, and we move about 500 tons a day. The question of head shields has been brought up by some of our environmentalists. I cannot, quite honestly, see how head shields would have prevented the accident in Florida. I can see how buffer overides might prevent, in the event of a jack-knifing or a piggy-backing of the rail cars, some damage. Is there any advantage to be gotten from head shields?

I had a chance to talk to both government experts, as well as industry experts, and I believe that they all agree that the basic reason for head shields was to allow the couplers not to rupture the heads of the tank cars. They work to a 35-40% degree. They feel it is effective to some extent; however, they feel it is rather redundant to have both head shields as well as what we call in the United States shield couplers, since they both do approximately the same thing.

QUESTION— LIAM O'CLEIRICH: What is the inspection frequency on rail cars, and what method is used?

ANSWER— JIM MASSIE: There is as frequency inspection in the United States. I cnnot give you the exact dates, although it is both a visual inspection as well as hydrostatic vessel inspection. I believe the visual is a requirement. It is at least within every two years, and the hydrostatic testing is within every five years, maybe a little more frequently than that.

QUESTION— LIAM O'CLEIRIGH: Do you have any idea of the number of incidents per ton mined of ammonia moved in rail transportation?

ANSWER— JIM MASSIE: No, but I could get that for you. It is relatively very low in comparison. We move a tremendous amount of tonnage by rail in the United States.

QUESTION FROM THE AUDIENCE: Mr. Howe, do you know how the fire started?

TOM HOWE— ANSWER: We have had many insurance inspectors, as-well as state fire marshalls and the local fire people, out, and the cause has not been pinpointed specifically. We do know the area it started in. We had two employees in the building at the time of the fire. It was in a location, the southeast corner, where we had a gas space heater. There was an electric welder that one of the employees was working with. The guess would be it was started from one of those two devices.

QUESTION— PAUL BRZUSZKIEWICZ: This is for Mr. Massie. You failed to mention in your dfissertation of the accident in Florida any reference to the L & N Railroad. This was somewhat publicized in the press as being the accident-prone railroad of the United States. Could you elaborate on this point?

ANSWER— JIM MASSIE: Well, first of all, my lawyers cautioned me not to draw any libel or slander while I was over here today. Second of all, I believe the L & N, to some extent, has gotten a bad rap. Agreed, there are some questions about the way they managed the company and handled their own actual maintenance of the railroad themselves; however, this particular piece of track, itself, was considered by the track safety specialists to be one of the best pieces of track on the L & N railroad in the United States— ranked in the quality of some of the better railroads in the United States as far as being continuously well-tracked rail, new ballasts, relatively new ties and new spikes, had just come off F.R.A. hazardous material restriction, and had just passed a series of strenous tests. So, I believe that that's not the key cause of the accident. There were a series of other numerous events that surround the accident. I know that I will end up in court if I made any projections on why that occurred. The N.T.S.P. report should be out shortly, though. We will allow them to draw those conclusions.

QUESTION— ALAN ANDREWS: Mr. Massie, what kind of exposure is a producing company opening themself up to when they do provide people technical assistance at an accident?

ANSWER— JIM MASSIE: It actually depends on the mode in which you provide assistance. I had the chance to visit with legal counsel to some extent. If you come in and act like the expert and plan on telling the emergency forces how they should respond, you assume all the responsibility of any of the events that may occur thereafter; however, if you come on the site, indicate your affiliation with the chemicals involved or your technical knowledge of the product involved, indicate to the fire department you are willing to assist in any nature, I find that all of our chemical companies that have been involved and had done it in this nature, bearing no liability, basically fall within what a lot of people consider the "good Samaritan" clause. I caution you not to present yourself as the expert and open yourself up to assuming all liability. Anyone, in this instance, would love to shovel the liability from himself over to the next man who comes along.

DAN WALSTAD: That's a very good question. Our lawyers in our company have discussed this with us a number of times. Mr. Massie's statement is exactly what they have told us. Under a "good Samaritan" law, you can assist, but don't try to transfer the liability from the other person to yourself. I think I will thurn this meeting now back over to Walter Sackett, who has a few words before we close this session.

WALTER SACKETT: Thank you, Dan. Well, that closes proceedings for this afternoon's meetings. Thank you, gentlemen. (Applause)

See you all at the Cocktail party at 6:00 p.m. Hope you can all attend to enjoy an excellent social gathering to help you relax. Thank you again.

Thursday, November 1, 1979

Final Session
Moderators:
Frank C. Nielsson

Al Malone
Business Meeting

CHAIRMAN NIELSSON: On the final morning, of the last day, we have "Our Little Business Meeting." It gives us a chance to shoot off our mouths and gripe about things if you do not like the way they have been going. Also if you like the way things are going, we will appreciate your saying so.

To get going here we always have our Secretary-Treasurer, Paul J. Processor, Jr. give his Financial Report and The State Of The Union. Paul please. (Applause)

Secretary-Treasurer Report

Paul J. Prosser, Jr.

Good Morning Ladies and Gentlemen. That is what they do in my church. I will read the Financial Report.

Financial Statement

October 26, 1978 to October 27, 1979

CASH BALANCE — October 25, 1978		$ 9,684.10
Income October 26, 1978 - October 27, 1979		
Registration Fees — 1978 Meeting	$12,988.44	
Sale of Proceedings	1,451.81	
Transfer from Cocktail Party Fund	188.55	
Total Receipts October 26, 1978 — October 27, 1979		$14,628.80
Total Funds Available October 26, 1978 — October 27, 1979		$24,312.90
Disbursements October 26, 1978 — October 27, 1979		
1978 Meeting Expenses	$ 1,127.20	
1978 Proceedings Including Printing, Postage, etc.	9,882.84	
Miscellaneous Expenses Including Postage, Stationery, etc.	425.99	
Membership Letters, Including Postage	1,061.37	
Directors Meetings	938.77	
1979 Meeting — Preliminary Expenses	418.95	
Total Disbursements October 26, 1978 — October 27, 1979		$13,855.12
CASH BALANCE — October 27, 1979		$10,457.78
Less Reserve for Cocktail Party Fund		842.01
Total Cash Available October 27, 1979		$9,615.77

Respectfully submitted,

PAUL J. PROSSER, JR.
Secretary-Treasurer

That's my report. A few comments. You might note that the expenses increased just about as inflation takes us. I would expect that, next year, we will have an increased expense for the Proceedings, because I have the impression that this meeting is running a little windier than others. We are going to have bigger book. Also, would have the usual increase.

At this count, for those who had bets of money on the attendance, we have registered approximately 350 people, including a few who pre-registered but did not get here. I believe that that is probably an increase of 7 or 8% above 1978. I hope that we will be able to continue that kind of registration, but I believe, as a forewarning, that I am going to recommend to the Board that we increase next year's registration fee from $40 to $50. That's a good round number. When you register next year, bring even $50 bills, so we don't have to make change. Thank you very much. (Applause)

CHAIRMAN NIELSSON: Are there additions or corrections? If not they stand as read. Paul, have you an even $10,000 that you can put into a 13% six month money market certificate? Or will you get in trouble with the I.R.S.?

PAUL PROSSER, JR.: We probably do but I have a great hesitancy to put my Social Security number on that.

CHAIRMAN NIELSSON: Okay. Thank you Paul. (Applause)

At this time Wayne King, who is head of our Nominating Committee has a few things to say. Wayne, please. (Applause)

Nominating Committee Report

Wayne W. King, Chairman

Thank you Slugger. I hope everyone can hear me. We have a problem. We have been limited to 50 people on our Board of Directors. We did everything that I think we could to redistribute our Board geographically. We have two names to add to our Board of Directors. If the Gentlemen are here I hope they will stand up—

John L. Medbery — I.M.C. Corp
Robert E. Ferdon — Stedman Foundry & Machine Corp.

I would like to place these two Gentlemen in nomination to our Board of Directors and then come back to several deletions.

CHAIRMAN NEILSSON: Do I hear a second? Yes, several Aye's. No opposing. Motion carried. (Applause)

WAYNE KING: The deletions and letters of resignation from our Board are—

Charles M. Grau, Senior V.P., Agrico Chemical Co.
Allen Jackson, President, J & H Equipment Co.

Charles Grau has been transferred to Agrico International and Allen Jackson has taken on other responsibilities and both have resigned voluntarily. We thank you Charles and Allen for your time and many helpful suggestions you have given to our Round Table. Please attend our meetings whenever you can. (Applause)

We also have one switch. William W. Threadgill, Group Vice President, Farmland Industries, Inc., is now with Occidental Chemical, Director of Marketing. I do not think we need a motion on this. He will remain a Director on our Board. I am always glad to be here. (Applause)

CHAIRMAN NIELSSON: The next thing is "where we meet next year and the year after". Tom Athey, who we are glad to see here feeling good and healthy, after a pretty bad operation, will tell us where we are going to meet next year. Tom please. (Applause)

Meeting Place and Dates Committee

Tom Athey, Chairman

Hi! Everyone. Glad to be here. (Applause)

It was agreed by our Board of Directors, several years ago, that we would meet on the odd years in Washington and on the even years we will go to "other places". Arrangements have been made with the Biltmore Hotel in Atlanta, Georgia, for our 30th Annual Meeting, to be held Tuesday, Wednesday and Thursday, October 28, 29 and 30th, 1980. None of the details have been worked out because I have been under the weather for a while. All of the details will be worked out before the next Board Meeting and I will have a complete report by then. The Hotel is firm. The dates are firm. We will see you all next year in Atlanta. (Applause)

CHAIRMAN NIELSSON: Tom Athey is also Chairman of our Entertainment Committee. He will give you his report.

Entertainment Committee Report

Tom Athey, Chairman

On behalf of "our members, our Board of Directors" and "our Officers" I wish to thank our "Hosts" for that "Beautiful coctail party" last night. Needless to tell you "The Hotel Management" did a magnificant job and that all of us enjoyed all of it. (Applause)

HOSTS

ATLANTIC UTILITY WORKS
C&I/GIRDLER INCORPORATED
COMMONWEALTH LABORATORY INCORPORATED
DAVY POWERGAS, INC.
FEECO INTERNATIONAL INC.
FESCO, INC.
FIBERGLASS EQUIPMENT DIVISION
  DART ENVIRONMENT & SERVICES CO.
HOWE RICHARDSON SCALE COMPANY
J&H EQUIPMENT, INC.

JACOBS ENGINEERING GROUP, INC.
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ST. REGIS PAPER COMPANY
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STEDMAN FOUNDRY AND
  MACHINE CO., INC.
UREA TECHNOLOGIES, INC.
WEBSTER INDUSTRIES, INC.
WHEELABRATOR-FRYE INC.

CHAIRMAN NIELSSON: Now we have a few words from our Publicity Chairman, Walter J. Sackett, Jr., who has, I think, done a wonderful job this year on letting the whole world know that the meeting was here, who we were going to have, and what the Programs were. If you belong to a number of Societies, like so many of us do, you have probably seen that Walter got his little fingers in there, and all of his Societies were telling people that there was a meeting going on. Walter. (Applause)

Public Relations Committee

Walter J. Sackett, Jr., Chairman

Thank you, Frank. I must be better than I thought I was. In fact, we have been sending out to the regular two, two and a half dozen magazines worldwide to let them know that we are here. We have also been running advertisements in Farm Chemicals and one other magazine. We have gotten something like four or five dozen replies out of the advertisements. I think that's doing well. As a matter of fact, Joe Reynolds told me the other day (we really are doing better than I thought) that he was talking to a fellow out in Missouri, and he started to tell him about the Round Table meeting. The fellow said, "I know all about it". He proceeded to read Joe a synopsis of the Proceedings. He said he got that out of something called The Grain News. I never heard of The Grain News, but I am sure they got our word some way. So, I am very happy with the way it's going. Thank you, Gentlemen. (Applause)

CHAIRMAN NIELSSON: We will now start with the Morning Session, the official, technical meeting. Al Malone, Production Engineering Manager, Agway, Inc. and a member of our Board of Directors, is our Moderator. Agway is that Company in my hometown of Syracuse, N.Y., that is in the Fertilizer Business. (Applause)

MODERATOR AL MALONE: I continue to be amazed at some of the "Extracurricular Capabilities" of this group. Besides having the "Nighhawkes and Owls" we have got a lot of "Jogers and Tennis Players". Now, for myself, I restrict my activities pretty much to "Walking and Hiking". Yesterday, during this nice weather, I was out "Walking" in the area. I got up the street about a couple of blocks and I saw a little boy just crying his heart out along the sidewalk. I said "Why are you crying?" He said "Boo, Hoo, Hoo, I cannot do what the big boys do." So, I sat down and cried with him.

This is the concluding session of our 29th Annual Round Table Meeting. We have a good agenda of speakers here. Right now I would like to ask that you hold questions until the program is over this morning. I think it is one of the most important sessions of the meeting. I am glad to see that we really do have a good attendance for the last session of the meeting. I am reminded of a passage from the Bible where Jesus declared that the first shall be last and the last shall be first. I hope this will be of comfort to our "Speakers" here, too. To our first two Speakers on the program, I want to say that it has been so, and it is going to continue to be that way. "Before the fertilizer is made and before it gets used", Agronomy still comes first. I think it is particularly important that we keep the Agronomy in the forefront today in view of the escalating cost of "Energy". We heard much about this yesterday and the real critical need for conservation. We all know that "Nitrogen Fertilizer" is a "Major, Major Energy Consumer". Moreover, "Nitrogen where it travels, is much concern environmentally."

Our first lead off Speaker today, is Dr. O. P. Engelstad. He will be talking to you about nitrogen losses from applied fertilizers. Dr. Engelstad is a native of Minnesota with a farming background. He obtained his B.S. and M.S. Degrees from the University of Minnesota and a P.H. Degree from Iowa State University, all in "Soil Fertility". Dr. Engelstad was a Research Agronomist with The Tennessee Valley Authority from 1960 to 1978, when he became Chief of the Soils and Fertilizer Research Branch. He is author or co-author of over 40 publications dealing with "Soils and Fertilizers". His professional activities have taken him to a number of foreign countries, primarily in Asia and Europe. He is an active member of the American Society of Agronomy and the Soil Science Society of America. We are all familiar with the contributions of Tennessee Valley authority to the industry, and we know that Dr. Engelstad has been a great part of this service to us. Dr. Engelstad, it is a pleasure for me to introduce you to this Round Table. (Applause).

Volatilization Losses of NH_3 Following Surface Application Of Urea and Urea Based Fertilizers

O. P. Engelstad

Introduction

Prior to 1960, the total amount of fertilizer nitrogen consumed in the United States was less than 3 million tons per year. Most of this amount was applied as low analysis dry mixtures and was for the most part incorporated with the soil during or after application.

Since that time, nitrogen consumption has increased to around 10 million tons per year. With this increase in nitrogen use, there have been increases in relative amounts of sources more subject to volatilization losses and in amounts applied to the soil surface without incorporation.

Figure 1 shows the current trends in consumption of N in the United States by selected sources. It is obvious that anhydrous ammonia is the strong leader in this comparison; however, N Solutions (one-half of N as urea) and solid urea are increasing quite rapidly. In fact, both of these sources have now surpassed solid ammonium nitrate in terms of consumption of N. We are rapidly adopting urea and urea-based sources that are subject to volatilization losses when surface applied without incorporation.

This paper examines the factors affecting volatilization losses of nitrogen from urea and urea-based fertilizers and discusses possible ways to reduce these losses. The primary concern will be with use of urea on upland crops grown on well-drained soils.

Factors Affecting Ammonia Volatilization From Surface-Applied Urea

Soil pH

Volatilization losses of ammonia from surface-applied urea can occur from either acid or alkaline soil. The critical pH is that generated in the site of urea application where the pH can exceed 9.0 upon hydrolysis to $(NH_4)_2CO_3$. Nevertheless, NH_3 losses are generally higher from alkaline or calcareous soils than from acid soils. Effects of initial soil pH on volatilization losses of NH_3 from surface-applied urea are shown in Fig. 2 using laboratory data from Ernst and Massey (1960). A fairly direct relationship was found between initial soil pH and NH_3 volatilization in their experiment. The hydrolysis reaction of urea is as follows:

$$CO(NH_2)_2 + 2H_2O^{\text{urease}} (NH_4)_2CO_3$$

The $(NH_4)_2CO_3$ (ammonium carbonate) is unstable and NH_3 can volatilize directly to the atmosphere. The effect of liming on losses of NH_3 from urea, ammonium nitrate, and ammonium sulfate is shown in Table 1, using data from Volk (1961). It is apparent that losses of urea occur on both limed and unlimed soils, and that losses from ammonium sulfate occur mainly on high-pH soils.

Temperature

Urea hydrolysis is an enzymatically mediated reaction, and is therefore strongly affected by temperature. As soil temperature rises from relatively cool to relatively warm, urease production by soil microorganisms and the activity of this enzyme rise dramatically and likewise the rate of urea hydrolysis. These effects are illustrated in Fig. 3, using data by Ernst and Massey (1960).

Generally, urea can be surface applied on cool soil without significant losses. In fact, late winter topdressing of urea on winter wheat in the Southern Great Plains has been quite successful. Likewise, surface application on cool-season grasses in the same area has been practiced without serious losses. With cooler temperatures, there is usually time for winter rains to move the urea into the soil before significant hydrolysis occurs. Surface application on warm-season grasses, however, has resulted in apparent volatilization losses. In the latter case, urea is applied to warm soil, resulting in a rapid hydrolysis to the unstable ammonium carbonate.

Even in warm soil, however, there is some delay before losses occur. The delay in NH_4 losses from urea is illustrated in Fig. 4. In this experiment reported by Gasser (1964b), losses of NH_3 from urea were significantly delayed as compared with that from $(NH_4)_2SO_4$. Whereas $(NH_4)_2SO_4$ can react immediately with $CaCO_2$ and release NH_3, urea must hydrolyze first before losses can occur. This can take several days, depending on soil temperature, moisture, and activity of urease.

Cation Exchange Capacity

The ability of the soil to hold catious such as NH_4^+ is a function of the exchange capacity (CEC). Coarse, sandy soils have generally low CEC and therefore cannot hold large quantities of cations. Medium- and heavy-textured soils have higher CEC, especially where clay minerals are of the 2:1 lattice types such as montmorillonite. Also, organic matter provides substantial CEC. The effects of CEC on loss of NH_3 from surface-applied urea are shown in Fig. 5, using data from Gasser (1946a). The loss of NH_3 decreased quite dramatically with increase in CEC.

Ammonium-N resulting from hydrolysis of surface-applied urea would be expected to be susceptible to greater losses on sandy soils than on heavier textured soils of greater clay and organic matter content, other things being equal. However, sandy soils can also dry out quite rapidly, slowing the rate of hydrolysis and loss of NH_2—N.

Soil Moisture

It is generally recognized that soil moisture is an important factor affecting loss of NH_3 from surface application. If a heavy rain occurs shortly after urea or other N source is applied, downward movement into the soil would largely prevent losses. However, if only an overnight dew occurs sufficient to dissolve the urea, the drying effect during the following day can result in substantial volatilization losses. Therefore, the amount of moisture received is critical in determining the degree of NH_3 loss.

It should be pointed out that the small amount of moisture involved in application of N solutions should not make any real difference in losses.

Effects of N Losses on Yield

In spite of the fact that we have identified the important factors associated with N losses from surface-applied urea and other N fertilizers, there still is a strong element of unpredictability. That is because the weather itself is still quite unpredictable. Temperature and rainfall can vary locally without warning; while each of these factors can affect the loss of N, interactive effects among these weather factors may be even more unpredictable in their effects on losses.

While N losses cannot be easily predicted, we can look at effects of certain losses on crop yields. In Fig. 6 is a yield response curve for corn grain[2] showing the effect of increasing rates of fertilizer N. It obeys the Law of Diminishing Returns; i.e., the yield response to each increment of N declines with increasing rate until no further yield increase occurs. If one arbitrarily assumed a loss of 40 lb. of N per acre, the yield effect of this loss would vary according to the section of the yield curve. At a rate of 160 lb. of N per acre, a loss of 40 lb. of N would result in only a loss of 10 bushels per acre; however, at a rate of 80 pounds per acre, a loss of 40 lb. per acre would result in a yield decrease of 30 bushels per acre. In the past when N fertilizer was relatively inexpensive, a farmer could in part compensate for N losses by applying a bit more for insurance. However, now we would regard this as an unwise practice and would prefer that the farmer choose instead to try to minimize losses. Also plotted in Fig. 6 are the net returns to N fertilizer, using prices of $0.17 per lb of N and $2.80 per bushel of corn grain. The loss of 40-lb. increments follows the same pattern as for yield; however, the cost of the N increment loss would need to be added to be exact; i.e., loss of 40 lb. of N at the 160-lb. rate would be $21.00 + $6.80 = $27.80 ($6.80 being the cost of 40 lb. of N).

It should be noted that the magnitude of NH_3—N loss may not be constant with increasing rate as implied here; in fact, it is often found that with higher rates of application, higher losses occur.

Prospects For Reducing Losses Of Urea-N

There are some possibilities for reducing the potential for losses of urea-N when surface applied. Naturally, where incorporation is feasible, this would be the most logical means of prevention.

Speaking somewhat facetiously, application of urea just prior to a good rain (1/2 inch) would also be effective. However, where these practices are infeasible, we must look at other means of prevention— or at least mitigation— of losses.

Chemical additives to urea can help reduce potential NH_3 losses from surface application. The purposes of such additives are to (1) inhibit urease activity (reduce rate of urea hydrolysis to ammonium carbonate); (2) reduce soil pH around the granule site; (3) reduce NH_3 loss by precipitation of Ca and Mg carbonates; and (4) coat the surface of the urea granule and thereby reduce rate of dissolution.

Urease Inhibition

One of the chief determinants of volatilization losses from surface-applied urea is the rate of hydrolysis. The use of a chemical additive that could retard or inhibit the rate of hydrolysis would offer real potential. Such reduction would be of primary concern for the period of time prior to the next rain or irrigation application. Research has identified numerous compounds with capability for retarding hydrolysis rates by their inhibitory effects on the enzyme urease. The problem is that while many of these are effective in solution, few are effective for soil application. Compounds that have been identified as having potential for soil application include the following: acetohydroxamic acid, dihydric phenols and quinones, 2,5-dimethyl-p-benzoquinone, and potassium azide.

As yet, prospects for a urease inhibitor are primarily theoretical. Research will continue on promising leads; in fact, TVA has plans to intensify its studies in this area.

Reduction of pH

Urea forms adducts with numerous acids and salts. An example of this is as follows between urea and calcium nitrate:

$$4CO(NH_2)_2 + Ca(NO_3)_2 \longrightarrow 4CO(NH_2)_2 \cdot Ca(NO_3)_2$$

Other adducts formed include urea nitrate $[CO(NH_2)_2 \cdot HNO_3]$ and urea phosphate $[CO(NH_2)_2 \cdot H_3PO_4]$. Both of these adducts form strongly acid solutions. Formation of such adducts in urea would help prevent the very high pH levels that can occur upon hydrolysis; these high pH levels lead to NH_3 losses.

Monoammonium phosphate or ammonium polyphosphate added to urea also tend to reduce the fertilizer solution pH and therefore restricts NH_3 losses. Addition of diammonium phosphate to urea would not be effective, since the solution pH of this compound is 8.2. Another compound that is added to urea is ammonium nitrate (in UAN solution).

Precipitation of Ca and Mg Carbonates

Research by Fenn, Taylor, and Matocha (1979) has shown that addition of Ca and Mg nitrates or chlorides to urea drastically reduced NH_3 losses. They postulated that as soil pH rose as a result of hydrolysis of urea to $(NH_4)_2CO_3$, $CaCO_3$ and $MgCO_3$ were precipitated as follows:

$$(NH_4)_2CO_3 + Ca\,(NO_3)_2[\text{or } Mg(NO_3)_2] \longrightarrow CaCO_3\ (\text{or } MgCO_3) + 2NH_4NO_3$$

This precipitation of carbonate reduced $(NH_4)_2CO_3$ concentrations and consequently, NH_3 losses. The problem is that addition of sufficient quantities of Ca and Mg salts seriously reduces the N content of the resulting product.

Khasawneh[3] showed that exchangeable Ca and Mg can also be precipitated as the carbonates; equivalent amounts of NH_4 are then absorbed on the soil CEC, thereby reducing atmospheric losses of NH_3.

Coating Urea Granules

The concept of coating a soluble N granule such as urea has been studied for a number of years. This approach slows the rate of dissolution from the granule and thereby reduces the amount of urea-N that is subject to volatilization during any given time period. A number of coatings have been tried; however, the most feasible coating yet developed is that by TVA of sulfur and polyethylene-oil sealant; TVA first tested a sulfur coating in 1961 and is now producing 10 tons per hour in a demonstration-scale plant at Muscle Shoals, Alabama. Surface application of this material on turf, forage, and other long-season crops has shown long-term release characteristics. Such slow release has not been shown to be very useful for fast-growing crops such as corn, cotton, small grains, etc.

Reducing Droplet Size of UAN

Prior to 1955, essentially all nitrogen was applied in the solid or dry form. Since 1955, there has been a pronounced increase in fluid forms, including both pressure and nonpressure solutions; over half of the nitrogen now applied is in fluid or nonsolid form.

Surface application (spray) of N solutions is the preferred method of application for the no-till system of row-crop planting of increasing importance in many areas of the country. A contact herbicide is usually added to the N solution to save a trip over the field. Research at TVA (Terman et al., 1968) shows that losses of NH_3 are in direct proportion to the amount of urea in the UAN solution (Table 2).

Other research in the Soils and Fertilizer Research Branch in TVA indicates that the amount of urea-N applied "per spot" is an important factor relating to losses by volatilization. While the microsite concentration of urea-N would be fairly high for granular urea, it would be very high for a large droplet of a UAN solution. If, on the other hand, the UAN solution was sprayed in fine droplets, the losses would be expected to be less. Therefore, the form of N becomes less important as the concentration of N in the site of application decreases. It should not be particularly difficult to avoid the use of large granules of solid urea or the use of large droplets of UAN solutions in the interests of reducing N losses.

Table 1. Ammonia lost from unlimed and limed grassland receiving 100 lb of N/acre (from Volk, 1961).

	NH_3 lost as % of N applied		
	Ammonium nitrate	Ammonium sulfate	Urea
Unlimed	0	0	29
Limed	3	20	36

Table 2. NH_3-N losses in 41 days from fluid fertilizers surface applied to Hartsells fine sandy loam (pH 6.3) (Terman, Parr, and Allen, 1968).

		NH_3-N volatilized, mg/pot	
N source	Total N, %	Aeration at 100% RH	Aeration at 70% RH
Solutions			
AN	20.5	1	1
75% AN, 25% urea	19.5	2	2
25% AN, 75% urea	20.2	16	28
Urea	20.5	45	55
Suspension			
UAN	36.8	20	22

Summary

Applying urea on the soil surface can lead to significant volatilization losses of NH_3—N. This can occur on both acid and alkaline soils, with somewhat greater losses on the latter. Warm temperatures coupled with drying conditions are associated with increased losses; losses are also greater from soils of low CEC (sandy soils, for example).

There are some measures that can be taken to mitigate such losses. Aside from application before irrigation or anticipated rain, one can avoid warm, drying conditions, and not apply to soils of low CEC. Beyond this, substances can be added to urea to reduce the pH in the granule site and to precipitate the carbonate that forms upon urea hydrolysis. Finally, the urea granules can be coated to slow the rate of urea dissolution. These modifications do entail some cost, but may be practical where no other measures are feasible.

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[2] From experiment at Tribune, Kansas (average of 1968-73 data). Reported in 1976 Report of Progress, Kansas Fertilizer Research; published by Agricultural Experiment Station, Kansas State University, Manhattan, Ks.

[3] Unpublished TVA data.

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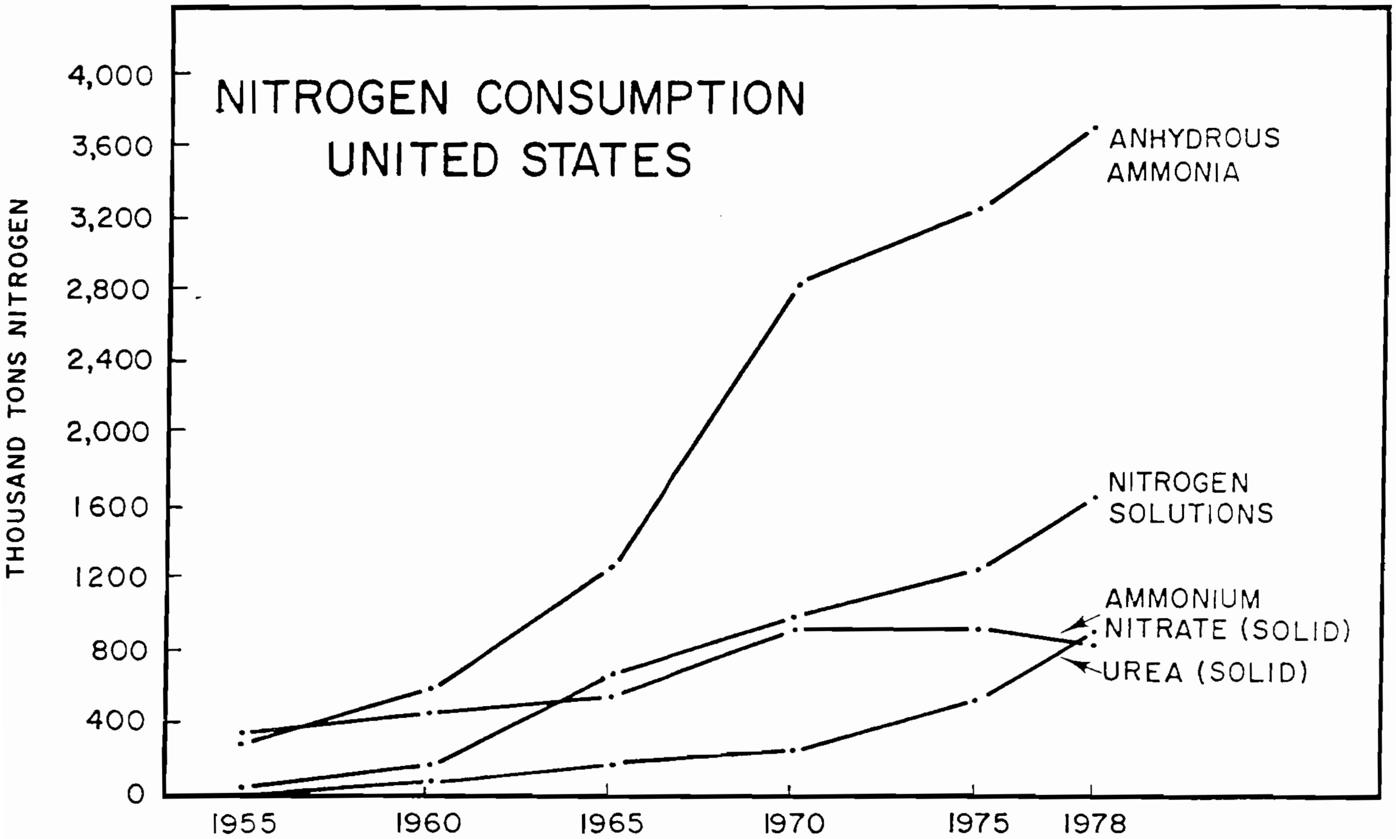


Figure 1. Consumption of selected sources of N over time in the United States.

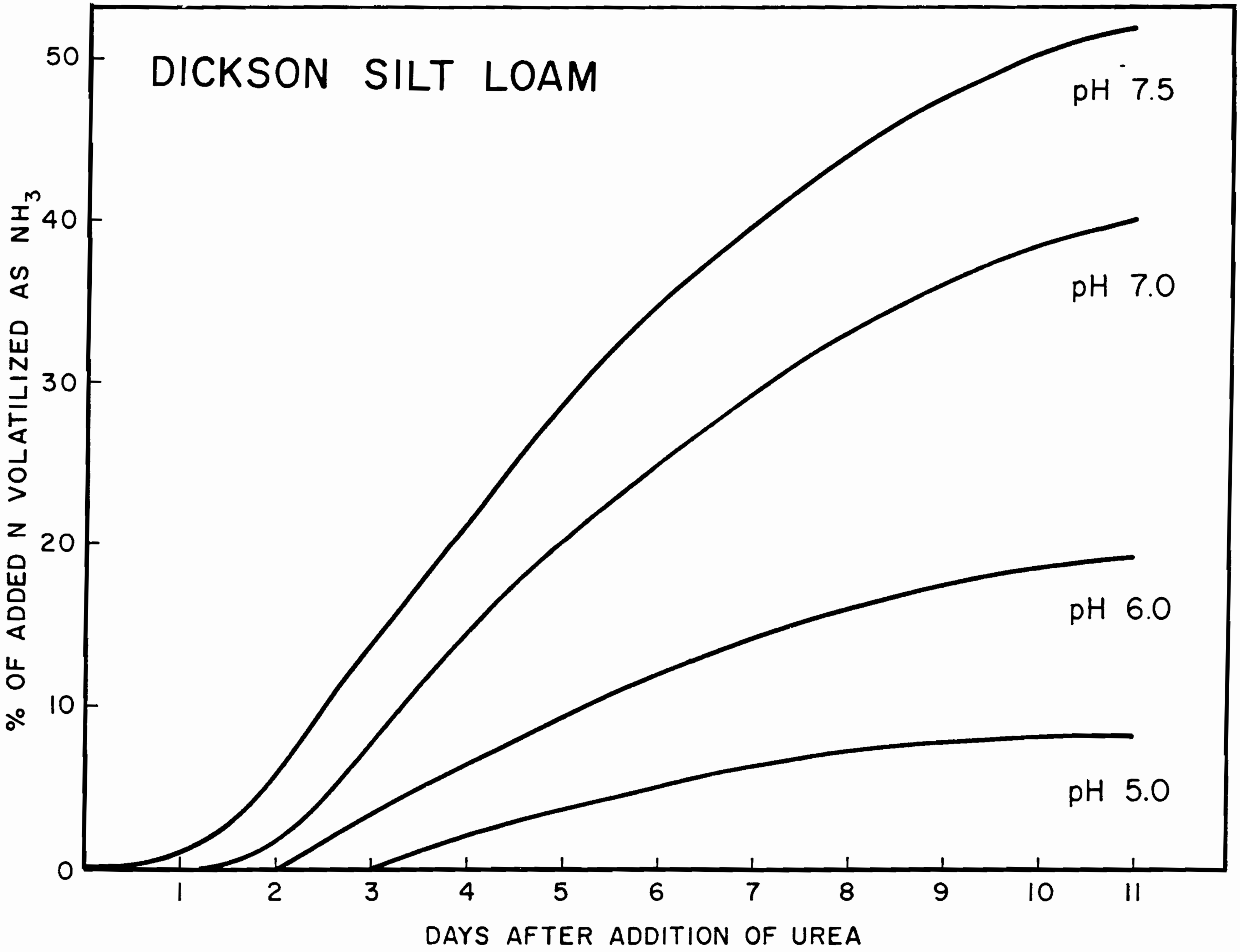


Figure 2. Cumulative loss of added N from urea as affected by soil pH. From Ernst and Massey (1960).

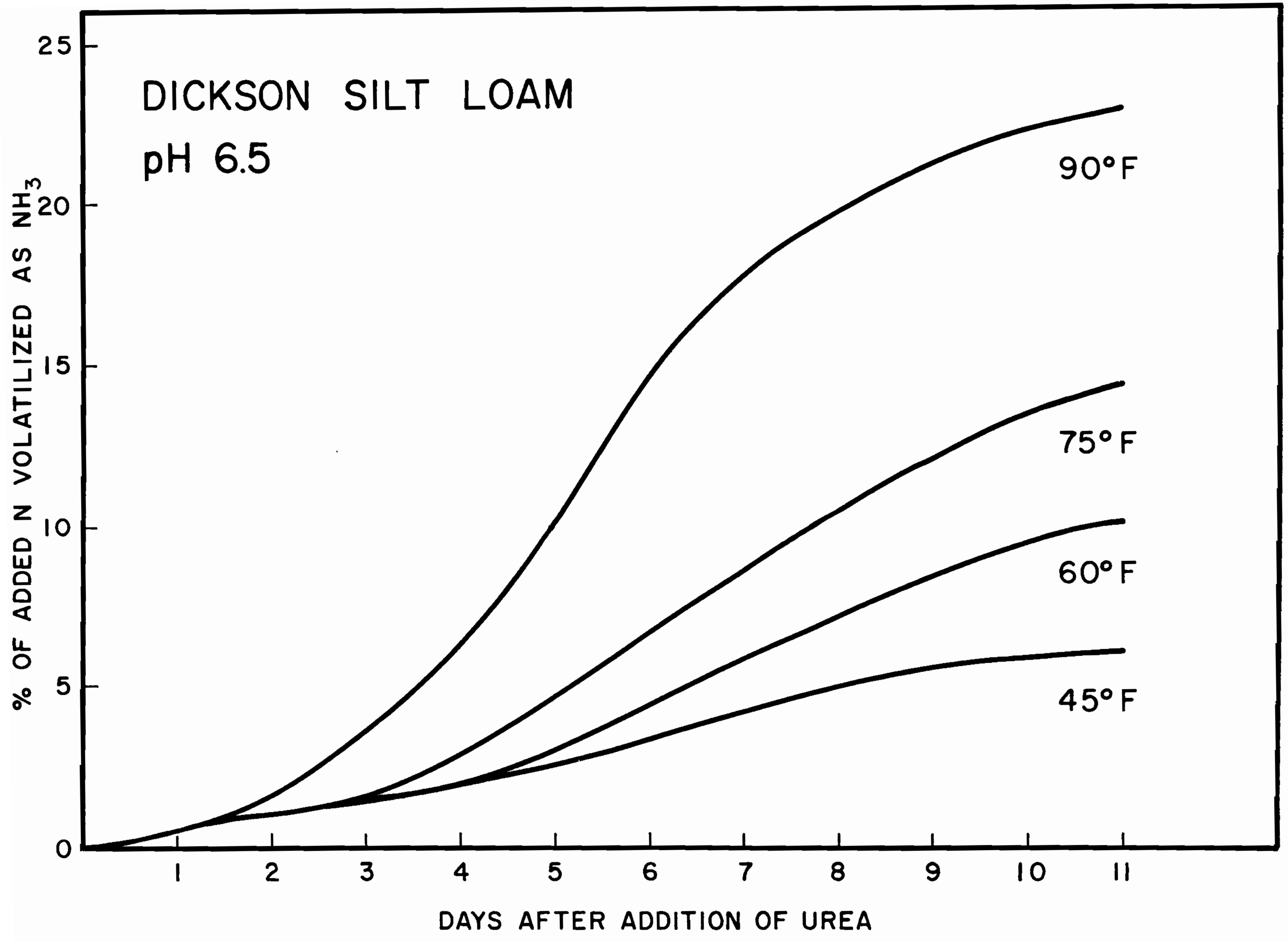


Figure 3. Cumulative loss of added N from urea as affected by temperature. From Ernst and Massey (1960).

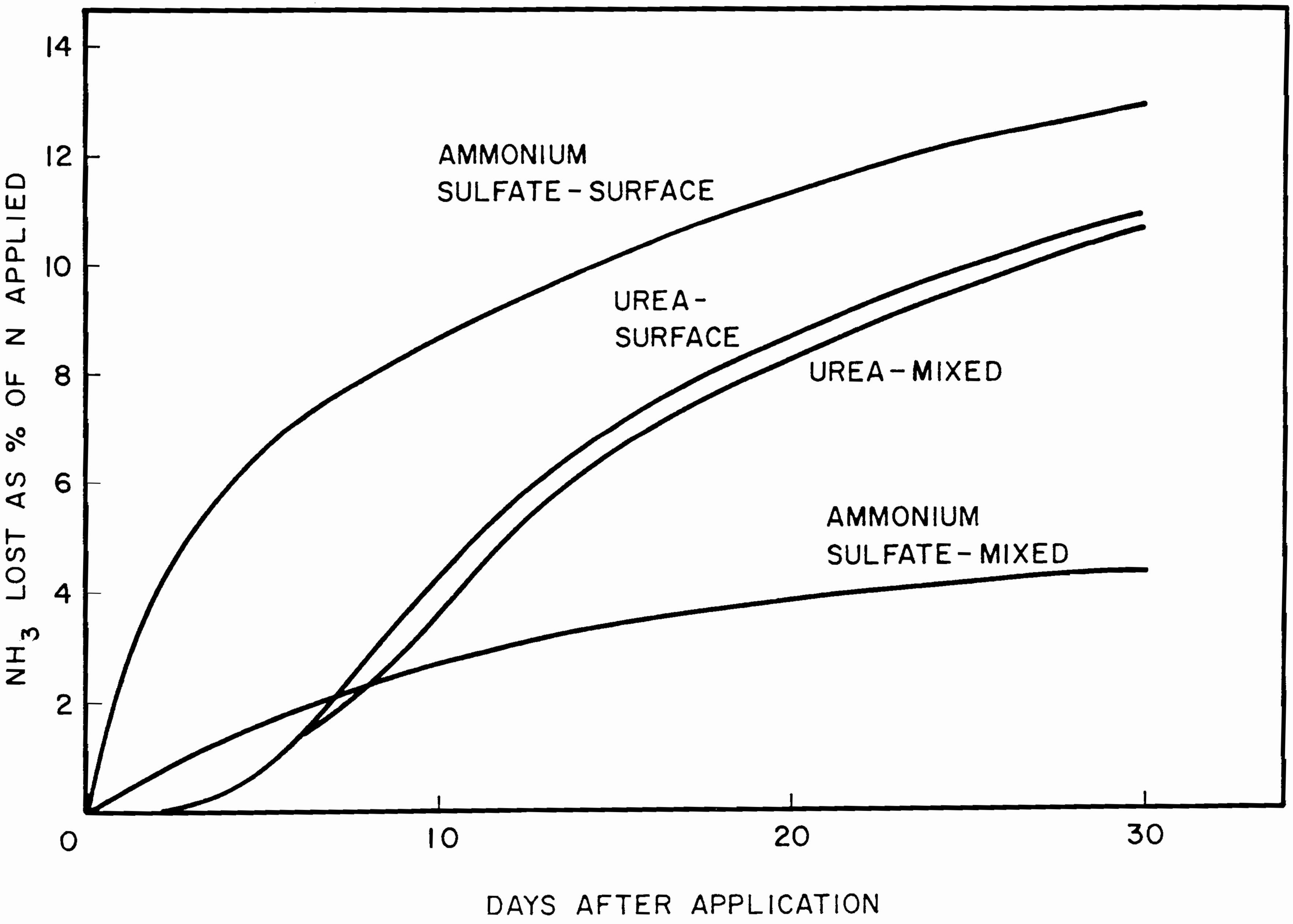


Figure 4. Cumulative losses of NH_4 from ammonium sulfate and urea broadcast and mixed with calcareous soils at 100 lb N/acre. From Gasser (1964b).

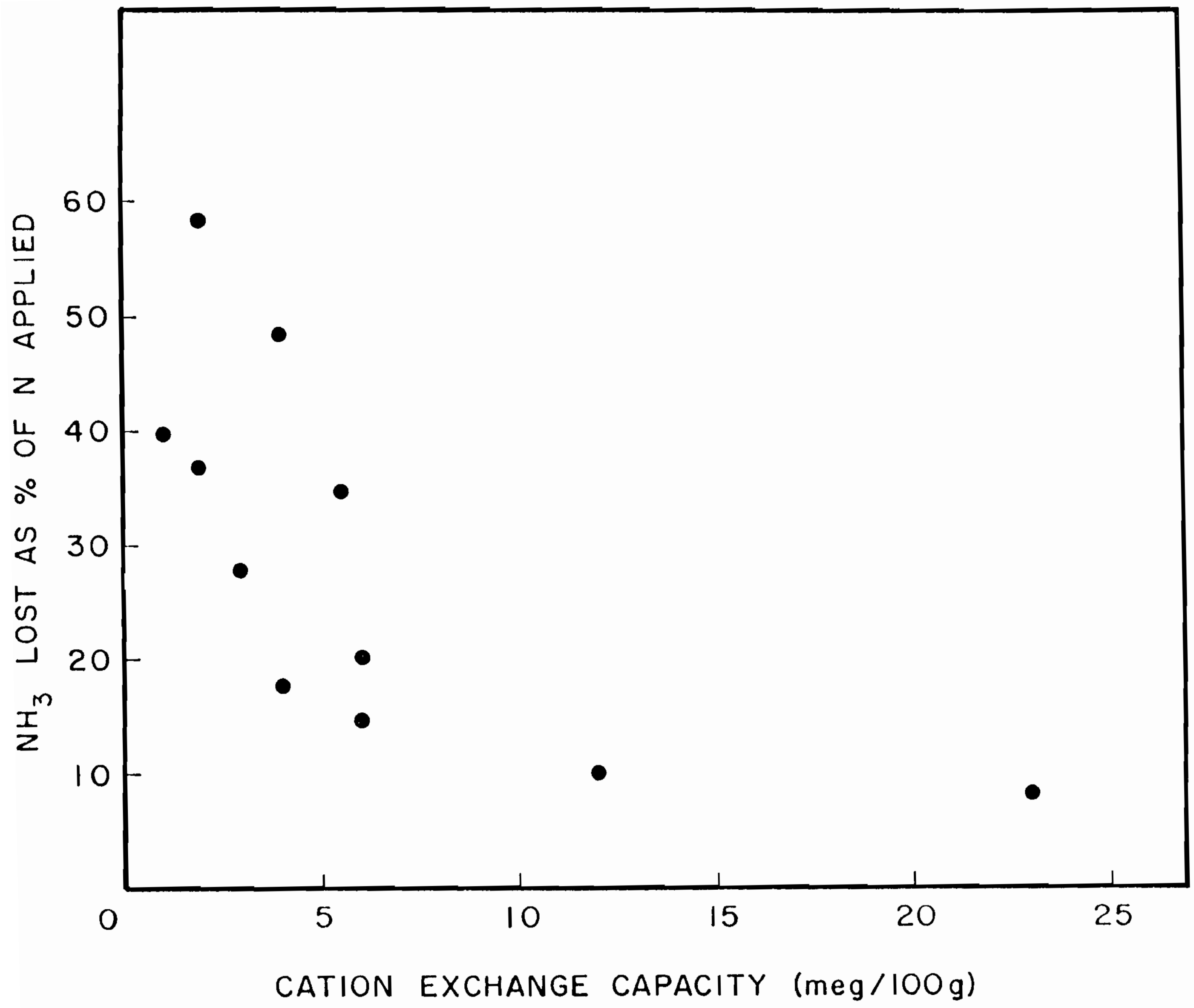


Figure 5. NH$_3$ lost from surface-applied urea as a function of CEC of soil (100 lb N/acre). Modified from Gasser (1964a).

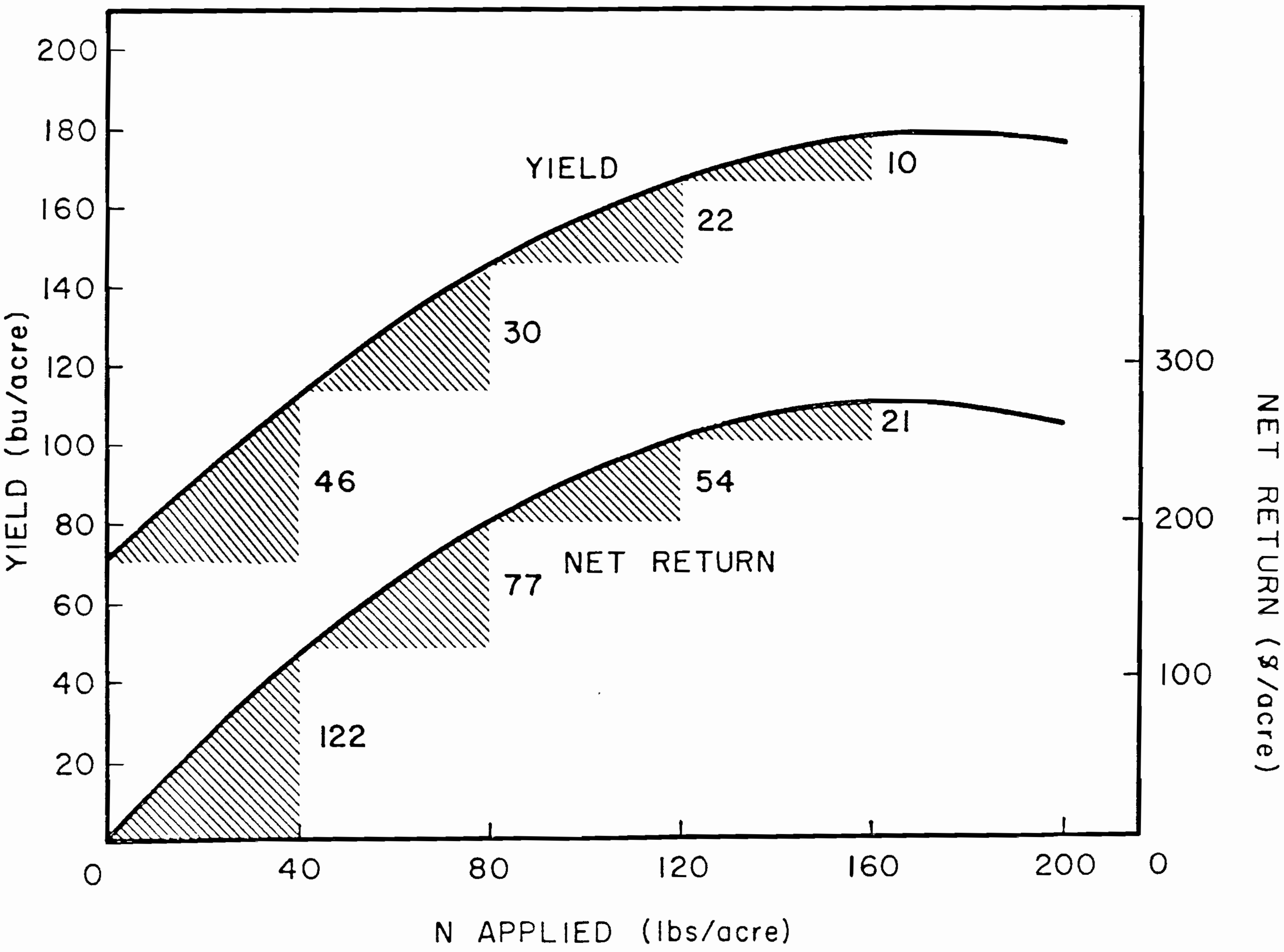


Figure 6. Yield response of corn grain and of net return to applied N for experiment at Tribune, Kansas (average of 1968-1973 data).

MODERATOR MALONE: Thank you, Dr. Engelstad, for a very excellent presentation. You have talked about one of our major nitrogen high volume commodities. I am sure you have generated a lot of interest here and a lot of potential questions. (Applause)

Our next speaker on the program is Henry Plate. Henry is going to talk about "Fertilizer for Planter Application — Is There A Difference?" Again, we have a timely subject here in relation to energy use and conservation. Now, Henry is a colleague, so I have got to be careful how I introduce him and read his pedigree. In the first place, he's bigger than I am, and the next thing is, I need a ride home from the airport when we get back to Syracuse. Henry is a native of the state of Maine. That's the place where you have the waves washing against the shores and the moose hide and the muskies show their teeth. He attended the University of Maine and obtained a B.S. degree in animal husbandry and a masters degree in agronomy. Since 1949, he has been employed by Agway, Inc. and one of Agway's predecessor organizations, the Eastern States Farmers Exchange. From 1949 to 1974, he has managed various research, technical and agronomic activities for these organizations. Since 1974, he has been the Manager, Agronomic and Technical Services for the Fertilizer Division of Agway. Henry is an active member of the American Society of Agronomy, American Association of Plant Food Control Officials, Pennsylvania Plant Food Educational Society and the Empire State Soil Fertility Association. He has served these organizations as director and in many other positions. Henry has been a previous Fertilizer Industry Round Table director, and I am sure many of you remember the many excellent presentations he has made previously at the Round Table. Henry, I am pleased to introduce you to the Round Table. (Applause)

Fertilizer For Planter Application Is There A Difference

Henry Plate — David Matthews

Presented by Henry Plate

In 1974 I was on the same podium discussing with you "Designing Quality N-P-K Fertilizers and Fertilizer Programs". One of the areas I touched on at that time was the use of urea-DAP mixtures for planter application. My comments at that time were "some research shows that urea-DAP mixtures are not totally compatible with close placement to the seed".

I'll continue to quote from that talk.

"Urea-DAP mixtures are an enigma as far as their adaptability to planter type application. Several experiment stations have given warning — Mississippi, Purdue, Ontario, New York — that ammonia may be released too rapidly from either the urea or from the second molecule of ammonia in the diammonium phosphate, and cause ammonia toxicity to the crop. We don't have the full answer on this one. We, personally, have done work for two years with all sorts of combinations, several planting dates, several crops, in an attempt to hit the right weather conditions that might induce this injury. We have not found injury. Yet look at the information published by New York in 1968. The yield reduction in 1966 amounted to 20 bushels of corn when an 80-40-40 was banded 2" to the side and 2" below the seed".

"Based on this type of data it appears one should avoid a urea-DAP mix applied through the planter. Yield reductions, even if they occur only once in five years are significant enough to cause farmers real problems".

End of Quote

Since that time we have done continuing research at Agway's Farm Research Center in Fabius, N.Y. on the effect of various types of fertilizers applied through the planter on corn and beans. The information we have now is far more specific and I would like to share that with you today. I would also comment that researchers at Penn State, University of Maryland and elsewhere, have reached virtually the same conclusion.

Our trials encompass over 10 cropping environments counting the various years, locations and planting dates. Conditions conducive to injury or conditions not conducive to injury may or may not be present at the time of any one given trail. As we look at this work, keep in mind that the purpose of fertilizer and in this particular situation, the planter box fertilizer, is to increase yield.

Let us review the results of a starter fertilizer source, rate, and placement trial conducted in 1976, when conditions favored fertilizer injury.

In this four replicate trial, seven different fertilizer treatments were used as listed in Table I. In three, urea was used as the primary source of nitrogen combined with three different phosphate products — diammonium phosphate, mono-ammonium phosphate and triple superphosphate. Ammonium nitrate was substituted for urea in another three treatments utilizing the same phosphate carriers. And finally these were compared with an ammoniated granulated 10-20-10 corn starter.

Table I

Fertilizer Treatments

1. U-DAP-MP
2. U-MAP-MP
3. U-TSP-MP
4. AN-DAP-MP
5. AN-MAP-MP
6. AN-TSP-MP
7. 10-20-10 c.s.

In order to accentuate the injury, two placements listed in Table 2 of the fertilizer through the planter were used. First the fertilizer was placed 2" to the side and 2" below the seed in a conventional pattern as is normally recommended. In the second placement, the fertilizer was placed in direct contact with the seed to accentuate the injury that might occur and to duplicate conditions believed to exist in segments of the row under farm conditions due to vibration, movement of the corn planter, soil conditions, improper planter adjustment, variations in flow rate of fertilizer and segregation of ingredients.

Table 2

Fertilizer Placement

1. 2" to side and
   2" below seed
2. With seed

The fertilizer was applied at a constantly increasing rate from 0 to 1,000 lbs. of 10-20-10 equivalent in a 40 ft. row as shown in Table 3. The row was divided into 10 ft. segments for data collection during the growing season and for harvested yield.

Table 3

Fertilizer Rates
Pounds 10-20-10 Equivalent

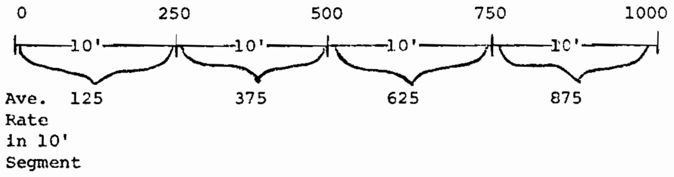


Table 4 indicates the average of 125 lbs. of fertilizer in the first 10' segment, 275 in the second, 625 and 875 in the third and fourth respectively. These rates refer to quantities of 10-20-10 fertilizer — other treatments were applied at rates that would deliver the equivalent plant food.

Table 4

Fertilizer Rates

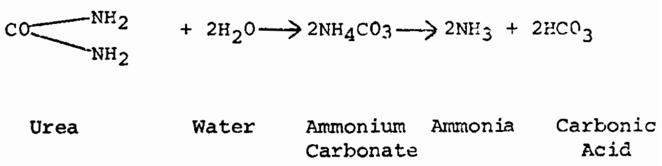
Each plot was planted at a variable rate from 0 to 1000 lbs/A of 10-20-10 equivalent. Plots were harvested in 10' increments representing four average rates.

1. 125 lbs. per acre
2. 375 lbs. per acre
3. 625 lbs. per acre
4. 875 lbs. per acre

This variable rate of fertilization was accomplished by using a belt planter. A V shaped trough was placed upon the belt and the fertilizer spread at a uniform depth within this V trough.

When the V was removed this straight line increasing application of fertilizer was the result. The corn seed was placed either right on the fertilizer resulting in direct seed contact in the soil or was placed on an adjacent portion of the belt to be delivered 2" to the side and 2" below the seed.

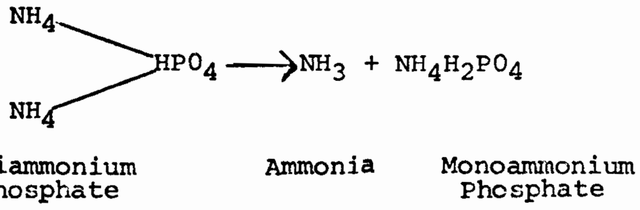
Both urea and diammonium phosphate are suspect from the standpoint seed injury. While too much of any fertilizer salts can cause injury, the problem we are concerned with revolves around the release of free ammonia in the soil. This results in ammonia toxicity to the young seed and/or seedling. This is the reaction that takes place with urea in the soil.



$$CO(NH_2)_2 + 2H_2O \longrightarrow 2NH_4CO_3 \longrightarrow 2NH_3 + 2HCO_3$$

In the presence of moisture and the urease enzyme, urea combines with water to form, first ammonium carbonate, which then dissociates into free ammonia gas and carbonic acid. Normally, the ammonia nitrifies into nitrate (NO_2) and then nitrate (NO_3)—the form preferred by the crop. However, under the right temperature, moisture, and high pH conditions, conversion to the ammonia form can be so rapid that it actually kills or temporarily inactivates the nitrifying bacteria for a short period of time. This results in an accumulation of ammonia which can prove toxic to the seed if present in too close proximity and too large quantity.

Similarly with diammonium phosphate we have two molecules of ammonia attached to one phosphate molecule as illustrated.



$$(NH_4)_2HPO_4 \longrightarrow NH_3 + NH_4H_2PO_4$$

One of the ammonia molecules can dissociate very rapidly leaving us with NH_3 and monoammonium phosphate. Again this ammonia comes off so fast that it accumulates, prevents nitrification and causes toxicity. The second molecule of ammonia (now in monoammonium phosphate) is held much tighter, is released much more slowly in the soil. This is one reason for good success with monoammonium phosphate as a corn starter.

Table 5 shows the plant stands with the various sources at all rates and placements. Sixteen plants would be a perfect stand. These are the number of plants that emerged over a 30 day period. With a 2" by 2" placement, averaging all rates of application, there is no real difference between the sources of fertilizer. However, when the fertilizer was placed directly in contact with the seed, there is a very marked decrease in plant stand from those treatments containing urea. Only eight plants emerged with urea-DAP treatment or four in the case of urea-triple super out of the sixteen seeds planted. This is the average of all rates. At the high rates there were no plants at all. Even when ammonium nitrate was used with DAP you see a marked reduction in plant numbers compared to the ammoniated corn stand. This may be due to either high fertilizer salts or ammonia where DAP was used. Keep in mind the lower plant stand with the urea-triple superphosphate. This will be discussed later.

Table 5

Effect of Fertilizer Source
And Placement on Plant Stand

Source	Placement 2" x 2"	In Row	Average
U-DAP-MP	15.6	8.5	12.0 cd
U-MAP-MP	14.8	8.2	11.5 cd
U-TSP-MP	14.4	4.1	9.3 e
AN-DAP-MP	15.3	10.7	13.0 bc
AN-MAP-MP	14.8	13.8	14.3 a
AN-TSP-MP	15.9	10.4	13.2 b
10-20-10 c.s.	14.8	13.3	14.1 ab
Average	15.1 a	9.9 b	12.5

Source LSD 1.12 @ 95%
Placement LSD 0.79 @ 99%

Table 6 shows the influence of four rates of fertilization. With an accurate 2" by 2" placement, rate has little effect on plant stand. On the other hand, when placed with the seed, increasing rates of fertilizer markedly reduced the plant stand.

Table 6

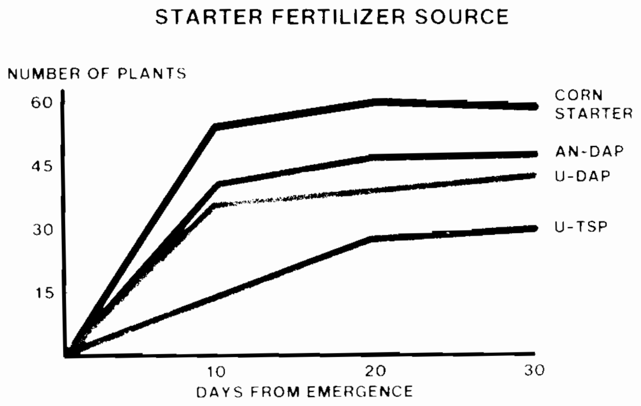
Influence of Fertilizer Rate and
Placement on the Number of Plants

Rate	Placement 2" x 2"	In Row	Average
0-250#	15.5	12.9	14.2 a
250-500#	14.8	10.1	12.5 b
500-750#	15.0	8.5	11.7 b
750-1000#	15.0	7.9	11.4 c
Average	15.1 a	9.9 b	12.5

Placement LSD 0.80 @ 99%
Rate LSD 1.12 @ 99%

Graph #I shows the relative number of plants emerged at three different times — 10, 20, and 30 days after the first plant appeared for four of the treatments. At the end of 30 days with the ammonium nitrate-DAP, urea-DAP, and the urea-triple superphosphate showed lower total emergence than ammoniated corn starter. In addition to the lower final total emergence, note the delay in emergence with urea-triple superphosphate, which contains the highest level of urea. Delayed emergence can be detrimental to yield in relation to the period of maximum radiation which is one of the primary purposes of early planting. For simplicity we have left three of the treatments out of this chart. The urea-MAP would have been between the urea-DAP and urea-triple superphosphate. Ammonium nitrate-MAP would be quite similar to the corn starter, while the ammonium nitrate-triple superphosphate live, due to the high concentration of salts from ammonium nitrate, would be close to the ammonium nitrate-DAP.

Graph I



Views of the stand at 875 lb. average, in row placement, of urea-DAP, urea-TSP, and granulated ammoniated corn starter showed the poor to non-existent stands with the first two compared to a fair stand with the corn starter under extreme conditions.

Table 7 shows the effect of fertilizer sources and placement on the yield of 32% dry matter corn silage. The 2" by 2" placement averaged 17.0-18.8 tons of silage per acre in six of the seven treatments, except for the urea-triple superphosphate treatment gave the lowest yield — 15.7 tons per acre. However, the in-row placement reduced the yield with all urea combinations down to 9.8 tons with the urea-triple superphosphate mix. Even the ammonium nitrate-DAP treatment gave a significant yield reduction probably due to the presence of DAP.

Table 7

Influence of Fertilizer Source and Placement on The Yield of 32% Dry Matter Corn Silage in Tons Per Acre

Source	Placement 2" x 2"	 In Row	 Average
U-DAP-MP	17.8	10.4	14.1 c
U-MAP-MP	17.7	8.8	13.3 c
U-TSP-MP	15.7	4.0	9.8 d
AN-DAP-MP	17.0	12.8	14.9 bc
AN-MAP-MP	18.8	16.5	17.7 a
AN-TSP-MP	17.9	14.1	16.0 ab
10-20-10 c.s.	17.6	14.8	16.2 ab
Average	17.5 a	11.6 b	14.6

Source LSD 1.80 @ 95%
Placement LSD 1.28 @ 99%

Fertilizer rate and placement as indicated in Table 8 produced yield differency similiar to the effects that were shown on stand in Table 6.

Table 8

Influence of Fertilizer Rate and Placement on the Yield of 32% Dry Matter Corn Silage in Tons Per Acre

Rate	Placement 2" x 2"	 In Row	 Average
0-250#	16.5	13.9	15.2 a
251-500#	18.0	12.3	15.2 a
501-750#	17.6	10.7	14.1 ab
751-1000#	18.0	9.6	13.8 b
Average	17.5 a	11.6 b	14.6

Rate LSD 1.36 @ 95%
Placement LSD 1.28 @ 99%

The question is how often or how great is the probability that injury will occur in the field? This depends upon many factors. It depends upon accuracy of calibration of that corn planter and adjustment to properly place the fertilizer 2" to the side and 2" below the seed. It depends upon soil conditions and these are hard to define. We find injury in both cold wet soils and warm dry ones, but seldom experience it in soils in good tilth for planting. But who knows what's going to happen to that soil tomorrow after you plant today. It also depends upon the number of rocks in the soil that kick the planter around, speed of planting, slope of the land, which may drift the corn planter, etc. Based upon the work that we have done, we find that we have had significant injury two years out of five — a 40% probability. And what does this injury cost? Table 9 indicates the dollar benefit per acre attributable to use of an ammoniated corn starter over a 10 year period, based on injury occuring 4 years out of 10. For instance, if ammonium nitrate-DAP is substituted for corn starter, the grower will lose $76.00 per acre in 10 years or $7.60 per acre per year, compared to what his yield might have been. Use of a urea-DAP combination will cost him $156.00 or $15.60 per year and urea-triple superphosphate could lose up to $37.00 per acre per year. On a 100 acres that figures out to $3,700. These computations are based on corn silage at $20.00 a ton and ammoniated granulated corn starter costing about $2.25 more per acre than the blend.

Table 9
Dollar Benefit Per Acre
Attributable to Corn Starters
(10 year period)

(Based on injury occuring 4 years out of 10)

10-20-10 c.s.	-
AN-DAP	$76.00
U-DAP	$156.00
U-MAP	$168.80
U-TSP	$372.00

Corn Starter @ $2.25/A more than blend
Corn Silage @ $20/Ton

The particular ratio of nutrients also has an effect on a planter box fertilizer. Look at these two formulations in Table 10 providing listing the ingredients (N-P_2O_5-K_2O) for a 20-40-20 or a 20-20-20. Less diammonium phosphate by half in the 20-20-20, but almost triple the amount of urea that is present in the 20-40-20. Only one of the two molecules of ammonia in diammonium phosphate releases rapidly, but all the ammonia in the 2.8 fold increase in urea can release rapidly.

Table 10
Blended
Formulations in Pounds

Sources	20-40-20	20-20-20
Urea	9.4	26.5 (2.8x)
DAP	87.0	43.5
MP	33.4	33.5
Total Pounds	129.8	103.4

The effect of various sources of phosphate on the formulation of a product is indicated in Table 11. To supply 20-40-20 (N-P_2O_5-K_2O) per acre, a urea-DAP blend requires 9.4 lbs of urea. Substituting monoammonium phosphate for diammonium requires 21.7 lbs of urea, a 2.3 fold increase. When triple superphosphate is substituted for diammonium, 43 lbs of urea is needed, a 4.6 fold increase. In our opinion, urea is far more critical from a potential toxicity standpoint than is the diammonium phosphate, although diammonium phosphate in large quantities is known to cause problems. Monoammonium phosphate is a good starter fertilizer, when used alone or with some muriate of potash. But if monoammonium phosphate is used to blend a mixed grade, higher in nitrogen than a 1-4 ratio, it is bad news. Its not that the monoammonium phosphate is bad, but it is the extra urea that must be added to it. Ammonium nitrate-MAP could be acceptable, but almost no one is using ammonium nitrate at this time.

Table 11

Blended
20-40-20 Formulations in Pounds

		U-DAP-MP	U-MAP-MP	U-TSP-MP
Urea	46-0-0	9.4	21.7 (2.3x)	43.0 (4.6x)
DAP	18-46-0	87.0		
MAP	13-52-0		77.0	
TSP	0-46-0			87.0
MP	0-0-60	34.0	34.0	34.0
Total Pounds		130.4	132.7	164.0

Blended fertilizer is excellent for many uses. It is particularly useful for meeting prescription soil test recommendations where the exact mix of N-P-K can be formulated to supply and balance out the soil needs. It is great for broadcast applications, plow down, disc in, and side dressing, but it is not the fertilizer to be used through the planter.

In conclusion, blends can be harmful to crop growth when used as a starter if:

1. Segregation occurs.
2. Rate of application is excessive at any point in the row.
3. Placement is not uniformly precise.
4. The ratio of nitrogen to phosphorus is 1-2 or higher — remember the comparison of 10-20-10 and the 10-10-10.
5. Urea is present.
6. Additional elements such as secondary or micronutrients are required.
7. Weather conditions favor injury.

Now if one were to design a good planter box fertilizer, what do we look for? Fertilizer should be homogeneous granules with some nitrate nitrogen for a fast start, about 15-25%. A low urea content and a low diammonium phosphate content. It needs a high level of readily available water soluble phosphorus such as monoammonium phosphate, with secondary elements and micronutrients added as required for local soil conditions, but not added unnecessarily. And of course the N-P-K grade should be tailored to the particular soil conditions present.

Its been fun to review this data with you. You see the areas of agronomic concern. If I was a farmer I certainly would not use a urea-DAP blend as a planter box fertilizer. I would look for an ammoniated granulated product that was homogeneous, or consider a monoammonium phosphate or monoammonium phosphate with potash, but certainly not one with urea added. In closing, urea has many excellent uses, it is an excellent source of nitrogen for many applications, but the planter box is not one of them. (Applause)

MODERATOR MALONE: Thank you very much, Henry, for that excellent presentation. I saw some things I hadn't seen either. I don't get down to our Agway Research Farm very often except during the time that our experimental sweet corn is maturing and their apples from the experimental orchard are ready to pick. So, I learned a lot. Henry, you generated a lot of interest, and I know you will have questions, too. We will move right along.

Our next speaker on the program is George M. (Jim) Hebbard. He is going to be talking about "Production of DAP — Present Practices". Again, we have a real interesting subject, particularly since I heard the figures that about eight million tons of DAP were produced last year in the United States. With that kind of a major volume fertilizer, certainly it is a major matter of interest to all of us. It is a major ingredient in most bulk blends and also a major direct application fertilizer. Jim was born in Michigan. He has lived in California, Maryland and Florida. He graduated in chemical engineering from Lehigh University. He has worked for W.R. Grace & Company in Maryland and A.J. Sackett & Sons in Baltimore. He has experience in fertilizer production, SO_2 recovery, scrubber design, industrial chemical manufacturing and equipment fabrication from the standpoint of both process supervision and engineering management. He is now Process Engineering Superintendent at the New Wales Chemical, Inc., division of I.M.C. near Mulberry, Florida. Jim it is a pleasure to welcome you to the Round Table. (Applause)

Present Day D.A.P. Production

G. M. Hebbard

Preface

This is an exciting time to be addressing the Round Table on Diammonium Phosphate Production. The present DAP production scheme, which had its roots in work done by Virginia Carolina Chemicals and then TVA in the late 50's and early 1960's, has achieved the status of the old standard and is only now being challenged by alternate methods. One of these, TVA's own pipecross reactor, has been widely discussed. Now is a good time, however, to pause and consider some of the factors affecting production in the conventional process.

Present-Day DAP Production

The present large DAP plants operating at roughly 100 TPH and above, are remarkably similar. Gone are early day worries over hot screening after the dryer. The energy balance has been enhanced by returning all but the product rate product size back to the granulator, often at near dryer discharge temperatures. Granulator discharge temperatures of 200°F. and higher are typical with granulator discharge moistures in the 1 to 3% range.

Over granulation is so common that most producers maintain a coarse recycle often containing 50% or better product size. I.S. Mangat, in his excellent paper on Slurry Process Granulation for the International Conference on Granular Fertilizer and their Production, given in London in 1978, states that; typically, "no attempt is made to do a highly efficient grinding job on the oversize" in the slurry process. Most producers have gone to product recycle feeders which eliminates the need to bind the product screens in a near constant attempt to keep enough recycle in the plant.

As present plants move closer and closer to what we think of as melt processes, the possibility of eliminating the dryer altogether appears. An optimistic article by Bob Danos of Badger American in the October 16*th*, 1978 Edition of *Chemical Engineering* magazine proposes just that. At the present time I know of no large plant that is being built with this concept, as most operators prefer the flexibility of a large, under utilized dryer with its ability to pull them out of a wet start-up or even out of a granulation upset. Tests continue with the pipe cross reactor but no major commitments have been made in this country. Product specifications enter into the above discussion. If DAP were sold on a dry basis, freight allowed, then there would be a little less hesitancy to risk 3.0 moistures. But more of this later.

(Slide #1) What is a typical flowsheet for a present day DAP plant? This first slide shows what must be considered best available technology if the capital dollars invested are allowed to vote. Double deck screens after the dryer separate out the product fraction, much of which is destined to overflow back to the, typically, dragflight recycle conveyor. The oversize, passing through mills first, and the fines and cyclone products return directly to the granulator feed elevator.

Preneutralization

(Slide #2) Feed is supplied at roughly the maximum slurry solubility point of 1.45 mole ratio of NH_3 to H_3PO_4. The preneutralizer evolved from early work by Virginia Carolina Chemical and was discussed by C. E. Floyd and Philip E. Stone in the Round Table proceedings of 1957 and '59. If you look these references up, please note the pipe reactor described by Grace's Mr. alfrey in an adjacent article. Present preneutralizers are operated at roughly 240°F. and 1.52 specific gravity. This slide shows the relationship of solubility in grams/100 gram solution to the degree of ammoniation. Operation at the peak of solubility causes a reduction in solubility and, of course, additional heat release, upon further ammoniation in the granulator, accounting for the expression "drying up in the bed".

These solubility relationships are valid also in NPK plants using preneutralizer or pipe reactor feed systems. However, I am not aware that anyone has a set accurate at the non-equilibrium conditions and high temperatures encountered in today's granulators. Also, as shown by steam sparging a preneutralizer, the degree of supersaturation can be controlled and is used to good effect by some producers. Thus the variables of preneutralizer residence time, acid contaminants, specific gravity, mole ratio, and temperature are major determinants of plant capacity.

I cite temperature as a dependent variable as, almost without exception, a DAP reactor or preneutralizer operates as a boiling vessel. From inception, the major determinant of granulation plant water balance control has been the operation of the preneutralizer. Its role has become increasingly important as the need to absorb more and more fresh water input has occurred. Many plants have insufficient phosphoric acid evaporation capacity or are steam poor and the portion of the P_2O_5 feed stock supplied as 30 or 40% acid must be increased. Additionally, a majority of DAP plants have some form of fresh water scrubbing, as opposed to recirculated gypsum ponds waters often saturated in fluorides. This additional water must be evaporated in the scrubbers, preneutralizer, and granulator. By far the large portion evaporates in the P.N. Since most producers shoot for something like 110° - 115°F. in their stack gases, the tailgas scrubber will pick most of this water back up, and possibly add to a water balance problem X-battery limits.

There is currently considerable interest in preneutralizer operating conditions. One suggestion that comes up frequently is to ammoniate to 0.6 mole ratio in a first stage, overflowing to a second stage where ammoniation is completed to 1.45 or so. This way steam evaporated in the first stage would be virtually NH_3 free and could be condensed in a small, simple ejector scrubber using whatever cooling waters were available. The portion of the main scrubber water balance thus freed up would add measurably to the ability to handle fresh water scrubber blowdown. Actually, vapor pressure of NH_3 over ammonium phosphate solutions are quite low up to 1.2 or 1.3 mole ratio and a properly designed gas-liquid reactor will have minimum loses of NH_3. A number of people here today would appreciate comments of anyone having experience in this area.

Another method of helping out the water balance is the introduction of an ammonia vaporizer to the preneutralizer and sometimes the granulator ammonia stream. Opinion is mixed on the latter and generally in favor of the former. Ice balls tend to form in a reactor using liquid ammonia unless agitation is intense and the extra heat does help. Further work is needed before the valve of vaporized NH_3 to the granulator will be generally accepted.

Another consideration in preneutralizer operation is residence time. Early systems often incorporated two tanks, the first overflowing into the second where pumps were located. Several modes of operation were possible such as ammoniating to 1.7 mole ratio in the first tank with addition of phosphoric acid in the second tank back to 1.4 ratio or so. The main disadvantage of this, other than being unnecessary, was the formation of citrate insoluble P_2O_5 forms in the higher pH section. Values as high as 1.5 to 2.0% C.I. were present at one plant before going to a single tank. Results now are 0.1 to .2 or less. Another stated purpose was to give better conditions for pumping the slurry from the final tank. Several standard pumps have proven satisfactory for removing boiling, highly ammoniated slurries directly from the prime ammoniation vessel. At New Wales we have been using open impeller model AF Wilfleys with good success.

The two stage reaction also reduces the amount of super-saturation present in the granulator. Remember, liquids can be ammoniated, solids must be dissolved first. When two stage neutralization was used, plants were probably not pushed as hard as they are now. At high rates, crystal bloom is capable of keeping oversize down. Overall, however, it would probably limit the nitrogen grade somewhat as the increased quantity of crystal matter would reduce ammoniation. Therefore, short residence time and high supersaturation are desirable.

Scrubbing

DAP production is an inherently pollution free process if you work in Florida and value your dust. Ammoniation of ammonium phosphate slurries under normal conditions liberates little fluorine and there is no control limit set on ammonia. I suppose this latter is an attempt to neutralize acid rain. Anyhow, the acid scrubbers shown usually do an effective job of picking up ammonia as well as any valuable product exiting the cyclones.

We have run numerous tests showing lower F—leaving our three acid scrubbers than leaving our tailgas scrubbers. At first glance this would seem to be due to some loss of the 500,000 #/day F^- circulating over our crossflow tailgas scrubber packing. Our consultant, Dr. Aron Teller, tells us that it is actually Ammonium Bifluoride created by the gas phase ammoniation of HF liberated in our acid scrubbers during ammonia upsets from the granulator and the preneutralizer. Our plant's flowsheet allows no contact of fresh acid with ammonia bearing gas streams for this very reason.

In an attempt to find out how some of you good people are getting away with spraying 30% acid in granulator ducts, etc., we happened upon an interesting fact: A number of producers have gone to fresh water tailgas scrubbers.

(Slide #1-A) These take two forms depending on where the heat load from the scrubbers is absorbed: *(Slide not available)*

Tertiary scrubbers:

cyclones → acid venturis → gypsum pond water over packing
(cooler) → fresh water over packing →
Dual scrubbers
cyclones → acid venturis → captive scrubber pond water
over packing (cooler)

If a hot (but visible) stack is desirable for water balance reasons, the fresh water is allowed to recirculate and reach an equilibrium temperature. Otherwise, a captive scrubber water cooling pond is required. The first operates generally with some form of neutralization such as caustic addition and the second requires a moderate sized pond to keep the water inlet temperature in reasonable range. This loop must remain relatively pure, but recall that NH_3 keeps the pH up and the actual F^- addition is only several hundred pounds a day at worst. Another point to consider is the primary acid scrubber sump gravities. Problems in F^- emissions seem to occur when 40% P_2O_5 or stronger acid is used without dilution. Sump pH is considered important but varies from 2 to 5.

In our particular case, we are spending several millions of dollars on our granular plants to insure we go into the 1980's with clean stacks. Included in this is a dry scrubber for GTSP fluorine using an absorbent called Nephelene syenite. This is for GTSP production. Dr. Teller assures us it is the wave of the future for DAP plants as it can operate at high temperatures and eliminate cooling ponds. Such a unit would follow the acid scrubbers and absorbent requirement would approximate 10 to 50 #/hr. For our DAP plant, however, we are settling on detail changes for the present.

Overall, best available technology appears at present to be some form of Tertiary scrubbing or dual scrubbing with a captive fresh water pond.

Grade Control

If there are any Texas Gulf people in the audience you may want to commiserate with them on their difficulty in keeping P_2O_5 grade below 47 and nitrogen grade below 18.5 at Aurora. For the rest of us, we need sympathy that DAP is sold O.B. basis and not D.B. (dry basis). I have to make a plug here for the agronomic value of those good old micronutrients we throw in for free in our Florida rock based DAP.

Seriously, most wet process phosphoric acid plants spend a great deal of effort getting impurities down to the point the acid will ammoniate to 18-46-0. Traditionally the phosphate-bearing solids that come out during acid concentration were absorbed in R.O.P. triple super, then granular triple super, and MAP. A certain percentage remains in the DAP acids supplied above 40% P_2O_5 simply because of the difficulty in removing it. As a crude guide, 54% acid containing over 2% suspended solids or less than 63.5% P_2O_5 calculated on dry basis from a Karl Fischer titration will be difficult to ammoniate to 18-46-0. All sorts of strategies have been tried from ignoring the problem to adding urea. Those willing to make DAP from Merchant acid will not need to bite the bullet . . . . . directly.

High Mag Rock

Another problem that arises is acid magnesium content. IMC has recently evaluated tests using DAP feed acid with MgO levels as high as 1.5%. The combined I&A and MgO/P_2O_5 ratio exceeded 0.1. At this level most people might expect difficulty making grade. The pilot work, done at TVA, achieved the following results:

(Slide #3)

	ACID			PRODUCT	
	I&A	MgO	$\frac{\text{I\&A + MgO}}{\text{P205}}$	O.B. N	O.B. P205
RUN 7 & 8	2.71	1.44	$\frac{0.100}{1}$	18.4	47.9

Many of you will be familiar with this data as it has recently been published by our Art Baumann and Frank Nielsson on several occasions. The relatively low I&A is typical of large deposits of rock with the higher magnesium level which is as yet unmined.

Several problems were noticed in processing this rock to R.O.P. triple and DAP. For triple, the product was extremely sticky, building up on idlers and belts. For DAP the preneutralizer slurry had to be more dilute for pumping and the resultant liquid phase increased the required recycle ratio. Some increase in oversize formation was noted. As a result of these tests and others, some feel the problems processing high magnesia rock will largely be physical rather than chemical. The fact remains that whenever producers encounter high MgO levels grade problems generally ensue.

Very recently IMC and others have been looking at a $Mg\text{-}NH_3\text{-}PO_4$ complex with N. waters of hydration, called struvite. One western producer finds N to be 6-8 in value. This bound water acts as a diluent and that producer has difficulty in exceeding 17.2 N when MgO levels appraoch 0.7%.

(Slide #4) Other grade problems arise in DAP. The most serious is Citrate Insoluble P_2O_5. The IMC work done at TVA gave C.I.'s as high as 3.7% of total, or 46.4 APA (available phosphoric acid, expressed as P_2O_5). Still not bad, but indicative of C.I. complex formation. The second compound shown was recently identified by TVA from samples submitted by a Florida producer and is a known cause of C.I. P_2O_5 values.

MgNH4 PO4 · N H20
FeNH4 (HPO4)$_2$ · 1/2 H20

(Slide #5) A very interesting paper published by some Simplot people, J. L. Smith and C. M. Davis, in the May, 1968 issue of *Farm Chemicals* and earlier in the 1967 Round Table Proceedings points out that the AOAC C.I. method was developed to detect undigested rock in super phosphates. The C.I. in DAP is available to plants and some compromise may be necessary in years ahead to compensate producers for P_2O_5 supplied in this form.

An analysis of the C. I. material isolated by Smith and Davis is given here. No specie identification was done but it is likely their agronomic findings apply to a variety of compounds.

The next slide *(Slide #6)* gives just a few of the over 250 associated compounds in fertilizer identified by James Lehr and others.

Process Flow Variations

Water of hydration, on the other hand, is a definite penalty producer. No one wants, in this energy and rail car short era, to ship more water than necessary. Obviously TVA and IMC, in our tests, have avoided grade problems. How? We're not sure.

Art Baumann has developed an interesting ammoniation efficiency concept which shows the existing TVA pilot plant, and producing plants roughly 10 years ago, had higher ammoniation efficiencies than the present New Wales plant. The difference is suggested to be recycle conditions and other plant factors.

(Slide #7) The TVA pilot plant flowsheet shows cooling after the dryer but before screening. It is essentially the same as the flowsheet published by Young, Hicks, and Davis in the November-December, 1962 - *Journal of Agricultural and Food Chemistry.* The results are recycle and preneutralizer temperatures that differ from present as follows:

(Slide #8)

TEMPERATURE OF PROCESS STREAMS °F

	TVA	IMC-1966	IMC PRESENT
preneutralizer slurry	225-226	235-250	240-265
granulator discharge	170-180	180-195	190-200
dryer product	156-178	-	175-190
recycle	108-126	-	155-160

Recycle ratios of 5 to 1 are common now. TVA regularly has run at 2.9/1 and during this test went to 4.8/1 due to the increased water needed for pumping from the preneutralizer. The cooler recycle and the minimum recycle have apparently reduced formation of high water of hydration complexes and retarded formation of C.I. PO_4 complexes.

The DAP producer submitting the iron containing sample has indicated residence time in the preneutralizer as critical in C.I. formation. By lowering his reactor level a definite decrease in C.I. P_2O_5 in the DAP product is seen. There are indications this is true in Struvite formation also.

Experiments at New Wales have shown it is possible to drive off some of the waters of hydration without losing too much ammonia, thus enhancing grade. It is possible that some of this bound water is lost as the recycle is cooled. In any case, x-ray studies of the IMC-TVA product showed no Struvite, anhydrous or otherwise.

(Slide #9) Much more must be learned about this inner chemistry of DAP before predictions can be made. Granulation technique, however, is fairly well understood. The next slide shows the relationship of several variables for the IMC-TVA DAP tests.

This data is the product nitrogen grade and ammoniation efficiency compared to granular discharge moisture. Other factors could be correllated, such as slurry specific gravity, but the fit is even less good. Even though the fit is not great, one can imagine that the data is at fault. This is especially easy for one producer, who varies his preneutralizer gravity, and thus his recycle rate and granulator conditions to optimize either nitrogen grade or production rate. This company has four DAP plants at the same site. With equal acid feeds, one plant can be running 0.2 to 0.3% N higher based solely on granular feed moisture. Maximum rates are at minimum grade and 3/1 recycle ratio.

The next slide *(Slide #10)* compares preneutralizer slurry moistures versus recycle ratio. The higher moistures relate to higher recycle rates and, of course, lower liquid viscosities. The factors important here are surface area to soak up the extra liquidity, and more even liquid coating which supposedly gives the higher granulation efficiencies.

Recycle Rates

I would like to diagress here to discuss recycle rates. The historical slurry granulation theory called for recycles of 8 to 10 to 1 or higher. As producers began to practice what I call phase granulation, the causing of precipitation and phase changes in the granulator rather than merely drying of the recycle in the dryer, recycle rates dropped. The classic example is certain types of easily soluble MAP in powder sizes, which due to high surface areas and ammonia dry up, can be granulated to DAP grades at recycle ratios of 2/1 and less. Melt processes should operate under much the same conditions, yielding low recycle rates. Typically, however, most plants operate at 4 to 5 to one or higher. Why? Probably the size of the recycle. Recycle by design absorbs the liquid phase on its outer surface. As partical size haves, surface area doubles. Hence allowing the oversize to accumulate increases the demand for recycle even more, a common Catch 22 for present plants. Remember also, the recycle temperatures shown earlier. The reduced temperature of the granulator feed solids will also cause a reduction in recycle ratio.

Future Flow Sheets

Capital costs have increased but so have fuel costs. If a producer could be sure of making satisfactory DAP at 3.0 to 3.5 recycle ratio, he might be willing to sacrifice some energy efficiency for higher rates in the same plant. In some cases he can do this by increasing the surface area of his recycle with additional grinding, or he may want to increase the effectiveness of his existing mills by cooling the recycle. With the same recycle elevators and conveyors he should thus be able to produce, say, 20% more by dropping from 4.5 to 3.5 to one recycle ratio.

Another possibility should be considered. Today much of DAP production goes into bulk blending. Cracked particles that used to look so bad in direct application are less obvious in bulk blends. Those people who have screens on their mill discharge are not exactly sources of tales of woe about customer rejection. It certainly does not make sense to send a 3 mesh particle back to the granulator.

(Slide #11) With this in mind, I would like to discuss this new old flow-sheet. As you can see I am suggesting cooling the oversize and rescreening it after milling. Plants are operating with the flowsheet with good results. I would appreciate your comments if you know of any specific pros or cons with this arrangement.

The screen cloth on a single deck dryer screen can be selected on the coarse side to avoid too much recycle cooling. Our recent tests with high magnesia rock showed a tendency to over granulate and the T-10 fraction ran about 20% of the dryer product. Converting an existing plant with double deck dryer screens would allow some recycle tuning with the "product" size as the bypass, or alternately, a portion of the "on" material can be milled as shown here. As higher magnesia acids are used to produce DAP, this flowsheet may become more common. The reasons for this are part fact, part speculation. In order of current importance they are:

1. Grade advantage. Even with 1.5% MgO the IMC-TVA DAP never ran over 0.57% C.I. P_2O_5, and ammoniation efficiency was higher than current large plant experience.

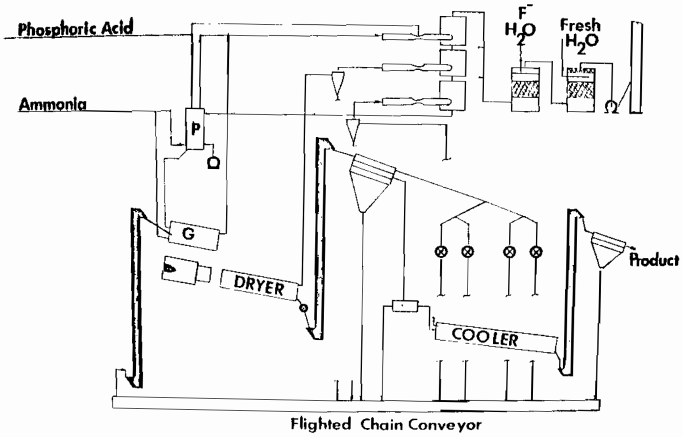
2. Recycle ratio. At the slightly higher preneutralizer moistures needed to aid pumping the more viscous slurries, unless recycle size and temperature control is excellent, the recycle ratios will increase.

3. Grindability. Producers regularly handling high MgO rock are faced with continuous mill problems and accelerated cleaning schedules. Cooling the oversize should help here too.

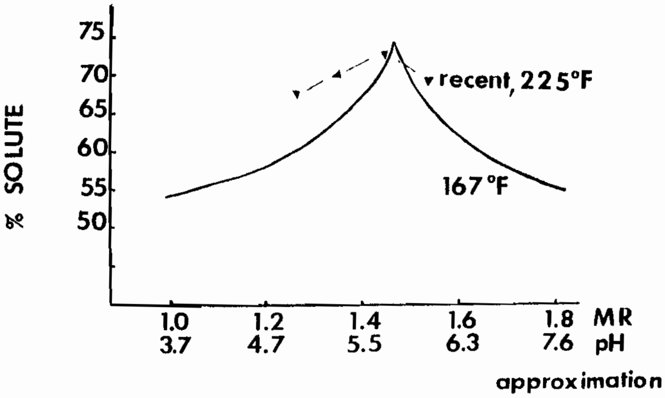
4. Water balance. The preneutralizer mode shown should not normally be necessary but may help if water balance is a problem.

We were very pleased at the results of our DAP tests with high MgO rock. This is part of a continuing effort to understand those results and apply them as necessary. It has been my pleasure to share it with you. Thank you. (Applause)

MODERATOR MALONE: Thank you George for that fine presentation. We certainly appreciate all of this information and please stand by, I am sure for questions.



Slide 1



Slide 2

ACID			PRODUCT	
I & A	MgO	$\frac{\text{I\&A+MgO}}{P_2O_5}$	O.B.N	O.B. P_2O_5
2.71	1.44	$\frac{0.10}{1}$	18.4	47.9

Slide 3

$MgNH_4PO_4 \cdot N \cdot H_2O$

STRUVITE

[redacted]

$FeNH_4(HPO_4)_2 \cdot \frac{1}{2} H_2O$

Slide 4

C.I. P_2O_5 EXTRACT

☐ T.P.A. (P_2O_5)	40.89
☐ T. Nitrogen	7.92
☐ W.S.N.	0.16
☐ Fe_2O_3	1.77
☐ Al_2O_3	12.78
☐ MgO	10.82
☐ F	7.64
☐ SiO_2, SO_4, CaO, Na_2O	nil

Slide 5

COMPOUND X

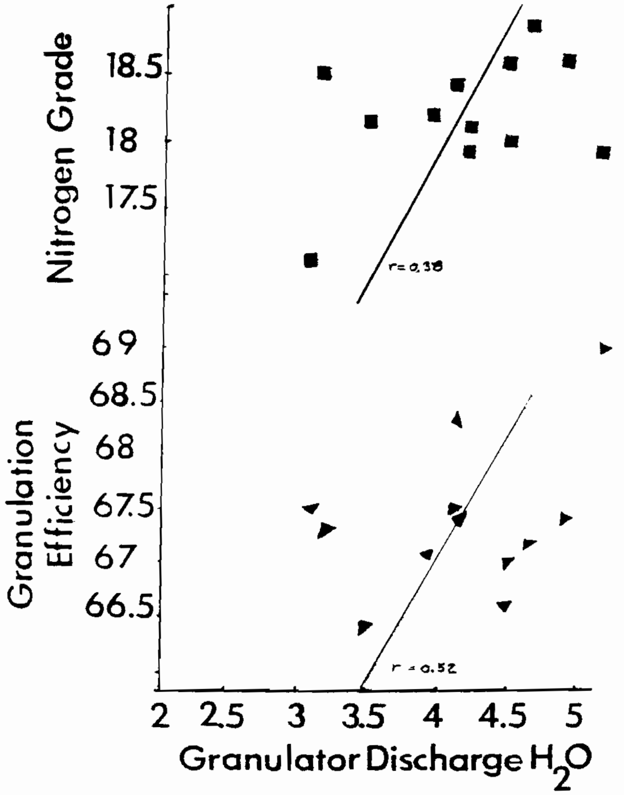
$Fe_3KH_{14}(PO_4)_8 \cdot 4H_2O$

$Al_3KH_{14}(PO_4)_8 \cdot 4H_2O$

$Fe_3NH_4H_{14}(PO_4)_8 \cdot 4H_2O$

$Al_3NH_4H_{14}(PO_4)_8 \cdot 4H_2O$

Slide 6



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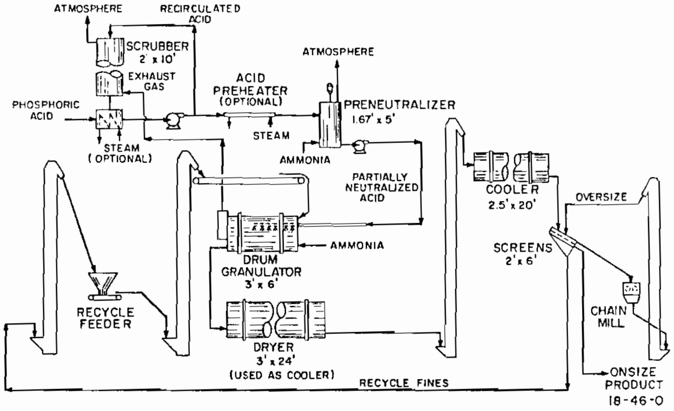
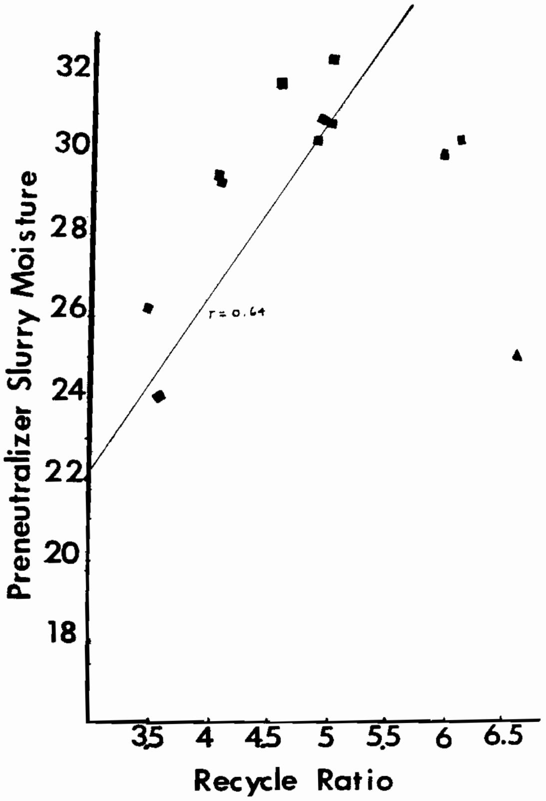


Slide 7

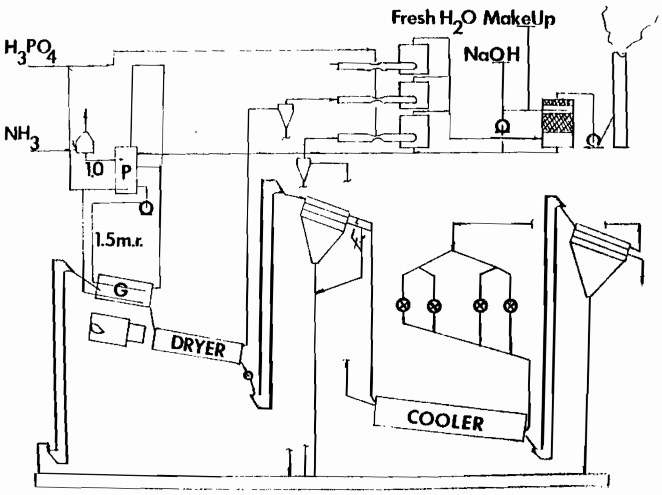
DAP PLANT PROCESS TEMPERATURES

	TVA	IMC 1966	IMC PRESENT
Preneutralizer Slurry	225-226	235-250	240-265
Granulator Discharge	170-180	180-195	190-200
Dryer Product	156-178		175-190
Recycle	108-126		155-160

Slide 8



Slide 10



Slide 11

MODERATOR MALONE: Our "wrap-up" speaker for this morning's session is Lyman B. Johnson, and he will be speaking about "Bulk Blending in the '80's". Lyman was employed for 13 years with Lucky Farmers, Inc. of Lucky, Ohio. He advanced from Field Representative to the Fertilizer and Pesticide Manager of this company. In 1975, he accepted a position with the Ohio Farmers Grain and Supply Company in Fostoria, Ohio as Manager of their Plant Food Department. Currently, Lyman is Vice President, Agronomy Division, of the Ohio Farmers Grain and Supply. During the past 17 years, Lyman Johnson has held many positions on state and local trade organizations of the fertilizer industry in the state of Ohio. He holds board positions with CF Industries, Long Grove, Illinois and Inter-Regional Fertilizer Cooperative. Lyman, I am pleased to welcome you to this wrap-up speaker position for the 29th Fertilizer Industry Round Table Meeting. (Applause)

Bulk Blending In The 1980's

Lyman B. Johnson

I. BACKGROUND OF OHIO FARMERS
  A. History of
  B. Operations of
    1. Geographical area
    2. Products marketed
      a(grain
      b) feed
      c) seed
      d) farm supplies
      e) TBA
      f) pesticides
      g) fertilizer
        1) st. ingredients
        2) trace elements
        3) liquid fertilizer
        4) fertilizer equipment
        5) bulk blends
  C. Services performed for Dealers in Agronomy Field
    1. Agronomy Reps
      a) consultation with dealers on all agronomy products
      b) help with "on farm" programming
      c) perform farmer meetings
    2. Most Important tool is Use of Soil Tests
      a) promote use of testing with dealers
      b) pay for 1/2 of soil tests
      c) work with local lab in developing good agronomy recommendations for dealers
    3. Use of Tours of Agronomy Plots & Fertilizer Plants
      a) the "look-see" performance is always impressive
      b) how new systems can be benificial for dealers
      c) new developments are shown to dealers and farmers
        1) "no-till" versus "conventional tillage"
        2) new starter fertilizer for the future new hybrids -new varieties - new pesticides

II. BULK BLENDING of GRANULAR FERTILIZER
  A. How and Why Ohio Farmers became involved in the blended fertilizer market
    1 . 1935 — Built first blender
      a) cement type rotary
      b) ingredients - potash, anaconda 45% phosphate, ammonium sulfate, & filler (sawdust, ground cinders or muck)
      c) built five plants in Northern Ohio to get product closer to farm market
      d) very powdery and dusty
    2. World War II Years fertilizer ingredients became very tight and young men to operate blend plants became scarce
    3. Manufactured fertilizer took over after war, being replaced by granulated ammoniated fertilizer in 50's

    4. Cycle turned back to blend in early 60's with cheaper blends and prescription blending for farmers

B. Past Methods of producing and storing blends
    1. Bagged blends were the only way many farmers could handle fertilizer
    2. Bulk blends were mixed at central point and hauled to out lying warehouses
    3. Farmers were satisfied with common analysis such as 6-24-24, 6-24-12 or 12-12-12
    4. Early 60's blended products segregated badly, due to poor sizing of ingredients
    5. Bulk storage for ingredients very limited, thus couldn't take advantage of "off season" prices
    6. Didn't utilize the high analysis forms of nitrogen or trace element products

C. Present and Future methods of Bulk Blending
    1. Farmer will have very little use of bagged fertilizer, especially with the advent of hydraulic augers to fill starter fertilizer boxes on planters - or the use of auger tender units or side dump boxes to fill floater spreaders
    2. Bulk blenders are now located at the dealers place of business (where the action is)
        a) size of blenders becoming larger for more speed
        b) blenders more compact "on scales"
        c) not as costly — thus ease of purchasing
        d) developing blender unit to mix more throughly with more tonnage output
        e) use of noncorrosive materials such as stainless steel and fiberglass
        f) overhead holding bins of ingredients or finished products to speed movement of product
    3. Farmers want high analysis, lowest cost, no filter blends
    4. Sizing of most ingredients in 6 to 14 screen grades - thus lowered segregation problems
    5. Blenders on local level building bigger and bigger plants, either replacing old plants or adding on to present plants to increase storage capacity
        a) able to capture more lower priced ingredients in off season
        b) not fearful of running out of product in season
        c) business growing to the extent more storage is needed
    6. Blenders now spreading the total fertilizer and herbicide needs of farmer
        a) applying all or most of N-P-K (especially with granular urea) in one pass over field -farmer puts little starter in row and fertilizer job is done
        b) incorporation of herbicide on dry blends gaining acceptance in many areas
        c) trace or secondary elements can be added for farmers individual soils needs on local level
    7 New Blend Dealers now realize the profit and inventory controls gained from bulk blending

III. THE FUTURE OF BULK BLENDING
    A. Ohio Farmers very optimistic about future of bulk blending
        1. More and more dealers programming farmers utilizing soil tests - result: higher fertilizer usage and prescription blends
        2. Use of floatation equipment, bigger farmer equipment, and condensed planting season mean dealers have to be more responsive to farmers - result: larger blending units with faster output
        3. Farmers want higher analysis, low cost fertilizers - answer: bulk blending
        4. Farmers like the total spread concept -meaning one pass over the field and everything done except for little starter in the row - result: higher urea usage and normally more correct N-P-K usage
        5. More use of herbicide incorporated on bulk blends and the employment of secondary or trace elements (ideal products for blending) - result: higher yields at less cost with more smiles
        6. No-till corn farming growing in Ohio Farmers trade area: result higher nitrogen and potash broadcast grades with higher use of phosphate in row — lends itself to bulk blending beautifully
        7. New fertilizer high analysis dry ingre-

dients on horizon (urea polyphosphate 45-90-0) - results: higher analysis, lower cost and better crop uptake

B. Bulk Blending Potential for the Midwest and rest of U.S.

  1. Bulk blending has reached a "so called" plateau in many areas of midwest -many other regions bulk blending still hasn't reched full potential Why:
     - a) dealers not using full value of soil testing
     - b) dealers not providing full custom services to farmer customer
     - c) dealers not programming farmers for high yield goals
     - d) dealers not using all the resources that bulk blending can perform which are:
       - 1) total spread concept
       - 2) use of high analysis blends
       - 3) stressing service, not price
       - 4) use of secondary or trace elements
       - 5) Impregnating herbicides in blends
     - e) we as an industry still cannot agree totally on standard sizing for blend — take coarse or granular potash (which does blender use?)
     - f) how much are we providing the dealer in the way of agronomic services, blending schools or use of major or trace elements in blends?
  2. Potential is inlimited when we as an industry breakdown the past problems I have mentioned
  3. Just owning a blender doesn't put a dealer instantly in business with farmers breaking down his door pleading for products — He must sell the farmer on the advantages of a blend, of his services and his ability to deliver in the heat of the season, — the answer — Sure there is lots of room for growth with blenders, but it takes work — The blend business is there all you have to do is go get it. (Applause)

MODERATOR MALONE: Thank you very much Lyman. You have certainly fulfilled the challenge of wrapping up this morning's program in a real fine fashion. I believe you even thew out some challenges to Frank Achorn and Dick Farst with their figures and the projections on the suspension fertilizers too. I am sure the speakers will entertain any questions that any of you have right now. Here is your opportunity.

Questions and Answers.

QUESTION AND COMMENT—Lyman Johnson: I would say that, again, our problem, as we have especially seen it this year, is that our phosphate people, especially, right now, quality is way in the back of our mind. The most important fact that they are looking at now is quantity. So, therefore, the product that we get out in the field very many times is not the particular grade that we would like to see to be able to match with our granulated urea and granular potash. Again, I think that we do have a problem here as to trying to figure out — I know it is strictly an economic problem — what market are we going to try to serve? Are we going to try to serve the international market or are we going to try to serve the domestic market? Are we going to be looking at and trying to come up with a better quality product? We have seen in the past, traditionally, if you look especially at the studies that T.V.A. has done, that the DAP-Triple, especially, are undersized in comparison to the granular urea and the granular potash.

MODERATOR MALONE: Would anyone else care to comment on the question of quality?

GEORGE HEBBARD: I would like to make a comment on DAP sizing and such things, as a producer. We are pushed right now. We are pushed, not because we want to make the money, but because the demand is there. We are barreling through the plants as hard as we can. There's bound to be compromises, but the cash flow is there now to take the time to fix these things. For example, I know of a number of plants right now that are putting polishing screens on. They are getting their plants to a position where they are catching up with the production rate. I think, over the next few years, you will see all manufacturers paying constant attention to quality. It is not a matter of just barreling the stuff out for export markets.

QUESTION: FRANK ACHORN: I have a question for George Hebbard. First, I want to say you made a very excellent presentation. The data you have collected certainly will be helpful to all of those in DAP manufacture. I wonder, on grade control, have you any extra data on the increased temperature in the granulator, increased temperature of drying, as related to the I and A content of the acid used?

ANSWER—GEORGE HEBBARD: To answer you, Frank, the amount of data right now is very small. One of the main purposes of my talk was to present the fact that there are some things that should be looked at. I was embarrassed in my talk not to have given credit to the many, many people I talked to and the many people that shared information on this subject I spoke about. To me, the impressive thing about this industry and about this talk is the cooperation that people are willing to give each other. No, we do not have any firm information on C.I. production in the plant. We don't have a C.I. problem that we are aware of. We were amazed to find out that a lot of people do. I think probably the reason we don't is, even at the high temperatures we are running, (We are pushing our plant at 90 tons an hour — It is a 50 ton plant — We are building two more plants which will be 140 tons total additional.). We are pushing these plants so hard, we have no residence time. If I would point at one factor for C.I. and C.S. or whatever (a loss), first of all, it would probably be that it isn't a loss, and second of all, that it has to do with the residence times at these high temperatures. So, this is why I emphasized making attempts to get the temperatures down, which, at the same time, would reduce the residence time in the system.

COMMENT—CHAIRMAN NIELSSON: I just want to back up Mr. Hebbard a little bit. I will be giving a paper in London on these tests we made with high mag. rock where we made some acid in our Port Macon plant, and made triple there. Then we did the pilot plant work at T.V.A. We compared it with our regular acid from New Wales. The thing that we say in the paper finally is that things were better than we expected it which indicates that may have been due to design, because the T.V.A. Pilot Plant data just gave results that nobody expected, Actually, personally, most of us involved in this test work felt (and this you cannot tell to the boss, because it won't do any good) that what is happening is that everybody is running their plants 100% over design. Now, the T.V.A. data shows pretty well that, if you slow down, and run at design, in a properly designed plant, you can make grade. You can just look at the numbers. You look at the lower temperatures, those that you had up there, Hebbard. You look at years ago. At T.V.A. they ran 20 to 30 degrees cooler in their pre-neutralizer, in the dryer. When you look at that kind of data, you realize that now we are running higher. The higher the temperature, we know that DAP is a little bit unstable. We know that higher temperatures cause adverse reactions. I think that if everybody who has problems will just slow down for a while — but, you can't do that. Especially, when you can sell the stuff at $265 a ton.

MODERATOR MALONE: Thank you very much, Frank. Yes, we do want to keep that DAP rolling into our plants. Another question? Yes, Travis Hignett.

QUESTION—TRAVIS HIGNETT: This question is for Henry Plate. You compared bulk blends containing urea with a starter fertilizer which was homegenous granular fertilizer, which I presume did not contain urea. Is that correct?

ANSWER—HENRY PLATE: That's correct, Travis. It did not contain urea.

QUESTION—TRAVIS HIGNETT: Would you care to speculate what would happen if you added a one to one homegenous granular fertilizer containing urea?

ANSWER—HENRY PLATE: I guess it would depend a little on how much urea was in there. If you went all the way, I guess I would get a little worried. I have no idea. Have you tried this at all, Travis?

ANSWER—TRAVIS HIGNETT: I think that might be of some interest in the future to granulators who are considering using urea and making homogenous granular fertilizers.

MODERATOR MALONE: Does anyone have any experience with starter-type fertilizers with a large amount of urea in them?

ANSWER—FRANK ACHORN: There are people that are using urea now. No one has conducted any agronomic tests with that, have they?

ANSWER—CHAIRMAN NIELSSON: I know just enough agronomics to get myself into trouble. I always say I am not an agronomist. What I am wondering about in all this talk about urea, I can't believe that all of it is due to decomposition, all the way to CO_2. You never indicated biuret contents because on the way to complete decomposition of the urea, you do get one ammonia coming off and biuret. I know you have to get 50 lbs. of "N" to an acre from biuret to get biuretoxicity. From the test that you show over there, as you go to more and more urea, you get more and more burning, which could be salt effect or something else. Has anybody looked at the possibility of biuretoxicity as you get into more and more urea?

ANSWER—GEORGE HEBBARD: The only thing I would say to that, Frank, is the product we were using was about 1.2 to 1.4 biuret. Beyond that, I don't have any further information. Of course, the practical side of it is, we are not even too sure whether it is ammonia toxicity or nitrite in addition to the biuret thrown in. You get something here from the urea.

MODERATOR MALONE: Any further comments from anyone on this matter?

QUESTION—LEO L'ECUYER: I would like to ask Mr. Johnson. You mentioned the cost of building the bulk blend was $30,000. It seems to me that only a mixer costs approximately $15,000. Where do you get your estimate?

ANSWER LYMAN JOHNSON: Very good question. That was the cost of the building and the mixer together. I won't give you the — well, I would be advertising the cost of the particular mixing company, to tell the truth. You can put up a pole building that is probably 15 x 25 in size and has a four ton mixer on scales with a plywood leg, and that's what the cost is. This is elctric and everything.. So, that is actual cost.

QUESTION—PAUL BRZUSZKIEWICZ: I have a question for the gentlemen from Ohio Farmers. You showed in one of your slides that you do a certain amount of impregnation of dry bulk blend with pesticides. This is very good in Ohio corn country, but what is your procedure when you want to apply dry fertilizer to an alfafa field where you have done some impregnation for a corn field?

ANSWER—LYMAN JOHNSON: Would you repeat the last part of your question.

PAUL BRZUSZKIEWICZ: Yes. When you change from one mixture, going out into a corn field using impregnated fertilizer, don't you have a mixture for an alfafa field or a hay field? Do you do anything as far as cleaning your processing equipment, your blending equipment?

ANSWER—LYMAN JOHNSON: Yes. Stauffer's recommendation on their label soap says this. They would like to see a potash type mixture, especially a high potash mixture, as the following mixture after your impregnated blended product. They don't feel that there should be any problem at all, but, again, they are trying to eliminate the risk factor.

QUESTION—PAUL BRZUSZKIEWICZ: Have you had a problem with this in your plants at all?

ANSWER—LYMAN JOHNSON: No, we have not. In fact, we are in tomato country up there. If there is any crop that is most susceptible to herbicides, it is tomatoes. We have had no problem at all. The high potash mixture goes on the corn.

MODERATOR MALONE: Any more questions for our group? I think we have had a real fine group of speakers here and excellent, great presentations. I think we ought to give them an extra hand. (Applause)

This concludes our session for the 29th Fertilizer Industry Round Table. Our Chairman, Frank Nielsson, is here to conclude our program this morning.

CHAIRMAN NIELSSON: Thank you, Al. He's done a nice job today. I just want to remind you all, the first session on Tuesday morning, we finished on time. Today is the last session. We are finishing on time. We will try very diligently next year to make sure that in the intermediate sessions, we will have one less speaker, at least, allow each speaker more time, and, hopefully, finish on time. I know that, in my younger years when I used to be a speaker, I always told them that the one thing that tee's me off is to be the last speaker at 5:35 on Tuesday night and Wednesday night when they are having a cocktail party and all you guys are going "ungh". So, we didn't quite have that this year, but we came close. Next year, believe me, we will try to do better. Thank you. Dismissed. (Much Applause)

Comments By Albert Spillman

Editing Chairman

I am confident you will find "Our 1979 Proceedings", covering our 3-day, 5-session Program, most interesting.

We had an "Excellent Meeting", covering "Updated Discussions", which should materially help us in our "Day To Day Operations".

Our Audience seemed to be very much interested in "Our Program Presentations". There was much applause.

My pleasure again, as it has been since "Our Round Table started 29 years ago", to "supervise, edit, organize and deliver to our printer approximately 530 thoroughly checked script sheets, covering all of the activities, talks, slides and questions and answers".

All of my contacts, with many of you by "correspondence, telephone, etc.", asking for "answers necessary to permit our proceedings to be published accurately as possible", sent me their replies within a reasonable time, considering being away from your office when necessary.

My thanks to "all of you, our Chairman, Directors, Moderators, Speakers, Secretary-Treasurer—Paul Prosser, Jr., his most cooperative secretaries, our printer, Tom Sabia, Manager of Quickee Offset, Inc.—-Baltimore, Maryland, and his most helpful organization". To you I say "Much Appreciation".

Hope you can attend "Our 30th Annual Round Table Meeting" to be held in Atlanta, Georgia, The Biltmore Hotel, Tuesday, Wednesday, Thursday, October 28-29-30, 1980. We promise you another most interesting Meeting.