PROCEEDINGS
OF THE
12th ANNUAL MEETING
FERTILIZER INDUSTRY ROUND TABLE
1962

Held at the
Mayflower Hotel
Washington, D. C.
October 24-25-26, 1962

Executive Committee

Vincent Sauchelli, Chairman
Housden L. Marshall, Sec'ty-Treasurer
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Executive Committee

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Fertilizer Industry Round Table

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Wednesday Morning Session, Oct. 24, 1962

The Fertilizer Industry Round Table, Twelfth Annual Meeting, convened at nine forty o'clock a.m., in the State Room, the Mayflower Hotel, Washington, D. C., Dr. Vincent Sauchelli, Moderator, presiding.

MODERATOR SAUCHELLI: Let's come to order, please. I am sorry for the delay. We delayed in order to give the registrants an opportunity to register.

Welcome to the twelfth gathering of the Round Table. We have all looked forward to these sessions with eager anticipation of meeting old and making new friends and to learn some of the new evolutionary changes in the technology of our dynamic fertilizer industry.

I sincerely hope none of you will be disappointed. Your Executive Committee has organized a comprehensive agenda that has something worthwhile for each of the several segments of the industry.

I want to acknowledge here the fine help that the other members of the Executive Committee have given me in organizing this program. They have worked hard.

As you know, following the sessions of each Round Table, the Executive Committee begins with some apprehension to plan for the next meeting. It is a problem. It is not getting easier. We lean heavily on suggestions and problems you, the membership, furnish us as a basis for the coming program.

So far apparently, we have been successful. We trust that this year's program will come up to expectations.

As you were informed by letter, if your specific inquiry is not incorporated in any of the agenda subjects, please don't hesitate to restate it from the floor at the time the subject is presented.

Our Round Table is distinguished by its informality and by the frank exchange of ideas and information. I like to think that we have analytic and catalytic minds in our audience. You never know how your comments or suggestions may catalyze another's thinking. So once more, I plead with you, do not hesitate to participate in the question and answer period following each presentation.

That is the heart of our Round Table Sessions, the discussion from the floor and the participation of you all in the discussion. Unbiased information is one of the best public services that these Round Table Sessions can offer. It is the inverse of secrecy.

We like to believe our meetings have contributed a great deal to the removal of the former secrecy which prevailed in the industry regarding processes and formulations.

During the year, I was privileged to participate as Chairman in two regional conferences on fertilizer technology, sponsored by the National Plant Food Institute. One was held in Savannah, Georgia for the Southeast Region; the other at Dallas, Texas for the Southwest. These regional conferences do not compete with our Round Table. They supplement it.

Many of the smaller fertilizer producers in each region have local problems on which they like to have information. They also believe they cannot justify the expense of sending their men to our meetings here in Washington, and especially since we deal in subjects of more or less national interest.

The two regional conferences turned out to be very successful. The enthusiasm shown by the local interest was really heartwarming. One feature of the meetings which was particularly commented on by all was the high percentage participation of the audience in the discussions.

We recognize that it is easier, when you have a group of about 60 or 70 people in an audience, for the group to participate and to speak frankly. When you have too large a group, there is some hesitation on the part of persons to stand up and ask questions. They fear they are taking up time and some feel even a little bit timid about raising some question which might reflect on their own knowledge, and so on; but I hope you won't feel that way. None of us knows too much about these problems and a frank discussion is welcomed.

Plenty of opportunity for questions and answers was provided and as I said, they made the most of it. I sincerely hope these regional meetings will continue. The changes which our industry is undergoing are so rapid and almost revolutionary. Operational people cannot take refresher courses at colleges or elsewhere to keep pace with these changes. The technology conference offers them a chance to meet with colleagues and to learn through the lectures and personal contacts something practical about what is going on in their particular line.

They provide on a regional basis what our Round Table does at the national level. In this connection, it may be pertinent to refer to the TVA demonstrations of fertilizer technology held on August 7 and 8th at their Wilson Dam Research Center. It was a well attended affair and attracted fertilizer personnel from all sections of the United States and from many foreign countries. It had all the air of an international meeting. Many of you here today were there.

The TVA Chemical Engineering staff is to be commended for the high standards set at these affairs and the efficient manner in which demonstrations are put on. They help to get fertilizer personnel acquainted with new developments in fertilizer technology and with each other. The big advantage of the TVA meetings is that they use pilot plant and full scale operations to show what the new developments are and then the demonstrations are supplemented by detailed, informative lectures.

I am certain that all who are privileged to attend will agree that those demonstrations comprise a most useful service to our industry.

Now let me turn the spotlight on our agenda. Our program starts with that major nutrient, called "The Quiet One," because we hear less about it than the other two. I refer to potash. Since our last meeting, we have, however, been hearing quite a lot about potash, especially about that tremendous deposit, 450 miles long, 50 miles wide and ten to twelve feet deep in the Canadian Province of Saskatchewan.

Potash problems are going to demand great skill and ingenuity for their solution. It is estimated that by 1966 or '67, the supply from North American potash mines will reach 5.5 million tons against a demand of about four million tons K_2O basis.

World output of potash in 1961 was about 10 million tons K_2O basis. Referring again to the Canadian potash, it seems that scientists have found some differences between the Saskatechewan and the Carlsbad products. The opening panel discussion will discuss some of the physical and chemical characteristics of potash from these two sources.

Following the potash panel on this morning's program are items which will deal with plant equipment such as classifiers, screens and the reduction of particle size.

This afternoon a panel discussion on the subject of specialty fertilizers. A recent survey revealed that sales in the lawn and garden chemical line would hit $525 million this year and by 1965, would jump to $700 million. In 1960, Mr. Mehring's survey sponsored by N.P.F.I., estimated that about three and three-tenths million tons of specialty or nonfarm use fertilizers were sold in the United States at the retail value of at least $150,000,000. It is big business.

This is a new subject for the Round Table and we believe its growing importance justifies its appearance on our program.

Also on the afternoon program are discussions on diammonium phosphate, pneumatic handling systems and a phase in continuous granulation processes, each presented by a person expert in his field.

Tomorrow forenoon, we have an unusual treat, a talk illustrated by a movie showing the complete operation of a fertilizer plant from raw material to bag.

In addition, a visual demonstration of what happens when mixed goods are handled in and out of storage and a very interesting interpretation of the problems which derive from the operation.

In the afternoon, the agenda is devoted to processing and dust problems, very much worthwhile for the production personnel.

The last session deals with the amazing innovation in marketing which has the whole industry talking. I refer to bulk blending. One of the major fertilizer companies recently announced it was planning to spend 2.5 million dollars in an installation and expansion program devoted to bulk blending. Many of the old line companies have been opposing this innovation but farmers like it and want it and therefore someone is going to provide it.

Our unpredictable friend, Wayne King, has something up his sleeve, I believe. He insisted that he wanted to get the floor and who is going to stop Wayne King from coming up on the floor?

Presentation of Plaques To Each Executive Committee Member

Wayne King

MR. KING: You stay right here with me now. Don't you go away.

I am going to read this so it comes out with the verbs in the right place.

I rise to a point of personal privilege and/or of order, as a card bearing proletariat member of this group and I wish to say that I have a thing or three to say about this Round Table Executive Committee. They are top men in their craft. A higher compliment I couldn't think of.

What I propose to do here is highly pleasurable to me, I assure you. Here is a little phrase I like to use for the Round Table: "A dynamic present and a still brighter future."

Future I've got less of than most of you but anyway, that is what I like to think about. It has occured to me and to the corporation that sponsors me, The W. S. Tyler Company of Cleveland 14, Ohio, that a recognition, a tangible reminder, is in order for our Executive Committtee.

This Executive Committee, as a group, has our profound thanks for their excellent efforts, work, toil and sweat in bringing to us these excellent meetings. We merely wish to sort of put this in print or etched in bronze.

Too frequently, we take so much for granted and fail to allow for some form of positive recognition of a tangible nature. It would be trite for me to enter into any eulogizing here. We are well acquainted with the tremendous contribution by the Executive Committee, which means the Chemical Fertilizer Industry. Never have four young men done so much for so little.

So, without a lot of fancy words by me, to our chums, I have a little something here.

Now then, Vince Sauchelli, Housden Marshall, Joseph Reynolds and Albert Spillman, come over here a minute.

This reads on there: The Fertilizer Industry Round Table to Vincent Sauchelli, Founder, Chairman of the Executive Committee and the date, October 24, 1962. A token of recognition of dedicated service to the Fertilizer Industry.

I left my name off of this but on the back, I think it has a little something.

Now, these meetings in my oppinion are positive proof that Dr. Sauchelli, who is an author, also appreciates that knowhow is hard to come by out of a book.

(Presentation of plaque; applause.)

Now, Al Spillman's plaque reads just the same. He is the key man in our arrangement. We have our meetings on Saturday mornings, preferably in his office and also at Brown's Club Coffee Shop on Clinton Street.

I guess some of you have been there.

And when I am invited, I always go and enjoy it.

Al, that's for you. Al Spillman.

(Presentation of plague; applause.)

Where is Joe Reynolds? Here he comes.

Here you are, Joe. These all read approximately alike but for Joe, he kind of gives us the looks, you know.

He dresses up our group a little bit and he helps us remove what the medics call the brain block.

(Presentation of plague; applause.)

Now where is Doc? Doc Marshall.

You little old winemaker you, now come here.

You hold that. They all read approximately the same except that I hope I gave each one of you the one with your name on it. Now Doc is quite a person. I have enjoyed a long and happy friendship with this fine gentleman.

For Doc I have a little something extra.

And in addition to that, I am going to take over to his house one of these days a five gallon jug of Indian oil. Now this is very handy if you know any Indians.

(Laughter.)

(Presentation of plaque; applause.)

That's it and thank you for your indulgence.

(Applause.)

Moderator Sauchelli: Again I'll say, that Wayne King is the most unpredictable individual.

Well, that's it. Now you have asked for the meeting and you have presented to us your problems and questions. We have done our best to meet your wishes. So let's go.

I'll now call on our good friend, Dick Powell of the International Minerals and Chemical Corporation. Dick certainly doesn't need an introduction to this group.

He will introduce his panel members and the subject.

Dick.

Canadian Versus New Mexico Potash

Richard Powell, Panel Leader

Mr. Powell: Good morning, gentlemen. I'm Dick Powell, Technical Services Manager for the Agricultural Chemicals Division of International Minerals & Chemical Corporation. The subject the panel is going to explore today is Canadian potash.

Because potash has been known and used since the time of the cavemen, you may be wondering what there's left to talk about. Happily, there's quite a bit. Unhappily, we're not going to be able to talk about all the things we'd planned to discuss—and I'll explain why as we come to them.

Canadian potash is 350 million years old, but our Canadian potash production is less than three months old. IMC started up its new mine and refinery near Esterhazy, Saskatchewan, during the last few days of August.

This ended a 5-year battle to open up the world's largest high grade deposit of potash, buried more than a half-mile underground. All this work has culminated in the world's largest and most efficient potash mine and refinery—and a shaft so safe that it stands as a tribute to modern mining technology.

Potash is a good business to be in—if you know the business. The field's open. All anyone needs is 50 million dollars, some four or five years' time, an exceptionally capable engineering staff and crew—and the patience of Job, the tenacity of a bulldog, and perhaps a bit of borrowed luck of the Irish.

Our five-year struggle demonstrates that.

We knew that the potash was here, 3100 feet down, under 316 feet of glacial till, 2,724 feet of water-bearing shale and limestone, and 100 feet of rock salt.

Twelve hundred feet down was the Blairmore. It is a 200-foot mass of fluid quicksand under pressure up to 475 pounds a square inch. This formation has blocked all previous attempts to reach and mine the potash successfully.

We started down in 1957. First step was to freeze the 200-foot glacial till and consolidate its water-bearing sand, clay and boulders. We set 34 pipes 200 feet into the ground in a circle around the shaft area, and pumped calcium chloride through them at minus 40 degrees Fahrenheit, then sank through the ice block.

In June of 1958, we had the concrete-lined shaft down to 1,200 feet, just above the Blairmore.

First — according to plan — we tried to solidify the Blairmore by a method known as grouting. Twice the Blairmore flooded the shaft, once up to 120 feet below the top of the shaft.

Then we decided on a technique never before used in North America.

First we froze the Blairmore —a 12-month job. Even as it froze, the Blairmore struck back. It expanded—and the expanding broke some of the 62 freeze pipes sunk into it.

Much of the old refrigerant, calcium chloride, escaped into the Blairmore. Now we not only had to free the Blairmore anew, but the escaped calcium chloride as well. We used lithium chloride brine, at 60 degrees below zero.

Finally, when we had our three million cubic foot ice cube, we started to sink the shaft. We had to use pavement breakers—blasting could have ruptured the ice wall. We went down only five feet at a time.

After each five feet we installed a cast-iron lining called tubbing. Five feet wide and five feet high, each 4-ton segment was tediously put in place. Eleven segments formed a complete ring around the shaft.

And so it went for 200 feet through the Blairmore and for 150 feet above and below it. Men worked at 34 degrees below zero and still found pockets of calcium chloride that hadn't frozen.

In March, 1961—almost three years after we had first tackled the Blairmore—we buttoned it up for good.

Still ahead were ten water-bearing zones—some with pressures of up to 1,100 pounds a square inch. We grouted—with a total of 200,000 bags of cement.

To speed up sinking, we used a Galloway stage, a device never before used full cycle in this hemisphere. This three-decked device permits simultaneous activity in the main phases of shaft sinking and construction—drilling, preparation of concrete forms, and pouring and finishing of the shaft wall.

We finally hit the potash mining level at 25 minutes before midnight on June 8 of this year. We were 3,132 feet down.

This was the toughest shaft-sinking project ever successfully completed in the Western Hemisphere—perhaps the most costly for its size and depth that's ever been sunk anywhere.

By the time we struck potash, we were ready for test runs through the mill. And now it's in operation, and moving into full-scale production—the most modern and efficient potash mine and refinery in the world.

Now Jim DeLong will discuss the difference between the chemical and physical properties of the ores and products from Esterhazy and Carlsbad.

James M. DeLong, Panelist

The basic chemistry of component potash elements, of potassium, for example, doesn't differ one whit from one ore to another or from potassium derived from any other source in the world. The chemistry or combinations of materials found in the ore at each location does differ markedly, however. The potash from Canada and Carlsbad are the same; but the ores—brought to the surface and processed—are different. To illustrate these differences, let's look at comparative typical analyses of the two ores.

Typical Chemical Analysis of Potash Ores

Component	Carlsbad, N. M.	Esterhazy, Sask.
K	12.32	19.60
K_2O	14.84	23.61
KCl	23.53	37.44
Na	28.20	23.1
NaCl	71.73	58.75
MgO	0.95	0.58
SO_4	3.38	0.10
Combined Water	0.44	1.60
Free Water	0.20	0.30
Water Insol	1.02	0.50
NaCl:KCl	3.05	1.56

Of course, the most striking difference is the grade of the ore, or its % K_2O content. I hesitate to label these analyses "typical." While the Carlsbad analysis is typical of IMC ore at Carlsbad and is actually an average of several analyses, it is *not truly* typical of *all* Carlsbad ore. Ore taken in some of the Carlsbad mines runs considerably higher in K_2O than this analysis.

The analysis of Canadian ore shown is typical of that taken from several hundred yards of drift mined in Canada to date and of several drilled core holes. Many variations from this typical analysis will probably be found in the 450 by 50 mile deposit in Canada. I would like to call your attention to the bottom figure on this slide. As you can see, the ratio of salt to potash is over three-to-one in Carlsbad ore while it is only 1.5 to 1 in Canada.

Now, let's see what these differences mean in terms of processing and in final product. This slide shows the mineralogical composition of the two ores.

As you can see, there are many more mineral species found in the Carlsbad ore. The presence of each of these mineral species has its effect on the processing and recovery of muriate. In this case, the key difference is the almost total absence of sulfate in the Esterhazy ore, about 1.0%. This, coupled with the fact that the small amount of sulfate in Esterhazy ore is completely tied up in the insoluble anhydrite form, means that one of the K_2O-capturing mineral species can form as the temperature and solubility relationships change in the refinery process. This, of course, contributes to higher recoveries and lower operating costs. This different mineralogy changes the appearances of the product as well. It looks different. We are all familiar with the usual red potash from productions at Carlsbad. In fact, the opinion is widely held that potash, in the original crystalline form, is red. This is not the case. The Canadian potash from IMC's mine, much lighter in color than the Carlsbad product potash comes, from the iron oxide which is present as hematite. While the hematite content of Canadian ore is less than that of Carlsbad ore, this is not the real reason for the absence of red color in the muriate product. As you know, a very little iron oxide goes

Typical Mineralofical Analysis of Potash Ores

Component	Formula	Carlsbad, N. M. Amt.	Esterhazy, Sask. Amt.
Sylvite	KCl	23-28%	42-59%
Halite	NaCl	71%	58%
Langbeinite	$K_2SO_4 \cdot 2MgSO_4$	Tr-2%	———
Kainite	$KCl \cdot MgSO_4 \cdot 3H_2O$	0.1-0.5%	0-Tr
Leonite	$K_2SO_4 \cdot MgSO_4 \cdot 4H_2O$	Tr-0.1%	0-Tr
Kieserite	$MgSO_4 \cdot H_2O$	Tr-1.0%	———
Carnallite	$KO \cdot MgCl_2 \cdot 6H_2O$	———	1.0-1.5%
Polyhalite	$K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$	0.15%	0-Tr
Anhydrite	$CaSO_4$	———	Tr-0.1%
Insol.	(Ca) $MgSiO_3$ & Fe_2O_3	0.5-1.5%	0.7-1.0%

a long way in coloring .The difference is in the basic mineralogy. When crystals are formed, they have the inherent property — or ability, if you like—to selectively absorb various foreign materials. In the Carlsbad crystal species, sylvite, the principal potash mineral, shows the greatest affinity for hematite. In Esterhazy crystal species, however, where the mineral carnallite is found, the Hematite is no longer occluded in the potash. This is due to the stronger affinity of carnallite for the hematite. The iron is, therefore, totally concentrated in the carnallite and eliminated in the final product because this carnallite is dissolved in the refining operation.

As a matter of fact, if the Sylvite crystals in Canada could be perfectly and cleanly floated from the Canadian ore, without any of the clay materials tagging along, a perfectly clear white product would be obtained. The Sylvite crystals in Esterhazy generally occur as a glass-clear product. This, incidentally, is exactly opposite to the situation in Carlsbad. The halite, or NaCl, crystals at Carlsbad are generally clear or water-white while the few sylvite crystals which have escaped the hematite inclusions are cloudy and milky-white in appearance. In Canada, the sylvite is water-clear and the halite is milky-white.

Another major difference between Carlsbad and Esterhazy ore is due to the fundamental mineralogy of the deposits. the average crystal size of the component parts of the ore determine the degree to which the ore must be crushed in order to physically separate the sylvite from the halite. This critical size is known as "liberation size." In Carlsbad, this is approximately 14 mesh, the maximum size for relatively complete separation. The liberation size for Canadian ore, however, is about 4 mesh. This means that with less crushing, it will be possible to float the potash cleaner than can be done with a comparable size at Carlsbad. As a result, the shipping grade will generally be higher, 61.5% K_2O, than the Carlsbad product, which is about 60.5% K_2O.

Typical Chemical Analysis of Potash Products

	Carlsbad Standard	Esterhazy Standard
K	50.29	51.00
K_2O	60.6	61.45
KCl	96.07	97.28
Na	0.92	0.65
NaCl	2.34	1.65
Ca	0.05	0.04
Mg	0.23	0.15
SO_4	0.93	—
Insol.	0.33	0.50
Free Water	0.10	0.06

This table shows the typical chemical analyses of IMC's standard products at both Carlsbad and Esterhazy and clearly illustrates the essential product differences. We can conclude that these major differences in chemical and physical properties point out definite advantages from a producing standpoint. First, there is almost twice as much potash per quantity of sodium chloride in Esterhazy ore compared with Carlsbad ore. Secondly, because of substantially less miscellaneous minerals, this ratio, KCl:NaCl, in the Esterhazy *product* is nearly 50% higher, 590:1, as compared to 411:1 for Carlsbad product. Obviously, the richer the ore and the less contamination in this ore, the easier and more economical it is to mine and refine. Now, since I don't wish to pre-empt any portion of Mr. Sheehy's talk, perhaps this would be a good point to turn the subject over to Tom who will discuss the technical differences in mining and refining of Esterhazy potash as opposed to Carlsbad potash. Thank you.

Tom Sheehy, Panelist

Before starting a discussion of the basic differences in mining and refining between Carlsbad and Esterhazy, I feel that a little fundamental background is in order for those of you who are not too well acquainted with the variety of operations in Carlsbad. From the foregoing talk, you have learned that ore grade is quite important and that we know the grade of ore in the Carlsbad area will vary appreciably. Depending upon the grade of this ore, numerous methods of upgrading are possible. The lower the ore grade analysis, naturally, the greater necessity for an economical process. Flotation is probably the most common and accepted methods of refining, however, the method is dictated purely by the economics.

Mining methods at Carlsbad also vary but to a lesser degree than refining methods. Underground mining at Carlsbad takes place 900 feet below surface level. This involves mining a potash-rich area in the shape of a room, leaving pillars at prescribed intervals to support overhead weight and insure safe working conditions. Later on, when the mine area has been completely worked out, some of the pillars are cut in criss-cross fashion to extract as much valuable ore as possible. IMC's Canadian mine is presently employing the "room and pillar" method, however, as mining patterns develop and are extended, the "modified long wall" method will be adopted. This method consists of mining long tunnels of specified width and length, each essentially parallel to each other and approximately 30 feet apart. This is contended to be the more efficient method of ore removal where continuous mining equipment is used.

In Esterhazy, the mining area is 3,140 feet below ground level. That's more than a half a mile underground which means there is considerably more downward pressure on the ore body than in Carlsbad. This downward pressure exerts sufficient force on the salt deposits to actually cause them to flow. These salt deposits in both Carlsbad and Esterhazy exhibit plastic characteristics, that is, they behave under pressure much like a tennis ball. The rate and extent of flow at Esterhazy is more pronounced than at Carlsbad, however, it is not sustained for sufficient time to do damage to underground openings...it is a common phenomenon in most deep mines. Ninety per cent of the flow, or creep, is dissipated within 24 hours after the ground is opened. The remaining 10% gradually tapers down to a negligible amount within a relatively few days.

Now, as you have probably guessed by this time, this plasticity must be taken into account when plotting the potash removal maps and selecting mining techniques. For instance, in Esterhazy, only 35% of the existing ore is recoverable. Stated another way, 65% of the available ore must remain in its native state to insure roof support and to control this creep within safe limits. This is almost a reverse ratio to the situation in Carlsbad. Here they mine about 65% of the existing ore, leaving 35% as pillars in the mine. The continuous miner technique is also ideal in Canada, not only because of its one step removal of the face but also because dynamite is not necessary and the configuration of the completed mine face precludes the possibility of drift damage as a result of creep.

Editors' Note: Slides 1 through 7 were not available for inclusion in these proceedings.

Slide No. 1. Continuous miner, front view showing synchronized rotary augers.

This slide shows the circular boring augers or cutters of the continuous miner. Notice that the vertical walls are rounded and that all walls are relatively smooth, for the most part eliminating the need for barring down boulders loosened by dynamite. The working face looks like this:

Slide No. 2. Working face of mine, continuous miner removed.

This slide will give you the perspective necessary to estimate the height of the working area. The loose ore material on the mine floor is typical of the size material removed from the face by the continuous miner.

The method of ore removal in Carlsbad is quite different. The mine face is first undercut with this mechanical undercutter.

Slide No. 3. Undercutter at Carlsbad.

which removes a slice of ore about 6″ high by 12-14 feet deep from under the face. The face is hydraulically drilled and then dynamite or a suitable explosive is used to blast down the face.

At the present time, both mines are using Joy loaders like this to move the ore conveying equipment.

Slide No. 4. Joy loader (choice of two slides).

These are electrically operated self-contained conveyors fitted with crab-like arms, designed to scoop the loosened ore onto the conveyor which loads it into waiting shuttle cars. In Esterhazy, these shuttle cars move the ore directly to the shaft via long belt conveyors. In Carlsbad, the shuttle cars unload into underground railcars which transport it to the shaft by trainload. Because blasting is employed at Carlsbad, the ore size is such that an underground gyratory crusher is necessary at the train dump. This is not necessary, however, in Esterhazy because of the degree of primary crushing taking place at the face.

Coming to the surface portion of the two operations, we can now describe the differences in flowsheet as well as the reasons for these differences. The first major difference is found in the crushing and grinding circuits. At Esterhazy, a very little additional crushing and grinding is necessary once the ore reaches the surface. Single deck scalping screens divert the oversized ore to mills which effectively reduce the ore to flotation-feed size. This is an entirely dry process. At Carlsbad, a considerably higher percentage of the ore must be ground in dry mills to insure liberation and then wet ground in rod mills to insure a properly sized, slime free particle. The second major difference in processing involves the Esterhazy unique method of removing undesirable carnallite. This mineral must be removed prior to flotation to assure manufacture of quality products. To do this, two entirely different circuits are employed.

Slide No. 5. Interior view of entire flotation process.

The equipment on the left represents the leaching circuit while the red equipment, upper right, is the flotation circuit. Let's have a closer look at the latter. It is the common method of floating potash from the tailing salts.

Slide No. 6. Close-up of flotation cell (choice of three slides).

To those of you familiar with the flotation cells at Carlsbad, this cell will appear to be floating salt, rather than potash, because the floated material is white. Be assured, however, this flotation froth is rich in the purest form of potash. The last major difference in the two operations involves filtering and washing of salt tailings. At Carlsbad, a rotary salt-type filter pan is used. At Esterhazy, the more efficient Prayon Travelling pan type filter is used.

Slide No. 7. Prayon pan filter.

Although this slide doesn't actually show the pan filter in operation, it does clearly show the individual pans which through successive stages, fills, drains, washes, again drains and then dumps the potash-free tailings to be sluiced to waste ponds.

There are undoubtedly other slight differences in the two operations which I haven't mentioned, and I'm sure there will be considerably more in time to come but I think we have covered the more important ones.

An around-the-clock-process, IMC's Esterhazy operation even at night, typifies the modern approach to industrial processing. Clean, streamlined architecture, makes this operation as functional as it is attractive.

Economics of Labor Standards and How They Apply to Fertilizer Manufacturing

Frank Nielsson

Today, if you do not make a profit, you have two choices. You can go bankrupt or you can become subsidized. Either choice is undesirable for the majority. To stay in business, we must make a profit, and to make a profit. we must produce goods for less than their selling price.

Cost of labor, together with the costs of raw materials, freight in and overhead, make up a total sum called "Cost of Goods Sold." This is subtracted from the selling price to arrive at a gross profit before selling and administrative expense.

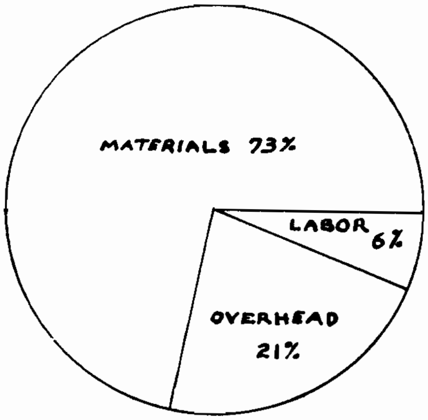


Figure 1

The ratio between labor, overhead and raw material costs varies in different categories. In the fertilizer industry, assuming that IMC's Plant Food Division is typical, raw materials constitute about 73% of the cost dollar, if we count freight in as part of the raw material cost.

Although the cost of raw materials averages 73% of the total operating cost with only 6% allocated to direct labor, direct labor continues to be one area over which in-plant control must be exercised to prevent a loss operation. Ten percent of overhead is effected by direct labor because of items like premium time, off duty compensation and associated payroll costs, or another 2% of the cost dollar is effected by direct labor.

By direct labor, I mean labor directly involved in the manufacturing operation. This includes the labor involved in unloading, manufacturing of super, manufacture of mixed goods, and shipping. Direct labor also includes the labor spent in dynamiting, sampling, and routine cleanup. We class as indirect labor the labor involved in janitor service, watchman service, yard work, unusual cleanup and rehandling. With IMC, indirect labor is part of overhead. Repair labor is a separate overhead category.

To control direct labor, the IMC Plant Food Division has set up a system of labor standards. These are first set up at each plant for each operation by making a time study of the work involved. Time studies indicate short time peaks of effort that indicate maximum possibilities. The results of the time studies are tied in with the normal variations of the plant operation to yield a compromise figure called a labor standard. This labor standard is reported as man hours per ton.

To put it simply, labor standards are a practical estimation of the number of men it takes to handle a given operation at a guaranteed output of tons per hour. Let's look at a shipping operation in three plants in the 30,000 ton per year shipping range, but each having different packaging equipment.

Plant A uses one mill with 2 manual Atlanta Utility packers, 100 lb. open mouth bags and a sewing machine. It takes 14 people to run the operation for a guaranteed long time average of 30 tons per hour, or a standard of 0.466 man hours per ton.

Plant B uses one shipping mill that feeds 2-Model 327 valve packers for 50 lb. bags. The operations require 12 people for 20 tons per hour, a standard of 0.600 man hours per ton.

Plant C uses one shipping mill that feeds a Model 160 valve packer for 50 lb. bags. The operation requires 9 people for 15 tons per hour, again a standard of 0.600 man hours per ton.

Dividing the number of men needed by the tons shipped yields the factor "man hours per ton."

Under certain conditions, each plant can ship much more than the standard output. Plant A has been known to load four 25-ton trucks in one hour when the same grade was loaded into the four trucks.

Plant B will load an 18 ton truck with one grade in 30 minutes.

Plant C will load a 50 ton box car in 2½ hours with one grade in each end of the car.

But the standard takes care of grade changes, small and large trucks, waiting on trucks that said they would come in and something happened so they failed to show up. Over a year's operation, the man hours per ton figure is realistic. This is what it costs for the shipping operation when you multiply the man hours per ton by the average wage rate per hour.

Labor standards have various uses:

1. They can be used to compare the efficiencies of plants having similar facilities and marketing conditions.
2. They can be used to evaluate

Table 1. Typical Shipping Operations

Plant	A	B	C
Bag size	100#	50#	50#
Type	O. M.	V	V
Equipment	2-At. Ut.	2-327	1-160
Jobs			
Tractor driver	1	2	2
Mill operator	2	1	1
Packer operator	2	2	1
Sewing machine operator	1	—	—
Bags and tags	1	2	—
Loader	1	1	—
Hand trucker	3	—	3
Lift trucker	—	1	—
Stacker	2	2	1
Relief	1	1	1
Total	14	12	9
Tons/hour	30	20	15
Man hours per ton	0.466	0.600	0.600

the effect of process or marketing changes at a given plant, e.g., shipping in 50 lb. instead of 80 lb. bags, or going from powdered to granular fertilizer.

3. They can be used for predicting operating costs for the coming year. This is one of their more important functions in our division.
4. They can be used as the basis for a supervisory wage incentive program. This use also is important at IMC.
5. If the time studies are made as part of a better methods program with the full cooperation and understanding of the supervisory personnel, labor standards together with a wage incentive program can result in a significant decrease in direct labor.
6. And finally, labor standards are a concrete way of expressing possible savings if you ask top management for labor saving machinery.

Standards between plants can only be compared when operations and equipment are identical. Obviously, a Georgia buggy operation will take more labor than a hopper system. However, the hopper system will have higher overheads because of depreciation and repairs than will the buggy plant. In the same manner, a granulating plant will have different standards for manufacturing base than will a powdered plant. With these limitations in mind, let us look at some of the available data. The principal operations in a plant are unloading, manufacturing and shipping. Unloading can be from tank cars, bulk box cars, bulk hopper cars or bagged goods from box cars.

Table 2. Unloading Man-Hours Per Ton

	Range	Ave.
Tank cars	0.029-0.050	0.033
Bulk box cars	0.038-0.200	0.100
Hopper cars	0.042-0.110	0.060
Bagged goods	0.275-0.300	0.295

For tank cars, we show standards that vary from 0.029 to 0.050 man hours per ton with 0.033 being a good average. For bulk box cars, we show 0.038 to 0.200 with 0.100 being a good average. Oddly enough, hopper cars have a range of 0.042 to 0.110 man hours per ton with 0.060 being a good average.

For some unknown reason, bagged goods unloading fluctuates in the narrow range of 0.275 to 0.300, probably because the placing of bags on hand trucks or pallets is limited by the men in the car doing the actual unloading.

In manufacturing, there are two main categories: One in the manufacture of superphosphates, the other, the manufacturing of mixed fertilizers or basing as we call it.

For super manufacture, we show standards that vary from 0.164 man hours per ton to 0.400 man hours per ton. The latter is for a plant having a 10 ton Sturdevant den. The data cover Sturdevant dens, a Broadfield den and a number of box dens. No one type has an advantage. 0.20 would be a good average for the plants with large super budgets and 0.30 would be a good average for plants with small super budgets. We have no crane operations.

In basing we show a wide range. For powdered plants it runs all the way from 0.175 man hours per ton to 0.583. The 0.175 is a hopper system, while the 0.583 is a Georgia buggy operation. Again 0.438 would be a good average.

In granular plants the range is narrower, from 0.450 to 0.666. 0.500 man hours per ton is a good average.

Table 3. Manufacturing Man-Hours Per Ton

	Range	Ave.
Superphosphate	0.164-0.400	
Small plant		0.30
Large plant		0.20
Mixed Goods		
Conventional	0.175-0.583	0.438
Granular	0.450-0.666	0.500

Shipping is another operation with variations. Some plants ship nothing but 50 lb. bags. Others ship only 100 lb. bags. Some have mixed shipments. Then again, some plants use sewn open mouth bags, while others use valve bags. Our range in man hours per ton is from 0.541 to 0.880. A good average for the southern plants with sewn open mouths would be 0.60. The corresponding figure for the northern plants with valve bags would be 0.70.

Table 4. Shipping Man-Hours Per Ton

	Range	Ave.
Bagged goods	0.541-0.880	
Southern		0.60
Northern		0.70
Bulk	0.148-0.640	0.250

We have one small northern plant that ships all bagged goods in 50 lb. sewn open mouths using hand trucks. Its standard is 0.666. A comparable valve bag plant has a standard of 0.680.

Bulk shipments have a wide variation in standards, from 0.148 man hours per ton to 0.640 man hours per ton. Some plants are designed for bulk shipping, others use makeshift arrangements like loading with a payloader. A good average for a mechanized bulk loading operation would be 0.250 man hours per ton. We are not discussing bulk super shipping which involves loading cars with a slinger.

What do these standards mean? You can estimate how many tons will be unloaded, based and shipped in the various categories. Multiplying by the proper man hours per ton figure for each category will show your total estimated man hours. Multiplying the total man hours by the average wage rate will yield an estimated labor cost.

How good is this? We have supplied data from plants covering a major portion of the country's fertilizer producing areas. These plants have a wide difference in processes, equipment and ethnic labor groups.

Despite these differences, the majority of the plants spent an amount for direct labor that came within $3,000 of the predicted figure in the year 1958/59. A similar accuracy has existed in other years.

IMC has found labor standards to be an important factor in cost control. We believe many plants would benefit from a labor standard program.

Table 5. 1958/59
$ Direct Labor Variation From Predicted Cost

Chicago Heights	$10,324
Texarkana	4,719
Mason City	4,475
Greenville	4,210
Winston-Salem	4,012
Spartanburg	3,162
Tupelo	2,922
Augusta	2,858
Mulberry	2,730
East Point	2,170
Clarksville	1,767
Americus	1,562
Tifton	1,058
Pensacola	1,001
Cullman	952
Florence	864
Fairfax	766
Hartsville	412
Somerset	(170)
Buffalo	(868)
Fort Worth	(1,342)
Jacksonville	(1,815)
Lockland	(1,957)
Woburn	(2,549)

Moderator Sauchelli: That certainly was a very informative presentation by the group. Now is the time for some questions.

Who wants to direct a question to the panel. You recall what I said in my introductory remarks, we like to have these question and answer periods fruitful and we like to have the group participate in them.

There must be some question about this potash.

A Conferee: I wonder if you could tell us the significance of the potash. How was it formed inititally? In your description, you talked about the various strata. How did it derive this status, bypassing chloride and so forth?

Mr. Powell: I could give you a general description but I would like to refer the question to the gentleman on my left who has had far more experience in that than I have.

Mr. De Long: Originally this salt material was a part of an ancient sea and it was a briney material. All of these deposits in Carlsbad are crystalline deposits that have come out of this ancient sea and have become covered over a period of years.

As far as Canadian potash is concerned, I don't honestly know. I presume it too was a part of a brine and preferentially crystallized one period at a time. In looking at the ore deposit last month, it looked to me that potash and the sodium chloride were the first materials to crystallize because the carnallite looked like a matrix around these materials. Does that answer your question suitably?

A Conferee: Yes.

Moderator Sauchelli: Any other questions?

A Conferee: In the Canadian operation, you went down to 3,000 feet. In the Carlsbad operation, actually getting the potash out, wouldn't it be costing you more to get the potash out of Canada than it would at Carlsbad which you say goes down 900 feet? Is there any cost associated with bringing the ore out at the 3,000 foot level versus the 900 foot level?

Mr. Powell: Actually the capital investment to get down there is considerably more. The materials of construction, the way the shaft had to be so designed for the hoists all presented additional costs. The major difference is the concentration of the ore and the reduced number of personnel in the mine to actually mine the ore is such that it is much cheaper to bring the ore to the surface than at Carlsbad.

At Carlsbad, roughly speaking, it takes four or five operations to get the ore into the skip hoist to bring it to the surface whereas we estimate this is about three operations at the most.

Moderator Sauchelli: There is a question in the back there.

A Conferee: What is the average temperature at the 3100 foot level?

Mr. Powell: It runs around 75 to 80 degrees. It is very pleasant. Oddly enough, one of our major problems up there during the wintertime—they have winter up there nine months during the year—it gets down to 40 below and these men go down in the mine and work in a temperature of 75 to 80 degrees and it is very pleasant. In fact, it is a little bit warm working very strenuously and when we bring them back to the surface we almost have to go through the same thing that a deep sea diver has to go through, a depressurizing system, except it is a detemperaturizing. If they dropped right off to 40 below, they wouldn't be back the next day.

Moderator Sauchelli: Is there another question?

A Conferee: What would happen to this $50 million hole if you had an earthquake?

Mr. Powell: I imagine that the Board of Directors and a couple of insurance companies would have heart attacks. I don't know.

The people who surveyed this area naturally took this into consideration and apparently there is no fault seen along that particular bed that we would anticipate such a thing happening. If a missile comes over, I don't know what is going to happen there either.

A Conferee: Would you give us your opinion of the possible differences in cost in solution mining in Canada that is now being explored? What is your opinion of the possibility of success in solution mining?

Mr. Powell: My opinion is somewhat prejudiced. We have investigated solution mining in our own research development engineering groups and we have not felt it was feasible. It is currently being investigated again, as you all know.

This solution mining, if it does prove feasible, certainly the cost of getting to the ore bed would be less. Regarding the cost of processing the ore itself, again, I just have to express an opinion. I think it would be higher due to the large volume of liquid that has to be handled, but if they can successfully get down there and bring it up, perhaps the difference in the capital investment and the number of personnel to bring it to the surface would offset the amount.

There may be somebody here who could answer this. We have an expert.

Mr. De Long: Hardly any expert but I was involved in conversation on the subject just this last week. You are talking about tremendous depth here and I don't know whether — I presume there are pumps available to do this sort of thing—however, to stage these pumps in such a way as to get that material to the top would be rather difficult and expensive.

On top of that, you recall Mr. Sheehe mentioned some deep pressures down there. It is very difficult because of the creep factor to maintain a location. Anything you put down there might have a tendency to break off or shift.

MODERATOR SAUCHELLI: There is another question.

A CONFEREE: Could we have some idea of the variation in the size of material shipped of the potash?

MR. POWELL: Yes, we could do this very readily. In fact, we would love to but in deference to the fact that we do want to make this a rather non-commercial presentation, if you will come to Room 581, I will be glad to go over this with you.

We have some wonderful opportunities up there due to the type and size of crystals liberated, to be flexible in adapting our specifications to any entire range. We keep a very tight rein.

MODERATOR SAUCHELLI: Are there any other questions?

SAUCHELLI: There are many facets to this industry of ours and the mining segment isn't always discussed at our meetings and you can see that there are many interesting and difficult problems that have to be overcome.

Mr. Bulton up there in Esterhazy has certainly presented the company with many difficult problems and it is surprising and amazing the ingenuity used to over come them and the cost too, but the ingenuity in solving those problems is the admirable thing.

Well, if there are no other questions, we will proceed to the next item wnd we want to thank this panel.

MODERATOR SAUCHELLI: The Buell Engineering Company may not be known to many of you. It is a well establishred reputable engineering firm which offers complete laboratory and field specialist services in all types of recovery and collection installations.

Our program called for Mr. Goldberg of the company to give the talk. In his place, however, Mr. Paul Vandenhoeck, a good Dutch name, will explain to us the principles and operation of the Buell gravitational classifier.

Mr. Vandenhoeck is a mechanical engineer. He graduated from the Yale School of Engineering. He has had an abundance of experience and also, he holds many patents in the field of air classification and related fields, so I am sure that we will have a very interesting presentation by Mr. Vandenhoeck.

Buell Gravitational Classifier

Paul J. Vandenhoeck

Thank you very much, Dr. Sauchelli, for the very nice introduction.

Five years ago, Buell Engineering Company introduced a line of air classifiers designed to separate materials from 20 microns to 10 mesh. We have three basic classifier designs. The gravitational classifier which I will discuss this morning has an operating range of 65 mesh on up to 10 mesh. Over these past 18 months this equipment has found acceptance in the fertilizer industry.

Figure 1 is a schematic of the gravitational classifier. The principles of operation are very simple.

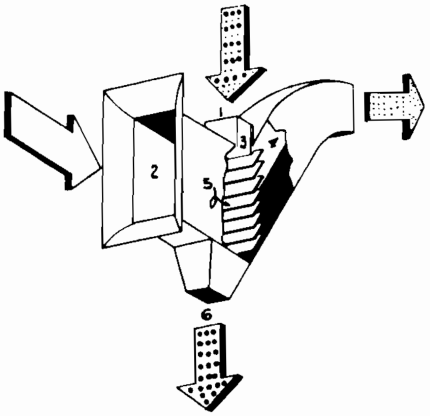


Figure 1

The material is introduced at the top (1) in a well distributed curtain, the width of the unit.

The air stream entering through the side of the unit (2), is made to sweep through the curtain of falling material (3) which is dropping in front of the air outlet (4) provided with widely spaced vanes.

The air stream enters the feed curtain perpendicularly but is changed to an almost parallel, but reverse direction to the feed curtain as it passes through the vanes. The fine material is picked up by the air stream and carried to a collecting device—either a cyclone or bag type dust arrester.

The coarse material flows by gravity to the bottom of the unit and is discharged to conveying equipment. After the fines have been collected, the air stream goes through a fan and is then released to atmosphere or recirculated through the unit.

The sizing is controlled by the velocity of the air as it is passed through the classifier and the curtain of material. The velocity, in turn, is controlled by means of a simple damper.

Operating Advantages

1. Instantaneous variable cut point to meet different market requirements.

In other words, if you have an installation designed to operate at a cut point from 65 to 35 mesh, you can control your cut point within this range by changing the damper position.

2. Extremely low maintenance. There are *no moving parts* and almost no contact of coarse materials with the walls of the classifier.

3. Elimination of variance in product specifications through screen rips or blinding.

4. Dust free operation. The classifier is normally operated under negative pressure. There is no dust created in the process.

5. Complete immediate access to all parts.

6. Elimination of vibration and noise.

Limitations

As with almost any piece of equipment, there are some limitations.

1. Lower theoretical sizing efficiency, but not necessarily "prac-

tical" efficiency when compared with commercial size screens in the 20 mesh or coarser range.

In other words, the equipment will operate at a certain efficiency on a particular material with a particular gradation. This efficiency is fixed. There is nothing you can do about it. You cannot increase the classifier size and obtain better efficiency.

Conversely, it is not affected by material put through the unit as long as you do not exceed the maximum figure established for a particular classifier.

Higher power requirements 0.1 to 0.5 HP per ton per hour of material treated.

Process Advantages

There are several process advantages available with the gravitational classifier.

1. Very low or non-existant material breakage or attrition.

2. Can be adapted to cool selectively, either oversize, undersize or both.

3. Will separate identically sized materials with different mass.

I don't know whether this is pertinent to the fertilizer industry but in a pelletizing process, this can become very important. Pellets of identical diameter but different lenght can be sorted with this equipment due to their difference in mass.

4. Not as subject to detrimental effect of electrostatic charge on sizing efficiency.

The material introduced in the classifier is not jogged around and there is, therefore, little chance for the material to pick up electrostatic charge by mechanical agitation due to classifier operation.

5. Will handle hydroscopic materials by recirculation of classifying air.

We have handled very hydroscopic materials with success by using inert gas or treated dry air.

6. No material temperature limitation.

We have made studies for sizing material at temperatures as high as 2,000 degrees Fahrenheit.

7. No construction material limitations.

We can fabricate the unit in stainless steel or glass, if necessary.

8. Will operate on inert gases for reacting materials.

9. Can be automated to operate in conjunction with other processes.

This equipment has been tied in with related equipment where the sizing of the unit is controlled by the demands of another device. This is done simply by putting an automatic operator on the damper to control air flow to the classifier and thereby the cut point.

Feed Rate V.S. Efficiency Effect of Efficiency of Gravitational Classifier A Compared To Screens

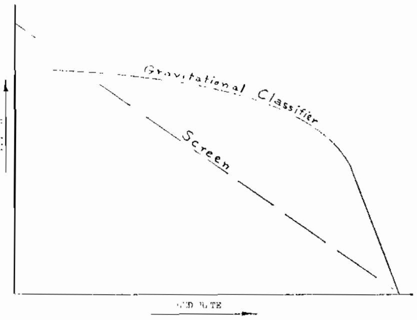


Figure 2

Capacity

We have had on the average a capacity per foot of classifier width of four to twenty TPH of feed material. In other words, you can introduce four to 20 TPH of material through the classifier per foot of width. If you have a ten foot unit this would correspond to 40 to 200 TPH.

The tonnages that you can handle through the classifier effectively is strictly dependent on the cut size at which the equipment is operated. The Material idiosyncrasies in an air stream and the material gradation.

Efficiency

As mentioned previously, in equipment limitations, the classifier, on a particular material, will have a certain over-all efficiency for this material; that is fixed. There is no way of increasing it. If you put 0% material per hour in a particular unit, you would have 100 per cent efficiency.

As soon as you put one gram per hour through the equipment, you will obtain a certain efficiency which will range anywhere from 70 per cent to 98 per cent, depending on the material and its gradation. Normally, the average efficiency is around 90 to 95 per cent.

As you increase the feed rate, the efficiency for this particular material will remain the same up to a certain point. After you have increased the tonnage capacity beyond the established maximum point for this particular material and particular size classifier, you start getting a very rapid decrease in efficiency. There will be more fine material in the coarse fraction.

Actual Examples of Classification

Here are 4 actual examples of classification obtained by the gravitational classifier on commercial installations.

Figure 4 is the commercial installation performing the classification outlines in figure 3. This is a gravitational classifier with an automatic choke gate feeder arrangement at the top. Above the classifier is a storage hopper. This is an open system. That is, the air is drawn from atmosphere through the ball mouth inlet.

This classifier operates on minus six mesh potash and it is adjustable to make a cut from 65 mesh on up to about 35 mesh.

The minus or the undersized fraction is pneumatically conveyed to the next classifier. I will not go into its description, but it is a gravitational-inertial classifier. This particular unit makes a cut at 150 mesh. The minus 65 by 150 mesh goes to a compactor. The minus 150 mesh goes to recrystalization and is collected by a cyclone after the classifier not shown in the picture.

Potash Crystals

99%+65 Mesh Separation
4TPH–750 CFM per foot of Classifier
Feed 84%+65 Mesh

Undersize	Oversize
24.1%	85.9%
43%–65 Mesh	99%+65 Mesh

Efficiency 90%

95%+35 Mesh Separation
5TPH–1000 CFM per foot of Classifier
Feed 56.7%+35 Mesh

Undersize	Oversize
49.3%	50.7%
68%–34 Mesh	95%+35 Mesh

Efficiency 84%

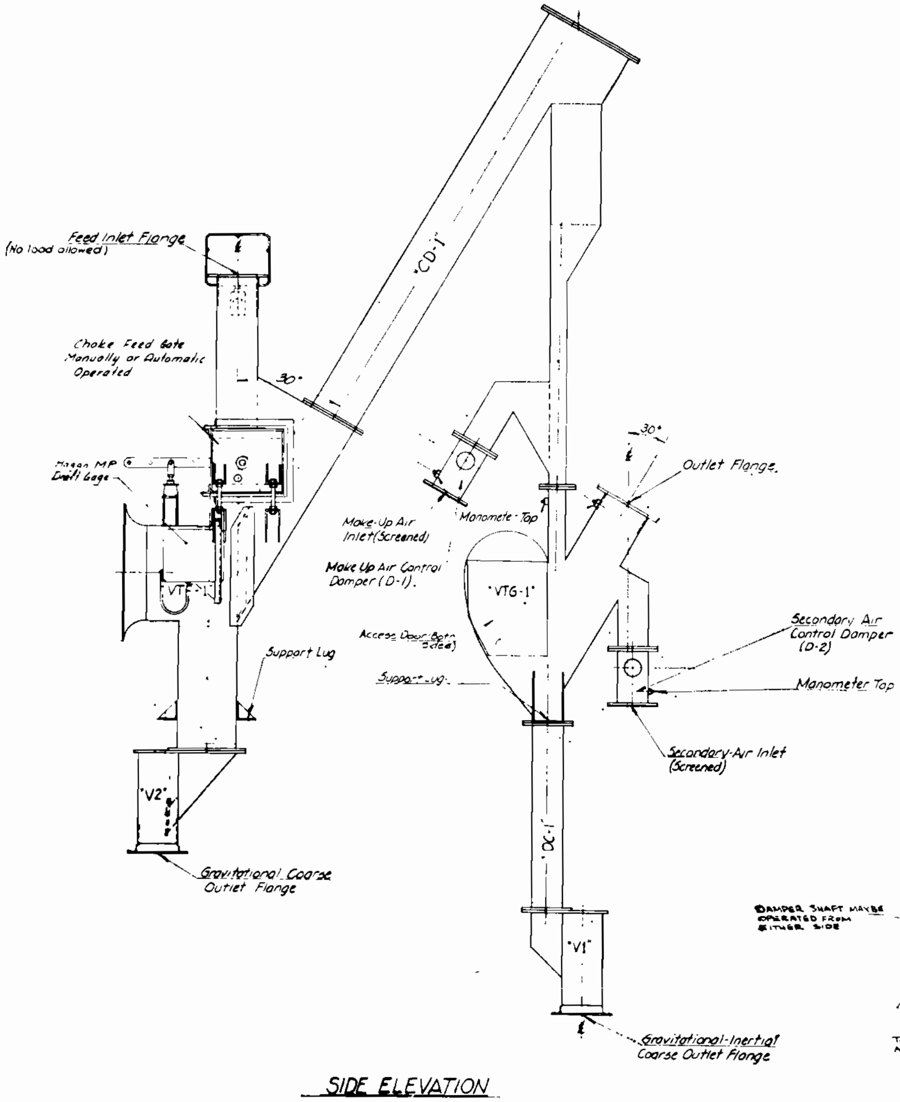


Figure 4

Figure 5 illustrate a classification of ammonium sulfate.

Figure 5

Ammonium Sulfate

99%+28 Mesh Separation
5.5TPH—1500 CFM
per foot of Classifier
Feed 90.%+28 Mesh

Undersize	**Oversize**
17.0%	83.0%
81.4%—28 Mesh	99.2%+28 Mesh

Efficiency—86.2%

Figure 6

Di-Ammonium Phosphate

99%+28 Mesh Separation
7 TPH—1140 CFM per foot
Feed 92.7%+28 Mesh

Undersize	**Oversize**
7.6%	92.4%
44.2%—28 Mesh	99.0%+28 Mesh

Efficiency—95.8%

Figure 6 illustrates a classification of di-ammonium phosphate.

Di-ammonium phosphate is very like ammonium sulphate, but classified better.

In reviewing these classifications it might seem that there is a lot of oversize in the fine fraction, but you must keep in mind the fact that the fine fraction in the size fraction is a very small amount of the total feed.

Figure 7 shows the classifier on separation of di-ammonium phosphate and ammonium sulphate. The collection chamber right after the classifier is what we call a knock out chamber. It is a low velocity device and its purpose is to remove as much material as possible from the gas stream before it reaches the cyclone.

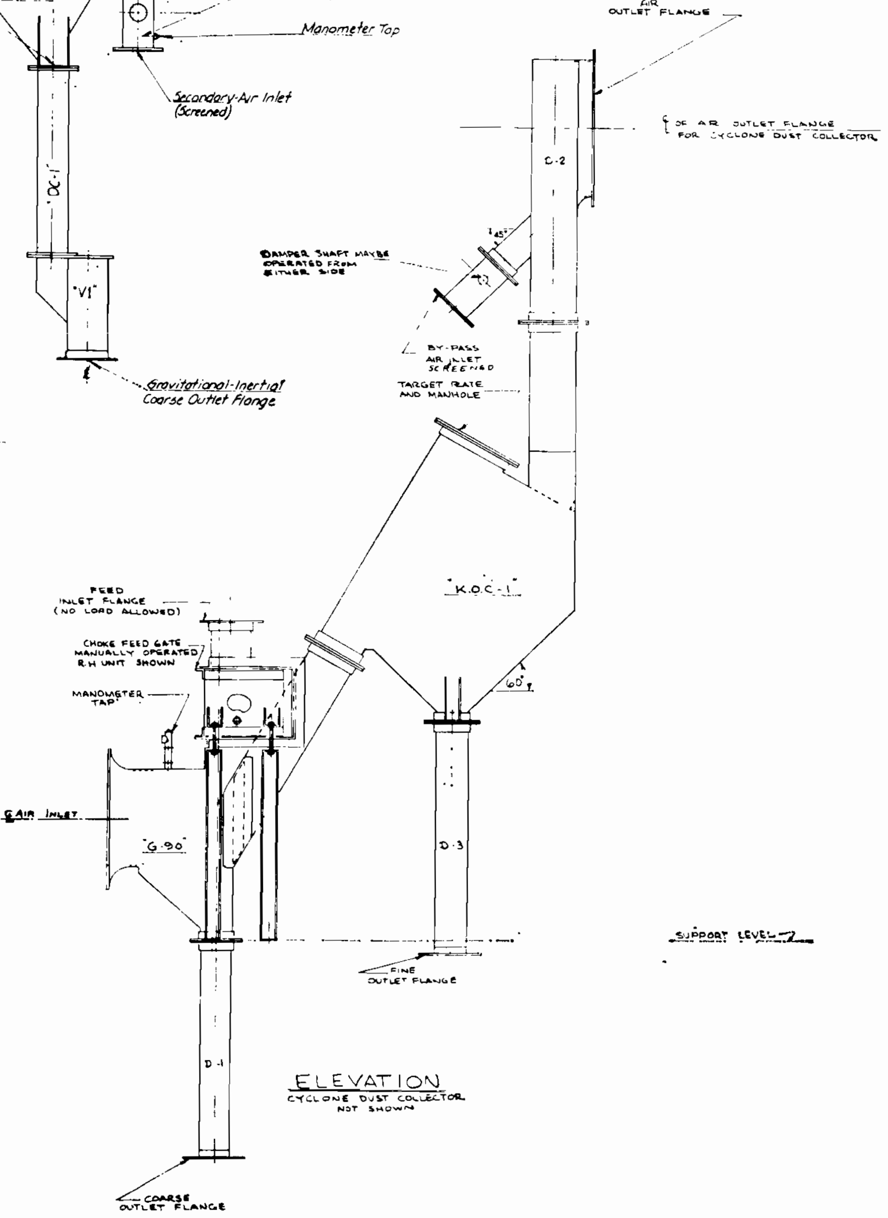


Figure 7

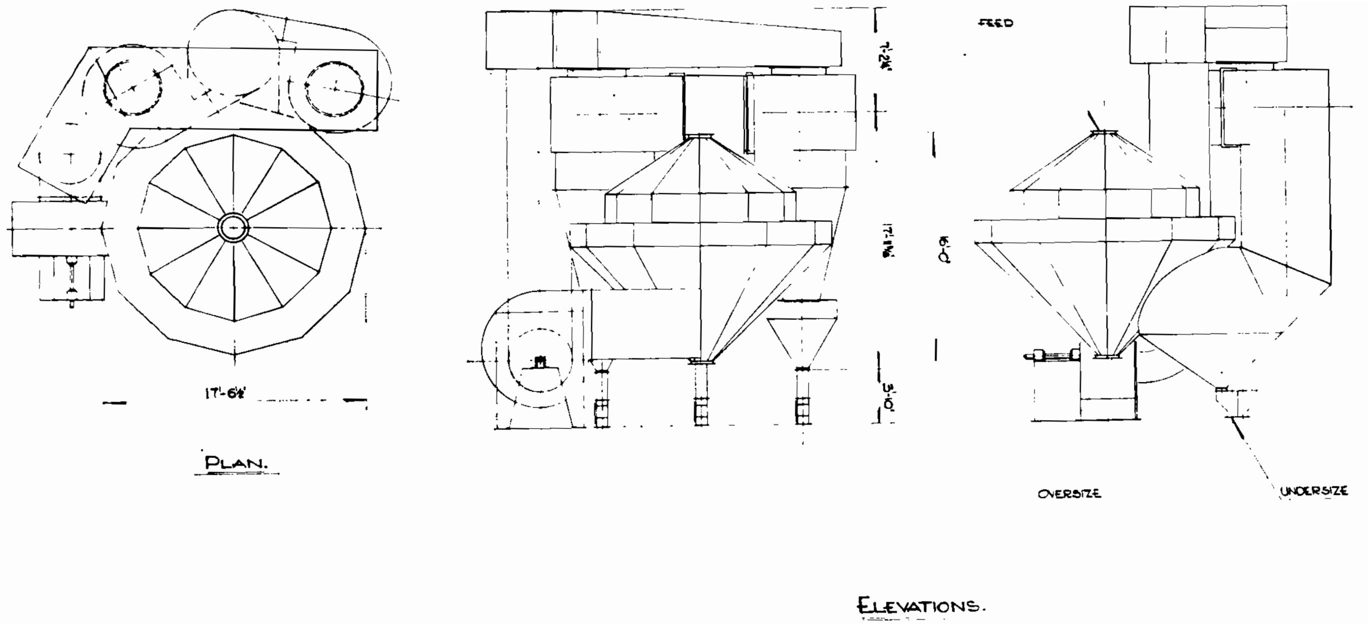


Figure 8

Figure 8 is a gravitational classifier in a circular arrangement. The maximum size conventional classifier we make is 10 feet in width. This particular unit has 36′ of vane width and can handle 350 TPH of potash for a 28 mesh cut.

Figure 9 illustrates the classification of Granulated Fertilizer.

Figure 9

Granulated Fertilizer

95%+16 Mesh Separation
5TPH—1800 CFM per foot of Classifier
Feed 72%+16 Mesh

Undersize	**Oversize**
23%	77%
81%—20 Mesh	96%+20 Mesh

Efficiency—95.6%

95%+20 Mesh Separation
5TPH—1500 CFM per foot of Classifier
Feed 78%+20 Mesh

Undersize	**Oversize**
34%	66%
78%—16 Mesh	95%+16 Mesh

Efficiency—92.5%

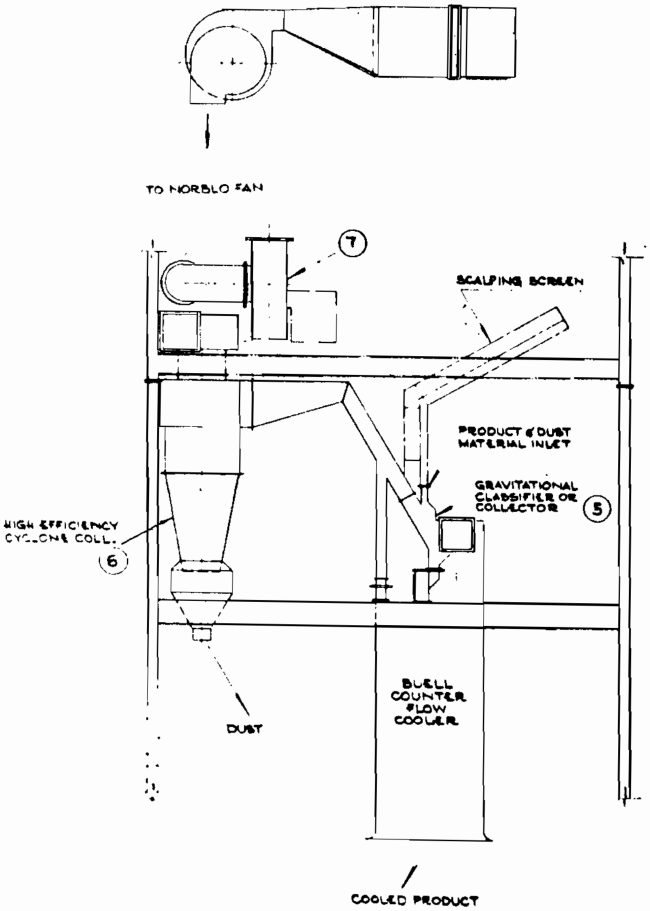


Figure 10

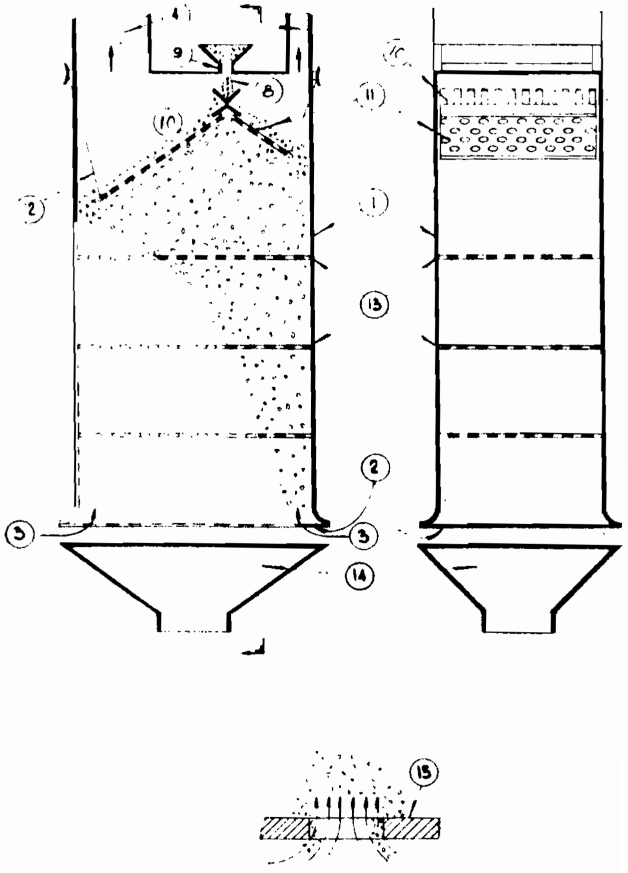


Figure 11

Figure 10 shows an installation employed in granulated fertilizer. This is a conventional classifier with the exception that instead of having a bell mouth inlet as seen in the other units. It has a duct air inlet, what we call, a closed circuit arrangeemnt. The air is introduced in the duct and distributed by means of a perforated plate.

The material is introduced at the top from the pan under-flowing a fine mesh scalping screen.

The coarse material is dropped through an airlock into a vertical counterflow cooler. The classification is controlled by a damper. When we open the damper, we bypass air from the classifier directly and therefore reduce the cut point or the mesh sizing of the classifier.

The cyclone is collecting fine material. The undersize goes back to granulation. The coarse material is dropped into the counterflow cooler.

Figure 11 is a drawing of the counterflow cooler. The cooler consists of a vertical duct, Figure 1 (1) open at the bottom (2). Air is introduced at the bottom (3) peripherally and withdrawn at the top through two passages (4). The cooling air is passed through a classifier or deduster, Figure 10 (5), or directly to a collector or collectors Figure 10 (6), a fan, Figure 10 (7), and then released to atmosphere.

Material to be cooled is introduced at the top of the duct in an even, well distributed curtain the width of the cooling duct, (8). Care is taken to limit the flow of air with the material to a minimum (9). The curtain of material is split proportionally by means of a riffle splitter (10) so that a proportionate amount of material is fed to the right and left of the material point of introduction (9).

The right and left-hand curtains are made to slide on inclined perforated plates (11) whose incline angles are independently regulated by means of chains (12). The plates (11) extend almost to the vertical ends of the duct and are the full width of the duct.

Additional perforated plates (13) may be installed horizontally the full width and length of the duct to increase retention time of the material in the cooler.

A transition hopper (14) with a width and length in excess of width and length of the cooling duct is installed below the cooling duct to concentrate the falling cooled product into a compact stream.

The cooling duct dimensions are such that the upward velocity of the air exceeds the settling velocity of the smallest particle handled. Theoretically, all particles whose settling velocity are less than the upward velocity should be pneumatically conveyed with the gas stream. In practice, due to flow turbulences created by the falling material and resulting concentration of material streams in large ducts, the gas velocity in the vertical duct can be substantially higher than the settling velocity without undue carryover.

In order to obtain complete surface exposure of all discreet particles to the cooling air and to employ the whole of the air stream to cool the whole of the material, while at the same time obtain maximum retention time of the particles in the cooling gas stream, it is essential to have good material distribution throughout the horizontal cross section of the cooling duct. This is obtained by sliding the material across perforated plate with air passing throug the apertures in excess of the settling velocity of the average particle handled by the device.

In order to pass through an aperture, a particle must not only build up a sufficiently high inertial force while sliding to overcome the draft force impeding its passage through the aperture, but it must also follow a limited approach path to the aperture in order to fall through it. This curtails the flow of particles per opening to a very low level, thereby spreading the material over a wider surface than would be feasible if no air or low air velocities were passed through the apertures. The particle flow rate per aperture if controlled by the velocity of the gas through the aperture and/or the incline angle of the perforated plate. Adjustments in either one or both of these variables permit the distribution of the material to the degree required to operate the cooler effectively.

Retention time of the material in the cooling gas is obtained by its hindered settling rate created by the flow of cooling gas traveling in the opposite direction.

Further retention time is obtained by the horizontal retention plates (13) by preventing the material from flowing directly through the perforations due to highgas velocity. The only way a particle can pass the plate aperture is to sneak by the aperatures' periphery, (15), where air velocities will be low due to the contraction of the gases by the vena contracts phenomenon. If the flow rate through a particular aperture is too low to accommodate all the particles presenting themselves to it, the material buildup will block the air flow temporarily and divert it to another aperture. As soon as the air flow stops, the aperture which is large enough to accommodate great material flow rate releases the temporarily retained particles and the cycle is started all over again.

Power requirements are extremely low as the floating velocities employed are low and the falling material never forms a dense curtain of particles through which the air is forced to channel at high speed. As each particle is enveloped by a highly turbulent stream of air, there is maximum possible transfer of heat from the particles to the surrounding air stream. This greatly reduces the retention time required to cool the particles while attaining high heat transfer efficiencies.

Gentlemen, this concludes our presentation. I thank you.

MODERATOR SAUCHELLI: Thank you, Mr. Vandenhoeck. We have a little time for a few questions.

MR. JOHN POWELL: What kind of pressure valves do you have through your equipment? I don't believe you mentioned that.

MR. VANDENHOECK: No. In this particular unit that I showed you, the total resistance of the vertical cooling duct, classifier and cyclone is six inches water-gauge at 130 degrees Fahrenheit.

Moderator Sauchelli: One other question?

A Conferee: The cooler that you described, do you have a unit in actual operation?

Mr. Vandenhoeck: Yes. We placed one unit in operation two months ago and we have some information on what it is doing. It is doing a good job. It is meeting its performance guarantee. This cooler is on a batch granulating operation and it was very difficult to obtain a good reliable technical data.

I can say that on the average the material is discharged out of the dryer at about 225 degrees Fahrenheit and by the time it reaches the classifier, it has gone over a scalping screen and into a bucket elevator, and the temperature is down to about 170 degrees Fahrenheit. It is discharged from the cooler at about 120 degrees Fahrenheit and by the time it reaches the pile, it is down to between 90 and 100 degrees, Fahrenheit.

The ambient temperature at the time was 70 degrees.

A Conferee: Have you been able to obtain the retention time of the material in the cooler?

Mr. Vandenhoeck: We have tried to but due to the particular location of the equipment, it was difficult to do so. We have, we believe, another installation going in very shortly in which we have made provisions to study the retention time.

This will be a Southern installation where the ambient temperature is higher so that we have to pay a little more attention to the retention time.

Moderator Sauchelli: Any other questions?

Thank you very much, Mr. Vandenhoeck.

Moderator Sauchelli: When it comes to classifying screens, who comes to mind? Well, of course, none other than our genial friend and roundtable booster, Wayne King.

Our production men like that Tyler classifying screen but they have had a devil of a time trying to maintain it clean. Well, Wayne at several of those coffee shop sessions that he spoke about this morning devised a simple way to clean those screens and here he is going to tell us how it is done.

Maintenance of Classifying Screens

Wayne King and Steven J. Janovac

Mr. King: Thank you, Vince. Knights of the Round Table. We come here to become knowledgeable in our chemical fertilizer industry. I prefer to think that we should proceed serendipitously. When you get home, look that up. It means something. It means you find out a lot of things you didn't come here to find out about, you know, and you open up a question and the first thing, you have answered something that had never occurred to you.

I wish to make only one profound statement. It has been said that cleanliness is next to Godliness. I would like to be quoted: "Keeping your equipment clean is just as necessary as washing your hands when the occasion demands."

To read his paper, I am privileged to introduce my associate an application engineer of the W. S. Tyler Company out at Cleveland who correlates our efforts in the chemical fertilizer industry, an expert in our equipment pertaining thereto, including parts, maintenance, operation and very importantly, wire cloth screen sections as to specification and application.

He has an engineering degree. He is a product of Ohio State University and Penn State University.

Mr. Steven J. Janovac

"Maintenance" this one word alone has several different meanings, one of which is "enough to support life." This, applied to us, individually, would certainly not present any bright prospects for improvement, and yet this same definition is often applied to equipment i.e. "enough to support life" or, translated to mean preventive maintenance. However, too many times what equipment is functioning receives little or no preventive maintenance and is left to function until it finally stops running. The energies then that were needed to perform preventive maintenance must now be exerted in greater effort to cure a malfunction caused by a lack of preventive maintenance. This is something more than work, and involves a comparison of an hour a month or 12 hrs./year of prevention versus 16 to 20 hours at the end of the year to rebuild.

I know there are many factors affecting what maintenance is required and you of course are the ones to decide. I know too that we all are familiar with the old adage, "anything worth doing is worth doing well." However, to do anything well requires that almost all factors must be present at the same time to accomplish what we want done well and all too frequently the act of doing well is postponed "ad infinitum" and all we have left is what we started with—the intention of doing well.

Now, if you would allow me to change one word of this same saying to mean "anything worth doing, is worth doing badly." Think about this. "Repeat" what do we mean—Let's take it one step further and interpret this to mean if some piece of equipment requires attention, then do it—make the effort, catch it before it gets worse or catch it to make it perform as it should. We also don't mean "do something even if it is wrong" rather do something because it will be right. Right because some corrective or preventive action has been taken, some energy expended in doing something to correct something else. Follow through, results pay.

We are not at the same point in life as the elderly man complaining to his doctor about sleepless nights and after a thorough physical the doctor reported all's well but told the patient to eliminate half his love life. The patient replied "which half, talking about it or thinking about it." This man's plight is apparent.

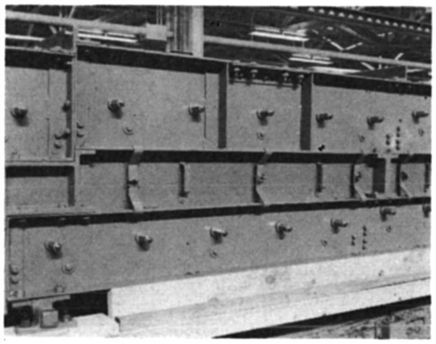
However, when we come to screen maintenance we can talk about and think about it, but we must also do something about it. This brings us to the present point of our discussion, specifically screen cloth binding, and what we can do about it. In the fertilizer industry it is a problem we must acknowledge. It happens at almost every plant, at various times, making high analysis granular fertilizer. It happens on all types of vibrating screens.

Before we get too far into this, I think we should first clarify our position in that we cannot pose as experts on all types of vibrating screens. We know how they work. We know the mechanics of vibration and such as that, but it would be trite for us to assume or presume to know as much about others as our own. We should therefore like to limit ourselves to Tyler equipment.

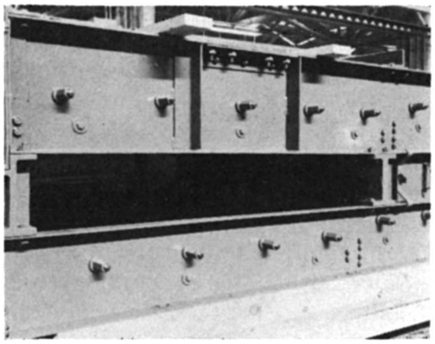
We know blinding occurs, but to degrees. In other words blinding is cumulative, and the finer the separation then the more probable the problem. In a fertilizer application, blinding is generally caused by the fine, damp, dusty, "romantic" (per Al Henderson) material adhering to the wires and building up from this point. The longer it takes to build up then the less frequent and severe the problem and the less time required to free the cloth from this residual material. In the fertilizer industry we use both our Niagara Mechanical Screen and Hum-mer Electric Screen but apply them differently. However if we were to apply each to the same application of classifying granular fertilizer the mechanical screen with its more gentle action would be subject to blinding in a much shorter time period than would the Hum-mer with its high speed, high impact, stinging action.

However, if and when blinding does occur some corrective action must be taken to maintain screen capacity. The problem then is how to clean the cloth, and we don't mean by beating it or raking it with a hoe. Actually we still have two choices. (A) Clean in place or (B) by removal. (A) is the obvious choice since (B) is eliminated due to time and expense. The next question is, what screens do we clean? 1) Raw materials 2) Classifier or 3) Shipping.

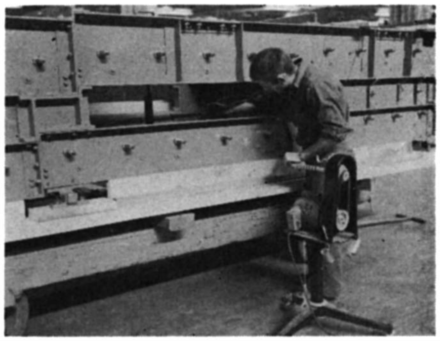
Obviously, the classifier screen is the principle problem. This is the screen making both the coarse and fine separation. This is the screen that carries 50-75% of the total feed on the second surface which is the surface on which we depend for removal of the fines. As you know our standard classifier screen is the two surface Hum-mer varying in length from 10′ to 15′ to 20′ (1st slide 15′ Hum-mer side view) with this type unit we maintain easy access to the bottom or second surface through the side inspection doors between the decks on both sides of the screen (2nd slide side view 5′ w/doors).* This access is easily made even with the Hum-mer operating if necessary by simply removing these doors (3rd slide side view 5′ w/o doors). With this accessability on each side, then the distance to the center of the screen panel is slightly more than two feet and well within arm's reach. However raking a hoe or beating a compartively fine Ty-Rod cloth is not conducive to good cloth life. *But* with a portable, vari-speed flexible shaft machine turning at approximately 1800 RPM with a 6″ diameter wire cup brush or 6″ wheel (4th slide man w/machine) the cloth is quickly and effectively cleaned of all residual buildup and wedge blinding. (This particular slide is for illustrative purposes only but we do have some excellent field results.) These units can be purchased for approximately $100 and up, are vari-speed and can be either mounted on casters or suspended. Standard models would include ¼, ⅓, ½, ¾, 1 and 1½ H. P. with the model shown here (5th slide) ⅓ H. P. It makes little difference as to the manufacturer of this equipment, the important thing is that it works. It's fast, efficient, relatively inexpensive and readily lends itself to other uses in the plant.



Slide 1



Slide 3



Slide 4

Slide 5

Access to the screening surfaces is important for both inspection and cleaning, if necessary. Plants using Hum-mer Screens are aware of this accessability and should use it to advantage.

That's all. Thank you Any questions?

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*Note: Slide 2 similar to Slide 3 except with doors in place.

A CONFEREE: That wire brush there on a finer mesh screen cloth, when you build up, you use the wire mesh rather than on the surface; does that effect the screen without spreading?

MR. JANOVAC: No. We have had some good reports from the field that this does not injure the cloth itself, it doesn't spread the wire.

A CONFEREE: Any type of brush?

MR. JANOVAC: Well, the brush that I showed here was a much too heavy a wire. However, this is the only thing we had. A six inch wheel brush with 0.020″ or 0.016″ wire diameter bristles would be better.

A CONFEREE: Would it eliminate the material that gets down in the space between the wire?

MR. JANOVAC: Yes, it will do that. It will effectively clean it.

Is Phil Stone here this morning? Phil, did you get any reports about that?

MR. PHIL STONE: Yes, I have something, not in too much detail. He had comments that were quite favorable. His machine is quite similar to the one you just demonstrated.

MR. JANOVAC: Thank you. He did mention, Steve, that his wheel is a six inch wheel but it is more like a wheel that is mounted on a shaft like you see in a shoe shop and it comes out on a flexible shaft and turns at a right angle. It has a handle about a foot long to permit operation between the decks of the Hum-mer. About a seven foot length of pipe for the shaft, it is driven with a three-quarter horsepower motor.

I asked him what difficulties he might have in the use of this piece of equipment and he mentioned primarily that if the operator pressed too hard on the tie rod in scraping he thought that there was some danger of spreading the wire. I am not certain but I think his rpm was 3600.

MR. JANOVAC: Yes. They make these anywhere from 900 up to 36,000 rpm but for most practical purposes 1800 rpm is best.

MR. STONE: In general, he said he thought it did a good job. I think our screening problems in this particular plant where it was tested are somewhat better than at some other places that I would like to see it tried. We have had it in use for maybe two or three months. We will probably put more of them in use in time at other places.

MR. JANOVAC: Thank you.

MODERATOR SAUCHELLI: Any other questions?

Thank you, Wayne and Steve.

I think Wayne really has become the efficient executive. He just passes on his job there to somebody else. That is fine, Wayne.

Because of the time, we are postponing our next talk to be the first talk right after lunch.

We stand adjourned until two o'clock. Please be on time at two o'clock.

(The meeting adjourned at eleven fifty o'clock a. m.)

Wednesday Afternoon Session, October 24, 1962

The meeting reconvened at two o'clock p.m., Vince Sauchelli and Joseph Reynolds, Moderators, presiding.

MODERATOR SAUCHELLI: Let's please come to order.

One of our old friends and one who has participated in our meetings frequently and has been a great help to us is the next speaker. His subject is Selection of Proper Equipment for Reducing Particle Size. This is a very interesting subject, one in which most operational personnel are interested in and I am sure our next speaker, Harold Krueger of the Stedman Foundry and Machine Company will give us much worthwhile information.

Selection of Proper Equipment for Reducing Particle Size

Harold R. Krueger

MY assigned subject has been further delineated and most directly confined to the oversize from the manufacture of granular fertilizers. This particular subject does not make me deliriously happy because of all of the products for which our company has furnished grinding and sizing equipment, granular fertilizer oversize is one of the most difficult for which to select the proper equipment.

Basically, all crushing operations are simply the application of force, or horsepower. When any moving object encounters any other moving or stationary object the weaker of the two in crystalline structure will crush or disintegrate. At this point, I would like to say "thank you" and sit down and I am not too sure that all of you would be grateful.

All crushing operations fall broadly into two methods, impact or attrition. A stone, hit by a rapidly moving steel hammer, will fracture into small pieces, the size of which can be fairly carefully controlled by the speed of the hammer and the mass of the hammer. This is a simple example of impact crushing. This same stone, placed between two closely set steel plates, either both plates moving or one plate moving and one stationary, will also be crushed and this would be an example of attrition crushing.

Where it can be employed, impact crushing is always preferable over attrition crushing because it requires less horsepower and a very low rate of maintenance due to wear on the crushing surfaces. Since impact crushing will not give a completely sized product in one pass through the machine, it is most always necessary that impact crushing be done in closed circuit with scalping screens.

Since attrition crushing is usually done in a machine that will cause the product to pass through a controlled aperture or opening, the wanted top size can usually be accomplished in one pass through the machine. This type of crushing requires considerably more horsepower than impact crushing and engenders a fairly high rate of maintenance due to abrasion and deterioration of the closely spaced grinding components.

Perhaps unfortunately for the fertilizer manufacturing industry, the choice of machines to reduce granular fertilizer oversize is not nearly as simple as just picking a choice between impact and attrition machinery. The major problem in choosing a particle reduction machine for most complex granular fertilizers is the great tendency, of particularly the phosphate bearing ingredients, to adhere to both the moving parts of the crusher and the housings which contain them. I am sure that all of you here who have had experience in the operations of a fertilizer plant are more than familiar with this problem and I do not intend to dwell on it except point out that when we are called upon to recommend a machine for the reduction of granular fertilizer oversize, we must take this problem into account and perhaps somewhat compromise our recommendation for a machine in the favor of ease of accessibility and nonplugging characteristics.

In a granular fertilizer operation, the point at which the sizing operation is to be done will affect a crusher recommendation. For various process reasons, the sizing of granular fertilizer has been tried at three locations in a complete granular plant, the first location, and incidentally the most difficult, is between the granulator and the dryer, the second location that is sometimes used is between the dryer and the cooler, with the third location being at the cooler discharge. Quite naturally the crusher manufacturer always greatly prefers to try to size the product after it has passed through the cooler and the reasons are quite obvious as the temperatures are lower, the stickiness of the product is greatly reduced and the moisture content is greatly reduced. The ideal place for any crusher is where the temperature of the product is ambient, the moisture content is as low as possible and most of the chemical reactions have come near to equilibrium. I am sure that the screen manufacturers will agree with our thinking on this.

There are three generally accepted types of crushers now in use in the reduction of granular oversize, two of them being of the impact type and one being of the attrition type. Chain mills and cage disintegrators are impact type crushers and we might also include in the attrition group a fixed or swing bar type of crusher that has vertical grinding plates through which the bars of the crusher must pass.

The chain type crusher is the impact type in its simplest form. Crushing is accomplished by the impact of the revolving chains upon the particles as they fall through the feed opening and into the rotor. We must remember, as pointed out earlier, that this type of crushing is never going to deliver a completely sized product in any one pass through the machine. The reasons for this are twofold, the first being that not every particle is going to get hit, and if hit, is not going to be hit hard enough to disintegrate to size, and the second is that when the particle is hit hard enough to disintegrate, it will probably fracture into particles of a wide distribution of sizes, some of which will be finer than wanted. The chain type mill must be operated at a sufficient rate of speed to keep the chains extended rigidly enough that they will not fall back or bend when impacting the product as it passes through the machine, so a fairly high speed is required. One of the unfortunate results of the speed required is that some of the product will revolve with the chains and impinge itself upon the housings of the machine and now the build-up problem begins. Rapid accessibility to a chain mill type of crusher is of paramount importance. The chain mill is usually the lowest priced machine, its horsepower requirements are usually low and replacement costs of the crushing components are moderate.

The multi-cage disintegrator is the second type of pure impact crusher that is enjoying fairly wide acceptance in the fertilizer manufacturing industry. The counterrotating cages can be varied in speeds and pin spacings to produce a wide variety of sizes. Since the grinding implements, which are the pins, are firmly fixed, they are not dependent upon speed of revolution to keep them in operating position. Therefore size of product produced can be more carefully controlled and the production of unwanted fine material held to a greater minimum. To produce a carefully sized product, this type of machine, as the chain type, must be operated in closed circuit with sizing screens. The original cost of this type of machine is somewhat higher than chain type, and it requires two motors. The flexibility of this machine is worthy of consideration. Accessibility to this machine is also highly important because the problem of adherence of the product to the pins of the cages and to the interior of the housing may require a periodic cleaning operation.

The conventional hammer mill, when it is fully equipped with hammers and grate bars, is almost a pure attrition machine and for many years was the accepted piece of grinding equipment for conventional fertilizer plants when the only requirement of product size was that it pass an approximate 4 mesh screen and the percentage of fines or powdered material was of no importance. When a hammer mill is equipped with grate bars or perforated metal screens, it can deliver a very closely sized product as far as top size is concerned, however it will always produce a high percentage of finely ground material due to the attrition action that takes place when the product is forced between the hammers and the perforated metal screens. The unfortunate part of a hammer mill, when used to handle granular fertilizer particle sizing, is that the close clearance in this type of machine rapidly becomes completely plugged with glazed phosphatic and other material ingredients so that the onstream operations time is very likely to be of very short duration and the cleaning of a hammer mill is not a very easy or rapid operation. By removing the grate bars or screens and using various hammer arrangements, a hammer mill can be operated as an impact machine, however if used in this manner, it is not the best purchase for the money expended.

I had given some thought to including in my remarks here this morning, some typical results that we have encountered in our test laboratory on samples of granular fertilizer oversize furnished us for testing purposes by members of this industry. I was rapidly convinced that to attempt to present a comparative statistical tabulation of these results would be time consuming and not necessarily conclusive. I might say that we have tested 48 different analyses of granular oversize, representing 220 actual test runs, with materials being furnished by 14 producers. Some of this test work was requested to be of a confidential nature but I can quite frankly state that the results of crushing tests are of no particular value in themselves unless many other factors are unilaterally considered. The following is a list of some of the factors that we feel have to be taken into consideration when choosing the best or most applicable type of crushing machine:

- Location, in process, of grinding equipment.
- Formulation of the mixture.
- Temperature and moisture of product at point of grinding.
- Top and bottom screen specifications.
- Type and size of screening equipment.
- Desirability or undesirability of fines to be recycled.

Any one of these items could come in for major consideration.

You will probably note that I have omitted the cost of grinding equipment from the above list and this was done purposely. I believe I would be safe in saying that there is probably less thought given to the crushing of the oversize from granular operations than to any other part of the process and I believe I am equally correct in stating that in most instances this is a very serious error. The cost of grinding equipment, in fact all equipment, should be commensurate with its performance, not its original price.

Referring to the title of this presentation, I see where I perhaps should have told you by now, or made a recommendation for, the selection of proper equipment for reducing particle size in granular fertilizers and I am quite aware of the fact that up to this point I have not fulfilled that assignment. Quite frankly, I do not now, or later, intend to make a categorical choice of grinding equipment for this problem. The only definite recommendation that I intend to make is that when you are faced with this problem or are looking for improvement to your present methods that you request the assistance of a representative from a crusher manufacturer, particularly one who is familiar with the problems involved in crushing operations in granular fertilizer manufacturing. Above all, you must be able to rely upon his integrity because if he cannot be taken fully into your confidence and given the full facts of what goes on before, during and after a crushing operation, I do not believe that he can make an intelligent recommendation.

MODERATOR SAUCHELLI: Thank you, Harold.

Are there any comments or questions?

HUGH A. GRAYSON (ICI, Commonwealth of Australia): In talking of chain type mill, you mention the problem of build-up in the casing. I thought it might be worth a comment. In our Country where we have developed many of these things without the help of manufacturers, we've had this problem of casing build-up. By utilizing a chain curtain, a cracking curtain, I presume the principal reason for using the chain curtain in the first place is that the flexing of the chain breaks build-up from it and we have just taken it one step further and the curtain would do the same sort of flexing. I though it might be worthy of some comment and it certainly would be something that would be used quite extensively on sticky materials.

MR. KRUEGER: I might say that several of the chain mill producers and manufacturers have hung inside the casing a row of flexible chains to help the build-up problem. I do not know whether the chains themselves being flexible do not build up during operation but I think it is more when the rotor comes to rest and stops that they fall back and crumble any adhered particles away from them, because they are pretty stiff if you hold them out hard enough to do a good crushing job.

MODERATOR SAUCHELLI: Any comments or questions?

I hope we will have more questions as we proceed on the different programs and do not be reluctant to get up and ask or make your comments because they might be very valuable to the next person.

For the second half of our program, it gives me pleasure to turn the lectern here to my associate Joseph Reynolds.

MODERATOR REYNOLDS: Thank you very much, Vince. It is always a pleasure to meet before this fine group. The plaque that was presented this morning really touched me. It was strictly unrehearsed and unknown to any of us, but we say "thank you" and we sincerely appreciate it.

The theme of this afternoon's program will cover several different types of topics with emphasis directed towards granulation, lawn and specialty fertilizers, the use of diammonium phosphate in mixed fertilizer formulation and materials handling. Each subject in its own can be expanded, promoted into a full program but for obvious reasons, time will not permit, so we have assembled people who are well qualified on these various subjects to carry the ball and discuss these for us.

When continuous granulation processes entered our industry, we perhaps assumed that because we had installed continuous flow instruments and equipment, that a continuous flow system would result. We soon discovered that this was not the case. Raw material movement, in-process raw materials, completed fertilizer can be mechanically interrupted and liquid flows can fluctuate with resulting changes in granulation, efficiency and product recovery.

If product recovery changes, so

does the recycle requirements of oversized and fines which must be returned to process and regranulated.

Allen Jackson of Fertilizer Equipment Sales Company was interested enough in the possibility of surging loads in the granulation process to determine the magnitude of these loads. The information gained can be helpful in leveling out existing systems and also be used as a guide in new process design.

It gives me great pleasure to introduce the next speaker, Allen Jackson of Fertilizer Equipment Sales Company.

Surging Loads in Continuous Granulation Processes

Allen Jackson

Before I start, I would like to give a little bit of background on how we got into this particular work. We were working with a California plant this past year that was having a little bit of inventory problem. We took a gravimetric feeder, stripped down all the control devices leaving only the sensing mechanism, the recorder and a totalizer. The unit was put on the product conveyor or in the product conveyor line so that all of the material going to storage was weighed and the weight recorded as far as weight goes.

The plant is a small plant. It runs at about 12 to 15 tons an hour. Its fluctuations are probably a little greater than a large plant. In order to show you what we have in the way of machinery, I have had some slides made of schematics showing the schematic layout of the feed system. The plant itself is a simple ammoniator dryer-cooler screen, free recycle, with the crushed over-sized going back through the ammoniator, not back through the screens alone.

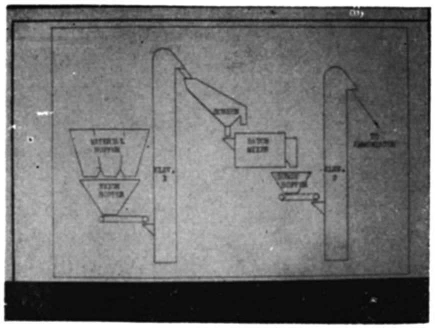


Figure 1

This is just as you would expect, a typical raw material feed system, a material hopper, a weigh hopper, screens, batch mixer and surge hopper. This particular plant does a lot of granulating of normal super. This portion of the equipment was aging. The normal super is made with alkylation acid with western rock and I don't think it makes the best super in the time that we had to store it.

So before we actually started running, a change in this layout had been made out of necessity, not out of choice. Figure 2.

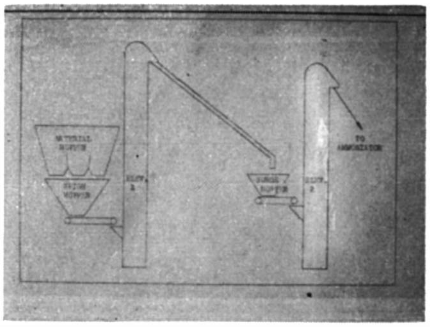


Figure 2

In order to make it run at all in this past year, they had to remove the screen in the mixer. So in effect, the material was weighed, it was unmixed and it went directly to a surge hopper where it was fed into the ammoniator.

These graphs were taken at different times during this past year to show some of the real problems that we had. This first graph is a mixed goods. It is a 15-10-10.

Fig. 3 – operated at 12 tons per hour. This graph is taken from the product conveyor. If you count the peaks between any of these hour marks, there are 12 peaks. This corresponds, of course, to the frequency that we were weighing in in ton batches. No mixing was done prior to this, so obviously we felt that the cause of these 12 fluctuations an hour was simply the result of poor mixing.

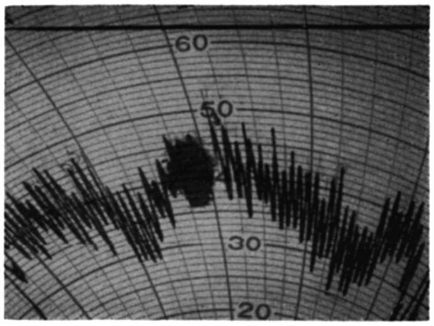


Figure 3

First to try to see what happened, instead of weighing in one-ton batches, we weighed in half-ton batches, 24 half-ton batches. The change that it made was a deviation from a normal line, about half of the previous deviation.

After we made that trial, we went back and changed the feed system to obtain further mixing (Fig. 4.) This feeder is strictly a volumetric feeder. The material was sent from the weigh hopper over here on a time basis. The feeder was operated so that it would run empty just before the next batch got to it.

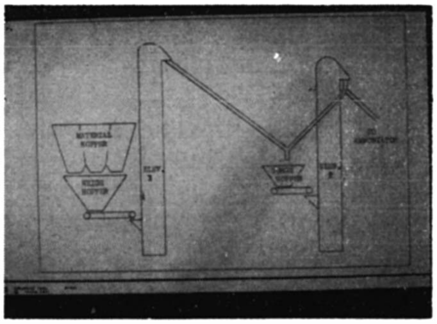


Figure 4

The material went up to the elevator going to the ammoniator and the load was split sending some back to the surge hopper to get some back and forward mixing at this point. As soon as we had made that change, the flucuation smoothed considerably.

(Fig. 5.) It still doesn't look good but the deviations here, top and bottom, are roughly half of what they were previous. What difference did it make? What did it gain? We tried sampling on the earlier slide at each of the peaks. We went around and

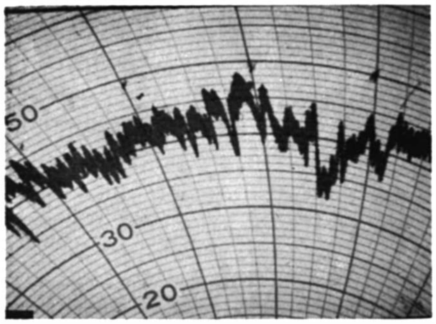


Figure 5

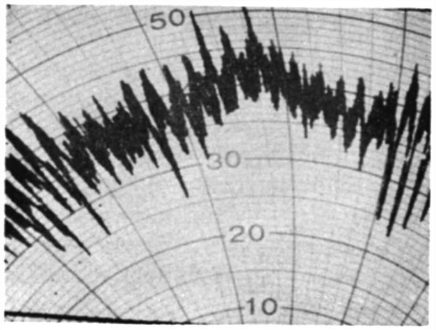
sampled at each of the valleys. We did that on the day before we made the change. We were so sure that the analyses of the peaks and the valleys would be different that we only made one sample.

We were disappointed. There was no difference, no appreciable difference. So after we made the change, we were wondering what good we had really done. The formulation generally in this part of the West Coast is all commercial nitrogen. Grades like 16-20-0, 15-10-10 and so on are made with quite high ammoniation rates. These particular grades had required about six tenths of a unit excess ammonia or excess total nitrogen to make grade. They would then come out on grade to a tenth of a unit over.

As soon as we had made this change, the grades began to come out about three tenths of a unit high. For instance, 16-20-0 formulated at 16.6, started coming out around 16.3 or 16.4. So the immediate change was we were able to drop our excess ammonia at this point about three tenths of a unit. There were many thousands of tons made, it made quite a bit of difference in dollar savings.

The next step was to see why in the world we had all of the fluctuations that we could not justify by blaming improper mixing. The next graph is a graph of superphosphate only. The super in this case is fed into the unit at a uniform rate. We expected to get a reasonably uniform pattern, not one anywhere near this amount of error.

Figure 6



(Fig. 6.) This is what came out and I assure you we were surprised. Notice here the regularity of the cycle. This particular plant has an ammoniator seven by ten, but I imagine it holds two to three tons of material. The dryer is 7 feet by 33 or 34 feet long. It had a small cooler. I don't remember the size of it, but I would say the system held about five tons.

Here we were running roughly at 12 tons an hour, yet we got roughly five major peaks an hour. If we held five tons of material within the system, if the system were cycling on a complete cycle,—in other words, if we made the fines at one time, it completed the course around the system and came back intended to generate more fines, we would expect maybe something like this to happen.

I believe this was happening because the screen analysis of the product feeding the screen was roughly 50 per cent on size. So at about 25 tons per hour, passing through the system, this pretty well checks out with what we would estimate the system would hold. We didn't try to sample this on peaks and valleys. We knew that there would be enough mixing in here not to give us any appreciable difference by this time.

Referring again to Figure 5.

This figure shows a mixing of the material not being completely mixed possibly, plus an overlay of system cycling. If you can follow through here, there seems to be a background of a frequency about five an hour again. So this again shows our system frequency, plus the frequency of the mixing itself which in this case wasn't really as bad as it looks, showing up in the final product line.

(Fig. 7.) Again this is another day on superphosphate. Some of the fluctuations are quite severe. Notice this goes from about 25 to about 45. That is nearly 30 or 40 per cent of the total rate of flow. You could identify operators, different operators would have different patterns. Some would hold it consistently within patterns like this. Others could operate quite far out of line.

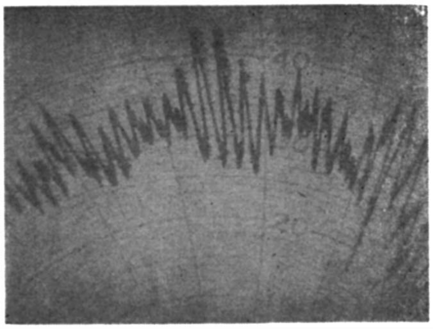


Figure 7

Figure 8

(Fig. 8.) This is another plant owned by the same company, running at about 20 to 25 tons an hour, a completely different plant. It has an ammoniator, a dryer, no cooler, screens, free recycle. Again, the same type of regularity in recycle fluctuations developed.

We went back then to see what we could do to stop this sort of fluctuation.

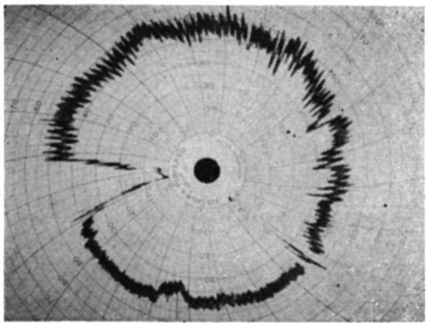


Figure 9

(Fig. 9.) This is the normal run during the course of a night. It shut down in the morning to clean up. We devised a rather crude gate to put on the fines hopper or underneath the screens to feed it back to the uniform rate. We took the oversized that we had and spilled it on the floor. We didn't even put it back in the system. When we cranked back up, immediately the cycling of the system had stopped. Fig. 10 This is the same type of thing—another day on the same pattern. Again here is an operator pattern that would show up with one operator. Everytime he would do that.

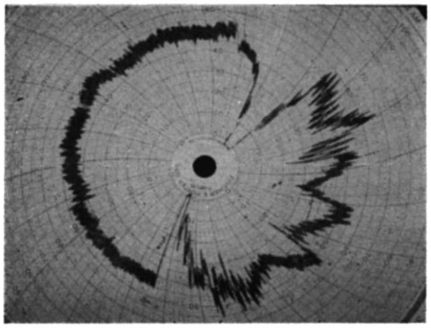


Figure 10

I am not sure though and I would hesitate to say what made that little frequency.

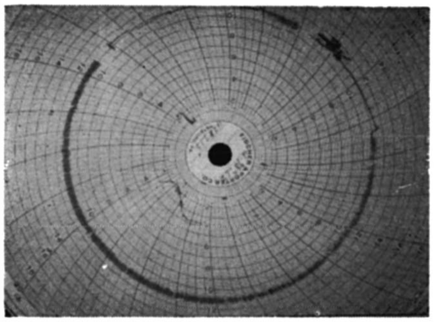


Figure 11

(Fig. 11.) This is the kind of graph we would like to get. Obviously, this is not one from this plant. This happens to be a recording from a gravimetric feeder. We would like to get this for two real severe reasons. First, if we can eliminate material variations, we can work with our raw materials closer to what we are trying to get out of it and not have to give quite so much away.

One of the results that we found on this previous graph was that when we were running without the fluctuations, the moisture in our product dropped from around three and a half per cent down to around two without any other changes. If we could run at a uniform rate, then, as far as loading is concerned, I believe we would find that we could either upgrade our rate of running closer to the capacity of the system or that we could upgrade our product quality. We would have two things to gain by trying to steady the rate of flow of a mill.

MODERATOR REYNOLDS: I think we have some questions. I am sure we do. Who is going to be the first in addition to Frank Nielsson and myself?

MR. PHIL STONE: I am not sure yet what conclusions we draw from our friend here. What he had was interesting. What is your conclusion? What should we do about it?

MR. JACKSON: I am trying to draw no conclusions. I am trying to show simply what exists in a plant, that if a method is made and put into a plant to find that such things as this exist, then track down to what is causing it, a little better performance can be obtained out of a given plant.

I don't believe any two plants would have the same problem but this is simply another tool that will help you to arrive at a good plant operation. I am not really trying to draw a conclusion from any of the graphs. I had intended to do this but this plant was being changed to take care of the actual problem. It is kind of like you have with your management sometimes. I can't quite get my customers to work on my schedule, so they aren't ready.

MODERATOR REYNOLDS: We have time for another question or two. I think this information is very enlightening. The frequency here, either from an operator's standpoint or from the processing standpoint I think is really an eye-opener. The first time I saw it, I was amazed.

Does anyone have any ideas as to what is causing some of these frequencies? Al, would you come to the mike, please.

MR. ALBERT HENDERSON: I think all of us know if you take a sample of material from a granular system and screen it and analyze it, each screen fraction will give you a different analysis and that is what you are doing when you upset recycle.

When you have a free recycle system, the next thing you have a free analysis system. It is as simple as that and I think this proves it.

MR. JACKSON: Again I am not trying to draw a real conclusion. I was just simply showing our problem does exist and probably does exist in any free-cycle mill. It is possibly one of the causes of irregular operations by different operators.

Different operators have different troubles. Some can cope with these troubles a little better than others. Granulation is an art and not a science. Again, it is only to show that problems exist and to the degree that they do exist. You can't tell this by looking at a belt. You can stand there and look at the conveyor belt and you couldn't tell that it varied or I couldn't.

MODERATOR REYNOLDS: Has anyone else performed similar work? Would you come to the mike, please?

MR. DAN WALSTED (American Cyanamid): I can't enlighten Al on the free cycle at all but he made one very interesting comment in passing and I would like to have him enlarge on it and that was in his test work, he took the cracked oversized, I believe, and dumped it on the floor to get it out of the system.

I would like to know why he did that and perhaps his reasoning in sending back only the fine undersized.

MR. JACKSON: The cracked oversized was put on the floor simply because we had no way to control the rate. If we had had some way to put it into a hopper or control the rate uniformly, no, it wouldn't have been put back. This was just that the system didn't allow itself in an hour modification any way to get the cracked oversized back into the system at a uniform rate. So the first thought the first day was simply to dump it and we ended up with 15 tons or so of the stuff. It had been through the roll mill. It just didn't go back.

The next day we were getting too big a pile, so we put it back into the hopper system. We were way out—I forget, 1600 pounds or 1700 pounds of fresh super, three or four hundred pounds of the cracked oversized, so then it was being volumetrically fed back into the system with the new material. Because nothing was being mixed, there wasn't any problem there. It was just super.

It was strictly just to get by the period of time to get a uniform feed-back into the system that we could not get in any other way.

Mr. Walstad: It occurred to me by taking the crushed oversized out of your return system, you were deliberately increasing the variation of fines that were coming back.

Mr. Jackson: Well, I am sure we increased the percentage of fines relative to the other materials coming back, but what was coming back was coming back uniformly. The oversized in this plant, and I am sure in many others, would fluctuate just like the fines would and we were just trying to take out all of the variables.

The one variable we did not take out was the material coming back from the cyclone. I don't believe that was a significant quantity at this time.

Moderator Reynolds: Any comments? Any questions?

Thank you very much, Allan. I think maybe next year we might have a continuation of this. I think we have a lot of thoughts going and maybe someone will come up next year with some more of the answers.

We will move along to the next part of our program, if there are no questions.

During the past several years, the lawn and specialty fertilizer field has expanded tremendously. The urban homeowner has the time and desire to relax, to work in the yard, maybe he is coaxed by his wife or by his own motives, but it has happened. Beautiful lawns and gardens have often taken shape and represented by the extreme devotion for this new type of hobby.

Appealing sales promotion and educational programs have encouraged and furthered the growth of lawn and specialty fertilizers in our industry. This subject has come up at the Round Table in past years and we have now picked what we consider the proper time to bring it before the group. So we toss this subject over to Bill Lewis of DuPont Company who has very kindly taken on the job of assembling experts to brief us on present and future trends in this lawn specialty fertilizer field.

Lawn and Specialty Fertilizers

James W. Lewis, Panel Leader

Thank you very much, Joe. We want to take a look this afternoon at the specialty fertilizer products in various of its aspects. We have quite a bit of ground to cover in a relatively short period of time. We have four people who are going to talk on various of these aspects and they will also be assembled here at the table at the conclusion of the total talks to answer any questions and discussions which may come up.

Briefly the areas that we are going to cover this afternoon are going to be the marketing, agronomic, and production aspects.

The first speaker this afternoon will be Mr. George Doherty of Topco Associates. Mr. Doherty is the Vice President in charge of organization for 27 chains of supermarkets comprising some 950 stores across 28 states, and as I am sure you realize, people in this area certainly should have their fingers on the pulse of the American market.

Progress Report on the Marketing of Fertilizer to Home Users

George Doherty

I have to assume that you have asked me to talk on this subject because of interest in my remarks last year at the Northeastern Conference. I'm flattered by this, and delighted to carry on, but I must disclaim the role of authority. (Judging by the program, this is a rather lonely role.) I have a great deal of interest in the subject, and am glad that this year we will be discussing it, exchanging opinions, in round table style. It deserves discussion.

Now I know that your interest in the non-farm fertilizer market is based on its exceptional rate of growth, considerably greater in recent years than that of agricultural fertilizers.

A good starting point on this subject may be to summarize what I said a year ago. I crudely estimated (with much help from Mr. Mehring) the home use market at $150,000,000 per year at retail prices; said I thought this will (conservatively) double by 1970, the doubling to come in part from new users (only half the non-farm families now use fertilizer) and in part from increased application by present users. I also expressed the opinion that self-service outlets, not just food stores but also other such outlets, attracted by the high markup and gross profits taken by some stores, will be strongly impelled to the promotion of fertilizer, and will lower prices and lower markups, will thus raise their share of the fertilizer market from at most 20% to a much higher percentage—perhaps over 50%.

Now, in rereading my talk last year, I noticed that it did not make clear my opinion that total home fertilizer consumption can and will be increased substantially through lower cost distribution with lower retail prices, accompanied by the usual self-service displays that promote impulse buying. This seems certain to raise consumption to higher levels, higher than the estimate of $300,000,000 per year, provided that customers can obtain in self-service outlets the products they want, of satisfactory quality, attractively packaged and displayed.

In the year since October, 1961, there has been no explosion of home consumption of fertilizer. Lacking year-to-year figures, we can assume a continuation this year of the steady growth of the last 10 years, between 5 and 10%. Nothing spectacular happened, to my knowledge, in 1962. There probably was no substantial increase, if any at all, in the percentage of total home fertilizer sold through self-service outlets.

Statistics are never, of course, the whole story in marketing. If you believe, as I do, that the burden of increasing consumption has to be carried by strong brands, both manufacturers' and retailers' brands, the most significant development this year was two new brands, distributed by manufacturers who have great skill in marketing through food and drug outlets. These two brands made beginnings in the home fertilizer market, and may emerge as dominant brands. But this year they were, esssentially, test marketed. I don't know what success they had. One was sold through all types of outlets including food stores. The other solely through convention lawn and garden outlets. The one sold through food stores was sold with a new kind of spreader, a plastic container hung around the user's neck, spreading more or less as seed formerly was sown by hand. The spreader cost $5.95, less on a combination deal with the fertilizer. I have so much respect for this company—one of the most effective, skillful, high-batting-average marketing companies in the food industry—that I hesitate to question any approach they might take to anything. But I do think that it might have been wiser to delay the introduction of the new kind of spreader, which involves a revolutionary change from the established habits of applying fertilizer in home use, until the product itself had been strongly established.

Sometimes it is a good idea to get into a business before you revolutionize it. But, of course, this depends to a great extent on how important it is to effect the change. If the basis of the product and marketing opportunity lies in the particular change or improvement, then it should be made immediately. In this case the company must have considered the method of application to be the principal and not a secondary advantage of the new product to the consumer. However, the price of the spreader must have deterred a good many people from buying the product. Especially since the product is, I think, inseparable from its method of application. It contains, as I understand it (perhaps someone here will correct me if I'm wrong) — no ureaform, and therefore, is very likely to burn unless it is spread in the sowing seed fashion. So, because this new product is inseparable from the spreader (which is of a type that virtually no fertilizer users now own or have had any experience with) we (and the manufacturer) probably did not get a clear cut resolution of the question of whether the product itself has appeal, or whether selling the product through food stores (rather than through higher margin service outlets) was a sound idea.

I have difficulty in getting away from the subject of this spreader, because it may prove to be just as important as this manufacturer apparently thought it to be. I say this because it has the following advantages to the home fertilizer user: low initial cost, much less than that of the conventional metal type; coverage of a much larger area, a strip about 6 feet in width as the user walks; and less likelihood of uneven distribution and resultant spot burning. In my mind there is no question that the established method of spreading must be very unsatisfactory to many users because of overlapping, missing strips, dumping excessive amounts at the end of the row, etc.

The other company new to the home fertilizer market introduced a product with a new method of minimizing the risk of burning, and as far as I know it's too early to say whether this product will be accepted as a better product by a large part of the market. In any case the second product, marketed by a successful marketer of products in the drug field, was sold through service rather than self-service outlets, and thus did not provide a test of whether the fertilizer consumption of home owners can be increased through lower cost distribution. Nevertheless, we can all be grateful for these effective new brands, because if they are successful they will enlarge the market for all home fertilizer brands.

Now, if you don't mind, I'd like to enlarge upon some of the ideas which were discussed a year ago, and go beyond them.

I submit, for your consideration, that the rate of growth of home fertilizer consumption will depend mainly on the following factors, and that, if these factors all operate effectively, the growth will be greater than anyone has estimated.

1. An increase in the frequency of application of home fertilizer by most users. (New users, the conversion of a large part of the 50% of all families who now use no home fertilizer, will also be significant, but is not, in my opinion, nearly as decisive in determining the rate of growth.)
2. An upgrading or improvement in the quality and performance of the whole complex of products that affect lawn care, including grass seed, garden hose, spreaders and lawn mowers.
3. Better understanding, by the consumer, of the principles of lawn care and the use and quality requirements of the various supplies and tools.
4. Lower prices of all these products through lower cost distribution. Along with lower prices, more frequent "impulse" buying of many of these products because they are displayed attractively in high-traffic, often visited, self-service outlets.

Let's consider these points briefly, one by one.

1. Increase in the frequency of application of home fertilizer by most users.

   Please keep in mind that I live in the Middle West, in Chicago, and that what I have to say may not apply to other regions, although I'd guess, considering our temperature and rainfall, that it would be more true of most other areas in the United States.

   At any rate, I have observed many lawns this summer. Even in higher income areas, 90% of all lawns have poor care, and this probably includes too little fertilizer. But, if this is true, is it surprising? How many families understand that, if they are really to have a beautiful green lawn, they must apply fertilizer several times; perhaps once a month (at least to certain parts of the lawn) during the season from March to October? How many think one application is good enough, and two, in spring and fall, quite generous? Most, I think. And if one or two applications are not enough, it is not self-evident to the user, because there are many other causes to blame for a poor lawn, or poor areas in the lawn, such as shade, rainfall, soil.

Even the manufacturer who has done most to educate American customers in lawn care for some reason soft pedals the need for several applications per year, fails to stress it.

Considering the pride Americans have in their homes and the relatively modest expenditures required, I think that much more fertilizer will be used on lawns if brands merchandise the need and educate the customer, who, except for a small elite who receive a certain direct mail publication, are still in the first grade on the subject of lawn care. I'm confident that brands will eventually merchandise the need for more frequent applications. Their interest in doing so is obvious.

2. Upgrading or improvement in the quality and performance of the whole complex of products and consumer understanding that affects lawn care.

As you all know, many things enter into the making and keeping of a fine lawn. Some of them have to do with products. For example, poor quality garden hose makes it very difficult to water the lawn adequately, the more so the larger the lawn. I don't know how much 3/8 inch hose is sold now; several years ago it represented, I think, a larger part of the market, and it is very inefficient and inadequate. Much garden hose still fails to meet U.S. Department of Commerce minimum standards. Unfortunately, there is no strong brand in garden hose, except Sears; Sears is carrying most of the burden of consumer education in this product.

A very large part of the grass seed sold in this country (about 50% in dollars and a larger percentage of pounds sold), are temporary rye mixes, which must be replanted. This is a bad buy on a per seed basis, for the user, and bad also per square foot of lawn planted, quite apart from the fact that the rye dies at the end of the season or in the first cold open winter.

In other words, you pay about the same for a square foot of rye planted as for the same amount of perennial grass that you don't have to replant. Rye is thus a very poor value for the consumer and operates to defeat and frustrate the increase of lawns in which people will have pride and which they will want to fertilize. One large brand, not sold through self-service outlets, carries the torch of illumination and education in grass seed, but, largely I think because no important brands are sold through self-service outlets, the considerable amount of grass seed sold through such outlets is rye grass.

Under the heading of good products, helpful for lawn care, we should mention lawn mowers that have relatively little maintenance and frustrating down-time; good, efficient, low-priced spreaders, possibly of new types; and, finally, but certainly not of least importance, improved fertilizers, and improved weed control products. This last is a large subject in itself. My guess is that the public is confused about the effectiveness and value of weed control products which undoubtedly presents very difficult problems. With respect to straight fertilizer, I don't know whether substantial product improvement is possible if you have in mind the best, highest priced products on the market. But much fertilizer is still being sold to home users which is poorly formulated in order to achieve low retail prices, and much of it fails to minimize burning. Such cheap fertilizers are poor values, in the same way that rye grass is a poor value, and they frustrate good lawn care.

These are deep waters, the waters of fertilizer product formulation, and I'm not a scientist. But I have the impression that anti-burning treatment is costly, whether it be ureaform or some other method, and that it would be a good thing, probably not a major thing, to reduce this cost. Also, all the problems of formulating a fertilizer which will not burn and yet not release too slowly, especially when the fertilizer is to be applied as often as once a month, have not yet been solved. Or have they?

Is ground limestone necessary for the care of many lawns? If so, it is not being promoted effectively.

3. Better understanding by the consumer of the use and principles of lawn care.

This point is pretty well covered under the second point, since it is so closely related to products, tools and supplies. I would add, simply, that I think home owners know a lot less about lawns than, on the average, they know about home or automobile maintenance. They are a lot more competent to wash cars, wax floors, and make minor repairs about the house, mainly because they've been doing these things longer and have had a lot more help from strong brands. Why, for example, do so many people with fine homes ruin their lawns in the summer by cutting them too closely?

4. Increased fertilizer consumption through low cost distribution, low prices and attractive displays in high traffic, self-service outlets.

Monthly, or bi-monthly, application of fertilizer is, in my opinion, well within the budgets and value systems of many American families. Even so, this will be encouraged and greatly increased by two things: (1) lower retail prices by reason of gross margins closer to 30% or 25% than to to 45%, possible only through self-service, and (2) showing the products and the concept under the noses of the users in outlets to which they go frequently, such as food stores, in the most attractive settings, with the most appealing packaging.

Neither of these things will, obviously, be accomplished until more strong national brands (in addition to the one already in self-service outlets) choose to distribute through such stores and, also, the self-service retailers become more interested in merchandising these products. Now as long as self-service retailers fail to take responsibility for the quality and value of the products they sell in the lawn-care market (witness rye grass seed, poorly formulated burning fertilizers, low in nutrients, and cheap lawn mowers), these outlets will not serve a large portion of the requirements of this market.

I think we need both strong national brands in our stores and more retailer interest and responsibility. I think both will come, and soon. When it comes, garden hose will be pulled out from under the lettuce display and fertilizer will be taken down from the top of the frozen food cabinet, or some other such place, and all these related items, including grass seed and lawn mowers, will be heavily promoted on spring and early summer week-ends, just as school supplies are promoted in August, or toys at Christmas.

This is a job for the retailer. It is up to him to give these products a home in his store, a place where they can be together, and achieve packaging and display impact, especiallv in the season of heavy use. This alone will operate the powerful psychological machine of impulse buying, which controls a substantial part of the consumption budgets of American families. (It's useful to recall that a shopper spends about ½ hour in a supermarket, and there are 7,000 items; she can't notice many, she won't notice the colorless, the obscure, and yet she enters the store undecided about what she will do with over ½ — some say 70% — of her buying dollar.)

One other suggestion. It is in the interest of all of us who are concerned with this home market, that the strong brands begin to interest women in the subject of lawn care. Why not appeal to them? Their home is their job, their pride. Many men shop in supermarkets, but a lot more women. In expanding this big market to its full potential, we need women who think fertilizer is not too complicated for them to buy. If they have confidence, they will buy it. I think it is quite possible that many women will be buying fertilizer 10 years from now.

I hope you won't think I'm dogmatic in these opinions. I don't mean to seem so! I am certain mainly of the fact that everybody with any interest or stake in this market will gain by the success of his competitors. Enlargement of the total market is the great objective.

Thank you.

Mr. Lewis: Thank you very much, Mr. Doherty.

During the next two or three presentations, you are probably going to hear the expression AI or activity index mentioned several times. In a recent publication of a related industry, I happened to be thumbing through, and much to my surprise I happened to run across a great big head line which said, "How is your AI?"

Obviously I proceeded to read the rest of it and I found out right quick though that they were not talking about activity index, rather they were talking about artificial insemination.

So in this case when we say "AI", we are not talking about your sex life, we are talking about fertilizer.

The next speaker, Dr. Joseph M. Duich, has had wide experience over many, many years in fertilization and management practices of turf grass. He is a recognized authority in this area.

Agronomic Aspects of Ureaform Fertilizers

Dr. Joseph M. Duich*

I was very amused by the opening remarks of the previous speaker when he concentrated his remarks on this new approach of putting fertilizer down, getting away from the conventional spreader. You know, sometimes engineers can sometimes be pretty damn stupid. They never stop to figure out that people like myself that are over six foot, six one and a half to be precise, just cannot afford to go out and push one of these spreaders that are made for a midget.

So maybe we are getting progress, if they can't lengthen the handle, at least we will have to carry it instead of pushing it.

Nitrogen is commonly recognized as the most important growth-producing element for plants. Natural supplies of available nitrogen in some soils may be adequate for certain short season crops; however, very few soils can supply sufficient amounts for long season crops. This is particularly true for turf-grasses which may be characterized as a very unique crop on the following basis:

1. Growth is limited to the vegetable phase in contrast to the more common vegetable-reproductive cycle.
2. Growth in terms of crop yield is discarded and serves only as an index of plant status.
3. Turf quality is difficult to measure both qualitatively and quantitatively and is most commonly considered in aesthetic terms.
4. Successful culture on a perennial basis is possible only when the grass plant can regenerate both leaf and root growth on an *annual* basis.
5. Species and variety differences dictate the nature of variable fertility management.

Many workers have shown that turfgrasses must receive variable amounts of available nutrients, particularly nitrogen, throughout the growing season to maintain satisfactory growth and quality. This discussion will be limited to nitrogen.

An understanding of soil and climatic conditions on the avail-

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*Associate Professor of Agronomy. Pennsylvania State University, University Park, Pa.

ability of nitrogen and use by the grasses is necessary. Unfortunately these vary somewhat from the habits and whims of the consuming public. Under favorable conditions grasses respond very quickly to available amounts of nitrogen. Excessive amounts cause an overstimulated growth which leads to deleterious effects from environmental and physiological responses (including mowing mismanagement). Maximum physiological injury is incurred when excess nitrogen not only increases top growth at the expense of root growth, but actually suppresses the latter. A properly nutritioned turf can endure the spring to summer transition period much better than an overfed, succulent type which we characterize as a feast-to-famine proposition.

For Pennsylvania conditions, we have found that most turf areas worthy of fertilization require about 4 pounds of actual nitrogen per thousand square feet. On more intensive areas where turf growth must be pushed and on grasses that require and can utilize more nitrogen, 6 to 12 pounds is necessary, especially if clippings are removed.

To supply a somewhat "steady" flow of nitrogen to our turfgrasses, we presently have three classes of nitrogen carriers at our disposal—quick, intermediate and slowly available. Agronomically, these materials must be handled on the basis of their soil and plant reactions. Especially since their duration is correlated with response.

1. *Quickly Available Nitrogen.* Comprised of water soluble carriers as urea and the various inorganic nitrate and ammonium salts. Application rates are usually limited to a maximum of 1 pound of N., thereby necessitating multiple applications. Lowest nitrogen costs must be rationalized with problem of injury to turf unless washed off the leaves, and multiple application factors such as cost. While labor cost is not a problem with the homeowner, it's difficult to convince them to do a fertilization job requiring 3-6 applications.

2. *Intermediately Available Nitrogen.* Comprised of the natural organics such as activated sludge, seed meals, tankages and other by products. Dependent upon and governed by soil organisms for decomposition for delayed nitrogen release, these materials can usually be applied up to 2 pounds of N per application. Main disadvantages are short supply, low nitrogen content (1-8%), and response variability due to temperature and moisture.

3. *Slowly Available Nitrogen.* The effort to control the availability of applied nitrogen to plants over periods of relatively long duration has been achieved with the synthetic ureaform group in recent years. I shall briefly consider the agronomic aspects of ureaform fertilizers for the remaining time.

Properly formulated ureaform carriers achieve reasonable portions of the nitrogen fertilizer objectives in our Utopian search for turfgrass perfection. Among these are the ability to safely apply large amounts of actual nitrogen to turf for controlled release over long periods and nitrogen content for the manufacture of high analysis goods. The physical form is desirable and the cost falls in an acceptable range when compared to similar improvements in various consumer products.

We have been involved with the practical aspects of ureaform use and evaluation for 15 days in our turfgrass program at Penn State. Factors in manufacturing, quality evaluation and agronomic use have been closely coordinated over the years with several manufacturers of dry ureaforms. To date, we feel that we have gained an appreciable working knowledge of the factors necessary to both evaluate and successfully use these compounds in a fertilizer program.

In order to determine the rate of ureaform nitrogen application for individual area use we should know the Activity Index (A.I.) and % Cold Water Insoluble Nitrogen (CWIN). The rate of application in turn determines the anticipated turfgrass response. The value of acknowledging the value of the A.I. and CWIN increases in importance as we go from light rates (½ to 1 lb.) to heavy rates of application (8-10 lbs.).

The A.I. is the percentage of cold water insoluble nitrogen in a ureaform which dissolves in a hot, buffered solution. It is intended to serve as an index of agronomic availability of the total CWIN. If we are interested in the ureaforms as a long lasting source of available nitrogen, it is quite obvious that the CWIN portion is as important as the A.I. in determining quality. Rate of application is an inseparable factor since it influences the availability of both the soluble and insoluble nitrogen to the plant.

We can conclude that quality is a factor with the ureaform based on the possible variations with different formulations for both A.I. and insoluble. This holds true for use alone and in specialty fertilizers. A review of present practices reveals some very significant differences in market products for the above mentioned variables of A.I., insoluble and rate.

Our results show that if the ureaforms are used alone as the nitrogen carrier the following rates are necessary:

Low Fertility Turf (Red Fescue)	– 2 to 4 N
Intermediate Fertility Turf (Bluegrass, Bent)	– 4 to 5 N
High Fertility Turf (Merion blue, Bent)	– 6-to 8 N
Very High Fertility Turf (Putting Green)	– 8 to 12 N

In event of mixtures of ureaforms with soluble and/or natural organics the limiting factor is the total soluble nitrogen involved at rate of application. Conversely, there is little practical value in applying less than approximately 1½ pounds of ureaform nitrogen per application in mixtures, and less than 2 pounds alone. Duration of response will vary with the insoluble content, in turn governed by the A.I. The A.I. will control the initial response along with other nitrogen components, and percent insoluble will condition the length of response.

* Growth rate and quality of turf produced by any nitrogen depend primarily upon how the material is used rather than the form in which it is applied.

The most satisfactory stan-

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*J. M. Duich and H. B. Musser, Response of Kentucky Bluegrass, Creeping Red Fescue and Bentgrass to Nitrogen Fertilizers. Progress Report 214, April 1960. Pennsylvania State University.

dardized method of evaluating nitrogen carriers in field studies has been the clipping weight method. Nitrogen availability to the turfgrasses has been found to be well correlated with vegetative leaf growth. We have utilized this method consistently since 1948.

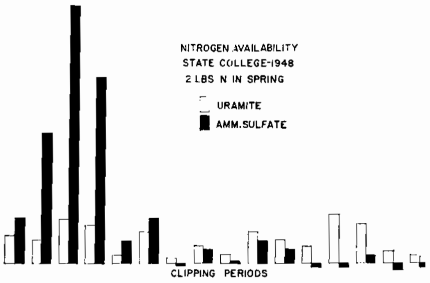


Figure 1

Figure 1. Differences in growth responses of a bluegrass-fescue turf to single two pound applications of ureaform (Uramite) and ammonium sulfate as compared to check treatment. This initial study showed the typical flush-type of growth followed by nitrogen exhaustion from the soluble sulfate source as compared to a prolonged release possible from the ureaform. The ureaform was one of the better products of the day, based solely on the urea: formaldehyde mole ratio.

Figures 2, 3, 4. Differential growth response of Kentucky bluegrass, red fescue and mixed bent turf to single four pound applications of ammonium sulfate, natural organic (Milorganite) and ureaform (Uramite) nitrogen, respectively, as compared to check treatment. Rates of application and individual species growth response were of interest during this period. Although excessive rates of sulfate and Milorganite were somewhat academic, the results illustrate their depletion from single applications depending both on the early and late season growth ability. Ureaform results confirmed earlier speculation that rates in excess of two pounds would be necessary for sustained growth at each period throughout the season. More important, the results showed that the fairly high rate of four pounds did not result in excessive turf growth immediately following application. The benefits and detrimental aspects of differential growth stimulation on the blue grass and fescue turf during the spring period followed by an inherent slow-down in the late summer period were also in evidence.

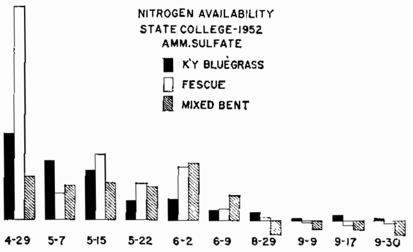


Figure 2

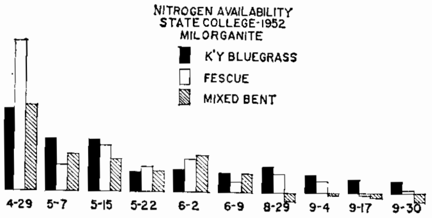


Figure 3

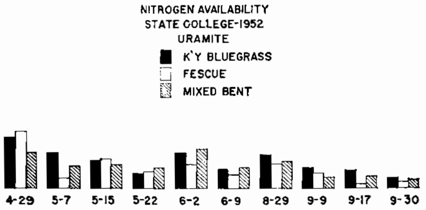


Figure 4

ping harvests over the three and one-half year period.

This particular segment of the study illustrates the importance of the ureaform "quality" factors, Activity Index (A.I.) and Total Insoluble Nitrogen (I.N.) on growth response. The two ureaform compounds had the following qualities: UF-1, A.I.=48, I.N=73; UF-2, A.I.=51, I.N.=57. Principle material difference was the I.N. content. A comparison of their results shows consistent differences in the response of the grass to them. UF-1 produced significantly lower growth response during the 1956 season and until approximately July 1, 1957. Following the latter date the results were reversed, with response to UF-2 consistently lower throughout 1958 and to July 1959 when the experiment had to be terminated due to campus expansion.

Results are interpreted as showing that the lower total insoluble (UF-2) formulation made more of its nitrogen available over the growing period following application, and conversely the higher insoluble formulation (UF-1) resulted in a carry-over between seasons before the more insoluble fraction was released. The results indicate that materials with high availability indexes, but with lower percentages of total insoluble nitrogen must be applied more frequently at lower rates per application to produce the greatest uniformity in growth stimulation.

The reversal in response also suggests the possibility of a greater carry-over of residual nitrogen into the next season from UF-1 due to its greater quantity of total insol-

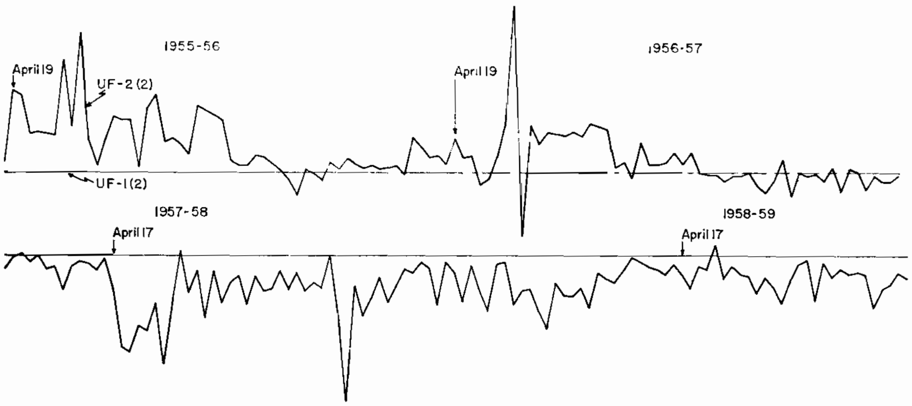


Figure 5

Figure 5. Differences in clipping yields between annual split (2) applications of UF-1 and UF-2 (UF-1 as straight line standard) on a putting green experiment over a 44 month period (1955-59). A total of 8 pounds of nitrogen was applied the initial year followed by 10 pounds annually in succeeding years. The ureaform nitrogen was applied each fall and spring and the data respresent 238 clip-

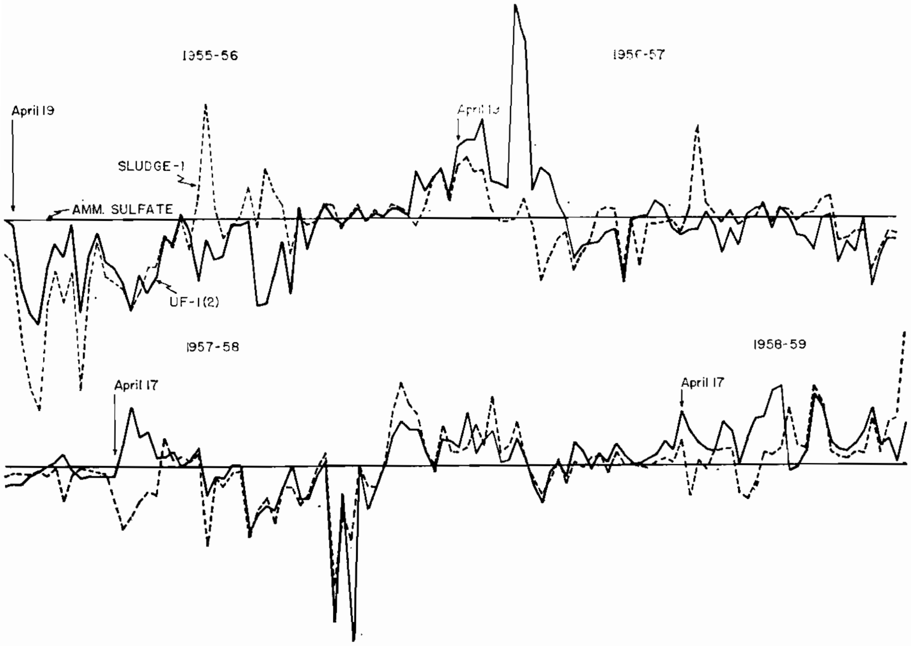


Figure 6

uble nitrogen. Further study of materials with known percentages of the various polymers would be necessary before definite conclusions were justified. If such residual effects were found to occur consistently, they would materially influence the practical use of various ureaform formulations.

Figure 6. Differences in growth response between ureaform, sludge and ammonium sulfate treatments in the previously mentioned putting green experiment, 1955-59. The total amount of applied nitrogen per year was identical for the nitrogen carriers, but the number of annual applications differed as follows: ureaform (2), sludge (5 or 6) and sulfate (10 to 12). Almost identical growth differences were obtained between the sludge and ureaform. Sporadic differences were accounted with the sulfate and these could be made to conform, if necessary, by regulating applications on a growth basis rather than on a set calendar day schedule as was employed. These results further illustrate that anticipated response is possible by handling radically different nitrogen carriers on the basis of their known soil and environmental reactions.

Figures 7, 8, 9. Results of a complete fertilizer mixture study with N-P-K being applied in a 2-1-1 ratio on bentgrass turf at a total of five pounds of nitrogen annually. Nitrogen carriers are compared alone and mixed and in varying numbers of applications over the season.

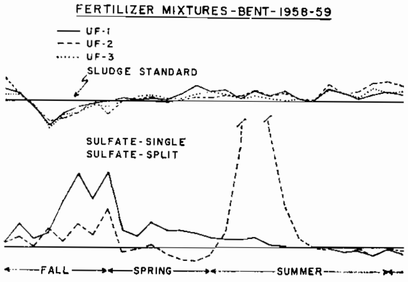


Figure 7

Figure 7 (top). Single fall applications of three differential commercial formulations of ureaform (dry) are compared with a split application of activated sludge (straight line standard). These formulations were commercially available in 1958 and show similar growth response as was anticipated on the basis of A.I. and I.N. The lower portion of the figure shows the more variable growth response of both a single or split application of sulfate compared to the same sludge standard.

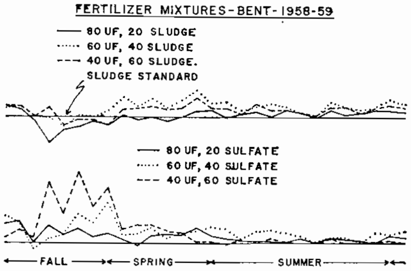


Figure 8

Figure 8. Results illustrate the response obtained in mixing varying proportions of ureaform and sludge (top) and ureaform and soluble nitrogen (lower). The U-F mixtures were applied in single fall applications and the sludge (standard line) in split fall and spring application. Most significant growth differences are apparent during the period immediately following application, particularly in the U-F and soluble combinations. The turf safety and steadier response of UF can be jeopardized with the application of excessive soluble. Obviously, as illustrated throughout this discussion, the amount of different nitrogen carriers in a mixture must be considered in terms of total nitrogen applied per application.

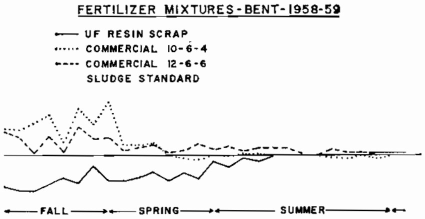


Figure 9

Figure 9. Differential single application response of two "commercial" ureaform-soluble mixtures and U-F resin scrap with split sludge application (standard). The resin scrap had an AI=5 and I.N=95, the value of which is again illustrated in practically no turf response until approximately 10 months following application. Both mixtures reputedly contain 70% U-F and 30% soluble nitrogen with the 10-6-4 formulated with a slurry UF source and the 12-6-6 granulated with a dry source. Figures 7, 8 and 9 are on the same scale and with the same "standard." Quite obviously the agronomic results show a *misrepresentation* of product or lack of *quality control* by industry.

The latter results pointedly illustrate the need and value of experimental results and educational meetings of this type to collectively serve the consumer.

A CONFEREE: How long a period of time does this represent in days?

MR. DUICH: What is that again, Sir?

A CONFEREE: How many days does that respresent?

MR. DUICH: Well, according to the chemist, we were arbitrarily told that this was over a six-month period. We feel as agronomists that the proof of the pudding is in the eating and the only way we can actually ever prove this is by growing the grass and this is what our work has been based on predominantly, true growth response.

A CONFEREE: You are talking about one application?

MR. DUICH: Right. Oh, we have used it in single applications and multiple applications. Now how long it is going to last is going to depend on the total amount of UF that is insoluble and this AI will actually serve as an index. We know in a good many cases that this portion back here, the longest chain polymers, the most insoluble portion, would not even become available the first year, the year of application. I think if you will bear with me I will be able to show you some of these results in a later slide very shortly.

A CONFEREE: Just a moment. How do you account for the ups and downs?

MR. DUICH: Okay, shoot that back. That is the way things grow. Some people would lead you to believe that we should draw a straight line completely across our growing season and say that we have to feed this much plant food to our plants right along.

Here we are getting into a species difference. Bluegrass and Fescue do not grow this way. They make their main growth in this part of the season (spring) and in this part of the season (fall). Bent grass is a grass that can grow, can be forced to grow during the higher temperature period. That is essentially why we can have bent grass on the putting greens and not have putting greens out of Bluegrass because there is an inherent difference. One is a stolonifera grass, the nature of food storage is altogether different than it is in rhizomatous grasses, like Fescue and Bluegrass. This is the way bent grass actually will grow.

MR. LEWIS: Thank you very much, Dr. Duich.

Let's turn now to the use of ureaform in manufacturing specialty fertilizers and just what we should do to protect these various points of quality that Dr. Duich has talked about.

In several areas, you will find that I will be overlapping in certain points that Dr. Duich has said. I think this is necessary for a matter of emphasis as much as anything else but also in order to get across the necessity for certain controls which must be followed.

The Use of Solid Ureaform in Specialty Fertilizer Manufacture

Robert J. Church and James W. Lewis

IN recent years we have witnessed a rapid expansion in the market for specialty fertilizers, especially those designed for the home lawn and garden. In addition to these products, we have numerous formulations especially made for one individual species of plant such as azaleas, roses, evergreens, etc. Of all these specialty fertilizers, the ones designed for turfgrasses offer by far the largest market potential and will be the principal subject of this discussion.

Specialty fertilizers for turf are by no means new. Various nutrient ratios utilizing the spectrum of N-P-K sources have been around a long time. For most of these earlier specialties, the phosphate and potash sources were usually the same ingredients commonly found in field fertilizers, while the nitrogen sources included the usual soluble materials and frequently one or more of the natural organics.

For the production man, these specialties were usually manufactured in the same manner and with the same techniques employed for his commercial grades and if his operating procedures were good, he encountered no more than the ordinary problems in making the desired product.

More recently, in an effort to produce a superior product, much of the mineral nitrogen in turfgrass fomulations is being replaced by ureaform. Because of the chemical nature of ureaform, unusual care must be exercised in the formulation, processing and storage of the finished goods, otherwise the quality of the urea-form may be seriously degraded. While this statement may have an ominous sound, fertilizers incorporating ureaform can and are being made in conventional plants with conventional equipment by knowing which of certain variables must be controlled and giving them close attention.

In order to better appreciate the necessity of close control, some understanding of the chemical nature of ureaform is most helpful.

By definition, *Ureaform* is the recognized generic name for certain reaction products of urea and formaldehyde and is further defined by the American Association of Fertilizer Control Officials as follows: "Ureaformaldehyde fertilizer materials are reaction products of urea and formaldehyde, containing at least 35% nitrogen, largely in insoluble but slowly available form. The water insoluble nitrogen in these products shall test not less than 40% active by the Nitrogen Activity Index for ureaformaldehyde compounds as determined by the appropriate A.O.A.C. Method."

Chemically, ureaform is a mixture of methylene ureas, ranging from small, water soluble molecules to moderately large, water insoluble molecules. These methylene ureas by virtue of their structure, varied molecular size and their controlled reaction in the soil, provide ureaform's unique pattern of nitrogen feeding.

The conditions employed in the manufacture of any high quality ureaform are of utmost importance and some acquaintance with these factors is desirable in order to appreciate the procedures for the use of ureaform in complete mixed fertilizers as will be prescribed later.

Starting with the same two basic ingredients (urea and formaldehyde) and by changing certain variables, reaction products can range in agronomic value from a high quality fertilizer, to the familiar formaldehyde-urea resins or 'plastics' which have little or no fertilizer value.

The variables which must be controlled in the reaction are:

1. pH
2. Temperature
3. Reaction time
4. Initial Mole Ratio of Urea to Formaldehyde

In the course of the reaction, a variety of products are formed and the principal reactions may be illustrated by the following series of equations.

U-F Condensation Reaction

$$1.\quad \underset{\text{Urea}}{NH_2\text{-}CO\text{-}NH_2} + \underset{\text{Formaldehyde}}{CH_2O} \underset{H_2O}{\overset{\text{acid}}{\rightleftarrows}} \underset{\text{Monomethylol Urea}}{NH_2\text{-}CO\text{-}NH\text{-}CH_2\text{-}OH}$$

$$2.\quad \underset{\text{Urea}}{NH_2CO\text{-}NH_2} + \underset{\text{Monomethylol Urea}}{NH_2\text{-}CO\text{-}NH\text{-}CH_2\text{-}OH} \xrightarrow{\text{acid}} \underset{\text{Methylene Diurea}}{NH_2\text{-}CO\text{-}NH\text{-}CH_2\text{-}NH\text{-}CO\text{-}NH_2 + H_2O}$$

Or

$$2a.\quad U + U\text{-}CH_2\text{-}OH \longrightarrow U\text{-}C\text{-}U + H_2O$$

$$3.\quad \underset{\text{Methylene Diurea}}{U\text{-}C\text{-}U} + U\text{-}CH_2\text{-}OH \longrightarrow \underset{\text{Dimethylene Triurea}}{U\text{-}C\text{-}U\text{-}C\text{-}U} + H_2O$$

$$4.\quad \underset{\text{Dimethylene Triurea}}{U\text{-}C\text{-}U\text{-}C\text{-}U} + U\text{-}CH_2\text{-}OH \longrightarrow \underset{\text{Trimethylene Tetraurea}}{U\text{-}C\text{-}U\text{-}C\text{-}U\text{-}C\text{-}U} + H_2O$$

$$5.\quad \underset{\text{Monomethylolurea}}{U\text{-}CH_2\text{-}OH} + CH_2O \longrightarrow \underset{\text{Dimethylol Urea}}{HO\text{-}CH_2\text{-}U\text{-}CH_2\text{-}OH}$$

$$6.\quad 2U + HO\text{-}CH_2\text{-}U\text{-}CH_2\text{-}OH \longrightarrow \underset{\text{Dimethylene Triurea}}{U\text{-}C\text{-}U\text{-}C\text{-}U} + 2H_2O$$

By adjusting the variables and controlling the reaction time, high quality ureaform containing a mixture of methylene ureas ranging from methylene diurea to longer chains containing six or more urea molecules can be made. By the proper selection of pH, temperature, and time, the reaction may be continued, retarded, or even stopped. It is important to understand, however, that the reaction, once stopped at the proper point, may be started again by readjustment of the pH or temperature of the system and can result in severe degradation of agronomic quality.

The nitrogen composition of ureaform may be classified according to its solubility. The bar chart (Fig. 1) illustrates this. One portion of the chart represents the fraction of the product which is soluble in cold water (25°C) while the remaining fraction is insoluble in cold water. The latter fraction can be further divided with respect to its solubility or insolubility in hot water (100°C). Thus there are four solubility fractions which may be described as follows:

1. Cold water soluble nitrogen or CWSN.
2. Cold water insoluble nitrogen or CWIN.
3. Hot water insoluble nitrogen or HWIN, which is insoluble in both cold and hot water.
4. Hot water soluble nitrogen or HWSN, which is insoluble in cold water but soluble in hot water.

This solubility characteristics is the basis of the Activity Index determination which will be described later.

The more complex or longer chain length methylene urea molecules constitute the insoluble fraction of ureaform which provides the slowly available nitrogen.

The rate at which ureaform nitrogen becomes available to plants, i.e., is converted to the nitrate ($^-NO_3$) form, distinguishes it from other sources of nitrogen. Nitrification studies in the laboratory are one of the generally accepted procedures for measuring the rate at which nitrogen from any source becomes available to plants.

Fig. 2 shows the relative nitrification rates of several nitrogenous materials, under carefully controlled conditions in the laboratory. Note that after six weeks, the soluble nitrogens are completely nitrofied and that the natural organic has about reached its peak. The ureaform, however, continues to nitrify at a steady rate over the remainder of the test period.

Note that the particular sample of ureaform used in the foregoing study was of high quality, with 75% of its total nitrogen as CWIN with an AI of 60. According to the A.A.F.C.O. definition, an AI of 40 is the minimum acceptable value.

As was noted previously, all ureaforms do not give the same agronomic response, e.g., the U-F resin scrap (Fig. 2) would be virtually worthless.

We find that the agronomic value of any given ureaform depends upon two factors:

1. The *quantity* of cold water insoluble nitrogen, which is the slowly available source of nitrogen, and
2. The *quality* of the cold water insoluble nitrogen as determined by its Activity Index, which indicates the rate at which the cold water insoluble nitrogen will be available.

The *quantity* is readily obtained in the laboratory by a simple washing technique after which the percentage of the total nitrogen that is insoluble in cold water is determined. This is the slowly available nitrogen.

The *quality* can be evaluated by nitrification studies but these are laboriously long (requiring many weeks) and a short-cut laboratory procedure is obviously needed. The various procedures using potassium permanganate which are acceptable in analyzing natural organics are unreliable when applied to ureaform.

Activity Index determination is a laboratory method by which the quality of the insoluble nitrogen of ureaform can be related to its nitrification rate. The higher

Solubility Composition of Ureaform Reaction Products

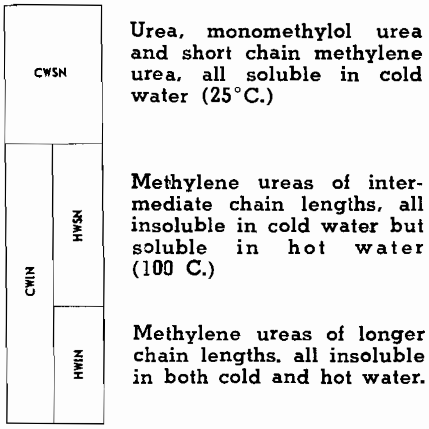
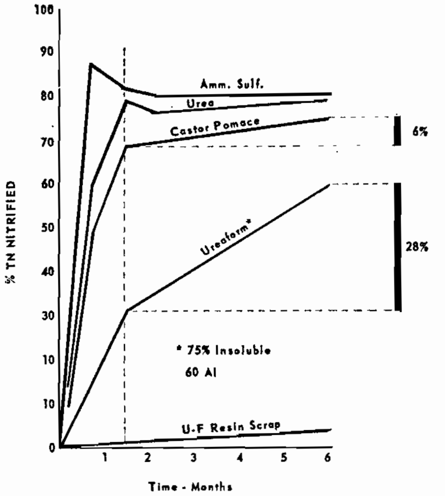


Figure 1

the AI, the faster the nitrification rate.

The actual determination of AI is based upon the solubility characteristics of ureaform as shown in Fig. 1. Using the prescribed washing techniques, the nitrogen content of each of the various solubility fractions may be determined. From these values, Activity Index is calculated as follows:

Relative Nitrification Rates of Nitrogenous Compounds



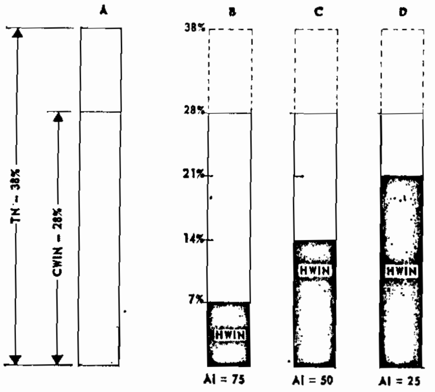
The heavy vertical bars at the right indicate the nitrogen released after all the soluble nitrogen is gone.

Figure 2

$$AI = \frac{(\%CWIN - \%HWIN)}{\%CWIN} \times 100$$

Note that AI depends only upon the relative values of CWIN and HWIN and is not a function of total nitrogen. This is illustrated in Fig. 3. Assume a sample of ureaform is 38% total nitrogen and 28% cold water insoluble nitrogen as represented in bar A. Without changing either of these values, the AI can change depending upon the quantity of hot water insoluble nitrogen as represented in bars B, C, and D, which illustrates AI's of 75, 50, and 25 respectively. Also, it may be seen that the total nitrogen could change in each case without affecting the AI.

Activity Index As Determined By The Solubility Characteristics Of Ureaform



$$AI = \frac{(\%CWIN - \%HWIN)}{\%CWIN} x 100$$

Figure 3

Fig 4 illustrates the relative nitrification rates of the cold water insoluble nitrogen from ureaform at three different AI's. Activity Index thus reflects the rate at which the cold water insoluble nitrogen will nitrify in the soil and is accordingly a measure of its agronomic quality.

We have previously outlined the various chemical reactions and controls that are necessary to manufacture high quality ureaform. It was also pointed out that changing certain variables such as pH, temperature, etc., could result in severe degradation of the quality of this product.

The following tables and figures illustrate the effect of pH and temperature upon the AI of ureaform when they are both properly and improperly controlled.

Table 1 shows the effect of pH on the AI of "Uramite."

The two formulas were prepared as dry blends and stored under similar conditions prior to analysis. "Uramite" M ureaform fertilizer was used as the source of ureaform nitrogen in both formulas. The important difference is the use of non-ammoniated superphosphate in Formula 1 versus ammoniated superphosphate with hydrated lime in Formula 2. Note the analysis of Formula 1 shows the AI is 27.1 with a pH of 3.8, while in Formula 2 the AI is 43.9 at pH 5.4. A pH between 5.4 and 6.2 has been found best for maintaining the AI of ureaform in complete fertilizer mixtures.

Relationship of AI to Nitrification Rate For Water Insoluble Fract'ons of Ureaform

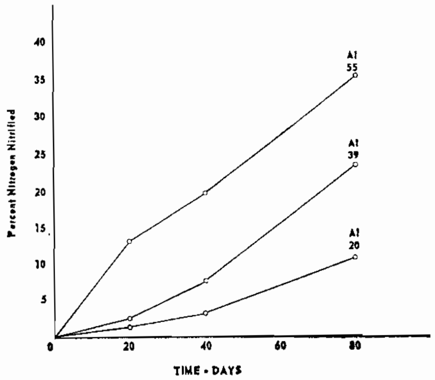


Figure 4

The effect of temperature on the AI of ureaform can be shown using the following formula for a 12-8-4 grade:

UAL-37	137 lbs.
"Uramite" Ureaform Fertilizer	380
Ammonium Sulfate	175
ROP Superphosphate	800
Muriate of Potash	134
Dolomite	373
Hydrated Lime	20
	2,055 lbs.

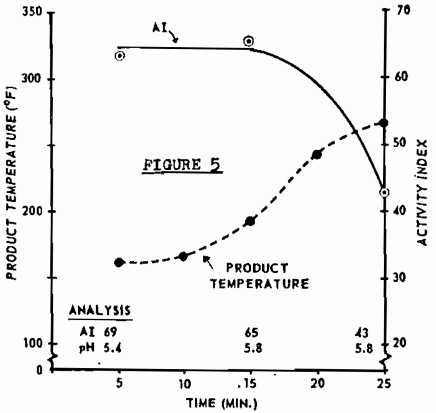
In this formula "Uramon" Ammonia Liquor-37 (UAL-37), "Uramite," and ammonium sulfate were the sources of nitrogen. Hydrated lime was also added to aid

Table 1. Effect of pH on AI of Ureaform in a Mixed Fertilizer Product

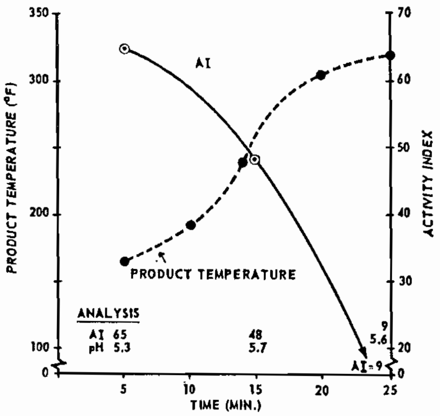
10-6-4 Formulation (Dry Blend Type)

	1	2
"Uramite" Ureaform Fertilizer	290 lbs.	290 lbs.
Ammonium Sulfate	409	200
6-16-0	—	750
ROP Superphosphate	600	—
Muriate of Potash	135	135
Organic — Natural	100	100
Dolomite	466	500
Hydrated Lime	—	25
	2000 lbs.	2000 lbs.
ANALYSIS		
AI	27.1	43.9
pH	3.8	5.4

Effect of Temperature on AI of Ureaform 12-8-4 Grade Fertilizer



Dryer Exit Gas Temperature at 350°F.



Dryer Exit Gas Temperature at 400°F.

FIGURE 6

in adjusting the pH of the product during processing. The results are shown in Fig. 5 and Fig. 6.

The data in Fig. 5 were obtained while holding the fertilizer in a laboratory model, cocurrent rotary dryer where the exit air temperature was held constant at 350°F. for 25 minutes. The AI decreases sharply as the product temperature increases above 200°F.

Fig. 6 shows the accelerated degradation of AI when the exit air temperature was 400°F. The 50° higher air temperature accelerated the temperature rise of the product and hence the degradation of the AI so that the ureaform became agronomically worthless in 25 minutes, even though the pH of the mixture was within the proper range.

Therefore, when ureaform is a fertilizer component, the usual conditions prevailing in the manufacture of field grade fertilizers are such that degradation will occur if steps are not taken to adjust to the new requirements.

The following general recommendations can be made to assure that the quality of ureaform in specialty fertilizers is maintained.

1. The pH of the fertilizer mixture during processing and in the pile should be maintained in the range pH 5.4 to 6.2 depending upon the particular phosphate source. This can be obtained by the use of hydrated lime and/or the proper ammoniation rate.

2. When using a rotary dryer, the product temperature exit the dryer should not exceed 200°F. In the cocurrent dryer this can usually be accomplished by controlling the exit air temperature in the range 200° to 210°F. For the counter-current dryer, the product exit temperature is a better guide because of the intense heat upon the product as it approaches the combustion chamber.

3. The product should be cooled to 100°F. or lower for storage, either by use of a rotary cooler or by rehandling of the product.

4. Recycle should be kept to a minimum to prevent repeated exposure to dryer temperatures and possible low pH in the ammoniator.

5. H_2SO_4 66° Be should never be used in a formulation containing ureaform unless it is completely preneutralized before entering the ammoniator. The only exception to this is in a batch process where the ureaform can be withheld from the mixer until all the acid has been reacted.

H_2SO_4 60° Be will also seriously degrade ureaform if allowed to come into direct contact. Follow the specific recommendation for your process and grade as detailed later.

H_3PO_4 75% (wet process or furnace grade). The nature of phosphoric acid is such that it may be introduced into the ammoniator in the normal manner without causing serious degradation of AI. (See specific recommendations later.)

6. The preferred ammoniating solutions for specialty fertilizers containing ureaform are the urea-ammonia-water type.

7. For supplemental nitrogen requirements beyond that supplied by the ureaform and ammoniating solution, urea is the preferred source although ammonium sulfate may be used if there is sufficient room in the formula.

8. Most lightweight fertilizers employ the use of vermiculite as the bulking agent, with the final product having a bulk density in the range of 30 to 35 pounds per cubic foot. Number 3 vermiculite has been found to have the preferred particle size. Number 4 vermiculite is too fine and Number 2 vermiculite too large for most processes.

Since vermiculite is fairly fragile, the particles may be broken down or compressed by the usual processing equipment, leading to a product with bulk densities higher than desired. This is particularly true if an attempt is made to produce a granular fertilizer of uniform spherical particles such as is desired for commercial fertilizers.

To help overcome this, it is recommended that in batch processes, the mixer be charged with no more than three-fourths its normal capacity and for continuous processes, the production rate should be reduced to 10 to 12 tons per hour.

The following specific recommendations detail the steps to be taken in order to maintain the quality of ureaform during the manufacture of various types of specialty fertilizers and with various processes. These recommendations may be modified, to a certain extent, depending upon the specific equipment and raw materials available for use. The various formulas are shown for purposes of illustration only.

Dry Blend Formulations

The formulas of typical dry mixtures are shown below:

10-6-4 Grade

	1	2
Ureaform	300 lbs.	300 lbs.
Urea	200	94
Organic (Natural)	–	110
6-16-0 Base	–	750
Triple Superphosphate	270	–
Muriate of Potash	140	140
Filler	1040	581
Hydrated Lime	50	25
	2000 lbs.	2000 lbs.

In Formula 1, urea supplies the supplemental nitrogen and triple superphosphate supplies the phosphate requirement. In Formula 2, the remainder of the nitrogen is supplied by three sources: (1) a natural organic; (2) an ammoniated base which also supplies the phosphate requirements; and, (3) urea. Hydrated lime is used in both formulas to adjust the pH for protection of the AI of the ureaform.

Recommendations for manufacture of these dry blends are as follows:

1. Use urea or ammonium sulfate for source of supplemental nitrogen.
2. Add 10 to 25 pounds of hydrated lime to formula when using a well-ammoniated base, or
3. Add 25 to 50 pounds of hydrated lime in the case where a non-ammoniated superphosphate is used. Mix the hydrated lime with the superphosphate prior to adding the ureaform and urea.
4. Segregation may be minimized by using raw materials having similar particle size and bulk densities.
5. Maintain the product temperature at less than 100°F. during storage.

Non-Granular Formulation

A typical 10-5-5 grade fertilizer is illustrated below for the non-granular type of product.

	10-5-5
UAL-37	140 lbs.
Ureaform	290
Ammonium Sulfate	180
ROP Superphosphate	540
Muriate of Potash	170
Dolomite	680
	2000 lbs.

Hydrated lime is not neeeded, as the proper pH range of 5.6 or over can be obtained by using the appropriate ammoniation rate for the phosphate source.

The following suggestions apply to the manufacture of non-granular products:

1. Use a urea-ammonia-water type of ammoniating solution.
2. Use urea or ammonium sulfate for supplemental nitrogen.
3. Use a 6 to 6.5 pound ammoniation rate for normal superphosphate or a 3 to 4 pound rate for triple superphosphate. This should assure the proper pH range of the final product.
4. Use dolomitic limestone as filler, fine particle size preferred.
5. Cool and store product below 100°F.
6. To granulate this type mixture:
   a. Add 6 to 8 per cent water prior to ammoniation.
   b. Keep product temperature at 170 to 190°F. in dryer, for no more than 15 minutes.
   c. Cool and store below 100°F.
   d. Keep recycle to a minimum.

The fine pulverized type of dolomitic limestone has been proven to be an excellent aid in maintaining the proper pH for the product during processing. The product should be cooled and stored so that its final temperature will be below 100°F.

Granular Formulations

Typical formulas for granular products are shown here:

	10-6-4	12-6-6	14-7-7
UAL-37	300 lbs.	259 lbs.	302 lbs.
Ureaform	257	296	345
Urea	—	69	81
Superphosphate	600	600	700
Muriate of Potash	134	200	233
H_2SO_4—60° Be	150	108	126
Filler	576	460	221
Hydrated Lime	50	50	50
	2067 lbs.	2042 lbs.	2058 lbs.

Only 60° Be sulfuric acid is used in these specialty fertilizer formulas; 66° Be acid is not advisable because it is extremely difficult, if not impossible, to protect the AI of the ureaform from degradation by the more concentrated acid.

Suggestions for making granular formulations by the *batch process* are as follows:

1. Urea is the preferred source of supplemental nitrogen.
2. Use 50 pounds of hydrated lime.
3. Use dolomitic limestone as the filler.
4. Use a 6 to 6.5 pound ammoniation rate for normal superphosphate or a 3 to 4 pound rate for triple superphosphate.
5. For processing, add the water required for granulation, followed by one-third of the ammoniating solution.
6. Add the acid simultaneously with the remaining solution.
7. Add the ureaform to the mixer and continue mixing to end of normal mixing cycle.
8. The product temperature exit the dryer should not exceed 200° F.
9. Cool and store below 100°F.
10. Keep recycle to a minimum.

Suggestions for the *continuous ammoniation process* are as follows:

1. Urea is the preferred source of supplemental nitrogen.
2. Use 50 pounds of hydrated lime.
3. Use dolomitic limestone as the major source of the filler.
4. Use a 6 to 6.5 pound ammoniation rate for normal superphosphate or a 3 to 4 pound rate for triple superphosphate.
5. Mix the ureaform with the dry raw materials.
6. Either partially or completely neutralize the acid with the ammoniating solution prior to addition to the ammoniator.
7. Where required add the remainder of the solution to the ammoniator.
8. The product temperature exit the dryer should not exceed 200°F.
9. Cool and store below 100°F.
10. Keep recycle to a minimum.

Light-Weight Formulations

Formulas for typical light-weight products are:

	16-8-8	18-8-5	20-10-5
UAL-37	257 lbs.	257 lbs.	322 lbs.
Ureaform	410	468	515
Urea	152	192	187
H_3PO_4 75%	294	294	367
Muriate of Potash	267	167	167
Light-Weight Filler	709	710	561
	2098 lbs.	2088 lbs.	2119 lbs.

Phosphoric acid, either the electric furnace or wet process grade, furnished the phosphate requirements of the formula, and fixes the free ammonia from the ammoniating solution. Phosphoric acid may be introduced into the ammoniator through the normal sparger pipe system. Using the recommended ammoniation rates, the resulting mixture of ammoniated phosphates provides the ideal pH range of 5.8 to 6.2 for the protection of the AI of the ureaform.

For manufacture of these products, a batch or continuous process may be used. Urea and a urea-ammonia-water type ammoniating solution are the preferred souces of supplemental nitrogen.

For the electric furnace phosphoric acid use an 8 pound ammoniation rate, or a 7.2 pound ammoniation rate for the wet process phosphoric acid. The acid and ammoniating solution should be added in such a manner to prevent any accumulation of free acid in the product.

A light-weight filler, such as vermiculite, should be used to give the desired bulk density. To preserve the light-weight feature of these products, it is suggested (1) for the batch process use a 1,000 pound to 1,500 pound batch; (2) for the continuous process operate at a reduced production rate, such as 10 to 12 tons per hour; and (3) avoid large bulk storage of the final product.

Maintain the product temperature less than 200°F. exit the dryer, cool, and store the product below 100°F., and keep recycle of the product to a minimum.

I am very happy to say we have a gentleman who has been making specialty fertilizer containing ureaform for some time, Mr. Willis Buie, Production Manager of the Sure Gain Fertilizer and Feed Division of Canada Packers from Toronto and Willis has kindly consented to give us a quick thumbnail sketch of their operation in Toronto.

Manufacture of Shur-Gain Turf Special (10-6-4)

Willis A. Buie

OUR company manufactures a 10-6-4 lawn fertilizer with 75% of the nitrogen derived from urea-formaldehyde sources, namely the solid urea-formaldehyde polymer and a commercial Ammoniating solution containing urea and formaldehyde.

Briefly I shall describe the equipment and layout of the plant, relative to the manufacture and granulation of this product, which by the way also does our regular fertilizers.

Solid ingredients are stored in 7 hopper bins, one an 80 ton bin for superphosphate over a hopper scale, and 6—10 ton bins over another hopper scale. Solid materials are weighed in batches by the above hopper scales and then dropped on a belt conveyor. Water soluble green dye is added manually to each batch as it passes along the belt. The dye is added at the rate of 1½ oz. per ton. From the belt the products are elevated to a holding hopper above a Feeco preblender ammoniator-granulator, 7′ by 16′.

From the holding hopper solid ingredients are fed into the preblender by means of an Omega belt gravimetric feeder, Model 37-20. The fines are also added to the preblender by means of a Syntron vibratory feeder. These fines are returned from a 20-mesh bottom screen.

Nitrogen solution, water, and sulphuric acid are added in the ammoniating section. The solution is pumped from storage by a variable speed positive displacement pump, Viking gear pump Model EJZ1, through a Fischer Porter magnetic meter, Model 10D1415A with a maximum flow of 10 imperial gallons per minute. The output of the meter is indicated and recorded by a Fischer Porter flow rate chart recorder Model 1102BH-02.

The amount of water added is measured by a Hayes Veriflow liquid flow meter Model No. 347.

The acid is pumped from storage by another variable speed positive displacement pump, Viking gear pump Model No. EHX1. It is also metered through a Fischer Porter magnetic flow meter which is the same as used for the nitrogen solution except the maximum capacity is only 6 imperial gallons per minute. A chart recorder is not used on the acid but the flow rate is indicated by a Fischer Porter dial flow rate indicator Model No. 1323BF01.

With the addition of the liquids to the ammoniator the dye dissolves in the liquid phase and blends with the materials.

After ammoniation, the material flows over the dam ring into the granulator. Here the dry Urea-formaldehyde is added by a calibrated screw feeder and granulation commences.

The material drops into a 8′ by 50′ counter-current oil fired dryer. This dryer is equipped with 5 million BTU's per hour oil burners. Both burners are used in the manufacture of regular goods but only when manufacturing 10-6-4. The heat input can be varied from 1¼ up to 10 million BTU's per hour.

This product requires a low fire with an inlet air temperature into the drying of approximately 400° F. and a maximum product temperature of approximately 150° F. on discharge. The burners are regulated by an automatic temperature control system.

The fertilizer then passes through a 7′ by 30′ cooler and is elevated to a 4′ by 15′ Hummer screen.

The material passing over the 10 mesh top screen is crushed in a Sackett hammer head chain mill and recycled to the screen.

Too much oversize leads to a poor final product as a great deal of the larger particles have dye on the outside only, and when broken up the undyed materials are conspicuous. Even more important is the fact that the fines resulting from the crushing are recycled through the ammoniator and the quality of the urea-formaldehyde polymer suffers.

Quality control is of utmost importance during manufacturing. Since this product derives a large proportion of its Nitrogen from Ureaform, the activity index must be watched and controlled constantly.

However, our process is in a sense contradictory in that the conditions which favour the creation of a urea-formaldehyde polymer also encourage degradation of the activity index of the finished polymer.

The low pH and warm temperatures which are necessary to the rapid development of the insoluble nitrogen from the ammoniating solution are the very factors which degrade activity index of the soil ureaform. These two factors are carefully controlled with the result that we never permit the pH to fall below a minimum of 5.5 or the temperature to rise above a maximum of 150° F.

Trial and error in formulation is necessary to establish the ratio of the solution to the solid urea-formaldehyde so that the final activity index does not fall below the minimum of 40.

As mentioned previously excessive recycle is a danger to be avoided as the polymer becomes subjected to repeated conditions of high temperature and moisture, causing a lowering of the activity index values.

With a dryer inlet air temperature of 400° F. or less and a maximum product temperature in the bin of 110° F. or less, degrading is avoided.

The real secret of manufacturing an excellent product is constant control at all stages by the production and laboratory personnel.

Mr. Lewis: Thank you very much, Willis.

Ladies and gentlemen, this concludes the program on the various aspects of specialty fertilizer production and manufacturing, and marketing. Brother Reynolds, I will be very happy to turn this back to you.

Moderator Reynolds: Thank you very much, Bill. That was a very fine presentation. I think you covered a lot of subjects and a lot of information we have been wondering about.

We are running a little bit close as far as time. We can have one question, I think. I think this fine presentation deserves that. I know there are some questions out there.

Mr. John Daniel (Virginia Carolina): I am wondering if the addition of urea in this thing would slow down, I think, the insoluble formation you get from UAL 37. I wonder how much of that—what insoluble will you get when you do these things to protect the solid ureaform?

Mr. Lewis: I can't give you exact percentages on that. However, we have been able to get normally—I would have to say, in the neighborhood of 90 per cent. The development is slower. There is a relatively narrow range. The pH range over which we have to operate is reduced considerably.

The temperatures have to be watched a little bit slower and you can normally, however, get pretty close to complete development of the insoluble, not quite. I can't give you an exact figure on it.

Moderator Reynolds: We will move along here. We have two other speakers for this afternoon. We will see how our time goes. I know most of you are very much aware of the little card you received when you checked in, so I don't think I need to remind you of that, but we will move along here to the next speaker.

Last year we had some discussion concerning the use of diammonium phosphate in mixed fertilizer formulation. This was a start. This year we hope to give a little more information on that.

Mr. O. A. Niles, U. S. Phosphoric Products Company, Technical Service Engineer for the Eastern Division, will discuss this subject.

The Role of Diammonium Phosphate in Mixed Fertilizers and Granulation

Owen A. Niles, Jr.

We have again received a number of questions concerning the use of diammonium phosphate in mixed fertilizers. A modified diammonium phosphate made from anhydrous ammonia and wet process phosphoric acid, has an analyses of 18-46-0, or 16-48-0. Higher analyses mixed goods are now a reality in all types of plants, using a modified diammonium phosphate. For the farmer, this results in a lower "in the ground" unit cost.

Reference is made to two previous papers concerning diammonium phosphate, which were presented at the Round Table—one by Barney Tatum in 1960, and one by Phil Stone in 1961. These papers covered mixing conditions under which diammonium phosphate might dissociate, and how diammonium phophate could successfully be used in many grades in all types of operations. It might be worthwhile for those of you who missed them to refer to these papers.

Two raw materials have achieved prominence in recent years for manufacturing higher analysis fertilizers, such as 15-15-15, 10-20-20, and 6-24-24. One is phosphoric acid. The other is diammonium phosphate. The latter could be termed an outgrowth of the former, in which the diammonium phosphate producer ammoniated the phosphoric acid for the fertilizer manufacturer. This, of course, has been attractive to fertilizer manufacturers desiring to make higher analysis goods, but after due deliberation felt they did not wish to follow the phosphoric acid route.

When used in mixed fertilizer formulations, diammonium phosphate affects granulation and heat reaction in ammoniating plants. In all types of plants, economics are affected.

First, however, I would like to emphasize that final product specifications must be satisfied in the selection of formulation and raw materials for a particular grade in a particular process. For an ammoniating plant, heavy emphasis has to be placed on the amount of liquid phase and chemical heat required for granulation. These must be held within proper limits for semi- and full-granular operations in order to achieve the degree of granulation ncessary.

An illustration can be made by comparing 1-4-4 and 1-2-2 ratio formulations. In a 5-20-20 formulation all of the Nitrogen should come from nitrogen solution to obtain as much liquid phase and heat as possible. In 8-16-16 or 10-20-20 formulations, too much liquid phase would be developed if all of the nitrogen came from a solution, and over-granulation would result. One has a choice of obtaining supplemental Nitrogen for a 1-2-2 grade formulation from ammonium sulfate, diammonium phosphate, or any of the other solid nitrogen raw materials. This selection is based on economics.

In a dry blending plant emphasis for satisfying product specifications is placed on raw material screen analyses and resultant product compatibility.

Economic considerations may too often include only the raw material costs when raw materials are being selected for a grade formulation. In ammoniating plants, production rate can also be affected. For instance, consideration of raw material costs alone would eliminate a modified diammonium phosphate from formulations for 12-12-12, in many locations. However, if a plant is producing good semi-granular products with solution, sulfate, normal and triple superphosphate, potash, and sulfuric acid, a long batch mixing cycle, with holding time in the mixer, is probably required. By substituting diammonium phosphate, the batching cycle time is shortened without reducing the physical quality of the product. The increased production rate more than offsets the higher raw materials cost. The plant producing a semi-granular product of something less than the best physical quality could probably improve the quality by including diammonium phosphate. In a continuous operation, diammonium phosphate utilized in the 12-12-12 formulation should result in a production rate increase of 10 to 20%.

There is another point which is difficult to put a "price tag" on, but which is receiving more and more attention. The water solubility of the P_2O_5 in mixed goods is used as a selling point in some areas. Some agronomists express the opinion that the P_2O_5 mixed goods should be at least 50% water soluble. As we know, water solubility suffers when normal and triple superphosphates are ammoniated. The use of diammonium phosphate partly offsets this problem, because the water solubility of diammonium phosphate is unaffected. Let's use 12-12-12 as an example again. The water solubility of the P_2O_5 in this grade is between 40% and 45% when normal and triple are used. If diammonium phosphate is substituted for the triple (approximately 5 units of P_2O_5 from 18-46-0), the water solubility of the P_2O_5 will exceed 50%.

It was requested that the economics on the use of diammonium phosphate in various mixed fertilier grades be considered here. One prime reason for diammonium phosphate's rapid rise in consumption is the achievement of higher analyses. However, there are the many-shall we say — medium high analysis grades where diammonium phosphate has permitted formulation flexibility.

Let us first consider D.A.P. in ammoniating plants. In a 1-4-4 ratio, diammonium phosphate should not be used in a 5-20-20 because, as previously stated, the Nitrogen should come from solution. Diammonium phosphate has to be used in 6-24-24 in order to make it.

In a 1-2-2 ratio, diammonium phosphate can seldom be justified in 8-16-16. It is necessary in 10-20-20 and 12-24-24. In a lower 1-1-1 ratio, diammonium phosphate can seldom be justified on economics alone. It is necessary in 15-15-15.

To compare 12-12-12 with 15-15-15, raw material costs, based on published prices, were selected for Indiana and Northern Iowa. These raw material costs were applied to semi-granular formulations for 12-12-12, with and without 18-46-0, and to a formulation for 15-15-15. The raw material costs for 12-12-12 when 18-46-0 was included were about $.25 more per ton in Indiana and $.35 more in Northern Iowa. It's up to the individual plant to decide whether the extra cost can be offset by the increased production rate and/or increased product quality mentioned earlier. The overall formula unit cost of 15-15-15 was $.06 more than for 12-12-12 in Indiana and $.04 more than for 12-12-12 in Northearn Iowa. It's up to the plant and his customers to decide whether the increased unit cost of the higher 1-1-1 can be offset by savings in handling, bagging, trucking, and spreading costs. You all know that these numbers which have been quoted will vary with the various raw material costs from one location to another. For the purposes of this discussion, consideration has not been given to the possibilities offered by phosphoric acid, anhydrous ammonia, ammonium nitrate, urea, calcium metaphosphate, 30-10-0, and the various other ammonium phosphate combinations.

In examining the economics of dry blending formulations, the 1-4-4 and 1-1-1 ratio grades will be discussed. Each grade was calculated three different ways. The first with 18-46-0, triple, potash and filler; the second with sulfate, triple and potash, and the third method with 18-46-0, sulfate when needed, normal super and potash. All raw materials must be coarse or granular. Costs for the Indiana and Iowa areas were again used.

For the 1-4-4 ratio, 5-20-20 can be made without diammonium phosphate, but diammonium phosphate is required in making 6-24-24. The lowest cost formulations for both grades in both locations utilized diammonium phosphate and granular normal super. The overall unit cost was slightly less further West.

For the 1-1-1 ratio, let's consider 10-10-10, 12-12-12, and 15-15-15. In Indiana, 10-10-10 had the lowest overall unit cost, but in Northern Iowa it had the highest. In both locations the least costs formula for 10-10-10 and 12-12-12 utilized diammonium phosphate and granular normal super. Grade 15-15-15, made with 18-46-0, 21% sulfate and 62% potash, has a slightly higher overall unit cost in Indiana, but it is the lowest in Northern Iowa. However, it must be pointed out that, in some areas, certain raw mtaerials of the proper specifications are unavailable.

To summarize—a modified diammonium phosphate

1. allows higher analysis
2. lowers chemical heat
3. increases on-size yield
4. increases water solubility
5. lowers the unit "in the ground" cost to the farmer.

We have also had several questions concerning the techniques of handling and storing diammonium phosphate. The handling of D.A.P. can be a little tricky since it is so free-flowing. It can very readily be handled in screw or belt conveyors and in elevators. However, the equipment should be in good condition. A leak in a conveyor belt or an elevator housing will leak more diammonium phosphate at a higher cost per ton than almost any other raw material. Payloader operators should be cautioned about over-filling their buckets. When they travel they dribble. Diammonium phosphate dribbles more readily than most other materials.

In storing diammonium phosphate there are no special precautions. Diammonium phosphate is slightly hygroscopic in humid weather, but moisture will be absorbed only two or three granules deep on the surface of the storage pile. The body of the storage pile will be virtually unaffected even after many months. There is one standard precaution. The storage bin should be in good cndition and every effort should be made to prevent mixing with other materials. Storage of diammonium phosphate contaminated with other raw materials creates additional problems.

Another question concerns the use of R.O.P. vs Coarse Triple Superphosphate in granular goods produced in ammoniating plants. In general, fine raw materials will result in a more uniform mixture of N-P-K in each granule in the end product. This minimizes the effect of particle size segregation in product storage. One should use the finest raw materials he can and still achieve the mechanical granulation required. In addition, formulation costs are usually higher if Coarse Triple is used instead of R.O.P. Triple. if the ammoniation capacity is limited, R.O.P. Triple is made for the fully integrated plant. Coarse Triple is made for the semi-granular plant.

The use of D.A.P. also enters into the consideration of "Coarse" vs "Fine" raw materials. Experimental work has been conducted using finer particle size 18-46-0. The results are promising.

Moderator Reynolds: Thank you very much. We are going to call this session to a halt and take off tomorrow morning.

If anyone has any particular question, I think we do have time for one or two questions here and then we will adjourn.

(The meeting adjourned at four fifty-five o'clock p.m.)

Thursday Morning Session, Oct. 25, 1962

The Round Table Reconvened at nine thirty o'clock a.m., Mr. Joseph Reynolds, Moderator, presiding.

Moderator Reynolds: We are going to try to start on schedule and go right on through according to the program.

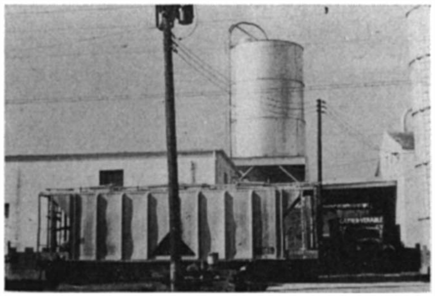
Grayson Morris, of Southern States Cooperative, related some actual experience to pneumatic handling, so without further comment I will turn the program over to Grayson.

Experience With Pneumatic Handling Systems

Grayson B. Morris

LAST year, at the Round Table, Mr. John Fischer of the Sprout Walden Company described a pneumatic handling system designed by them and installed at our Hopkinsville, Kentucky distribution point. Previous to the installation of this system, bagged materials were being used at this distribution point for direct application through bulk spreader trucks. The bags of muriate of potash and triple superphosphate had to be broken and dumped into the spreader trucks. We felt considerable savings could be made if a simple economic way could be found to use bulk materials unloaded from hopper cars at distribution points where the annual tonnage would range from 700 to 1,000 tons. Since the installation at Hopkinsville, Kentucky, completed in 1961, we have installed the pneumatic handling system at two more distribution points. The actual unloading operation is very simple. Adjusting the flow of the material from the hopper car so that it empties at a rate of around 12 tons per hour is all that is necessary. After the unloading starts, it is not necessary to remain with the operation. About the time one hopper is empty a man in the area who is responsible for the unloading will open the other hopper.

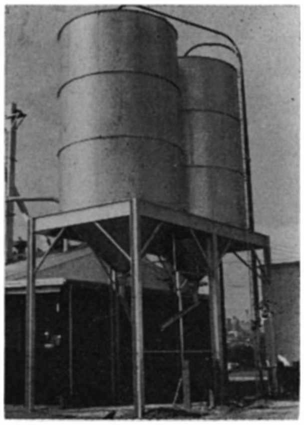
A few slides taken of an actual installation will give you an idea as to the simplicity and ease of operation.



Slide 1

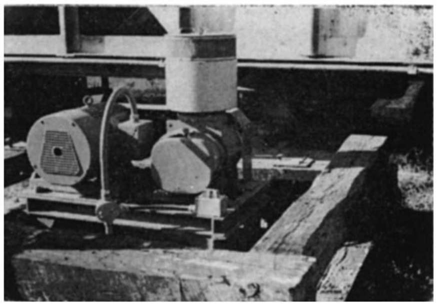
Slide 1. Gives an overall view of an installation at Richmond, Virginia. The hopper car in the foreground was being unloaded when the picture was taken. Just above the hopper car and to the rear, you see the bin where the material is being stored.

Slide 2. A general view, showing the bottom of the bins over the scale and the hopper car that is being unloaded.



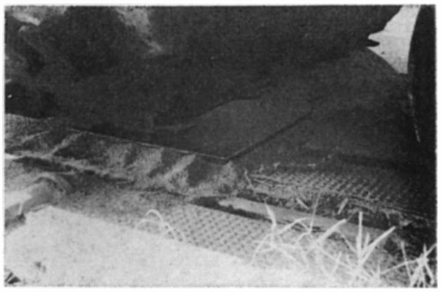
Slide 2

Slide 3. This slide shows the blower with a 30 horse power motor operating it.



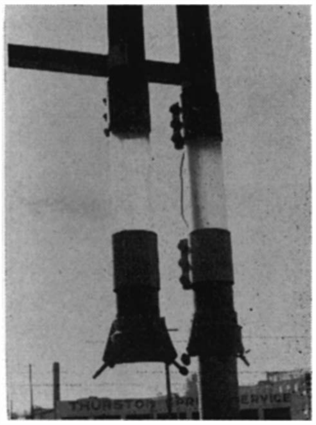
Slide 3

Slide 4. This slide shows triple superphosphate actually unloading from the hopper car.



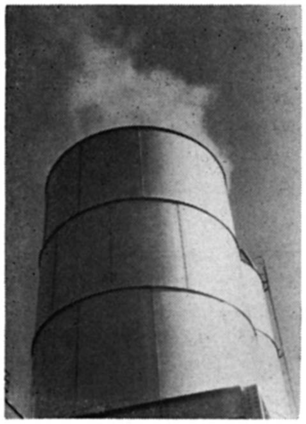
Slide 4

Slide 5. Flexible pipe connections to discharge into either bin.



Slide 5

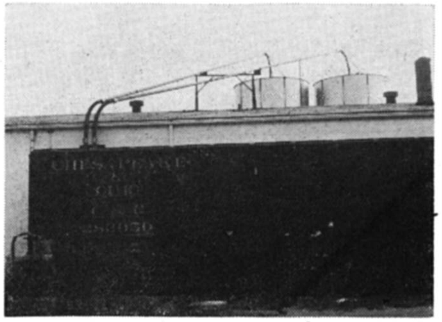
Triple superphosphate is actually flowing through the pipe and can be seen through the connected pipe.



Slide 6

Slide 6. Note the small amount of dust being discharged from the operation.

Slide 7. A system at Fredericksburg, Virginia showing the unloading installation on the tracks at the back of the building with the unloading pipes extending over the roof at an angle.



Slide 7

Slide 8. Showing the storage bins and scales on the front of the building at the same location.

Slide 8

One full year of operation at Hopkinsville, Kentucky, shows this point handled approximately 700 tons of bulk triple superphosphate and muriate of potash. Repairs to the equipment was $290.00. Of this amount $125.00 was a replacement of the flexible pipe that was used to switch the unloading pipe to the potash or phosphate bin. This new flexible pipe was made from stainless steel. Other repairs included the drying out of motors that got wet when the unloading pit became flooded.

We find the system will do the job of unloading granular superphosphate and potash satisfactorily from hopper cars. Savings in dollars is very small using the bag differential for bulk on the material as income, with depreciation, interest, rent, repairs, and taxes as expense, in fact, a nearly break-even proposition. However, considering the labor and time saved by using bulk, the installation is a paying proposition.

Moderator Reynolds: Thank you very much, Grayson. Are there some questions or any comments?

Robert B. Smith: Have you used this equipment in granular mixtures?

Mr. Morris: It is used on granular triple super and granular muriate of potash at the distribution point, but I see no reason why it will not work on a granular fertilizer. It will not work on pulverized.

Al Phillips: I think that last year there was quite a lot of discussion about the possible breakdown of particles in a system like this. What has been your experience in that respect?

Mr. Morris: The reaction I can give you to that would be that same thing, showing some dust coming from the top as it was unloaded. If there was any breakdown that was bound to have been what it was. But the purpose that we used it for, it did not present a problem in distribution in the field. This goes direct to the farm from the truck. It doesn't go through any mixing process or anything.

Mr. Tom Bridgers: What kind of material is that used on the part there, the transparent material that you can see?

Mr. Morris: That's just a plastic section in the pipe to let you see what's going on. It's just a section of plastic to see through.

Mr. Bridgers: Does it stay in there all the time?

Mr. Morris: It stays in there all the time.

Mr. Bridgers: You say it's just a plastic section?

Mr. Morris: Just a plastic section in the pipe.

Mr. Bridgers: What kind of plastic?

Mr. Morris: I can't tell you what it was made of. I will ask the Sprout Weldron Company who made the installation. (Later, Mr. Bridges was advised that the plastic material was Lucite.)

Mr. Albert Spillman: What's the cost of an installation like that?

Mr. Morris: The whole thing, complete: scales, tanks, unloading, equipment costs around $20,000. Those tanks will hold about 125 to 130 tons each. Approximately 250 tons of storage, and we have a big truck scale underneath it. The feature about the installation is, you can use that pipe to locate your bins and your scale in most any place you want. You notice in one we went over a building at an angle.

Mr. H. B. Tatum: What was the rate of unloading of granular phosphate and potash?

Mr. Morris: Approximately 12tons an hour. You see, they have plenty of time, and they are in no hurry about it. They only handled 700 tons last year. They didn't have many cars and they do not have to go very fast.

Moderator Reynolds: Grayson, one of the items discussed last year was the possibility of erosion of the pipe as it turned a corner. In other words, being able to maintain the metal. That's no trouble?

Mr. Morris: After one year, the only place we had any trouble was in the flexible pipe where we switched from one bin to the other. You have corrosion there and that flexible section was replaced with stainless steel flexible pipe.

Moderator Reynolds: As far as abrasions to your turnings?

Mr. Morris: We haven't had any break-through as yet and we don't know. It's on the inside, it could break through from abrasion, however, so far, it's only a year old. You can't tell anything in a year.

Moderator Reynolds: Thank you very much, Grayson.

We will move on to the next part of our program. Several years ago we had some speakers with us who described their plant operations from unloading, manufacturing and all the way through to the bag. This feature was a real highlight of the meeting and there has been considerable interest, comments and suggestions that we prepare another program along that line, so with the help of our fine group here we have been able to put together two such plant tours which will take you from raw materials to bag.

The first one that we will call before you will be a film plant tour of the Mississippi Federated Cooperative plant. As indicated on the program, that was to be narrated by Mr. Nash. Mr. Nash is unable to be here, but Allen Jackson, of Fertilizer Equipment Sales Company, has consented to take over the movie and prepare the comments for you.

I turn the program over to Allen Jackson.

(Mr. Allen Jackson then presented the film entitled "Complete Plant Operation—Raw Material to Bag.")

MODERATOR REYNOLDS: Thank you very much, Allen.

I am sure we have some questions to keep Allen up here a few minutes. Who will be first?

MR. R. D. YOUNG: I am interested in that cascade screen. I wonder if you would enumerate what the advantages are and the disadvantages?

MR. JACKSON: We have used the system now for several years. There are seven systems like this in operation. We chose this mainly to make all of the screens accessible, to get for the operator as much choice as possible as to product sizing with a minimum of work and not having to shut down.

The disadvantages of the system that people have brought up: "All of your oversize is being put over your fine screen." Every time that we have checked the feed of the screens, we have found between 5 and 10 per cent oversize. That means if it were a double deck screen you would only be taking out 5 to 10 per cent of the material before it got on your fine screen anyway.

Our feeling is that a 4 mesh particle, 5 mesh or 6 mesh makes very little difference on a 14 mesh or 12 mesh screen; it doesn't apparently reduce capacity. This was also used because of the flow pattern to get the broken oversize back in between the dryer and cooler. It makes a nice way to convey it. It takes a lot of frame to hold it up, but it makes, for the trouble you go to to put it in, a real easy operating screen system.

If this were put in combination with a controlled recycle the system would be easy and nice to run.

MR. GRANT MARBURGER: That scrubber, are you just scrubbing with a big fan on the ammonia?

MR. JACKSON: The ammonia does no scrubbing. I doubt if you would get any of the fumes out with this scrubber that you might generate of that size particle that comes from an ammoniator. This scrubber is mainly for any very, very fine nuisance dust that may be carried over. It will not take any fume out.

MR. JACK SMITH: Do you have dewpoint or corrosion problems in that cyclone?

MR. JACKSON: No, the times that I have checked the conditions, the dewpoint in this cyclone on a single system will be higher than it is in a cooler cyclone, but it is lower than the dewpoint is in a dryer cyclone. The resulting mixture of air is at a temperature in this case always kept high enough so there is never any condensation in the cyclone. The cyclone has never been cleaned. It has been opened up and inspected, it probably has an eighth of an inch of build-up, occasionally a flake of that will fall out through the discharge valve, but, as long as the temperature has been kept up, it has never had to be cleaned.

MR. SMITH: I had another question. I wondered why you use a roller chain drive.

We started out using roller chain in about 1953, '54. Our feeling has been there isn't much point in going in so many cases from a motor to a roller chain drive to a pinion to another drive. The roller chain requires no service but occasional light oiling. Another plant that has probably put the most tonnage through one of these, a little bit bigger unit than this, has had one about four years. I believe many hundreds of thousands of tons have been put thru and this is the first year that they have replaced the chain.

Overall it makes a very economical drive, an easy drive to maintain and it is very, very smooth running.

The initial cost disadvantage is that you must buy a gear motor of slow enough speed. For instance, this dryer runs at 5.6 rpm. There is a 10 to one reduction in the chain drive, so that the motor must be a 56 rpm gear motor.

It would be as cheap or probably cheaper to buy a 200 rpm gear motor and reduce it to a spur gear, but the direct chain drive gives the simplicity of one drive with a fluid coupling between the motor and reducer and there has never been any problem.

The big sprocket as well as the small are cut and hardened tooth sprockets.

MR. SMITH: When you are using the dryer up high you mentioned that you divert most of the air through the dryer but not as much through the cooler. What does this do to the temperature coming out of the cooler?

MR. JACKSON: If a grade, say, triple 13 is being made, you don't need too much drying, you are already relatively low in moisture. So most of your air then is diverted through the cooler.

We need more cooling on triple 13 than we would say on 4-12-12 or a low end grade, so we are able then to use, where we need less heat, to pull all the air that we have got, or as much as possible, through the cooler and get maximum cooling.

We go back to low nitrogen grades or granulating super where it takes a lot of heat then, yes, we have all the air we can get through the dryer, otherwise we wouldn't be able to convey the heat away from the combustion chamber.

Those grades normally are not dried as much, or at this plant they're not; they're dried to—0-20-0, for instance, would probably be dried to something like three and a half per cent.

But then, with the moisture in the product, enough moisture in the cooler to aid cooling by evaporation, we don't need quite as much air in the cooler.

Our feeling on this system, I believe, for instance on let's say a high nitrogen grade that for any given heat that you may use you may need 10,000 cfm of air. I'm just making up figures now, but to cool it adequately, you may need 30,000 cfm.

If you are making a low nitrogen grade with the heat used, you may want 20,000 cfm in the dryer to convey the heat through the dryer, to keep the stack temperature high enough. With the high moisture and the lower nitrate you get by with less cooling or less cooling air. You may be using 10,000 cfm in the cooler and 20,000 or 30,000 in the dryer.

So, instead of having to have two fan systems of 30,000 cfm each, there is one system of about 40,000 cfm.

With a single cyclone we can pull the air where we need it for the particular grade and use less total air over all.

A MEMBER: Do you control the velocity? Do you have maximum allowable velocity through the cooler? I don't know if you have ever experienced a carryback of material as it falls into the air velocity that will pull it back the other way.

MR. JACKSON: I'm sure that it does go back up to the cooler as it is rather obvious that there is no dust on the screen, on any of the product size.

In this particular plant, as most of these plants in this area, they try to screen reasonably close. Our fine particle size at this plant will vary between 10 and 12 mesh. Very rarely will they ever run a 14 mesh product.

MODERATOR REYNOLDS: One more question.

MR. DWIGHT SANDERS (Swift & Company): How do you control dust from the raw material, screen the raw material out of it, that is?

MR. JACKSON: The raw material screen, of course, is totally enclosed. The raw material elevator is simply restricted enough to where the elevator is not overfed going into the elevator boot.

We find most of the dust problems are simply overfilling the buckets, allowing them to spill. If you keep the overfilling down, there's very little dust.

I believe you could notice the elevator feeding the ammoniator, as the recycle and the raw material was going in, that there was no dust at all.

There are no tricks played on that, no vacuum being pulled. It was simply that the elevator capacity is greater than the material going into it, and really that we feel is the major cause of the dust there.

MODERATOR REYNOLDS: Thank you, Allen.

We will move along here as far as continuing this same theme. The next group on the program will continue the same type of program presentation. A panel has assembled here, so I will turn the program over to Mr. Sam Shelby, Vice President of Federal Chemical Company, who will introduce your speakers and take it from here.

Plant Operations, Raw Materials To Bagging

Panel Leader SAM SHELBY

Thank you very much Joe. This morning we do have a team that will discuss this subject, so briefly I will explain the order in which we will present this topic.

First, John Surber and Chuck Everhart will alternate. John will first discuss liquid material handling. Chuck will follow with solid raw material handling. They will briefly explain the production of 15-15-15 in a conventional TVA ammoniator -granulation plant. They will discuss the production of 18-46-0 in a conventional granulation plant. Ben Williams, of U.S.I. Films Products Company, will discuss the characteristics of polyethylene, how it is made and converted into a polyethylene bag and some of the usable features of polyethylene bags in packaging fertilizer.

I will conclude by showing a film packaging fertilizer in polyethylene 50 lb. bags.

Liquid Materials Handling

John Surber

OUR subject this morning is Fertilizer Operations from Raw Material to the Bag. Since all of the previous sessions of the Round Table have been devoted to distinct phases of this topic, it is obvious that we cannot devote the time necessary to adequately cover it.

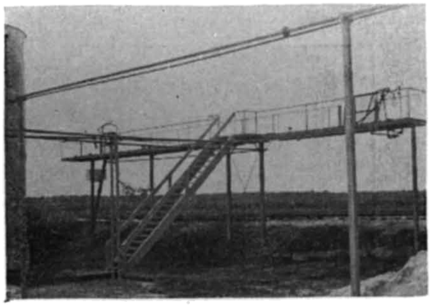
For purposes of our discussion we have divided our material into three phases: Raw Material Handling, Processing of Fertilizers and Product Shipment.

We have endeavored to select highlights of our operations which we feel may be of interest to the group. We do not intend to imply that the methods or operations which we illustrate and discuss are the best that can be devised. We are presenting them with the hope that some of you will pick up a few pointers which will be of benefit in improving your own operations. We certainly hope to stimulate some lively discussion in the true spirit of the previous Round Tables.

To set the theme for this subject we would like to show you the first slide.

First of all I would like to discuss one phase of raw material handling about which we at Federal feel very strongly. This is the handling of raw materials received in a liquid form. In recent years process developments in ammoniation and granulation processes have led to increased use of anhydrous ammonia, nitrogen solutions, phosphoric acid and sulphuric acid. This is in accord with the growing trend toward higher analysis mixed fertilizer and the consumer demand for it. Certainly we have found that the ability to effectively handle, transfer, and utilize all these materials is a necessity. Losses of materials, due to inadequate handling practices, can no longer be tolerated if we are to keep our materials costs in line with good management practices. With this in mind we believe that the best approach to this problem must begin with the unloading of tank cars. At all of our plants we try to arrange permanent unloading platforms. Various arrangements of unloading platforms can be worked out depending upon the amount of track available for allocation to tank cars and the amounts of these materials to be used.

We would like to show you some slides taken at several of our operations which will serve to illustrate some of the salient features of liquid handling operations.

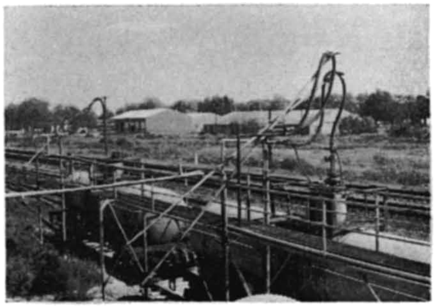


Slide 1

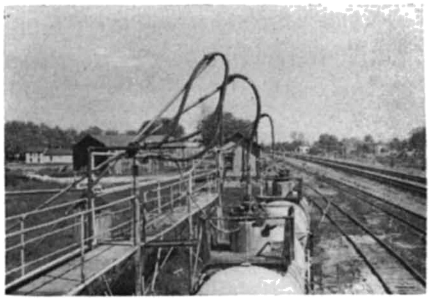
Slide 1. This slide illustrates an unloading platform designed to handle two tank cars. Connections are arranged to unload anhydrous ammonia, phosphoric acid or sulphuric acid to storage. No storage is provided for nitrogen solutions at this plant since these are used directly into the process.

Slide 2

Slide 2. Slide 2 illustrates a platform equipped for unloading five tank cars at one time. This platform was built from scrap pipe. This type arrangement requires minimum amount of unloading hose and also avoids kinking and keeps it conveniently out of the way when not in use.

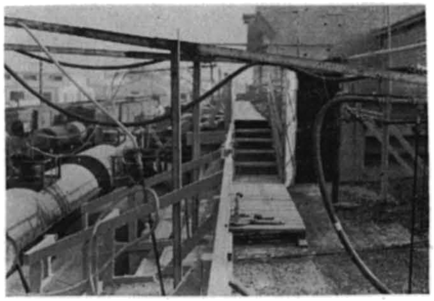


Slide 3



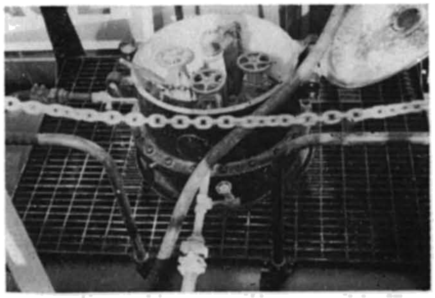
Slide 4

Slides 3 & 4. This view shows a dual unloading station which allows either one of two liquids to be unloaded at this station. This flexibility is particularly desirable during periods of heavy tank car movements.



Slide 5

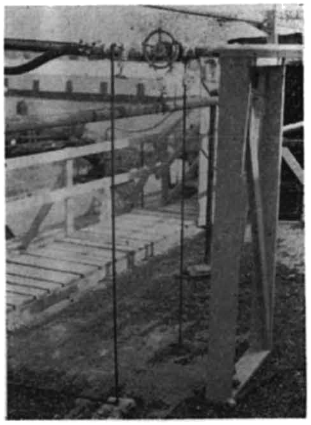
Slide 5. At another plant no track space was available except alongside of the main building. A wooden catwalk was constructed along the edge of the roof which extends from the unloading and storage area to the granulation tower.



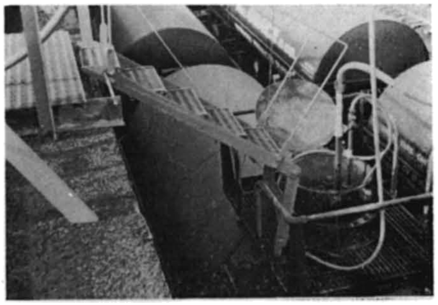
Slide 6

Slide 6. This is a top view of an anhydrous ammonia car dome with both vapor and liquid lines connected for unloading.

Slide 7. In this view we see the other ends of the vapor and liquid hoses. The small vertical pipes are bleed lines equipped with valves so that the pressure may be relieved from the hoses before disconnection. Any pressure left in the lines should be bled into a drum of water to absorb ammonia fumes.

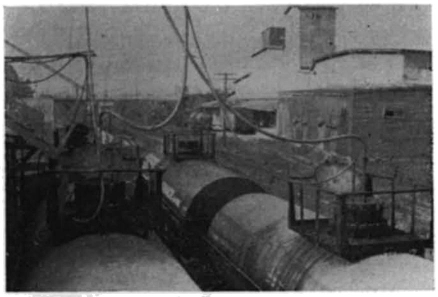


Slide 7



Slide 8

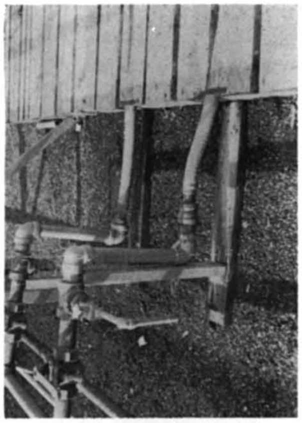
Slide 8. Since the roof line of this plant is higher than the top of the tank cars counter balanced stairs were constructed for convenience in hooking up tank cars from the catwalk (roof). These may then be raised out of the way when switching of cars is necessary.



Slide 9

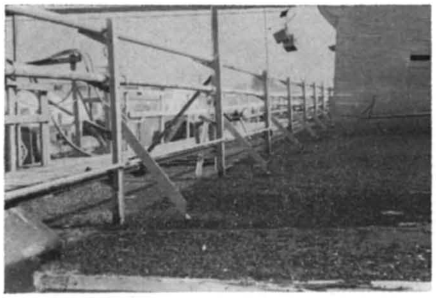
Slide 9. Since this plant also uses nitrogen solution directly from the tank cars it is a standard practice to hook up two cars at the same time.

Slide 10. This view shows how the solution hoses from each tank car are connected into a common header. When one tank goes empty it takes only a matter



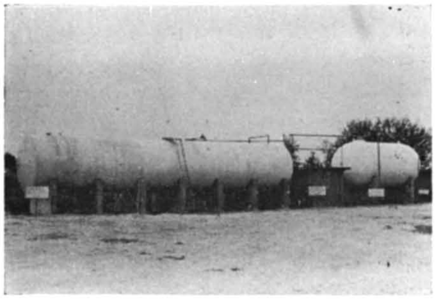
Slide 10

of minutes to change valves and operate from the second car.



Slide 11

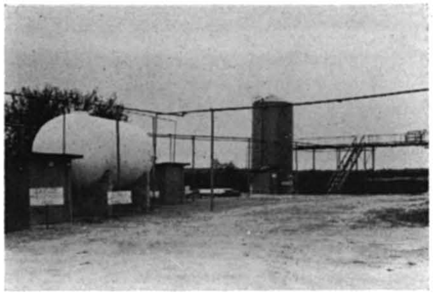
Slide 11. This view shows pipe lines from the storage area to the granulation tower. They are conveniently arranged and color coated so that they can be readily identified.



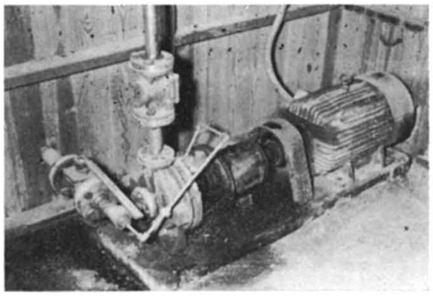
Slide 12

Slide 12. The size and number of storage tanks which are needed at a plant are determined by the trackage available, the availability of materials and the formulation of the grades produced. This slide shows the 30,000 gallon phosphoric acid tank and an 8,000 gallon ammonia tank.

Slide 13. This view shows the general storage area and an 18,000 gallon vertical tank for sulphuric acid. The small sheds at each tank location provide protection from the weather for pumps and electrical switches. Overhead lines are used to transfer liquids from the storage tanks to the granulation building.

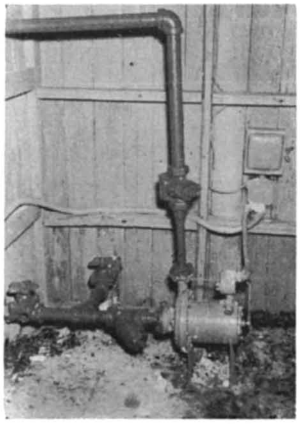


Slide 13



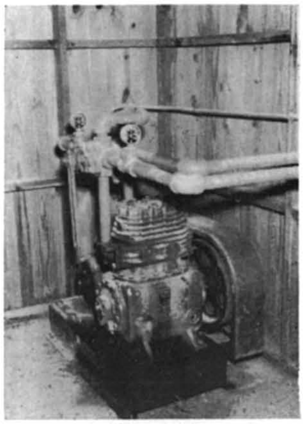
Slide 14

Slide 14. Durco Pump for transfer of phosphoric acid. Piping around the pump is 316 stainless steel and the lines to the tank car loading platform and to the process area are two inch Fibercast pipe.



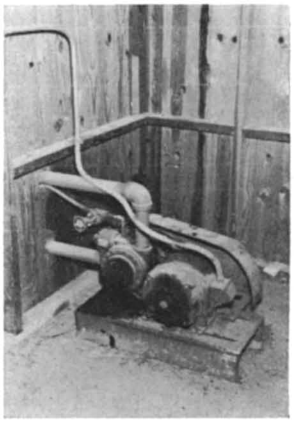
Slide 15

Slide 15. This is a view of the chemical pump for transfer of sulphuric acid. This little pump requires little maintenance and is most satisfactory when used in warmer climates.



Slide 16

Slide 16. View of ammonia vapor compressor for transferring the vapor between tank car and storage tank.



Slide 17

Slide 17. This is a Blackmer ammonia pump for transfer of liquid ammonia from storage to process.

Solid Raw Materials Handling

Chuck Everhart

In the handling of solid raw materials Federal pretty well follows the pattern used throughout the Midwest. Here is a glimpse of one of our modern handling systems (Slide I) Seriously there is little variation in unloading materials such as triple and potash. All of our plants but one, use a payloader to dig the material out of the boxcar. The material is dumped through a floor grate to a bucket elevator that can feed either the batching process or a bookshelf storage bin. Most of our plants have two or three unloading doors so that some economy can be realized by lining up different ingredients and using them directly in process. We are not too fond of our plant having an undertrack screw for unloading because of the inconvenience of getting a payloader into a boxcar when hopper cars are tight. To minimize contamination we have striven to separate our raw material unloading and storage from the mixed fertilizer.

All of our plants are equipped with a six compartment hopper batching system varying in size from 8 to 15 tons per section. Howe or Fairbanks-Morse Scales are used to batch weigh the dry materials. The gates on the Hoppers are air actuated and we find the Schroeder two way valves very satisfactory. Upon discharge from the weigh hopper the material goes up a bucket elevator, is screened and the oversized crushed by a hammer mill. In some of our plants a rotary or gravity mixer follows the screen while in others the material goes directly to the holding hopper over the dry feeder. We have not uncovered any significant analysis difference with or without the additional mixing. Our feeling is that the workers performance in accurate weighing has more significance on the analysis than premixing.

Several of our plants are equipped with an Omega Feeder. We also use a Merrick Scale or a Schaefer Poidometer at other plants to weigh the dry material on a continuous basis. On the slide you will note on the left a screw conveyor which feeds the fine recycle back to the ammoniator. The majority of our plants feed the recycle in this manner as it is generated in the system. Two of our major plants control the recycle by feeding it to the ammoniator over a variable speed belt. We could debate all day the merits of controlled versus uncontrolled recycle return and never settle the item. The equipment from here on through the rest of the process varies considerably but the flow principle remains the same. We go through a T.V.A. type ammoniator, Concurrent Dryer, Countercurrent Cooler, all rotary pieces, and size the product on a double deck Hum-mer Screen. Complete descriptions of the various type pieces of equipment used have been presented in previous Round Table discussions. "Doc" Marshall might just have a copy or two available of the 1959 proceedings which includes a good discussion of equipment by Al Henderson and Elgin Doidge. One comment I would like to make is that our personnel favor the combination ammoniator-granulator over separate ones or the ammoniator above. The retention time in the graulator section seems to give wet material from the ammoniation section a little drier, less sticky surface that doesn't cling to chutes and dryer flights as readily.

John Surber will now discuss our preneutralizer operations.

NOTE: Slide #1 mentioned was misplaced. Editors Note.

Pre-Neutralization

John Surber

SINCE one entire session of the 1960 Round Table covered Pre-neutralization we will not endeavor to present any theory but rather try to illustrate some of the operational problems and the remedies which we have used.

The question of whether or not to use pre-neutralization is an individual plant problem which we cannot readily answer. Disregarding the possible economic benefits we think that a pre-reactor is a valuable piece of equipment in operation of a granular fertilizer plant. Use of pre-reactor adds flexability to your formualtion practices. It can readily be adapted for producing almost any high analysis formulation. We have utilizer a pre-reactor in formulation of a variety of ratios which include 2-1-1, 3-2-2, 1-1-1, 1-4-4 and 1-4-2 in addition to di-ammonium phosphate.

We will confine our remarks to the production of two grades, 15-15-15 and 18-46-0. The normal reactor which we use is fabricated from 10 gauge type 316 stainless steel with dimensions of approximately 4 feet in diameter by 8 feet in height.

In the interior of the reactor straight pipe spargers are used to distribute the liquids at the bottom. A high speed mixer maintains agitation to prevent localized reaction. Temperature of the reaction is controlled automatically by addition of water through a control valve.

Our first attempts at the manufacture of 15-15-15 were at a plant not equipped with recycle control. Our original formulation was 15.5 units of nitrogen solution 440 (24-70-0), 15.0 units of potash and the remaining pounds made up of triple, phosphoric acid and sulfuric acid.

Initially all of the sulfuric and phosphoric acid was metered to the pre-reactor together with enough solution to neutralize all of the sulfuric acid and ammoniate the phosphoric acid at about a 6 pound rate (mole ratio of 1.25:1). The remaining solution was distributed in the ammoniator to ammoniate the triple and further ammoniate the phosphoric acid to a 7.5 pound ammoniation rate.

We found that excessive foaming took place in the reactor. In simple terms the reactor boiled over even at reduced tonnage rates. This foaming was attributed to use of wet process phosphoric acid since furnace acid had been successfully used at other operations.

To correct this situation we mounted a foam breaker on the agitator shaft and directed a jet of air at the liquid surface.

The next problem to arise was excessive amounts of liquid phase. We were distributing some 1200 pounds of slurry over 900 pounds of dry potash and triple with no control of the recycle.

The major difficulty was surges of recycle which we could not compensate for, which resulted in a product which varied in both appearance and analysis.

After several false starts we devised the formulation presently in use.

582 lbs. solution 440 (24-70-0) (12.8 Units N)
145 lbs. ammonium sulfate (1.5 Units N)
138 lbs. di-ammonium phosphate (1.2 Units N) (3.2 Units P_2O_5)
496 lbs. potash (60.5%)
310 lbs. triple super (54%) (8.4 Units P_2O_5)
127 lbs. phosphoric acid (54.4%) (3.5 Units P_2O_2)
275 lbs. sulfuric acid (93.2%)

All of the sulfuric acid is metered to the pre-reactor. 372 lbs. of nitrogen solution are metered into the reactor which neutralizes the sulfuric acid. The remaining 210 lbs. are distributed in the ammoniator beneath the rolling bed. The phosphoric acid is distributed on top of the bed. Slurry from the pre-reactor flows by gravity to the ammoniator and is discharged directly onto the bed at a point about 3 feet from the discharge end of the ammoniator. Reaction temperature is maintained at 275°-285°F. Nitrogen losses are negligible The average nitrogen content of 14 consecutive samples was found to be 15.47% N with a high of 15.87% and a low of 15.14%. Product appearance is uniform and a production rate of 25 tons per hour poses no problems. Plant personnel consider it the easiest of all grades from an operating standpoint.

Moisture content of the product determined by the AOAC oven method (5 hours. @ 100°C) was found to average 2.2%. Further moisture determinations by the Karl-Fischer titration and vaccuum dessication methods gave much lower average moistures. A particular sample that contained 2.0% moisture by oven drying only contained .8% by Karl Fischer titration and .65% by vacuum dessication. Further experiments are being conducted to interpret these differences which also occur in other grades containing ammonium phosphates. Chuck Everhart will now discuss 18-46-0.

The Production Of 18-46-0 In A Conventional Granulation Plant

Chuck Everhart

IN November, of 1961, Federal Chemical Company began the production of 18-46-0 in their conventional fertilizer granulation plant at Danville, Illinois. The only additional process equipment needed was a Schneible Scrubber used to scrub the ammoniator exhaust. The plant already had a Preneutralizer (4′ in diameter and 7′ high) that had been used in the production of high nitrogen mixed fertilizer grades. Other process equipment included a T.V.A. ammoniator, a separate granulator, a Link Belt Rotolouver Dryer-Cooler combination, dry cyclones, a 4′ x 15′ Tyler Hummer Screen, a Two-Row Cage Mill for crushing the oversize, a variable speed belt to feed the recycle and the bucket elevators, belts, etc. necessary to move the product. The ammonia was metered to the preneutralizer and the ammoniator by Fischer-Porter rotometers. The wet process phosphoric acid was metered by a 1″ Foxboro Magnetic Meter.

The production of 18-46-0 is a two stage neutralization of Phosphoric Acid by Anhydrous Ammonia. All of the Phosphoric Acid is put in the Preneutralizer and is partially ammoniated by Anhydrous so that the mole ratio of $NH_3:H_3PO_5$ is between 1.25 and 1.45. The hot slurry from the preneutralizer is then discharged onto a bed of recycle product in the Ammoniator and further ammoniated to diammonium phosphate (Mole ratios of 2.0). From the ammoniator the product passes through the granulator (which really isn't necessary for this product but we have it in our line), the dryer-cooler and is screened to the desired product size. Our good friends from T.V.A., R. D. Young and Gordon Hicks, along with C. H. Davis, have published a very good, detailed paper entitled "T.V.A. Process for Production of Granular DiAmmonium Phosphate." I'm sure many of you will want to read their fine article if you haven't already. This article includes complete discussion and data on their work on 18-46-0 as well as other ammonium phosphate grades.

When we first started production the Phosphoric Acid was diluted with fresh water and introduced into the system by spraying into the Ammoniator scrubber. The scrubber located directly above the preneutralizer feeds the acid to it. Because of excessive plugging of the scrubber the acid is now introduced directly into the preneutralizer. Fresh water is now used to scrub the Ammoniator exhaust and it removes any effluent of Ammonia to the atmosphere. This water is discharged to our waste pond. The ammonia to the preneutralizer is diluted with water also to reduce the formation of "cold spots" or lumps in the prereactor. An automatic temperature control system regulates the input of water to keep the preneutralizer slurrry at 240°F. Operating at this temperature there is no loss of Ammonia from the Preneutralizer. We feel that the Lightning Mixer used for agitation in the preneutralizer is necessary to reduce salt formation. We feed the ammonia beneath the bed through a 1½″ black iron pipe with holes spaced uniformly along the pipe.

During our year of operation we have learned a few things that may be of interest to some of you. One very enlightening feature was that no matter how badly we performed we couldn't "goof up" the analysis. Using only liquid ingredients through accurate meters probably accounts for this. After hearing this Mr. Poundstone probably wishes we could use only liquids in all of our fertilizer grades. We started out using Formula I shown on Table I at a production rate of 7 tons per hour. We put 280 pounds of NH_3 and 1852 pounds of H_3PO_4 in the preneutralizer which gives a mole ratio of 1.248 ($NH_3:H_3PO_4$). This slurry was fed through a saw toothed trough over about half of the rolling bed in the ammoniator. The reaction from the 171 pounds of Ammonia under the bed was only sufficient to raise the product temperature to 164°F (Recycle rate of 5.69 to 1). This did not give us enough heat of reaction to drive off sufficient moisture. By raising the mole ratio to 1.40 in the prereactor, (Formula II, Table I) increasing the total Ammonia from 451 to 461 pounds (12 pounds excess of a mole ratio of 2.0) and lengthening the saw toothed trough two feet we were able to increase our production rate from 7 to 12 tons per hour. Also, our recycle rate was lowered to 3.3 to 1, the oversized out of the ammoniator (+6 Mesh) was reduced from 25% to 10%, the temperature in the ammoniator rose to 195°-200°F and the moisture content of the product was cut in half. We were seriously thinking of installing an Ammonia Vaporizer to increase our reaction temperature in the Ammoniator but have shelved it because of the improvements cited. We also found that the oven moisture method five hours at 100°C is worthless for this product. We now use vacuum desiccation at room temperature for sixteen hours and the Karl-Fischer Method to determine moisture on 18-46-0.

Table I. Operating Date — 18-46-0

	FORMULA #I	FORMULA #II
Production Rate (tph)	7	12
To Preneutralizer		
Ammonia	280	314
Phosphoric Acid	1852	1852
Mole Ratio	1.248	1.40
Slurry Temperature	240°F	240°F
NH_3 to Ammoniator	171	147
Excess Ammonia (lbs.)	2	12
Recycle Ratio	5.69	3.3
Temperature °F		
Ammoniator	164°	195°
Dryer Inlet Air	400°	400°
Cooler Exit Air	125°	120°
Cooler Product	120°	110°
Product Analysis		
Moisture	2.90	1.40
Nitrogen	18.35	18.53
Available P_2O_5	46.75	46.95
Screen Analysis % (Tyler Series)		
+ 6 Mesh	.3	.4
— 6 + 8 “	29.5	27.8
— 8 +10 “	34.9	33.8
—10 +14 “	33.7	35.9
—14 +20 “	1.6	1.9
—20 “	.1	.2

The Heavy Duty Polyethylene Bag

F. Bennett Williams

YOU have just seen a short movie depicting the all polyethylene bag in use as a shipping container for mixed fertilizers. In the past few years there has been much discussion, experimenting, and confusion involved with the polyethylene bag.

Let me refer to it as the PE bag for brevity's sake, or we'll be here all morning just saying polyethylene.

However, approximately one year ago in August, 1961 National Distillers and Chemical Company, working collectively with their PE resin manufacturing division, U. S. Chemical Company, and their fertilizer division, Federal Chemical Company, developed and made available for commercial use the bag you just saw in the movie. The bag was considered to be a commercial product for several reasons.

It was competitive in price with existing fertilizer packaging materials.

It could be integrated into existing bagging systems with a minimum of changes to the system.

It could be filled with existing plant personnel at the currently existing bagging rates.

It was a bag proven to be successful in shipments.

Since the original commercialization of the PE bag by USI, the increased use of the PE bag has spread at a very rapid rate. Over six million bags were used in this Spring's fertilizer season; and three to four times that many are forecast for use in the 1963 Spring season. The reason for this rapid expansion has been the enthusiastic acceptance of the package by the farmers in those areas where they have been exposed to fertilizer packaged in PE.

As a PE bag manufacturer, we are very glad this enthusiasm of the farmer has stimulated the interest of you fertilizer manufacturers in wanting to know more about this package. I appreciate the opportunity to be here to discuss the PE bag with you. This morning I have with me several slides which might be of interest in explaining what PE is, what are its characteristics, how it is made, how it is converted into bags, and what are some of the usage features which differentiate it from paper.

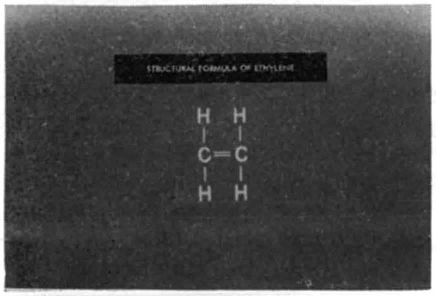
After we have gone through the slides we will have time for questions from the floor. I welcome these questions, so feel free to ask about any areas I do not explain clearly or have not included in the slides. To start with, let me offer a definition of a plastic, since the bag is often referred to as a plastic bag.

"A plastic is any synthetic or man-made material that is solid in both its unprocessed and processed states; but is softened through heat, and/or pressure during processing to be formed into various shapes." There are literally thousands of different plastic varieties on the market today. Some of the more common, with which all of you probably are familiar, are synthetic rubber, nylon, styrene, acetates, polyesters and polyethylene. The one we are concerned with in its use as a shipping bag is polyethylene.

The physical properties of a PE are mainly dependent on three basic molecular properties: density, average molecular weight, and molecular weight distribution. These properties in turn are controlled by the size, structure, and uniformity of the PE molecules.

Much of what has been found out about the details of the molecular structure of PE is very complex. It is presented here in a simplified fashion that, hopefully, I can explain.

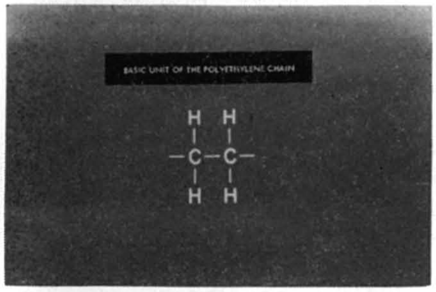
Structural Formula of Polyethylene



Slide 1

As the name would indicate, PE is made of ethylene gas molecules. Ethylene is a gaseous hydrocarbon, composed of two carbon atoms and four hydrogen atoms, arranged as shown on this slide. The two carbon atoms in the ethylene molecule are held together by a strong bond characteristic for some hydrocarbons.

Basic Unit of the Polyethylene Chain

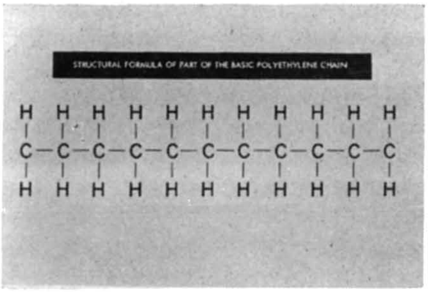


Slide 2

Under certain circumstances, however, this bond will open as shown here.

This gives one ethylene molecule a chance to join with others to form a chain. . . .

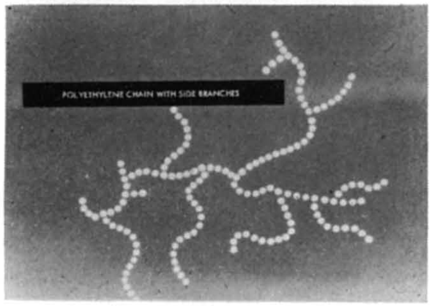
Structural Formula of Part of the Basic Polyethylene Chain



Slide 3

. . . IN WHICH ALL OF THE CARBON ATOMS ARE LINKED, each of them holding its two hydrogen atoms as shown. Such a chain of ethylene atoms is called polyethylene and the process of making it is called polymerization. Polyethylene molecular chains are not flat or two-dimensional as depicted here. They have a three-dimensional shape, the hydrogen atoms being arranged along an inner zig-zag chain of carbon atoms. PE chains may be rather short or enormously long, consisting of many thousands of atoms. In fact, the polymerization of ethylene creates a mixture of chains of unequal lengths; some of them may be very short—about 12 molecules or less—while others are giants containing several hundred thousand ethylene units. Thus, we are depicting here only a tiny part of an average PE molecule. There is no commercial PE existing that is built up exclusively of chains as simple as the one presented.

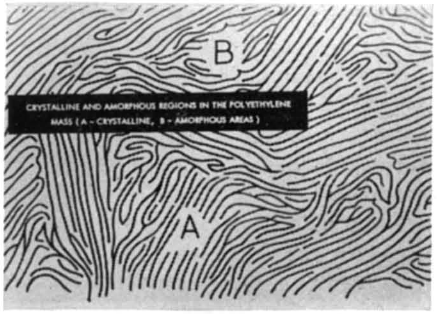
Polyethylene Chain with Side Branches



Slide 4

The molecular structure of most commercial PE resin is far more complicated. Laboratory examination has revealed that for every one hundred ethylene units in the molecular chain there are roughly one to ten branches, growing from the chain. This means the molecule is not a straight chain, but one with a great number of short and long side branches. Shown here schematically is a pictuure of a side branching chain. The branches radiate three dimensionally, just as the branches of a tree point in all directions from various places along the trunk.

Crystalline and Amorphous Regions in the Polyethylene Mass (A—Crystalline; B—Amorphous Areas)



Slide 5

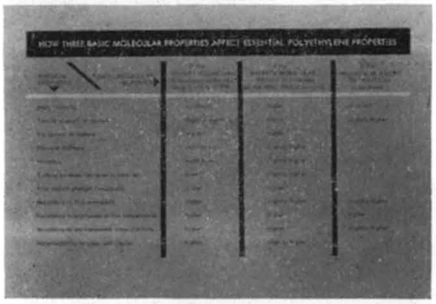
PE molecules are not all arranged parallel to each other. In some areas of the plastic mass. the molecular chains, though branched, are closely packed and lined up parallel like a pack of cigarettes in an orderly crystalline fashion as in the area marked "A". In other areas they are arranged at random, like boiled spaghetti. This structure is what the chemists call "amorphous" and is shown in the area marked "B".

Above its melting point, PE is always an amorphous mass. A PE which remained totally amorphous at room temperature would be soft, grease-like, and thus useless for extrusion or molding. A totally crystalline PE, on the other hand, would probably be too hard and too brittle to be useful. The right mixture of crystalline and amorphous regions is what the processors need for making good end products. An increase in crystallinity has a decided influence on some essential properties. Primarily, the higher the degree of crystallinity, the denser the resin. In review, we have said that the three characteristics that determines the physical properties of PE are the density, the average molecular weight, and the molecular weight distribution.

The slides showed that PE was ethylene molecules linked together by the carbon atoms. In addition, the three properties—density, average molecular weight, and molecular weight distribution — are controlled by the manner in which these ethylene molecules join together and arrange themselves.

A high density resin means the molecules are linked up in straight rows, producing a crystalline, stiff resin. A high molecular weight resin is a resin with long chains of ethylene molecules linked together, producing a tough, hard-to-break resin. A resin with narrow molecular weight distribution would be the resin with more of the PE molecules nearly the same length, as opposed to a wide molecular weight distribution which would mean short chains and long chains mixed together.

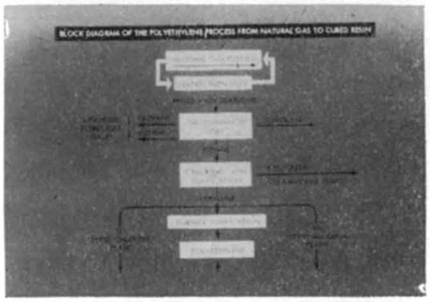
How Three Basic Molecular Properties Affect Essential Polyethylene Properties



Slide 6

This slide lists for us how the three basic molecular properties affect the physical properties essential to PE when used as a shipping bag. The resin currently being used to manufacture the fertilizer bag is of a very low density, high molecular weight, with a narrow molecular weight distribution. As we read down the essential physical properties on the left, it can be seen that in nearly every case the physical property is improved or strengthened by this combination of lower density, higher molecular weight and narrow molecular weight distribution. However, we see that some characteristics tend to offset each other as the resin is changed more in this direction. Most notable among these is surface hardnesss or abrasion resistance. A reduction in density lowers abrasion resistance while an increase in molecular weight increases abrasion resistance. However, to increase density to get more abrasion resistance would reduce tensile strength, elongation, and resistance to low temperature brittleness, to name a few. Therefore, the ressin currently being used is the result of over five years of research and testing of hundreds of different combinations to find the best balance among these properties. The present resin, when properly manufactured into a bag, has proved itself a successful combination of these properties important to the fertilizer manufacturer. Now that we know what PE is, and what things effect its physical properties, let's look at how it is made and converted into bags.

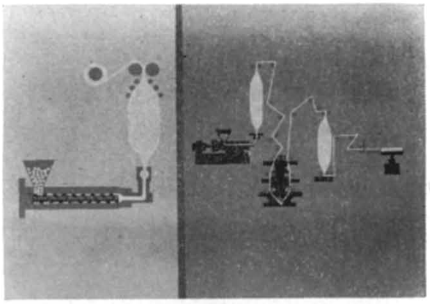
Block Diagram of the Polyethylene Process from Natural Gas to Cubes Resin



Slide 7

In block diagram form we have the PE process from the natural gas to resin cubes depicted here. The natural gas is piped into the petro chemical processing plant. In the first step, in an extracting unit, a general mixture of hydrocarbons of specified weights are removed and sent on for fractionization. Interesting to me when I was first exposed to this process is that the unused portion of the gas, less the hydrocarbons desired, is sent back into the pipe line and pumped on to its original destination to be used just as efficiently as ever by you and I in our homes, offices and factories.

In the fractionization unit the mixture of hydrocarbons is separated into the specific type of materials desired. These specific products are then sent to various parts of the petro chemical plant for further processing into liquified gases, gasoline, ammonia, and alcohols, as well as the PE. The fractionization unit produces ethane gas which is cracked apart into hydrogen and ethylene gas. The ethylene gas is purified and sent to the polymerization plant. There it is subjected to tremendous pressures and in the presence of catalysts the PE begins to form into a molten mass and flows into a separator. There it is cooled, solidified, cut in small cubes, and then sold to other plants for conversion into finished products. The resin cube looks somewhat like rock salt. It is cubes ⅛" in length and of a white, translucent color.



Slide 8

At the bag converters the resin is extruded into sheets of film, then printed and sealed into bags. The heart of the process is the extrusion itself, as shown in cross-section at the left. What you see here is really an overgrown heated meat grinder. As the resin comes down out of the hopper it is carried forward by an auger or screw. As it goes forward heat is gradually applied until the resin melts. Pressure is built up as the material is forced out through the restrictions of the die to shape the material. The die is doughnut shaped with a mandrel inside, filling most of the hole in the die. This leaves a circular orifice through which a tube of molten PE is extruded upward. The molten PE is then led up to a set of variable speed nip rollers, similar to the old-fashioned washing machine wringer where it is squeezed flat into a double sheet.

Air is then introduced into the tube and the molten mass is blown up like a balloon. The amount of air controls the width of the finished bag. To make a large bag, blow it up more; a smaller bag, let some air out.

After getting the tube up to size, the speed of the nip rollers is adjusted to stretch the film down to the desired thickness, just like stretching a rubber band. For a thin bag, the nips run fast; for a thicker bag, the nips are slowed down. There is now a continuous set of action in process that produces a tube of PE flattened into a continuous ribbon. As the extruder pushes the material out, the nip roll pulls it away. The volume of air trapped between the die and the nip roll acts to shape the tube continually to the same size. All the time this continuous process is in motion the molten PE is being cooled as rapidly as possible. Most generally cool or refrigerated air is blown against the film to get it in a solid state. If the material were not properly cooled before it reached the nip rolls, the inner surface of the tube would be laminated together when squeezed flat, and the bag would be difficult or impossible to open. As you see from this description, there are many variables in this process, such as the heat and pressure in the extruder and die, the size of the die or orifice, the speed at which the material is drawn away and cooled. These conditions, as much as those in the original resin manufacturing, controls the quality and strength of the PE bag. Probably the characteristic that is most directly affected by the extrusion process is the tear resistance of the bag. Bags of the same resin manufactured by two different bag makers can vary widely in tear resistance, as some unfortunate shipping experiences have shown in the past.

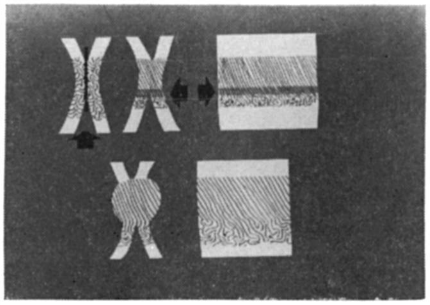
As shown on the right, after the tube is formed it leaves the nip roll in a continuous ribbon and is fed through a treater to scar or scuff the surface so ink will adhere. Then, on the printing press where the customer's design is placed on the bag. Note here that the bag must be printed each side separately, since we are dealing with a tube, not a flat sheet to be folded into a tube at a later stage.

The tube leaves the press to a drying oven to affix the inks. Then, since the bag has gone through several sets of rollers by this time, it is often run through a post-printing operation that re-inflates the tube to insure that there has been no sticking of one inner surface to the other.

The continuous tube is then fed into a bag making machine which cuts the tube into specific bag lengths. As the knife comes down to cut the tube, the end of the tube left in the machine after the cut is made is sealed with heat so that each time a length of tube is cut off a bag is formed.

The bags are automatically stacked and counted. After each predetermined count is reached the bags are boxed for shipment. That's all there is to the manufacture of PE bags for the fertilizer industry. If it was that simple why are we just within the last year producing a bag which satisfies your needs? As in all rapidly expanding industries, there are rapid changes and improvements in technology. So it is with the PE industry. We knew that the basic PE material potentially offered a package that would possess characteristics extremely important to the fertilizer industry. PE is basically strong, relatively inexpensive, light in weight, chemically inert, and most importantly, moisture proof. Yet four or five years ago, when the first actual work was done on this package, it was plagued with continual failures. The bag walls were not strong, the seals opened up, the bag punctured in shipment and in handling, the bags wouldn't stack, plus many other problems.

From our first series of slides you can visualize the problems and techniques developed to come up with the best resin. At the same time the resin development was in process our most bothersome and frustrating problem of sealing the bags was being attacked.

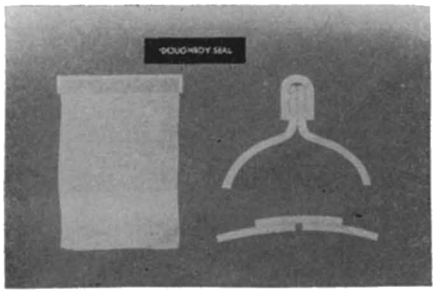


Slide 9

Here is a slide showing crystalline structure and the cross sections of three bottom seals. These top two situations depict the dilemma which we faced. The principle of the heat seal in PE is to melt the materials to be sealed and press the molten masses together. When they cool and solidify they are theoretically as one piece of PE. However, from our earlier slides we know that PE changes its crystalline structure and is amorphous when heated. Depending on the heat, pressure and cooling rate as discussed in the extrusion process, a PE sheet exhibits a certain specific crystalline structure. When that structure is re-heated as in the bag machine, the heat, pressures and cooling rates can never be exactly the same as when the film was originally produced. Therefore, the original film and the end seal on the bag were markedly different in crystalline structure under normally known bag making techniques. That resulted in a bag which could have good walls, and a good seal, but where the two joined together, just adjacent to the seal, there was no strength, since the molecules of the walls and the seal were not intertwined to any great extent. The way to overcome that problem, under then existing known techniques, was to reduce the extent of the seal. That is, not melt the PE so much, nor squeeze it together quite so hard. This did not free up the molecules to re-form into a new crystalline structure in the seal. However, as shown on Part II of the slide, it did not produce a complete intermingling of the PE on each side of the seal. Under stress of the fertilizer in stacks or in shipment the seal would gradually delaminate, pull apart, and open the end of the bag. After many blind alleys in pursuit of a solution and after many, many boxcars of supposedly bagged material had arrived in bulk, we came up with a technique which was a solution to this problem, as depicted in the bottom section of the slide. The answer was to apply heat and pressure in such a way that the desirable features of both previous approaches were exhibited in the ssame seal. The net effect was a seal that held a gradual transition from the amorphous film to the crystalline seal; a seal that was actually stronger than the original film itself. Our in-plant testing of this seal calls for dropping the filled bag twice from 14 feet on its edge to insure that the manufacturing conditions have actually provided this transition that is essential. In shipping experience with mixed fertilizers end seal failures have been negligible.

Therefore, the problem of the bottom or manufactured seal was solved reliably and economically. However, the seal on top, after the bag has been filled, was a totally different problem. The fine layer of dust that settles on the inner surfaces of the bag is sufficient to prevent the PE from mixing completely when molten during the sealing process. The result is gradual peeling apart of the seals under stress during shipment.

Doughboy Seal



Slide 10

This problem was finally solved by placing a piece of PE tape over the top edge of the bag and sealing through all four thicknesses, the seal looking like this. This proved to be a very reliable sealing system.

The seal reacts as shown in cross section on the right.

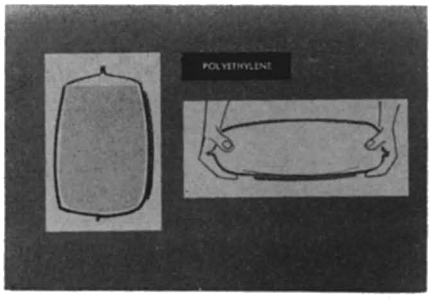
When the under surfaces of the seal peeled apart due to the dust contamination, the tape on the outer side acted as a second seal and prevented the bag from coming open. The tape in its position of stress has no tendency to peel apart. The peel stresses on the inner seal are converted to sheer stresses, therefore dust on the exterior of the bag does not represent a problem. This principle has been demonstrated many times by the adhesive or cellophane tape salesman. Taking a piece of the competitive sticky tape he applies it to the surface, probably your desk. Then he peels it up and says, "See how easily that came off?" Then he takes his own tape and applies it to the top of your desk. This time he pulls the end of the tape, not up as he did the competitive tape, but horizontally instead. He is then trying to scoot the tape from your desk. Of course the tape breaks before it comes loose, and he says, "See how much tighter my tape sticks!" The tape over the top of the bag does the same thing. It makes the fertilizer try to scoot the tape off the top of the bag rather than peel it off as happened to the inner seals.

This sealing operation is best done by a sealer manufactured by Doughboy Industries. The sealer tppically fits into the bagging line just after the sewing machine. In this way a line is capable of running the sewn package or the PE package interchangeably. The sealer is fed in a manner similar to feeding the sewing machine as the movie showed us. After the bag is fed into the sealer, the top is trimmed horizontally, the tape is dispensed, folded, applied over the lips of the bag and sealed into position automatically.

This can be done at 700 inches per minute, which is equivalent to about 33-34—fifty pound bags per minute. The reliability of the seal in actual shipment of fertilizer has been very good. As stated earlier, in approximately six million bags shipped this Spring, seale failures were very negligible.

After solving the sealing problem it was possible to go out to the fertilizer manufacturers and test the bags on a much larger scale. It was during these large scale tests that most of the answers were found ragarding the general question of handling the bag commercially. Most of the answers revolved around two areas; the first was getting a properly sized bag and the other was just letting the personnel get familiar with the bag.

Polyethylene

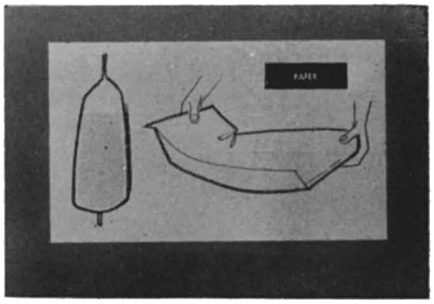


Slide 11

These next slides attempt to depict the difference in size between a paper bag and a PE bag for the same product. The PE bag works best with only three to four inches of empty bag over the product. This means the PE bag is generally three inches shorter than equivalent paper bags. The flexibility of the PE bag makes this possible. Since the PE bag is very pliable, it conforms to the shape of the product inside. A properly sized PE bag acts nearly like a skin wrap around the fertilizer.

The advantages of handling this type of bag can be seen here on the right. A larger bag which has several inches of free bag above the product tends to be loose and sag in the middle when picked up. This puts a strain on the fingers of the person handling the bag, and tends to tear the bag more easily. In contrast, a properly sized bag is rigid and lays flat in a person's hand. The fingers tend to grasp fertilizer as well as bag when the package is picked up. This tight packing of fertilizer results in a much stronger package with fewer punctures in handling, shipping and warehousing.

Paper



Slide 12

This slide shows the reaction with PE when the bag is sized the same as paper. Note the extra length of bag at the top, and how the package sags when lifted.

Slide 13

In handling of the bag previously, the stacking of the bag was a problem. However, as shown here, the bags can effectively be palletized for warehousing. Because there is far less wasted space in the PE bag than in paper bags, the filled PE bag of lay-flat construction takes up slightly less warehouse floor space than the filled, gusseted paper bag.

Slide 14

As shown here and in the movie, the bag performs very well on the flat bed truck. The pliability of the bag allows the product to conform to the shape of the bags around it. On the truck the bags actually nestle down on each other in a somewhat interlocking fashion. Shipping performance by truck has been outstandingly good.

Federal never has revealed to me how much fertilizer you need to buy to get to keep the girl that is on the truck.

Slide 15

In rail shipments breakage performance has been within a few hundredths of a percent the same as with paper from the same mills to the same destination. The average damage in over five hundred cars shipped this Spring was .8% of the bags shipped. Very significantly, however, there was less total product loss from PE than paper since a damage in the PE bag does not spread itself. A PE bag with a tear or puncture could still be dropped from 14 feet without further failure of the package. In all of the elements of handling the PE bag, filling, sealing, stacking and shipping, the bag is a little different from the present packages used. Certainly it is not more difficult, and in many respects easier, but it does take some practice and instruction to become as proficient as is necessary to operate in a fertilizer plant. The instruction and training on these differences in filling and sealing techniques, in different stacking patterns, as well as the sealer maintenance, are furnished free by our experienced technicians. These technicians enter your plant, install the sealers, train your crews and remain there until your crews are fully operative. These services are available at no extra cost with the purchase of the sealer and bags. So, in answer to my own question of a few minutes ago on why didn't we have this package before, I guess the only answer is, we weren't smart a few years ago because now that we do have it, you can see it is very simple and straightforward.

In summing up we could say:

1. There are hundreds of kinds of polyethylene and hundreds of bag makers and the complexities of putting it all together into a functional bag are manifold.
2. But when the right combination exists you have a bag that has been extensively field tested and proven workable.
3. The PE bag has had enthusiastic acceptance where it has been used in sufficient quantities for people to become familiar with it.

Naration By Film Packaging Fertilizer In 50 lb. Polyethylene Bags, Sam Shelby.

I will briefly explain to you a bag-loading system and I will show you a film packaging fertilizers in 50-pound polyethylene bags. We have had many requests from the industry to see this operation.

This movie was made at our Nashville, Tennessee plant where we now have three packaging lines equipped for packaging polyethylene bags. The bag is constructed of 5 mil polyethylene and is either 16½″, 17″ or 17½″ in diameter and 26″ long. The packaging rate is approximately 28 bags per minute. The package is filled by a St. Regis 185AS open-mouth unit and travels through a Doughboy Sealer. In the first portion the bag is trimmed off about ½″ at the top and 1″ polyethylene tape folded over the outside of the bag; then travels through heating bars and finally through water cooled bars. It then travels on to the conveyor system to truck or car. At mass production four men are used on the packaging and sealing line with from three to four men in the truck or car. This is the same size crew that we use in packaging open-mouth paper bags.

When the product in these packages are shipped on open flat bed trucks it is usually necessary to dope down the back tier bags, however, it is not necessary to cover the load with a tarpaulin as water tends to run off of these bags if they go through rain. We have received wide acceptance of this bag from our customers and all truckers are well pleased with the way the package stays on the truck during transit.

This concludes our assigned subject on Plant Operations Raw Materials to Bagging." Our panel will be very happy to answer any questions during this session or during our stay for the remainder of the meeting.

Moderator Reynolds: Thank you very much Sam, and your excellent panelists. I wish we had some time for questions, however, it is possible we can work in any questions this afternoon.

This session adjourned at 12.13 o'clock P.M.

Thursday Afternoon Session, October 25, 1962

The Round Table reconvened at two o'clock p.m., Moderator Joseph Reynolds and Albert Spillman presiding.

Moderator Reynolds: Let's get started with our afternoon session. We will try to keep on schedule and get under way at this time. As you will recall this morning we had a couple of our speakers on one topic carried over to this afternoon. We will continue from that point.

During the preceding Round Table meetings problems of chemical analysis have often been admitted by our industry. Some efforts have been directed toward statistical evaluation of the problems, however, the surface has only been scratched.

The next two speakers have taken time away from their schedules, primarily in regulatory work to investigate why some of the analyses vary between plants and operating conditions. The two speakers who will cover this subject are Mr. Bruce Poundstone and Dr. W. G. Duncan of the University of Kentucky. Perhaps many of you here know Mr. Poundstone, recognized in fertilizer control work, both in his own state and also nationally. Dr. Duncan has also done considerable work in this field, primarily in statistical work. He has devised some analytical interpretations for some of the behaviors of fertilizer. We feel very fortunate today to have obtained the services of these two gentlemen to discuss this subject for us. It gives me a great deal of pleasure to introduce Mr. Poundstone and Dr. Duncan.

Analytical Problems Resulting From Handling Mixed Goods "In and Out" of Storage

Bruce Poundstone and Dr. W. G. Duncan

Introduction

Mr. Poundstone: We have had an excellent exposition this morning on the subject of the mixing of fertilizer. We now direct your attention to the very end of the process. I refer to what is in the bag.

Everyone realizes that fertilizer varies in analysis. This is a characteristic of fertilizer. Sometimes this variation is rather wide. Sometimes it is narrow.

First, we wish to consider this variation. Recognition of the fact of variation becomes a means of setting forth the overall problem.

Following this we will review briefly why the analysis of mixed goods varies. There are many causes. Among them, one stands out in our experience as most important. This occurs in handling in and out of storage.

Finally, we will present a statistical approach for measuring and comparing these variations.

Dr. Duncan: Our interest in this subject was aroused some years ago by Robert Z. Rollins of California, a Control Official from that state. He sent us some information in which he had attempted to evaluate his manufacturers by using all the samples from the manufacturer rather than looking at one sample at a time. He developed two concepts that are of special interest. He described a manufacturer in terms of aim or marksmanship. The other was to speak of a manufacturer in terms of skill. He used scatter diagrams as a means of representing or picturing aim and skill. These showed clearly that fertilizer analyses tended to be normally distributed around their averages.

We have enlarged on some of Rollins' ideas. Since 1954, the information concerning all of Kentucky's inspection samples has been punched on IBM cards. We worked out a computer program and put these cards through our data processor at the University of Kentucky Computing Center.

We have put some 16,000 cards through our computer covering the last four years of analytical work. In addition to this, we have drawn on similar information from an adjoining state. This gave us a large amount of data for studying this problem of variation. Our conclusions have been reached by looking at this very large collection of chemical analyses.

The Problem

Table 1. Comparison of Analyses for Nitrogen in 10-10-10 Fertilizer for Three Companies

Kentucky—Spring Season 1962

Company A	Company B	Company C
9.9	10.6	10.0
8.6 L	10.8 H	9.9
10.2	8.6 L	10.2
9.8	9.6 L	10.2
9.8	9.8	9.8 L
9.7	10.5	10.2
10.0	10.3	10.1
9.5	10.3	10.0
10.2	9.8	9.9
9.5	10.6	9.8 L
8.8	10.4	10.1
9.9	10.6	10.3 H
10.3 H	10.0	10.0
10.0	10.0	
9.7	10.2	
9.6	9.8	
10.2	10.1	
9.7	10.2	
10.3 H	10.1	
9.4	10.4	
10.1	10.0	
10.3 H	9.9	
8.8	10.3	
9.3	10.1	
10.1	9.6 L	
9.6	10.0	
10.3 H	10.1	
9.0	10.4	
	10.5	
	10.0	
	9.6 L	
	10.0	
	9.9	

H = High

L = Low

Poundstone: The information in Table 1 gives examples of variation from these companies. These analyses are all of a 10-10-10 fertilizer for three plants of three different companies in the spring season of 1952. For simplification, we are showing only the results of the determination for nitrogen. The figures in the three columns illustrate the *diversity* of variation in analysis. The column at the left representing Company A gives data on 28 samples. These range from a low of 8.6 to a high of 10.3. Many of the samples are below the guarantee of 10. Here is a company with a rather wide spread or wide variation and apparently having difficulty in meeting their guarantee.

In the middle column representing Company B. 33 samples are reported showing a variation from a low of 9.6 to a high of 10.8. The variation here from low to high is less than for Company A. Also in the case of Company B, very few of the samples are below the guarantee of 10.

The column on the far right for Company C, with 13 samples, shows a low of 9.8 and a high of 10.3. Here we have a very narrow spread in variation and all of these samples are close to the guarantee.

The information in this table illustrates variation and the diversity of this variation. You may have little variation or you may have wide variation. This happens in varying degrees depending upon many, many conditions.

Manufacturers have not always understood this variation. I am not sure that Control Officials have understood it either. We have been anxious to explain this to ourselves as control people. We have been just as anxious to understand this so that we might intelligently discuss it wih our manufacturers.

Why Scatter

Duncan: I view the columns in Table 1 not just as numbers, but I can see them from the manufacturer's point of view. I was in the fertilizer manufacturing business for about 20 years. I know that every time I got a letter from Bruce, I opened it with a feeling of anxiety. A very high analysis coming out of a pile of fertilizer usually went to a customer who couldn't read. And if I had a low one with a penalty attached to it, the report invariably would go to some valuable customer that we had managed, with great effort, to entice from one of our competitors. When we received a report of a low analysis, I never understood exactly why because we knew we had put the materials together. We had overformulated according to the best information we could get from our suppliers. We never could understand why sometimes the analysis was low, sometimes it was high. We always suspected our manufacturers of raw materials had short-changed us or one of the inspectors had taken a bad sample. We didn't understand it at all. It wasn't until I started looking at this from a statistical point of view that I received any real understanding of what it was all about.

Poundstone: I remind you that Rollins was looking at the total picture based upon sample analysis. He wasn't looking at an isolated example. In the illustrations from your experience, Bill, you indicate you were doing the thing we so often do. We look at an isolated example and we judge the situation based upon that example. If it is low, then we are concerned because we are failing to meet the guarantees.

This is one of the important things we began to think about when we looked at Rollins' procedure. We realized we should examine the total picture.

Duncan: Instead of giving a lecture on statistics, I would like to use a little illustration. (Holds a toy machine gun) Let's imagine that this machine gun is set on a tripod. It can't move. The gun is aimed through a tunnel where the air is perfectly still. We get no effects from the wind. We set up a target. Our gun is now locked firmly in place. The question is if I fire a few rounds, will each bullet strike the target in exactly the same place? (Pretends to fire. Poundstone exhibits the target showing spread of bullet holes.)

There are several characteristics about these shots that may help explain this distribution. The total area covered by the shots is known as the impact area. The outline is more or less circular in this case. Most of the holes are clustered near the middle of the target. The center of the cluster of shots may be called our apparent aiming point.

We may have tried to aim above, below, or to one side of what turned out to be the apparent aiming point. Regardless of where we had the gun aimed, the average of our shots is the apparent aiming point.

These bullets did not enter the target in the same hole. Why? You can ask the same question as to why every bag of fertilizer that comes out of the same pile is not alike. The answer is there is a reason for the placement of every one of these bullets. We will never know the reason. If we had enough facts, we could predict where every bullet would hit. Every bullet looks exactly alike, but every bullet is not alike. There are small variations. A heavier bullet will travel a distance that is different from that traveled by a lighter bullet. There is a range of variation in the powder charge and quality. Bullets are not all made in the same mold so do not have quite the same shape. There are many variable factors affecting each bullet.

These factors combine in different ways. Each bullet hole is a result of one combination of these factors. As you would expect, most of these will be near the middle of the target since the bullets themselves will tend to average around each of these factors. Also, there may be a tendency for factors to compensate for each other. The lighter bullet, for example, may have a heavier powder charge. Such combination of factors will also tend to make the bullets go toward the middle of the impact area.

We are particularly interested, however, in the extreme values. Why did this bullet go so high? And another go so low? The same question, why is one bag of fertilizer so much higher in analysis or lower in analysis than other bags of fertilizer out of the same pile?

Let's assume the lowest bullet in our pattern happened to be the lightest bullet we could get within the range of our quality control in making bullets. It also had the lightest powder charge. The powder was of the lowest quality. The primer was the poorest. All of these things combined in this one bullet to result in a shot as low as it can possibly get.

In the opposite way, all of these variable factors combined to favor this shot which is the highest in the target area. The range between the highest bullet and the lowest bullet on the target expresses the sum of the negative factors on the one hand and the positive factors on the other.

Fertilizer is formulated with many variables. The maximum difference between the highest and the lowest analysis compares the situation where everything goes wrong as against the situation where everything goes right. The maximum range is the sum of the possible differences of all of the variables.

What are our chances of controlling this? We cannot eliminate variablity, but we can reduce it by reducing the range of as many individual variable factors as possible.

Fertilizer Analyses

Poundstone: Analogy of the bullets hitting the target and fertilizer manufacturing may first be found in the idea of an impact area. The impact area in making fertilizer is drawn by diagramming groups of fertilizer and analyses. These analyses may be of samples drawn from a particular pile, a particular "run" or a particular season for a given grade of fertilizer. The apparent aiming point is analogous to the average of all analyses.

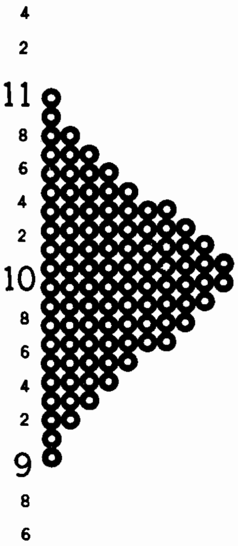


Figure 1. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 4% and averaging 10%.

Duncan: Figure 1 represents results of analysis of 100 samples from a 10% grade from the average Kentucky manufacturer. Most samples will be near the average. We will have at least one sample as high as 11 and at least one sample as low as 9. This is based on statistical probability and normal distribution. This is for the average manufacturer in Kentucky.

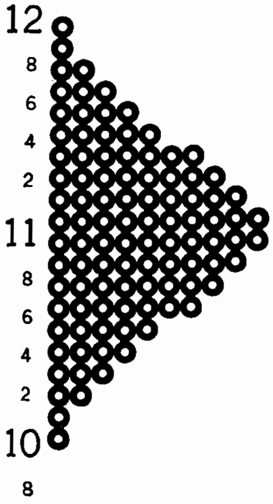


Figure 2. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 4% and all samples are at or above the guarantee of 10%.

You say a guaranty of 10%—What does a manufacturer mean? Does this mean that no customer will get less than 10%? If so, this average manufacturer would have to manufacture fertilizer at 11% to be sure that no single customer got less than 10%. This would be pretty expensive manufacturing. (See Figure 2) Fertilizer laws give manufacturers a break by what is called a tolerance. If all samples are to be within tolerance, over-formulation would be called for at 10.7 as shown in Figure 3.

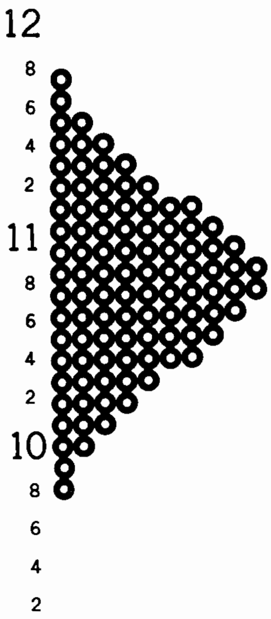


Figure 3. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 4% and all samples are within tolerance.

Suppose a manufacturer would be willing to risk having 7% of his samples come below tolerance. He would have to over-formulate at a little over 10.2% on the average as shown in Figure 4 to be sure that only 7% of his customers got a fertilizer below the tolerance.

Let us examine the record of what we will call a skillful manufacturer, a manufacturer with careful control over his variable factors. Suppose he wanted to manufacture a 10% grade and formulated at exactly 10%. His record would look as shown in Figure 5. He would not have any analyses below tolerance even though half of his customers would be getting slightly less than the guarantee of 10%. A manufacturer this skillful, by raising his aiming point to 10.1%, would have nothing below tolerance and most of his customers would get full guarantee (Figure 6).

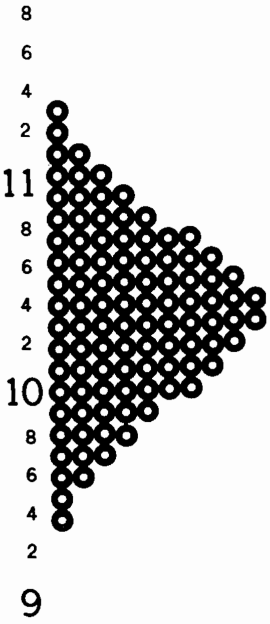


Figure 4. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 4% and seven of the samples below tolerance.

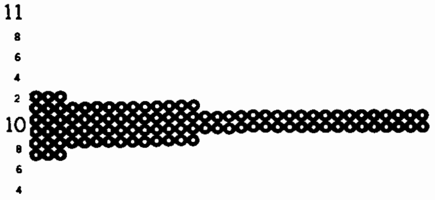


Figure 5. Distribution of analyses of 100 fertilizer samples with a coefficient of 1% and averaging the guarantee of 10%.

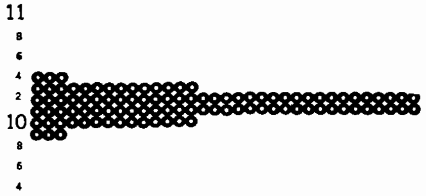


Figure 6. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 1% and overage analysis of 10.1%.

The spread or scatter of analyses of a given manufacturer has a lot to do with how much raw material he has to buy. Let's look at the record of a manufacturer less skillful than the average. Suppose he wants to be sure his customers received no fertilizer below tolerance. He would have to manufacture at 11.2% to do this. This is a high price to pay for his lack of skill (Figure 7).

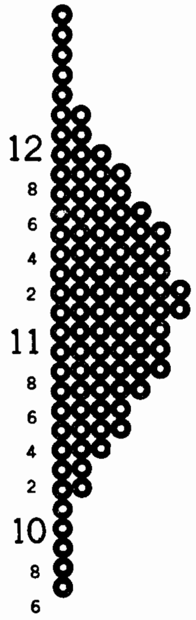


Figure 7. Distribution of analyses of 100 fertilizer samples with a coefficient of variation of 6% and all analyses above tolerance.

Segregation

Poundstone: This morning Sam Shelby and his group illustrated production procedures. In the plants they described, we saw many points at which variables could enter in. These bring about variability in the final results. Raw materials with variation in particle size and analysis is one of the first sources of variation. Methods of assembling, movement within the plant, weighing, charging the mixer, mixing rate, rehandling in the plant, introduction into the storage pile, removal from the storage pile, and handling at the bagger are some of the points at which variation can enter.

In our study of analysis data over a period of three years, we began to see differences and patterns emerge of more than usual interest. Some plants consistently showed a distribution represented by a skillful pattern such as is shown in Figure 5. Others just as consistently seemed to adhere to a pattern less skillful such as that shown in Figure 7.

In an effort to answer the questions as to the causes behind this, we visited most of the plants in Kentucky. We first went to the plants with records showing the least skill. We went there first because we wondered if these plants might have something in common. We soon observed what we determined to be the most significant influence. It was handling at the storage pile of finished mixed fertilizer that varied in particle size and thus particles varied in analysis. (This was illustrated at this point in the presentation by a movie.)

Fertilizer is usually dropped off the end of a continuous belt discharging over the center of a bin to build a conical pile. Some arrangements call for pouring the fertilizer into the edge of a bin. This results in what might be termed a half-cone. In any case, the smaller particles tend to build up directly below the point of discharge and the larger particles have a tendency to roll off to the side.

Any of you who have ever seen a fertilizer pile have seen the larger particles all along the side. We may have tended to ignore this saying it was just a function of storage. What really happens is to unmix what has been carefully weighed and mixed.

A loader securing a bucketful from the edge of such a pile will deliver to the bagger a load in which larger particles predominate. In the same way, a load secured from the middle of the pile would be predominantly small particles. Bagged in this way, shipments will vary from the average analysis of the pile.

We saw this over and over again in the plants we visited. Even in a continuous granulation plant with fairly uniform particle size, differences occur in their piles due to this. *If there is any difference in the particle size of a mixed fertilizer and there is variation in the analysis of these particles, you will have variations in the analysis of the final products insofar as these particles tend to segregate.* When segregation is overcome, there is no problem from this source.

Recognition of Problems

Duncan: This business of segregation is nothing new. It has been mentioned as a source of variation throughout the history of fertilizer manufacturing. There seems to be a tendency to ignore it or do little about it. Failure to realize its importance may be the real trouble. Most people notice the fact that particles at the "toe" of fertilizer piles are larger, but it does not occur to them that this means that this may indicate a variation in analysis throughout the whole pile.

It is our experience there is no relationship between the size of the company or the number of plants or how big their laboratory is or even how new the plant is in this problem. We think it is more a question of the recognition by the superintendent of the nature of the problem and the care he takes in putting this fertilizer together and handling the finished product.

Statistical Measures

We felt we should go beyond a simple recognition of the problem of variation. We wanted a means of expressing it in numbers. We have; therefore, selected two criteria. One is the one Z. Rollins used—the average. This is the average of all of the analyses of a particular grade and gives the apparent aim. I stress the word apparent because we can never know what the true aim was. All we can say is that based upon the samples we have, this is the apparent aim.

The other criteria needed is a bit more complex. We need to characterize the matter of scatter. We wanted a numeral basis, for example, of characterizing the scatter in Figure 5 to be able to compare it numerically with the scatter in Figure 7. This was done with what is called, in statistical terms, the co-efficient of variation.

If we were always dealing with one grade of fertilizer, say 10%, standard deviation would have served. Fertilizers, however, may run all the way from 4% in one grade to 40% in another. The standard deviation associated with a 4% grade is much less than the standard deviation associated with one of 40%. By dividing the standard deviation by the average analysis and multiplying by 100, we arrive at the coefficient of variation which gives a measure that is almost independent of grade. We can thus average these coefficients of variation for different grades. The coefficient of variation seems to be relatively constant for the same degree of skill. Coefficient of variation, therefore, is a measure of skill of the care taken in manufacturing.

The average analysis is a measure of how much material is put into a product. It takes control of both factors to get satisfactory performance as far as customers or Control Officials are concerned. With a high degree of skill, the average analysis may be lower and with less skill, the average must be higher.

Poundstone: You speak of a low coefficient of variation. How is coefficient of variation expressed?

Duncan: Coefficient of variation is expressed in percentage. The lower the number, the less the scatter or the greater the skill. The coefficient of variation for the example shown in Figure 5 is 1%. Higher numbers mean more scatter and less skill. The coefficient of variation is 10 in the example given in Figure 6.

Poundstone: This system of representation is described in Kentucky Regulatory Bulletin No. 169, copies of which are provided at the door. The explanation begins on page 13. An actual calculation is carried out on page 14. On succeeding pages, the apparent aiming point and this measure of skill is given for companies and plants. Every grade reported in the body of this bulletin is presented in terms not only of the individual analyses, but the apparent aiming point (average analysis) and the scatter or skill (coefficient of variation). We solicit your comments and reactions to this.

We believe data presented in this way relating the apparent aiming point and the relative skillfulness of the operator has many applications. A manufacturer may use it in the design, construction, purchase and installation of equipment, training of workers, and planning the movement of goods through a plant.

Control Officials, looking at all sample results, gain knowledge about a manufacturer's overall production. A single sample result gains identity in its proper perspective as a part of the total picture.

MODERATOR REYNOLDS: Thank you very much. We have time for some questions and comments.

A MEMBER: When you discussed the particle size, the large particles and the small particles, that was a physical difference. Are you saying that the large particles actually had a different chemical analysis than the small particles? This is why you get the variation?

MR. DUNCAN: In the particular case that we had in mind, this was the case. I think that most of us recognize, although you may argue this, no matter how you manage it, it's pretty hard to be sure that those large particles are exactly like the small particles. I don't think any manufacturer would be willing to have Bruce take an inspection sample and then run it through a sieve and throw away the big particles and analyze the rest of it and call it a fair sample. I think this is apparently true in the plant having a high coefficient of variation. The larger particles and smaller particles were not the same chemical analysis. There was segregation. The manufacturer may have assumed that they were the same chemical analysis without trying to find out about it and his results were miserable.

MODERATOR REYNOLDS: Another question?

MR. GEORGE HOFFMEISTER: I wondered if you could possibly comment on any ways that people are using in plants to avoid this segregation in bins?

MR. POUNDSTONE: In some places very little is being done about this. In others much is being done. At the meeting at the Woodner Hotel last fall, I was told of storage bins where fertilizer was introduced by continually changing the point of delivery so as to have a series of small cones instead of one large cone of fertilizer. I know of a plant where the piles are "raked down" as bagging takes place in an effort to overcome any segregation that has occurred. Some of you may have heard Don Bowman's talk in Cincinnati two weeks ago. In speaking about delivery of bulk fertilizer to a farmer, he said he always makes some provision to keep the material leveled off in the wagon bed. He said he put a man in the truck if the driver was not available to do this. I feel sure much more can be done. Perhaps more is being done. Our Kentucky manufacturers, after seeing this demonstration in Lexington over a year ago, now talk of little else. We look for more progress in this area. Real progress could be made if more attention were given to particle size in raw materials before using.

MODERATOR REYNOLDS: One more question.

MR. GEORGE WALTON: I'm not going to argue with a guy that's as good a shot as that fellow. One thing that's very evident to all of us is the segregation we get between large and small particles in a pile. We are also getting a good deal of segregation in our own bagging hoppers. This is less evident. In other words, with vibrating screens over a bagging hopper with flat sides, the fines will discharge on the first part of the screen, the coarser particles will go down towards the end of the screen, and very frequently when bagging it will be noticed that there is variation between the granules and you get a lot of fines at the tail end of your run. This can be avoided by putting a plate under the screen at the first part of the screen that will cause the material to discharge into the center of the hopper. I think it's something that isn't as easily recognized and some people may not have noticed it.

MR. GRANT MARBURGER: What about the coefficient of variation within an analytical laboratory?

MR. POUNDSTONE: You will find a statement about that in the bulletin over here (Kentucky Bulletin 169). The variation within a laboratory is much narrower than what we find the manufacturing variation to be. We have given too little attention to the fact that there are two kinds of variation. There is a laboratory variation and there is a manufacturing variation. These are combined in our data. The laboratory variation is very small compared to manufacturing variation. Bill, do you have any comment?

MR. DUNCAN: I just wanted to comment that the fact that some manufacturers get a coefficient of variation of as low as one would suggest that the laboratory variation must be much less than this.

MR. AL HENDERSON: Don't you think you can add a third variation to that, a sampling variation?

MR. POUNDSTONE: I would like to ask if there is such a thing as a poor sample. Some speak of sampling variation as sampling error. You take a sample of whatever you're sampling. If it is heterogenous you cannot possibly get a sample that is representative of the whole. When you take a sample, whether a spoonful, a cupful, a core or combining cores, all you can say is that based upon this sample, our results show so and so.

Every figure that we have dealt with in Kentucky as a sample is based on a combination of ten or more cores. This tends to cover up variations within a pile or shipment of fertilizer. I would be hard pressed to justify this procedure to a farmer, if I were asked why we cover up such variations. Nevertheless, the variation we show is what is left after we have combined several cores.

A man was in my office recently and he said something about sampling error. I would like to have somebody define what sampling error could be. I wonder if there is such a thing as sampling error.

MODERATOR REYNOLDS: Thank you very much Mr. Poundstone and Dr. Duncan.

This concludes my part of the moderating this afternoon. I will now turn the program over to Mr. Albert Spillman who will take it from here.

MODERATOR SPILLMAN:

Welcome to this 12th Annual Round Table. I wish to take this opportunity, on behalf of all of you and our Executive Committee, to thank Tom Athey, his Associates and Albermarle Paper Co., for the nice party given to us last evening. Thanks to Wayne King for the plaques presented to each of our committee. I shall cherish my plaque as a remembrance of this Round Table since its beginning 13 years ago and especially for the opportunity to meet and get acquainted with many of you fine cooperative people. It is my pleasure to moderate the remainder of this afternoon's program.

We have had many requests from our membership to present a thorough discussion on "The Pan Granulator" sometimes called "The Flying Saucer." This topic will be presented by a panel of operators who have had considerable actual plant experience with this equipment. Alvin B. Phillips, panel leader, needs no introduction to this group. He has contributed many valuable papers at a number of our Round Table meetings on fertilizer manufacturing technology. We are fortunate to have him on this panel. I turn this rostrum over to you, Alvin.

Panel Discussion On Use of the Pan Granulator

Alvin B. Phillips, Panel Leader

IT is indeed an honor to have been asked to assemble a panel of speakers to address you today on the pan granulator. I should like to thank the panelists for so generously agreeing to prepare a part of the program.

The information we have assembled is designed to give you a quick look at this relatively new device that has aroused interest as a tool for the production of granular fertilizers. We will try to tell you what the pan granulator is, some of the ways it has been used in different parts of the world, and perhaps what its limitations are. We hope this information will help you decide whether you should be interested in its use in your own operations. If any of you in the audience has experience that will confirm, contradict, or otherwise add to what we have to say, please let us hear from you at the end of the discussion.

I think it is appropriate that our first speaker be a representative of one of the companies that make pan-granulators. He will be able to give us a description of the equipment, its history, and how it is used in other industries. Also, he has participated in tests of pilot models on fertilizer materials at his company's laboratory and in several production plants. I am pleased to introduce Sales Engineer of the Dravo Corporation, Mr. Bill Engelleitner.

William H. Engelleitner

THE very fine work being done on the upgrading of fertilizers is exciting to those of us who work in the pelletizing field. A good deal of development work has already been done with more to be contributed in the future. For the present time, I would like to give you a summary of pelletizing background, equipment design and application, the status of research, and some attractive possibilities for pelletizing in the fertilizer field.

The growing popularity of disc pelletizing—pan granulation as it is called in fertilizer terminology — has a very logical base in the evolution of industrial processes. On the one hand, these processes have come to require a more rigid size control, closer specification of marketable products, and the elimination of dusting and air and stream pollution. On the other hand, there has been an increasing depletion of first-grade raw materials and a corresponding emphasis on preparation, concentration and other upgrading processes.

These developments, occuring together, have made agglomeration methods a major part of many plant flowsheets.

Early work on pelletizing discs was restricted to the preparation of iron ore sinter mix, as well as the balling of flue dust, filter cake, cyclone fumes, and other materials of the ore processing industry. However, in Europe the pelletizing disc soon found wider use in the agglomeration of phosphates, mixed fertilizers, cement raw mix, flyash, and metallic oxides.

In 1956, Dravo Corporation under license agreement with the Lurgi Company of Frankfurt, Germany, began the manufacture and sale of Dravo-Lurgi pelletizing discs in the United States. These discs were further developed and standardized, at the same time that a thorough research program established the pelletizing characteristics of a great variety of materials, many of them never before pelletized in any form.

The Dravo-Lurgi pelletizing disc is an inclined rotating pan supported by a stediment and driven through a gear-and-pinion set from a gear reducer and a constant or variable-speed drive motor. Smaller discs are driven through a chain-and-sprocket set, or a vee-belt drive. Usually the angle of the pan is adjustable from 40 to 60 degrees from the horizontal, with special applications as steep as 70 degrees. The Dravo-Lurgi disc is based on a shallow pan design, utilizing an outer re-roll ring for many applications.

Discs are normally made from carbon steel, but special applications sometimes require stainless steel or copper plating. In addition, pans can be coated with such materials as teflon and neoprene.

Discs have been built in sizes from the smallest 14″ diameter laboratory unit to the 18′ disc used, for example, in pelletizing magnetite iron ore concentrate. Spherical agglomerates (pellets) are formed in the disc by feeding finely divided raw materials into the pan at a constant rate, while selectively wetting the incoming feed. The rotation of the pan produces a tumbling and cascading action, forcing the dampened particles into intimate contact. The resulting capillary attraction of the particle surfaces and their molecular adhesion consequently hold these particles together in the form of green or moist pellets.

The following material factors are of greatest influence upon quality of the pellet formed by this method:

1. Particle size and shape
2. Moisture of raw feed
3. Bulk density of raw feed
4. Regulated feed rate
5. Selective water application
6. The possible use of additives (binders)

As the incoming feed is moistened, it forms seed pellets, growing with the addition of fines and finely divided droplets of water. The resulting pellet is dense, firm, nonlaminar, and free flowing.

From most materials, pellets can be formed in sizes from approx. 1/16″ to 1½″ in diameter. Many materials tend to form best at a certain natural size determined by the material itself. The size of pellet can be selected and controlled within limits by several disc variables, such as speed of rotation, angle of pan, and the location of feed and sprays.

Because of an inherent natural size classification action in the pan, the fines and small seed pellets stratify to the bottom of the pan and are retained for further growing, while finished pellets are continuously discharged within a very narrow size range. This eliminates the need for further screening, or, in many cases, requires only a nominal degree of scalping. As compared to a pug mill, a blender, a drum granulator, this makes the pelletizing disc a device with a greatly controlled product size.

Another advantage of the disc is that the operator can view the material in progress. There is little or no dusting for most materials; and for the rare case when very fluffy and dusty materials are processed, special dust covers can be provided.

Extrusion presses, pellet mills, briquetting and compacting machines as well as paddle mixers and pug mills present the problem of die, roll or blade wear because of pressures and material friction. Pelletizing discs require very little maintenance and still produce at very high throughput rates. The disc surface is covered with a protective material layer, maintained by the plows, which protects the metal from wear. This leaves only the plows or scrapers exposed to material wear.

Dravo-Lurgi discs have been used for the following pan granulation applications. Most of them are in the research or pilot plant stage, with present plant scale-up being studied:

Phosphate rock dust, calcined collector dust, super- and triple-superphosphate, sodium phosphates, dicalcium phosphate, ammonium sulfate, ammonium nitrate, urea, nitrochalk, blended trace element soil supplements, muriate of potash, potassium sulfate, herbicides, insecticides and fungicides.

Although the classifying action of the pelletizing disc makes it an attractive device for ammoniation and granulation of fertilizers, applications have been limited because of higher ammonia losses due to the open, shallow pan, and because of the interference of submerged distributors with the natural pellet pattern. This has been reported, for example, by Mr. T. P. Hignett in TVA Paper No. 193 "The Changing Technology of Granulation and Ammoniation."

In my opinion, the disc does offer advantages if it can be applied merely as a granulator and classifier in combination with a short drum ammoniator. This would reduce the drum granulator recycle from as high as 10 to 1 to a much lower proportion. Our pilot plant work has shown that for some materials the "on-size" fraction of the product might be as high as 80% 6-16, 6-20 or 7-14 mesh.

In pilot plant work conducted in Florida and at our own research center, phosphate rock dust was successfully pelletized in a study to determine use of pellets as electric furnace feed. 12′ Lurgi discs are in use in a European plant producing elemental phosphorus but to date the extremely low cost of these marginal phosphate fines has limited commercial applications in the United States.

As reported in the Chapter on Phosphates in the book "The Chemistry and Technology of Fertilizers," nearly one-third of all Florida phosphates are discarded in the form of tailings, with bone phosphate of lime (BPL) content as high as 25%. We believe the pelletizing disc can be used to recover this material and make it available for further processing, such as electric furnace feed.

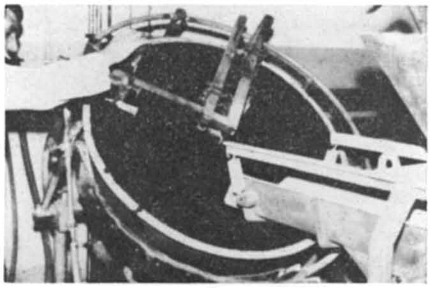
A very promising new field for discs in pan granulation is the production of granular nitrogen fertilizers, such as ammonium nitrate and ammonium nitrate sulphate, 30-10-0, 24-6-12. The feed in this application consists of a highly concentrated solution of salts sprayed on a cascading bed of recycle fines.

The obvious advantages are again the product uniformity, the low recycle rates, the lower cost of the equipment compared to prilling installations, and the greater flexibility of grades. This work has been described by Mr. A. B. Phillips during the Fourth Demonstration of Fertilizer Technology Development at TVA, where the demonstration was carried out on an 8′ pan granulator. It has also been the subject of a paper at this year's

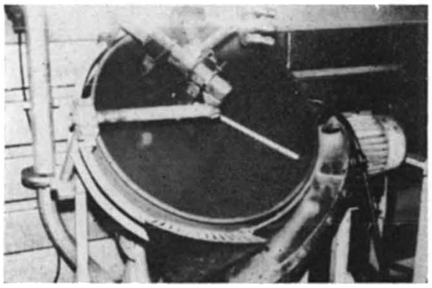
American Chemical Society Meeting.

We feel that this principle can also be applied to granulation of ammonium sulfate, urea, and grades containing urea.

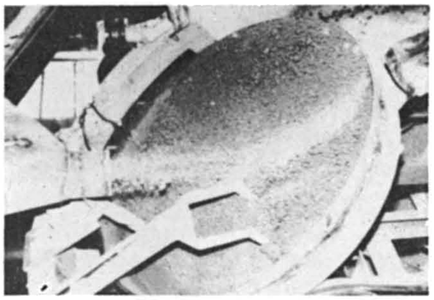
In summary, we feel that the disc pelletizer, or pan granulator, is a simple, efficient, and practical device for converting materials into uniform spherical agglomerates. The starting point can be either a freeflowing dry raw feed, a slurry, or a concentrated solution. Its applications now include a great variety of materials, supported by ever increasing research, development, and full-scale plant applications.



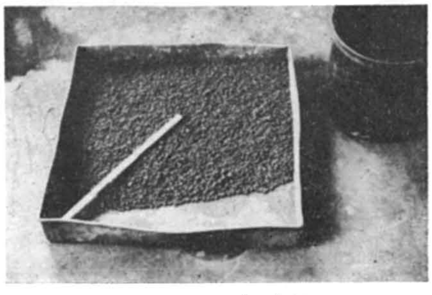
Lurgi Magnetic Test



Lurgi Test of Magnetic

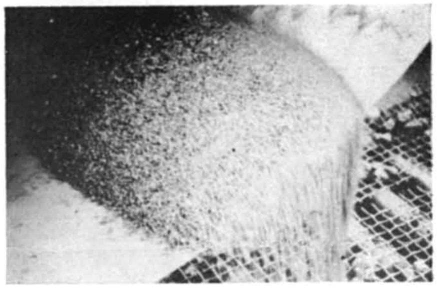


Dravo Lab Size



Fly Ash Pellet

Roll-feeder Pierrefit



Cooler discharge

Panel Leader Al Phillips: Our next panelist comes to us from Canada; however, he's no stranger here as he's been attending the Round Table meeting for several years. He is Production Manager for International Fertilizers, Ltd., in Quebec. I am glad to introduce Mr. C. Bolduc.

Pan Granulation of Mixed Fertilizers

C. Bolduc

OUR experience with the pan granulator as a means of pelletizing mixed fertilizers started in 1954 with the design, construction and operation of a 3-foot diameter experimental unit. Our objective with this unit was to examine some of the factors influencing granulation of mixed fertilizers on an inclined revolving plane, as well as to evaluate the adaptability of this principle of granulation to full-scale plant production. The experimental unit was equipped with a variable speed drive having a speed range of 5 to 35 rpm; the disc could be tilted in 5° increments and necessary accessories were provided to control solid and liquid feed.

It was observed then that the moisture content, the plate inclination, the chemical composition of the particles as well as their physical characteristics, were all factors governing pelletization. Thus with a given plate slope it was found possible to increase the granule size by increasing the moisture content of the solid feed; similarly, with a definite moisture content of the solid feed, it was demonstrated that the size of the granules could be varied simply by changing the angle of inclination of the plate. These two relations are shown graphically on the first slide.

Graph No. 1 shows the relation between the average pellet diameter and the feed moisture content at a fixed slope. The straight line of Graph No. 2 relates the pellet size to the pan inclination for a constant feed moisture.

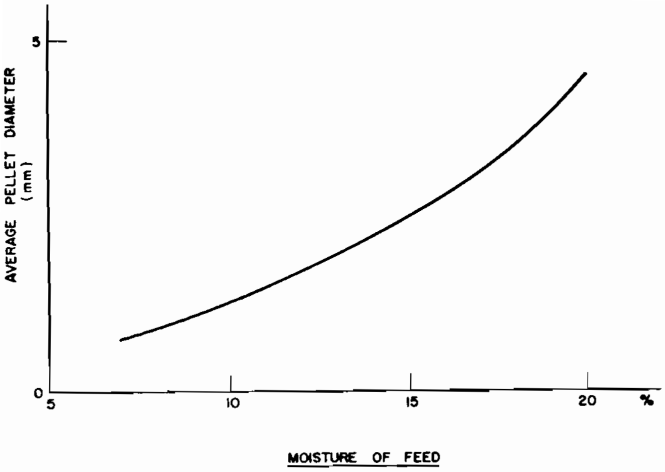
Further, the influence of the surface tension of spray liquid has been reported in the literature by Klatt (1) and co-workers. The relation between the moisture content of the solid feed and the specific surface area has also been reported in the literature (2).

In most experiments it has been established that the moisture content is the factor which most influences size when pelletizing with the pan.

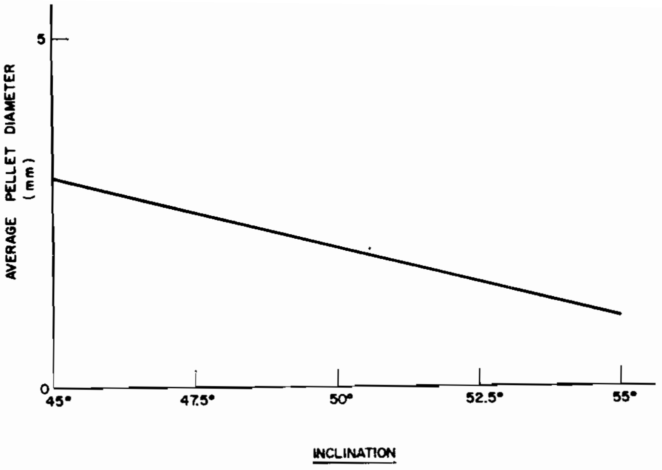
Under practical plant conditions, granulation is controlled mainly by moisture content, feed rate and formulation.

With the knowledge of these basic facts, and realizing that the experience of other manufacturers with this type of equipment was very limited, the pan granulator showed sufficient promise for us to risk any as yet undetermined disadvantages. In 1959 we therefore installed a commercial unit in a recently acquired plant located in Cornwall, Ontario. The 15-foot diameter unit, of a German design, was selected for the following reasons:

1) Relatively low initial cost
2) Small space requirements
3) Adequate anticipated production capacity — 8-12 t.p.h.
4) Low maintenance cost and simplicity of design



Graph No. 1



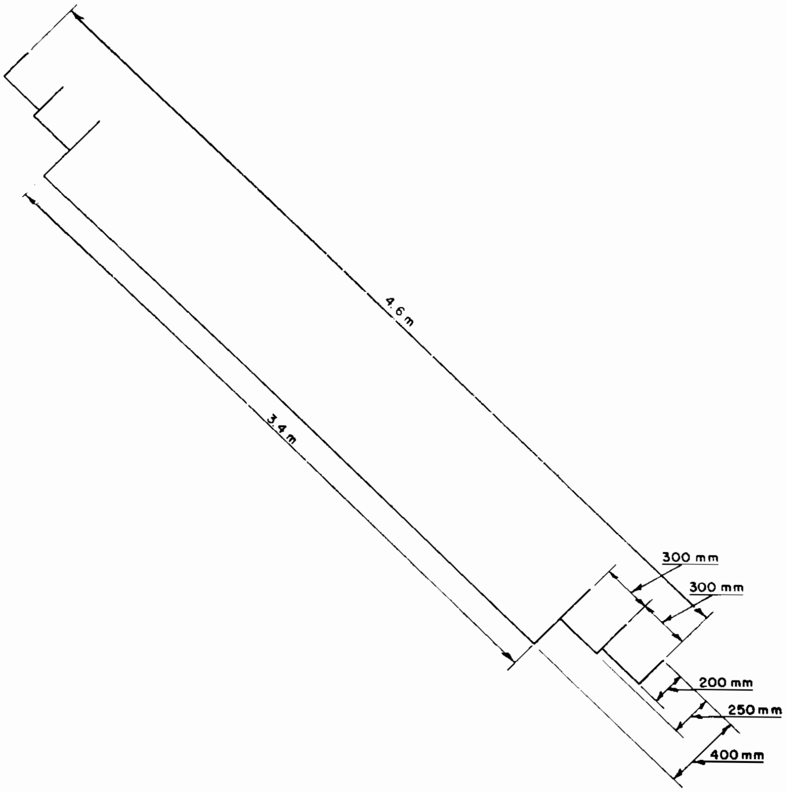
Graph No. 2

5) Adaptability to readily available standard auxiliary equipment.
6) Low time loss on change from grade to grade
7) Use of typical TVA process formulation using sulphuric and phosphoric acids, anhydrous ammonia and nitrogen solutions

The unit is 4.6 meters outside diameter; the innermost section where the primary granulation occurs is 3.4 meters in diameter. It is circled by a 400 mm high rim and two concentric channels 300 mm wide. These dimensions are outlined on the next slide.

The function of the outer channels is to complete the formulation of the granules as well as to provide a place for the addition of coating materials if desired. The unit rotates anti-clockwise at 11 rpm driven by a 30 H.P. motor and is inclined at 45°. A 3-point scraper, driven by an electric motor, oscillates along a horizontal radius preventing any large build-up on the bottom of the pan and permitting free rolling of the particles.

General Dimensions of the Commercial Unit



The solid particles which are fed at the highest point of the inner pan, acquire a certain amount of weight in rolling down and are carried back to the upper part of the pan by its circular motion. This cycle is repeated until sufficient weight is gained by the particle to roll over the rim by centrifugal force. This classifying action is well demonstrated by the large proportion of on size particles in the material leaving the pan for all the grades manufactured so far, as well as by the low recycle ratios.

Three different systems or flow sheets have been studied with the commercial unit.

Flow Sheet #1. In its original conception the pan was used both as a chemical reactor, a granulator, and a classifier.

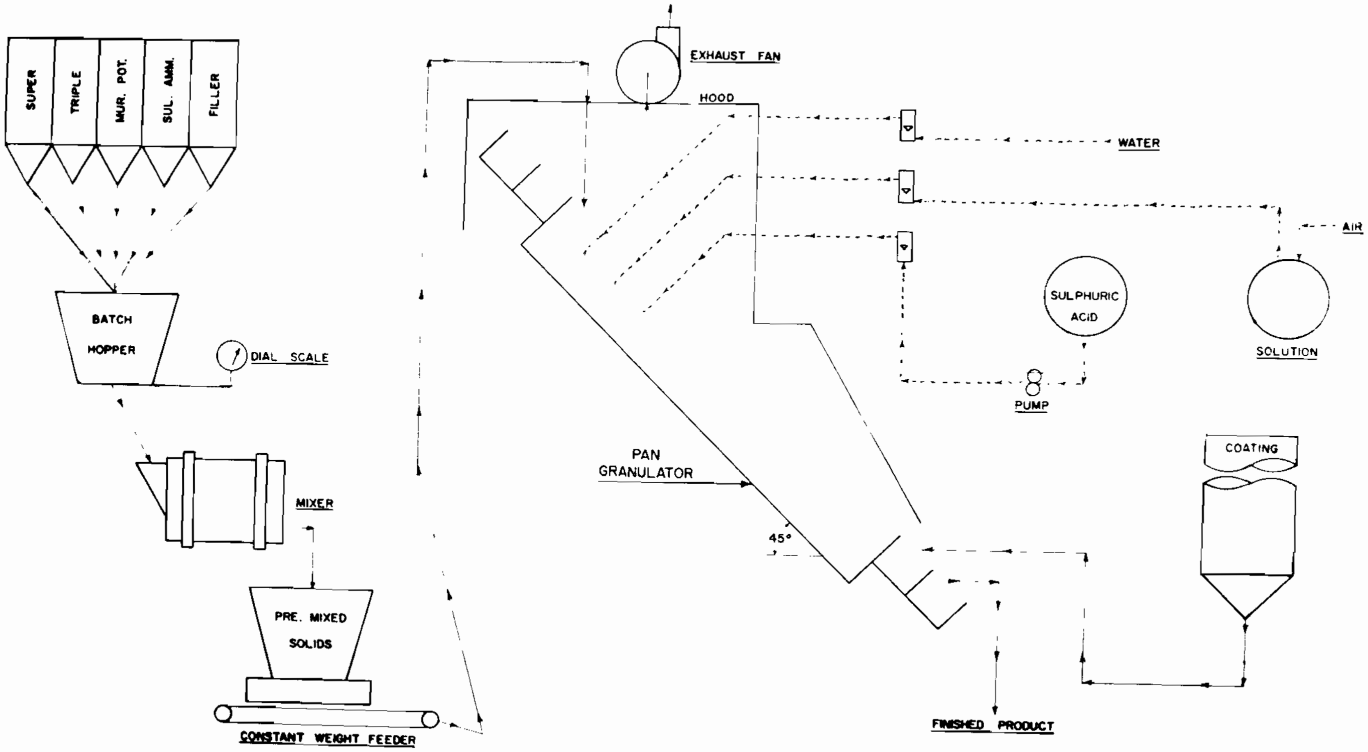
Flow Sheet #2. The ammoniation and neutralization reactions were performed outside the pan, thus using it exclusively as a granulator and classifier.

Flow Sheet #3. Finally in the third system cooling and screening facilities were added.

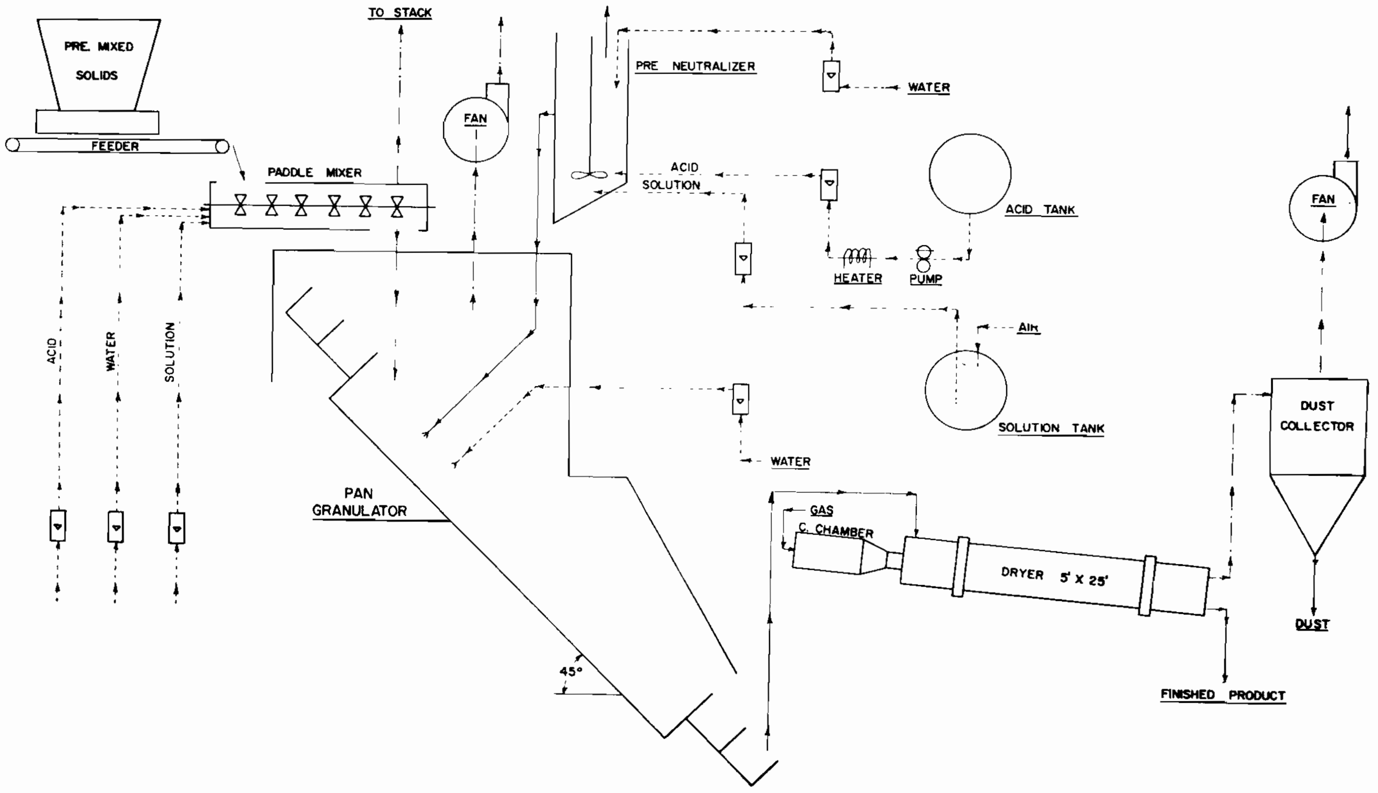
Let me describe in some detail each of these flow sheets. Our first installation, besides providing weighing and mixing facilities, included a constant weight feeder unit with a capacity of 5 to 15 t.p.h. Rotameters to measure the liquid flow and facilities for the addition of coating materials in the innermost channel of the pan were also provided.

The pan was hooded with plywood and a 5000 cfm fan was provided to handle the fumes. With this basic equipment, solid pre-mixed raw materials were fed

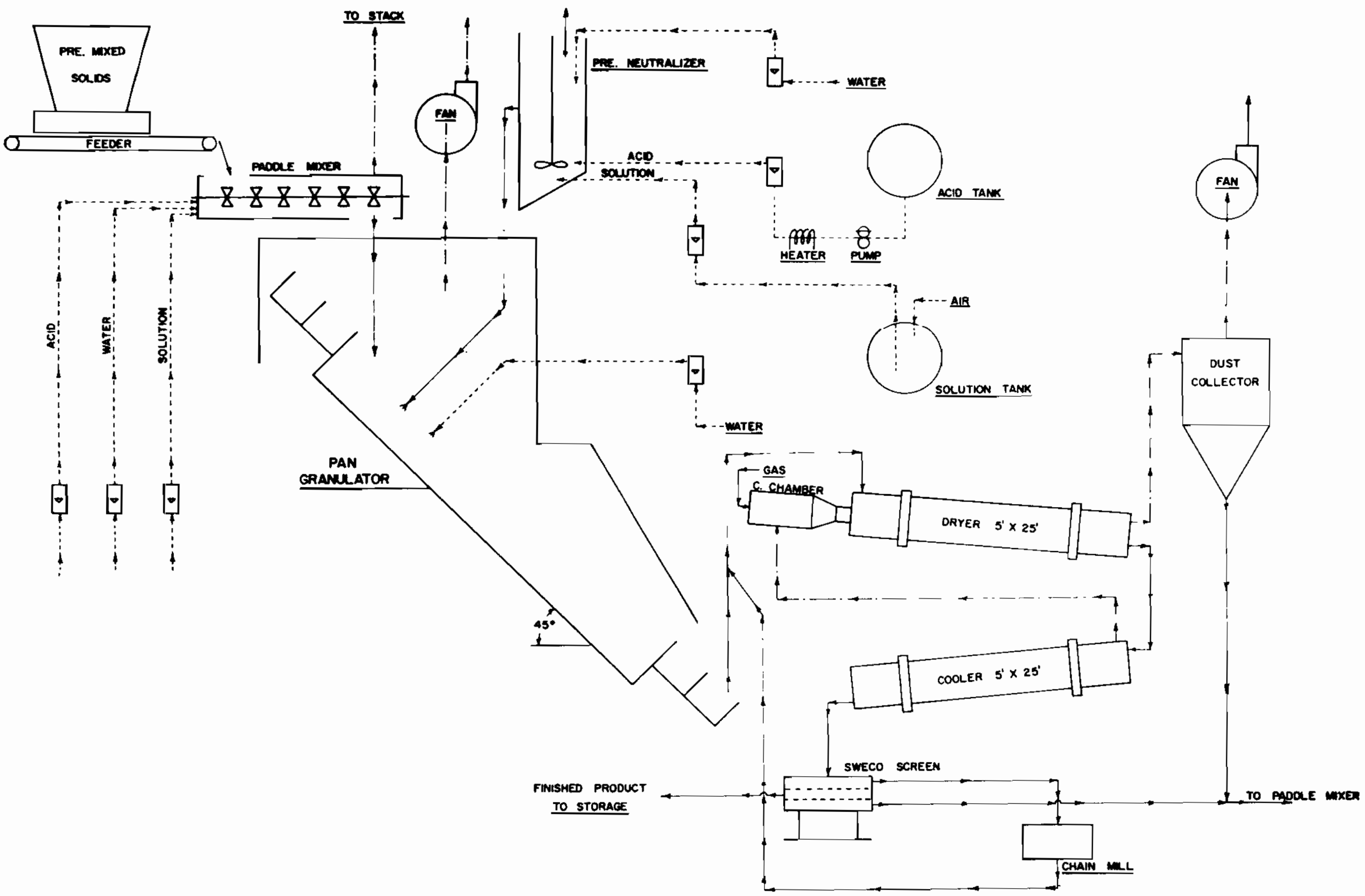
FLOWSHEET Nº 1



FLOWSHEET Nº 2



FLOWSHEET Nº 3

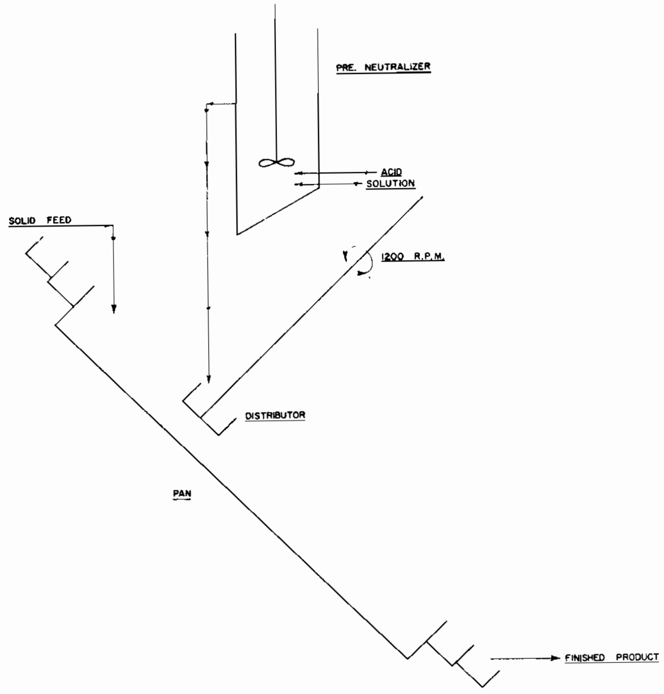


at a steady rate to the pan. Measured flows of sulphuric acid, nitrogen solutions and water, if required, were simultaneously added through spray nozzles onto the surface of the rolling solids. This system is illustrated *on flow sheet No. 1.* The complete formula for a mixed fertilizer being essentially that used for a well known TVA process granulator. Nitrogen losses were high, reaching 10% in certain instances. The all-too-short retention time of this system, coupled with the high residual moisture in the finished product, led to severe caking problems both in the bins and in the bags. The granulation, however, was very good and was somewhat influenced by the location of the spray nozzles. Various types and arrangements of sprays were tried to minimize the nitrogen losses. A very promising arrangement was the installation of acid nozzles immediately above solution nozzles, hoping the acid sprays would serve as scrubbers of ammonia vapors. In fact none of the numerous arrangements tried was entirely satisfactory and it was felt that the idea of using the pan as a chemical reactor should be abandoned and that ammoniation as well as other neutralization reactions should be carried out in separate reactions. It was also felt that a dryer was an essential piece of equipment to complete drying not accomplished by heat of reactions.

In fact, after the production of some 7,000 tons of various grades with this system, a short paddle mixer was installed in parallel with a pre-neutralizer both immediately ahead of the pan, and a dryer was also added to the system. This completed our *flow sheet No. 2.*

The dryer is 5 feet in diameter by 25 feet long, co-current, gas-fired, with a maximum calculated capacity of 4.5 million B.t.u. per hour. The double shaft paddle mixer is relatively small (6 feet) center of inlet to center of outlet, its primary function being to provide bed depth for carrying out the ammoniation of the P_2O_5 materials at normal rates. Facilities to add acid are also provided in this mixer, and have been used in some instances for neutralization purposes. The pre-neutralizer is of the conventional type made of 316 stainless steel with Hasteloy C spargers. It is 3 feet in diameter, 5 feet high, and is located above the pan. The paddle mixer is used in the manufacture of the low nitrogen grades, up to and including 6% N. For the higher analysis grades both the paddle mixer and the pre-neutralizer are used.

Severe difficulties have been encountered, however, with the distribution of the slurry from the pre-neutralizer onto the pan. Winter sub-zero temperatures, coupled with lack of steam generating facilities at the plant, complicated the problem. Crystallization of the slurry in the distribution pipe system was a major difficulty. The problem was overcome by feeding the slurry by gravity from the pre-neutralizer to a specially developed



Flow Sheet No. 4

distributor located immediately above the pan and perpendicular to it. This distributor consists of a stainless steel wire mesh basket, 6″ diameter, revolving at 1200 rpm. The basket has proved to be very effective not only as a slurry distributor but also as a means of controlling the liquid phase. In fact a good deal of evaporation occurs at that point. This distributor is shown on the next slide.

Nitrogen losses with this second system were reduced to normal levels and the moisture content of finished product was satisfactory.

Granulation was very good and even without screening the finished product was within reasonable size range as indicated by typical screen analyses shown on the next slide.

However, the caking problem was still with us, to a milder degree we must say, but sufficient to justify the installation of cooling and screening facilities. This third flow sheet is illustrated on the next slide.

The cooler used is of the counter-current type and is working in series with the dryer. Two Sweco screens are installed in parallel to size the finished cooled product. The oversize fraction is crushed and returned to the dryer and the undersize is recycled to the paddle mixer. Our experience with this third system is limited since it has been put in operation only last September but results so far are excellent. The production rates vary from 7 to 12 tph and it is believed that higher rates can be reached. The complete operation from mixing to finished product requires four operators with an average direct labour of 0.5 man-hours per ton.

In summary, and based on three years of operation and development on the "pan," we believe the pan is an excellent granulator. Chemical reactions involving non-volatile reactants can be carried out in the pan. On the other hand, the pan in its present state of development cannot be considered as a good reaction vessel. Further, the pan is capable of granulating effectively a wide range of formulas. So far the following grades have been produced: 0-20-20, 0-15-30, 2-12-10, 2-16-6, 4-24-12, 4-24-20, 5-10-10, 5-10-15, 5-20-10, 5-20-20, 6-12-12, 8-16-16, 10-10-10 and 16-8-8. On the next slide is shown some of the formulae used together with analytical results (next slide). It will be noted that the raw materials used are ammonia-ammonium nitrate solutions, ammonium sulphate, sulphuric acid, single and triple superphosphates, phosphate rock, muriate and sulphate of potash.

This range we believe can be enlarged by the use of phosphoric acid and anhydrous ammonia whenever their cost is economically desirable. The system described with the preneutralizer particularly is readily adaptable to the use of phosphoric acid and anhydrous ammonia.

References

1) Klatt, H., Zement, Kalk, Gips II 144-54 1958.
2) Grunder, Dr. Ing. W., Chem. Ing. Techn. *33* 749-753, 1961.

Graph #2. Pan Granulator—Production Data
Results Flow Sheet No. 3

Formula (lbs.)	0-20-20	2-12-10	4-24-20	5-10-10	8-16-16
470 (30-64-0)	—	90	175	217	357
H_2SO_4 (93%)	111	75	115	100	145
Super 20%	515	1,210	66	1,010	580
Triple 47%	525	—	1,000	—	434
Muriate of Potash 60%	667	334	667	334	534
Rock 28%	200	—	—	—	—
Filler	—	352	—	393	—
TOTAL	2,018	2,061	2,023	2,054	2,050
Chemical Analysis %					
Total Nitrogen	—	2.2	3.95	5.0	8.2
Available P_2O_5	20.6	12.2	24.10	10.3	16.1
K_2O	20.6	10.4	19.90	10.4	16.7
Screen Analysis %					
+ 6 mesh	4.7	4.6	6.30	12.6	7.0
− 6 + 20 mesh	87.3	87.8	85.80	78.7	82.7
− 20 mesh	8.0	7.6	7.90	8.7	10.3
Production Rate TPH	8.0	12.0	9.00	9.5	8.0
Recycle TPH	1.0	1.0	1.00	1.0	2.0
T° In Pan (°F)	115	135	165	160	170
Moisture (%)	1.61	0.90	0.84	0.70	1.0

Graph #1. Typical Screen Analysis Pan Granulator — Unscreened Product

Results Flow Sheet #2

Grade	+ 6	− 6 + 20	− 20
0-15-30	2.0	88.6	9.4
0-20-20	6.3	84.9	8.8
2-12-10	8.7	85.1	6.2
4-24-12	20.6	71.5	7.9
4-24-20	11.3	79.4	9.3
5-10-10	12.6	78.7	8.7
5-10-15	12.8	76.8	10.4
5-20-10	9.0	83.4	7.6
5-20-20	12.5	70.0	17.5
6-12-12	15.3	78.6	6.1
8-16-16	11.3	73.0	15.7
10-10-10	20.6	67.0	12.4
16-8-8	13.3	81.7	5.0

Panel Leader Alvin Phillips: Our next speaker needs little introduction to the Round Table. I think he is practically one of the charter members and has been a contributor to the program in past years. He comes from Jacksonville, Florida, where he is Chief Chemist for the Wilson and Toomer Fertilizer Company.

Albert Henderson

MUCH of the information developed by us has been of a confidential nature, both for our own organization as well as for other clients.

We have had several thousand tons of experience with agricultural products, generally of a special nature, which were produced in our pilot plant at production rates of 250 to 2500 lbs. per hour. The plant was frequently operated on a regular shift basis and the primary purpose was to manufacture a specific amount of a given product, thus a lot of our experience has been not only in determining research data, but the more practical aspects of how to manufacture on a routine basis.

Because of the confidential nature of the work, I will not divulge specific information, but will relate only general concepts which can be summarized briefly, as follows:

1. The pan granulator was useful for increasing on size product in the range plus 16 mesh and larger.

2. The pan granulator was also very useful in production of particles smaller than 16 mesh because of its excellent control characteristics.

3. In production of products varying from plus 6 mesh to plus 40 mesh, the pan was an aid in all ranges.

4. The pan was adaptable to all products, including materials of high solubility which usually tend to over-agglomerate as well as materials which were of very limited solubility and difficult to agglomerate.

5. The pan was found to be a most useful means of evaluating material granulation characteristics. Granulation tendencies of materials such as potash and sulphate of ammonia which contain varying amounts of amines, conditioning agents, and other additives, can be directly evaluated.

6. The pan proved to be an excellent method for adding small amounts of liquids to solids. This is a particularly difficult task in most other types of equipment.

7. The pan offered an excellent method of adding small to large amounts of liquids, such as mineral acids, as well as slurries, to solid materials.

8. The pan was not considered to be a good method for adding materials such as ammonia to superphosphate.

9. The pan was considered to be an important as well as significant aid to a continuous granulation system. Although in some cases it might possibly replace a continuous ammoniator its primary function is more an aid to the system and not generally a replacement.

10. I have on several other occasions noted that equipment, with other design purposes, has been relied on as a granulator. Machinery such as an ammoniator, a dryer or cooler, pugmill, and these types of equipment do not have sufficient flexibility and have not been designed principally as granulators. It seems a little odd that so much effort has been devoted to this kind of machinery, and so little attention directed at granulators. Apparently, most of us have little respect for the name "Granulator."

11. The pan is not suggested as a "cure-all," and it does present some problems, however, it is suggested that it can be useful as an aid to granulation.

Alvin B. Phillips

As my contribution to the panel discussion, I should like to add some information I have assembled on how the pan granulator has been used in the production of granular fertilizers.

The first application that I encountered was the granulation of ordinary superphosphate, practiced principally in Germany but also in Austria. Mr. Travis Hignett of TVA visited some of the installation in Germany last year. One of these was the Chemische Dungerfabrik Rendsburg, in Rendsburg, Germany. Mr. Klaus Eggers, a director of the company, kindly gave us permission to describe his operation here.

At the Rendsburg plant, fresh superphosphate is excavated from a batch den into a hopper from which it is fed to the pan granulator. At the beginning of a run, the superposphate is self-granulating and nothing need be added. Near the end of the run, when the superphosphate is a few hours' older, it is necessary to add 2 to 4 per cent water to promote granulation. The water is added by sprays near the top of the inclined pan. The granules are conditioned with one-half per cent of a mixture of phosphate rock and calcined dolomite in a trough located around the periphery of the pan. The product from the pan is screened at 8 millimeters, and the oversize is returned to the disintegrator on the den. The minus 8-millimeter product goes to a curing pile. After curing, the product is screened to recover a minus 5- plus 2-millimeter fraction. This is equivalent to approximately 4 by 9 mesh. The fines are used in mixed fertilizer production.

The pan granulator is about 10½ feet in diameter, not including the conditioning trough, and the depth is about 2 feet. The pan is inclined at an angle of about 50 degrees from horizontal and rotates at 10 revolutions per minute. The output is about 9 to 11 tons an hour. About 65 to 80 per cent of the material leaving the pan is in the form of onsize granules.

In similiar installations in Germany, pan granulators up to 16 feet in diameter are reported, producing up to about 20 tons per hour of granular ordinary superphosphate. In some cases, the product from the pan is dried to about 5 per cent moisture before it is stored.

Production of granular mixed fertilizers by ammoniation of superphosphate in the pan granulator was reported in an article in the June 1959 issue of *Commercial Fertilizers* which described the plant of William Houde, Limited, near Montreal, Quebec. In this plant low-nitrogen grades, such as 2-12-10, 5-10-15, and 4-24-20, were produced in a pan granulator. The solid ingredients including superphosphate were fed to the pan and ammoniating solution was added on the surface of the material in the pan through sprays hooded by an inverted funnel. Acid also was sprayed into the pan. Before it left the pan, the granulated material was conditioned in an outer rim with a mixture of limestone and phosphate rock. The only screening operation was carried out on a 4-mesh screen. No dryer was used, and cooling was accomplished on a conveyor belt. The pan granulator was 15 feet in diameter and 10 inches deep. It was tilted at an angle of 45 degrees. The production rate was reported to be about 10 tons per hour.

It is my understanding that this process originated at Chemiche Werke Albert at Weisbaden, Germany, where this development is being continued. The work is being directed toward producing higher analysis products without ammonia loss through the use of special sprays contained in a reaction dome, which I gather is a container to prevent evolution of ammonia before it has a chance to react.

Only a few weeks ago, two visitors to my office from one of the leading fertilizer manufacturers in Japan told me that they operate several pan granulators for the granulation of superphosphate and the manufacture of mixed goods. The pan granulators are 8 feet in diameter and are operated with a slope of 65 degrees and a speed of 17 revolutions per minute. Superphosphate or mixtures of superphosphates, potassium chloride, and ammonium sulfate or urea are added along with recycled fines to the top of the pan. Granulation is accomplished by spraying water onto the surface of the solids in the unit. The product from the pan is dried in a rotary dryer and screened to yield a product minus 5-plus 2 millimeters or about minus 4-plus 10 mesh in size. The oversize is crushed and returned with the fines to the pan. The product from the pan contains about 70 to 80 per cent onsize material, and the net production rate is 5 to 8 metric tons per hour. In some formulations, the material in the pan is ammoniated with aqua ammonia, anhydrous ammonia, or ammoniating solutions. The ammoniation rates are low, ranging from 2 to 5 pounds per unit of P_2O_5 as ordinary superphosphate.

TVA Pilot Plant Pan Granulator

About 6 years ago, we made pilot-plant tests at TVA to determine how the pan granulator would compare with a rotary drum in producing high-analysis fertilizers by the ammoniation of superphosphate. A 38-inch-diameter pan was used. Concentrated superphosphate and potassium chloride were fed continuously to the pan through a chute. Nitrogen solution and sulfuric acid were fed through distributors submerged in the material in the pan. The proportions of these materials were such as to make 10-20-20 fertilizer. May I have the *first slide*, please. After several attempts, fairly good granulation was obtained. This slide shows comparative data for the production of 10-20-20 in the pan granulator and in the TVA continuous ammoniator. The results were generally poorer with the pan granulator. The ammonia loss was high, and the granulation efficiency was not as good. The submerged distributors tended to interfere with the classifying action of the pan. When acid was applied by spraying it on the surface of the bed rather than underneath, severe fuming took place.

Admittedly, these tests were not very extensive. It is quite possible that some of the difficulties experienced could be overcome. However, on the basis of these tests, we considered it unlikely that the pan granulator would have any significant advantage over the cylindrical continuous ammoniator for this type of operation.

Slide No. 1

Ammoniation and Granulation of 10-20-20[a] In Pan Granulator and TVA Continuous Ammoniator

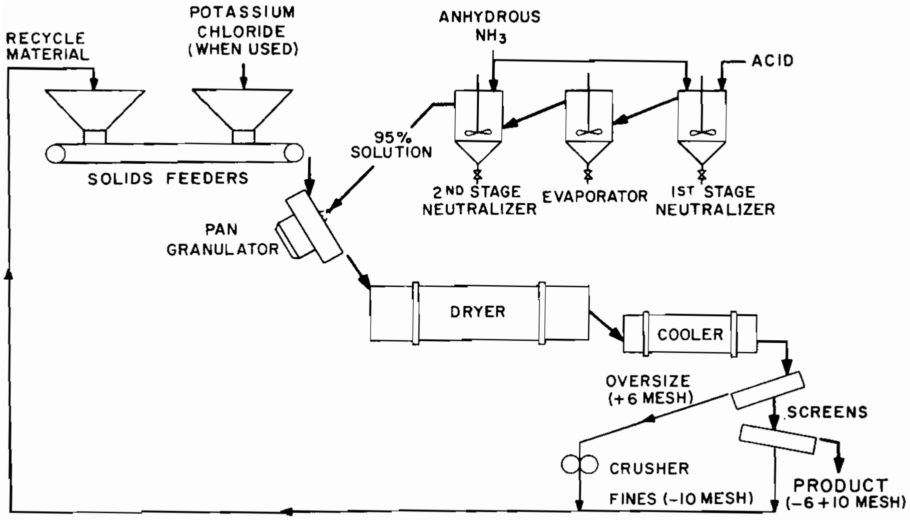
Type of Ammoniator-Granulator	Pan	Rotary Drum
Granulation, %		
Oversize (+6 mesh)	37	30
Onsize (—6 +28 mesh)	57	69
Undersize (—28 mesh)	6	1
Onsize after crushing oversize, %	85	91
Degree of Ammoniation, lb./unit P_2O_5	3.7	3.9
Ammonia loss, %	19.2	2.8

[a] Formulated from ammoniating solution, triple superphosphate, potassium chloride and sulfuric acid.

Diameter, Ft.	Depth, In.	Angle, Degrees	Speed, R.P.M.	Capacity Tons/Hr.[a]
3-1/6	9	65	25-30	0.5
6	14	65	18-22	2 to 2.5
8	16	65	15-18	3.5 to 4

[a] Ammonim nitrate or 30-10-0

The last application of the pan granulator I'll mention and the one we have been most enthusiastic about at TVA is the production of ammonium nitrate or fertilizers that contain a large proportion of ammonium nitrate. Our



Slide No. 2

work on this process was demonstrated at a meeting at our laboratories in August and reported in detail in a paper by C. H. Davis at the ACS meeting in Atlantic City last month, so I won't dwell on it too long here. The principle of the process can be seen in *slide two* which is a diagram of our pilot plant. In the first step, nitric acid, or nitric acid mixed with phosphoric or sulfuric acid, is neutralized in two stages with anhydrous ammonia. Two stages are used to minimize the loss of ammonia when neutralizing the mixed acids. An evaporator is located between the two stages in order to provide a final solution concentration of about 96 per cent, the same concentration that is used in the conventional prilling process for ammonium nitrate. The concentrated solution or suspension of crystals in solution, as the case may be, is pumped at about 300° F. through steam-traced lines and sprayed onto the material in the upper part of the pan granulator. Recycled fines are fed to the granulator to cool the solution, causing it to solidify in layers on the undersize particles. Usually a recycle ratio of about 2:1 is required. When the particles reach the proper size, they are discharged continuously by the natural classifying action of the pan. The material from the pan is dried, cooled, and screened; and the undersize, along with any crushed oversize, is recycled to the pan. Granulation efficiency is quite high, so the product can be screened closely, such as 6 to 9 mesh. In some of our pilot- plant work, screening was done between the drying and cooling steps. In commercial operation it would be necessary in either case to add a second dryer and cooler to assure good storage properties. Conditioning of products high in ammonium nitrate also is required.

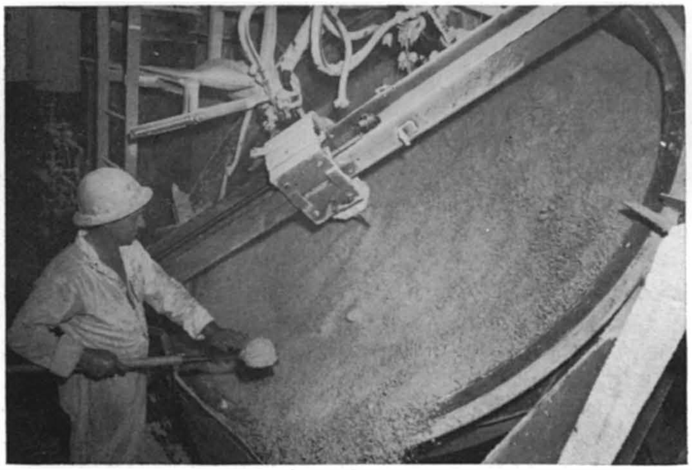
When making products containing potash, potassium chloride may be added either to the pan granulator along with the recycle or to the second-stage neutralizer.

Slide three shows a general view of our large pilot-plant pan granulator in operation. The recycle enters at the top of the pan and the solution is sprayed in the upper left-hand quadrant. The beam mounted diagonally across the pan is the support for the single-toothed scraper you see entering the bed at about the center. It moves slowly back and forth over the radius of the pan and is quite effective in keeping the bottom free from caked material.

Slide four shows a close-up of the sprays. They are located in this position in order to contact only the fines carried to the top of the pan and not the onsize material that tends to accumulate in the lower part of the pan. The solution is quite fluid when kept hot and is easily handled through hollow-cone sprays such as the Whirljet type shown here.

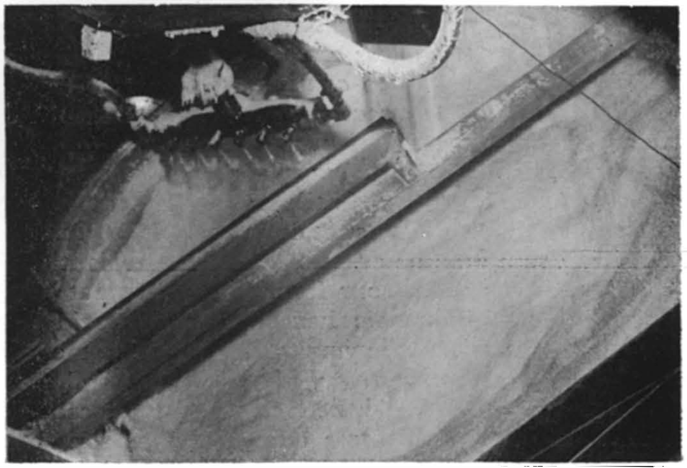
We have experimented with this process on three scales. *Slide five* shows the size, optimum speed, and capacity of the pans we used. The first pilot-plant work was done in a 38-inch-diameter pan. We then constructed a 6-foot-diameter pan, which we later modified to 8 feet in diameter in order to determine scale-up factors that would be required for a commercial-size unit. The production of ammonium nitrate, 30-10-0 ammonium phosphate nitrate, and an ammonium nitrate sulfate containing 5 per cent sulfur as ammonium sulfate was studied on all three scales. Potash-containing grades 24-6-12,

View Pan Granulator Pilot Plant In Operation — TVA



Slide No. 3

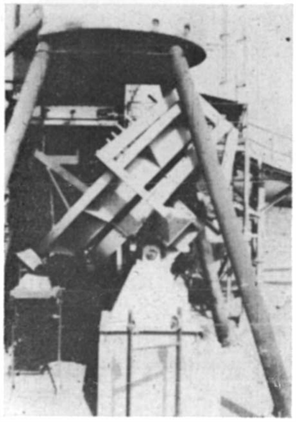
View Showing Spray-Pipes Pan Granulator — TVA



Slide No. 4

17-17-17, and 21-0-21 were made only in the small unit.

The capacity of the 38-inch pan was about 0.5 ton per hour. The 6-foot-diameter unit operated best at a production rate of 2 to 2.5 tons per hour. The 8-foot-diameter pan was operated satisfactorily at 3.5 to 4 tons per hour. The capacity of the pan appears to be approximately proportional to the area. This is in accord with the experience in other industrial applications. From about 12 to 15 square feet of pan surface are required per ton of product per hour. We estimate that a production rate of 10 tons per hour could be obtained with a standard 14-foot pan granulator.



Disc under dust tank
Note "taps" in feed chute

We believe that the process should be considered a competitor of the standard prilling process used extensively for ammonium nitrate. It should require less investment because pan granualtors are less expensive than prilling towers. The pan-granulation process is versatile, allowing the production of high-nitrogen grades of ammonium phosphate nitrates, ammonium nitrate sulfate, and potash-containing grades, as well as ammonium nitrate. We plan to continue development of the process on a demonstration scale, substituting it for our present method of making granular high-nitrogen fertilizers from ammonium nitrate crystals in a rotary drum granulator.

This is the end of our formal presentation. I hope we haven't confused you with so many different applications during this time. If we have, we'd be very happy for you to ask some questions. If any of you have any experience to add to this experience on pan granulators, we'd be very happy to have you speak about it.

Mr. Hugh Grayson: We have been operating pans for a number of years. We started our first panning in 1954, 9 foot diameter pans principally for granulation of superphosphate. I am going to swim against the tide here. As far as we are concerned, we operate both types of equipment and the reasons for this are twofold. Firstly, the granules produced in the pan are not as strong as those produced from tubes. Secondly, the output per unit area is larger from the pans than it is from the tube. Now, in one of the other companies in Australia they are using pans for granulation of superphosphate to a great extent, producing a very nice product, but again the output—they are using 20-foot diameter pans, and the output per unit area is low and at the present state we are thinking of pans that will limit raw material to superphosphate and in fact we are putting in blungers for granulation of our superphosphate.

Mr. Phillips: Thank you very much, Hugh. That's the sort of discussion we want. The pros and cons.

Any questions for the panelists?

Mr. Jack L. Smith: We conducted a study a year ago with the Dravo disc as to fragments or drops that we normally use on our cured triple super and found it to be only marginally better. We couldn't justify a change.

Mr. Phillips: This was on cured triple super. The other applications that we have heard of were on ordinary super.

Are there any other questions or comments?

Moderator Spillman: I wish to thank Alvin Phillips and his panelists for this very excellent discussion on the pan granulator.

As an aid to granulation how well do we do with steam or a combination of steam and water? This paper was prepared by J. M. Daniel and H. M. Griffith, Virginia-Carolina Chemical Co. Mr. Daniel will discuss the subject.

Use Of Steam As An Aid To Granulation

H. M. Griffith and J. M. Daniel, Jr.

THE use of steam as an aid to granulation is certainly not new. Reports on its use have been published by the TVA and others. V-C has been using steam at several of its granular plants for several years. Generally, the results have been good and the cost of installing boilers has been fully justified.

When one pound of ammonia is neutralized by sulfuric acid, the heat of reaction is 2,940 Btu's. Approximately three pounds of 66° Be. sulfuric acid are required to neutralize one pound of ammonia. When a pound of steam is condensed, about 970 Btu's are released. One pound of condensed steam is therefore approximately equivalent to one pound of sulphuric acid in heat developed.

Most of the steam boilers in use at V-C plants are 100 H.P. In many localities, this is the maximum size permitted without a licensed engineer. A 100 H.P. boiler will generate 3,450 pounds of steam per hour. The actual metering of steam consumption is difficult. We approximate this by reading a meter in the boiler feed water line over a production run of at least eight hours. The meter is read only when the water in the boiler is near the same level.

We attempt to maintain the steam pressure at the ammoniator near 100 psi. This permits us to get the quantity of steam needed through a 1½" sparger with fairly small holes.

The steam sparger which we use is a 1½" extra heavy pipe, 6'8" long, with 34—3/16" holes on 1¾" centers. This sparger is beneath the bed of tumbling solids just as the solution and acid spargers are. All our granulating plants use a modified form of the TVA continuous ammoniator.

The use of steam has been particularly helpful in alkaline or no nitrogen grades. The heat produced by condensing the steam aids the granulation as well as reducing the evaporative load in the dryer. In the past when we used cold water to granulate no nitrogen grades, the dryers were overloaded. Steam gives a harder particle and one that requires less drying. The reduction in the drying load has permitted us to increase the production rate of many grades by as much as 20%.

Steam is particularly useful in winter at plants where very low temperatures prevail. Good granulation is attained quickly in as much as the equipment warms up faster and steady state operating conditions are reached earlier. Steam is also an excellent means of controlling granulation. Many formulas that would be unworkable or borderline can be made to work satisfactorily because the operator has control of both heat and moisture in the ammoniator. This saves time and prevents the production of poor quality goods. Indirectly, steam improves screening and holds recycle to a minimum. All of these factors are important in producing high quality granular goods at low cost.

Test work at factory level has been conducted on several grades, such as 0-20-20, 0-20-0, 0-25-25, 6-12-12, 6-24-24, 5-20-20. Steam has no advantage on such grades as 12-12-12 and 14-14-14, but it has been helpful in 1-4-X, 1-2-X, and O-X-X grades.

Typical operating data for four grades is listed below:

0-20-20

On this grade steam consumption averaged 110 pounds per ton. The temperature exit the ammoniator was 184° F. The solids discharging from the dryer were 204° F. The final moisture content of the product was 2.0%. Experience indicates no caking problems with this grade when moisture is 2%. The production rate was 15 tons per hour. The formula used was:

	lbs.
Ground phosphate rock,	100
Muriate potash, 61%	656
ROP Super, 20%	771
Conc. Super., 46%	513
Total	2,040

The ground rock is used to neutralize the free acid in the superphosphate and to aid in the granulation.

0-20-0

For this grade the steam consumption averaged 130 pounds per ton. The average temperature of the solids leaving the ammoniator was 180° F. The solids discharging from the dryer were 190° F. The production rate was 15 tons per hour and the moisture content of the product was 2.5%. The formula used was:

	lbs.
Ground phosphate rock	150
ROP superphosphate, 20%	1,925
Total	2,075

Ground phosphate rock is needed here also to neutralize the free acid.

6-12-12

On this grade the steam consumption averaged 105 pounds per ton. The temperature of the solids leaving the ammoniator was 212° F. The solids discharging from the dryer were 216° F. The production rate was 25 tons per hour, and the moisture content of the product was 1%. The formula used was:

	lbs.
Solution 448 (25-69-0)	273
Muriate potash, 61%	393
ROP super, 20%	1,200
Filler	214
Total	2,080

6-24-24

For this grade the steam consumption averaged 150 pounds per ton. The production rate was 20 tons per hour. The average temperature of the solids discharging from the ammoniator was 204° F. The temperature of the solids discharging from the dryer was 214° F. The final product moisture content was 1%. The formula used was:

	lbs.
Solution 448 (25-69-0)	211
D.A.P (18-46-0)	155
Muriate potash, 61%	787
Conc. super, 46%	888
Total	2.041

The savings in formula cost by the use of steam is generally obtained by a reduction in sulfuric acid used. The magnitude of this saving therefore depends on the cost of acid and upon other factors, such as the cost of R.O.P. and concentrated super. The largest savings generally result at locations where sulfuric acid is purchased because purchased acid is usually more costly than acid produced at the plant site. On no nitrogen grades the savings result from an increased production rate and also from improved product quality. Although product quality is difficult to express in terms of dollars saved, the savings are certainly there nevertheless.

Our experience with steam in a batch mixer for semi-granulation is limited. Since the condensation of steam adds water to the product, we are reluctant to use it where we do not have a dryer to reduce the final moisture content of the end product.

In conclusion, we should say this: At those granular plants where we have used steam, the plant superintendent would be alarmed and unhappy if we told him that he could no longer use it. In fact, many of our operators will shut the granular unit down if something happens to the steam boiler. They look upon steam as a necessity for granulation.

MODERATOR SPILLMAN: Thank you Mr. Daniel. What do you figure your costs are per 100 lbs. of steam?

MR. DANIEL: Al, we would say that you can get by for approximately $1.50 per 1000 lbs. of steam. We think that is a little higher than actual, however, we use this figure in evaluations.

MODERATOR SPILLMAN: Do you have any City problems in your various plants on type of installations? At Baltimore, like many other locations, City officials demand we have a certified engineer on the job.

MR. DANIEL: We have to go by the ordinances that the respective cities have and that is why in most of our plants we have a 100 H.P. Boiler. If there were not some code to keep the level down like this we would probably prefer 125 or 150 H.P. boilers.

MODERATOR SPILLMAN: I have

one more question. On a 5-10-10 granular you need about 200 lbs. of water per ton or about 4000 lbs. of water per hour for a 20 ton unit. You probably use water and steam to give you this capacity?

MR. H. M. GRIFFITH: Normally a 100 H.P. boiler will produce 3450 lbs. of steam. You may have to cut your production rate a little but if it takes more steam than output of the boiler. Sometimes you add additional acid. The formulas discussed here did not have any acid in them, however, sometimes 25 or 50 pounds of acid will permit you to operate at a higher rate and if you're making your own acids you can do this without hurting your costs too much.

MODERATOR SPILLMAN: Any more questions on the use of steam? We had about a half dozen inquiries to bring this paper before our membership. Thank you very much, Mr. Daniel.

MODERATOR SPILLMAN: The membership sent in about one half dozen queries asking for best procedures to follow before final decision is made to appropriate necessary funds for installation of dust collecting equipment on packaging equipment, batching and shipping mills. Mr. Michael J. Kelly, President of Kelco Corporation, Baltimore, Md., with many years of experience in this field, has kindly agreed to discuss this subject with you.

Dust Control Systems For Shipping Mills In the Fertilizer Industry

Michael J. Kelly

My discussion today will specifically be related to experience, for the past 11 years, in dust control applications for shipping mills in the Fertilizer Industry.

I am sure approach to the solution of dust control problems can be best attained in the following manner:

Survey of Application: A survey of field conditions and the equipment to be ventilated to determine the number and type of connections involved and the total cubic feet of air required to properly control the dust at the various points of propagation on the shipping mill equipment.

Evaluation of problem: The overall problem is then evaluated in the Engineering Department to ascertain the best and most economical approach to the solution of the particular problem.

Design and Engineering: After the survey and evaluations are concluded, we then enter into design and engineering by making the best possible layout and selecting the most efficient Equipment, such as, type and size of fan, size of dust filter and the specification of the particular fabric to arrest and precipitate, the dust that the system collects at the respective points of propagation.

Estimate and Proposal: After the foregoing steps have been made, I then estimate the system for the particular requirements and submit a formal proposal covering recommendations on a guaranteed performance basis.

When contract is awarded we again go through all of the respective phases that were necessary to prepare the original estimate. At this particular time all locations of equipment, proposed hood design, etc. are tied down in final detail and presented to the customer for final approval and when approval is attained then proceed to manufacture the equipment.

If the customer elects to install the equipment he should be provided the necessary drawings and specifications, also the necessary follow through and know how to assist the Customer in every way possible.

We have seven dust control systems ventilating packer installations, in four plants, of one large cooperative operation on an individual system basis. Three dust control systems, ventilating packer installations in one plant of another large operation on an individual system basis. Three dust control systems ventilating packers and one bulk loading station in another large operation on a central system, I mean, a separate system for each packer and its auxiliary equipment. By central system, I mean, one large dust control system ventilating two or more packers and their auxiliary equipment, simultaneously.

On Individual Dust Control Systems the dust accumulated on the surface of the cloth fabric, in the dust filter, is removed by semi automatic shaking. By semi automatic shaking, we mean, that each time the system is shut down to change the particular grade of fertilizer being packed, or for a rest, lunch or quitting period, the system automatically goes through a shaking cycle, to remove the accumulated dust from the fabric and place it in the filter hoppers, for withdrawal. When this shaking cycle has been attained, the equipment automatically shuts itself down and all that is necessary to put it back into operation is to depress the start button of the push button station, all other functions, are, automatic.

The important benefits of efficient dust control attained are as follows:

1—Decrease in Maintenance: Deterioration of mechanical and electric equipment from acids released from reaction of free fertilizer dust and atmospheric moisture, is reduced.

2—Better working conditions: Good dust control enables employees to work comfortably in a clean, healthy atmosphere.

3—Better plant conditions: Good housekeeping is good public relations with customers, allowing them to conduct their business comfortably, without harm to clothing.

4—Better packaging: A dust free plant allows bags to be stored and shipped without cleaning, opens new possibilities, for eye catching packaged design.

5—Better production: Personnel can work at maximum efficiency, allows plant to reach peak daily output.

6—Product reclamation: Important dollars are saved by collecting and packaging fertilizer, that would be lost, if uncontrolled.

7—More accurate weights: Greater economy in operation is attained, by eliminating, the over weight shipment, of product.

My recommendation to prevent corrosion of dust control systems on fertilizer applications having surfaces exposed to dust laden air current be protected with Bitumastic Paint. The exterior of all equipment be protected with red lead paint. The materials used in fabricating dust control equipment be hot rolled and galvanized steel.

We recommend the fabric used in dust filters, for fertilizer applications, be continuous fiber, silicon treated, orlon. The fabric specification is a most important factor, for satisfactory control and reclamation of dust particles.

All electric control panels be factory wired and tested and control circuits designed to operate on 115 volt 60 cycle. They must meet all local code requirements.

Dust Collecting Systems must conform and meet the Requirements of all Local Codes and/or Regulations.

MODERATOR SPILLMAN: Thank you Mike for your thorough description on the pertinent guides to follow to determine proper survey design, engineering, fabrication and specifications, to insure best results from dust collecting systems.

Questions please. I see no hands. Mr. Kelly will be with us this evening. If you think of a dust problem on your bagging equipment, Mike will be glad to discuss the subject with you before leaving Washington.

MODERATOR SPILLMAN: The subject of plant food losses from stacks concerns all of us who are granulating. This has been discussed several times at previous Round Tables, however, we have had many requests to have this item brought up to date for this meeting.

Mr. Elijan B. Henby, Vice President, National Dust Collector Corporation, has very kindly accepted to discuss with us controls and equipment needed to eliminate to a minimum all possible plant food losses.

Magnitude of Plant Food Losses From Stack Effluents

Elijan B. Henby

YOU of the fertilizer industry probably already know stack losses — or have information available in the form of material balances for determining them—better than I as an outsider. I tried to obtain materials balance data from several fertilizer manufacturers in order to check my own data on stack losses, but after being politely but firmly refused such data—and rightly so—it dawned on me your materials balances are none of my business! My business as a guest at your meeting is to call attention to factors in your exhaust systems which can result in high stack losses.

Stack losses include dusts (small solids in a mixture released by conveying or screening — dusts can be formed by attrition of large particles as by grinding), fumes (small solids formed by the condensation of vapors of solids, e.g., ammonium chloride), gases, e.g., ammonia and finally vapors (gases normally found in a solid or liquid state, e.g., water). The stack losses include both raw and manufactured materials captured by the in-plant exhaust system.

The sources of the losses include:

Materials handling operations (elevators, screens, chutes).
Process Operations (preneutralizer, ammoniator, dryer and cooler.)

I shall use the term *dust* generally to include dusts, fumes, vapors and gases.

Altho the in-plant exhaust is the source of most material losses, it is a necessity for plant operations because it:

A. Provides control for some process operations (secondary air for dryer combustion and the cooling medium for the cooler).
B. Improves in-plant environment by removal of or dilution of contaminants injurious to health, e.g., ammonia and nitrogen oxides.
C. Reduces housekeeping tasks.
D. Lessens maintenance by minimizing corrosion and/or erosion induced by dusts.

The very definition of in-plant exhaust shows the necessity for well designed and well maintained systems:

Adequate control of dusts arising from operations *with the minimum exhaust* to avoid loss of product yet sustain good in-plant environment.

Poor systems are evidenced by:
Too much exhaust volume causing—
Pick-up of usable material
Cyclone overload
Hi-power usage
Hi-make-up air costs.
Too much exhaust volume with disadvantages mentioned plus:
Poor hood-duct design with inadequate pick-up of nuisance dusts.
or
Insufficient exhaust volume which:
Fails to collect dusts at origins.
Cannot provide flexibility for adequate process control, e.g., insufficient drier secondary air as in winter when building is closed.

Fig. #1
Dust Losses from 20 T/Hr
Granular Fertilizer Manufacturing

	Per Hour	Per 8 Hours
Solids lost using standard cyclones	225 lbs.	2,040 lbs.
Solids lost using cyclones and wet scrubber aftercleaner	15 lbs.	123 lbs.

Based on:
Exhausting ammoniator, dryer, cooler and fugitive systems.
1,500 cfm exhaust per ton per hour capacity.
A 1 grain/scf dust load in effluent from cyclones.
A 0.06 grain/scf duct load in effluent from aftercleaner.

Figure 1 shows the weights of *solids* per hour and per 8-hour day lost from a 20 T per hour granulating plant having 1,500 cfm exhaust per ton of capacity (30,000 cfm total) when the load from the cyclones is 1 grain/scf. Use of an aftercleaner, i.e., scrubber reduces the losses as shown. If the exhaust system or cyclone is not in good condition, cyclone losses can easily double or triple. You see how important it is that a cyclone operate properly; then the collected material may be returned to your processing system in usable form.

Aftercleaners, i.e., scrubbers, can keep the losses within the range shown for aftercleaners but the "catch" isn't immediately available for reprocessing—it's wet!

The choice, operation and performance of aftercleaners have been fully described at previous round tables, so they won't be discussed here.

We see then that process control and stack losses are closely dependent on the exhaust system; therefore, we should ask — what comprises the in-plant exhaust system:

Hoods must be designed to control dusts, not act as classifiers. They must provide capture velocity (150-500 fpm) at hood face to overcome opposing air currents and extend to furtherest point of source.

Must be near source—volume of exhaust required varies as square of distance from source. Double distance takes 4 times the volume.

Consider thermal currents, nature of machinery, material motion, movement of operator, room drafts, spot cooling or heating.

Figure 2

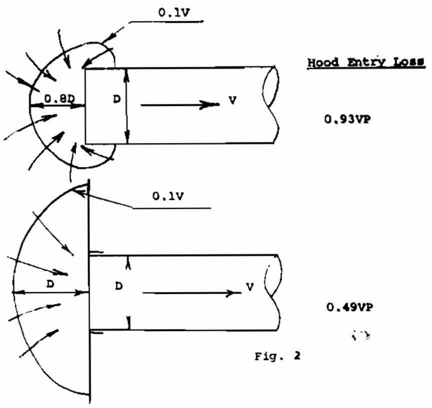


Fig. 2

(*Figure 2*) illustrates how ineffective ducts without hoods are for control of dust sources. Top sketch illustrates how little area is exhausted, yet has a high entry loss which is expressed as a portion of the velocity pressure of air moving in the duct e.g. 4000 fpm has a velocity pressure of 1″ water gauge.

Bottom sketch is better — almost half the loss yet more area exhausted with capture velocity.

It's an interesting phenomenon that air *drawn* into a duct has 10% of duct velocity at less than one diameter from end of duct, yet when *blowing* from the same duct the 10% velocity extends to 30 diameters from end of duct. Bottom sketch is similar to human nose—no asphyxiation, we inhale near nose but exhale to chest level!

Beagle with ears as a cape is illustrative of nature's method for good hood design.

Figure 3. Top sketch is poor design because there is limited area for adequate capture velocity and the entry loss is high—0.50 VP.

Figure 3. Bottom sketch is much better and only has 0.08 VP loss—illustrates improvement when good transition used.

Entry losses are analagous to stuffing handful of waste into duct opening—easier with gradual transition. After entry into duct the air must be raised to velocity in duct.

DUCTS — convey with minimum fall-out:

- Vapors OK at 2000 fpm because there are no solids to be acted on by gravity.
- Solids better at 3500-3800 fpm to keep solids in air stream.
- Metals at 4000-4500 fpm because they're heavier and therefore settle more quickly.
- Clean-out ports desirable to enable cleaning of ducts.

Figure 3

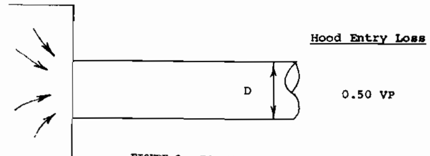


FIGURE 3 - TOP SKETCH

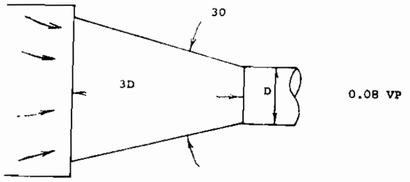
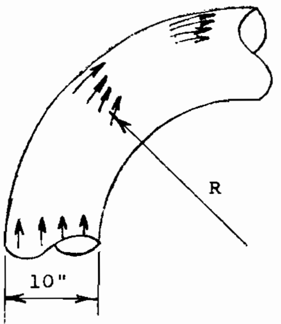
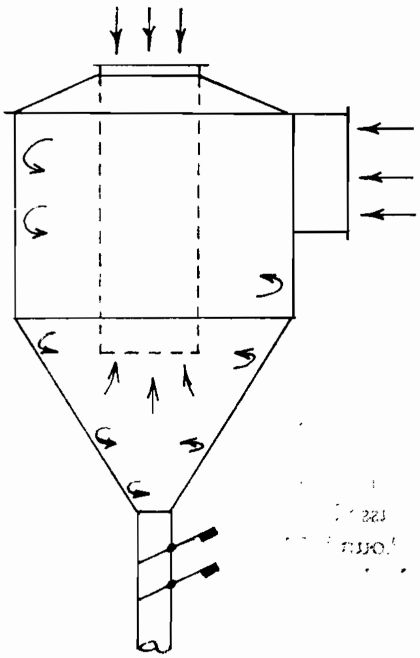


FIGURE 3 - BOTTOM SKETCH



R	Loss
12.5"	0.55VP
15"	0.39VP
20"	0.27VP
25"	0.22VP

Fig.. 4



Long sweeping elbows are desirable—radius of 2D is good as illustrated in *Fig. 4.* Air in low pressure systems considered non compressible; so it swings to outside of elbow and results in high static loss on sharp turns.

Cyclones (sketch at right) — illustrates necessity for good valving to avoid disruption of air flow. Slight leak in bottom causes lots of solids to be thrown out in effluent. Some cyclones have expansion chamber below cone to disengage solids collected from outgoing air stream.

Exhauster — fan is usually selected after designing system. Remember that system static increases as square of volume and that fan can operate only at intersection of its curve and system curve.

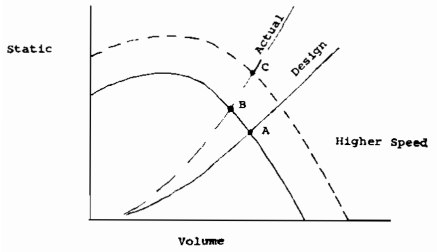


Figure 5

In *Fig. 5,* Point A is design operation. Perhaps an additional elbow caused increased system static so fan actually operates at B. To get volume up to design it's necessary to speed fan up to get design volume exhaust as at C.

Some believe a large fan is best — it does have advantages of slower speed and slightly lower horsepower. But it may not have the characteristics we want for a system as illustrated in *Fig. 6.*

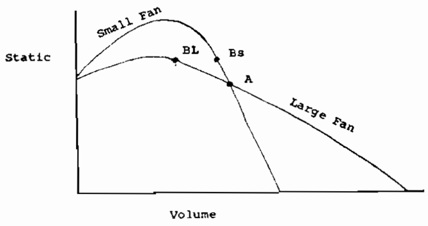


Figure 6

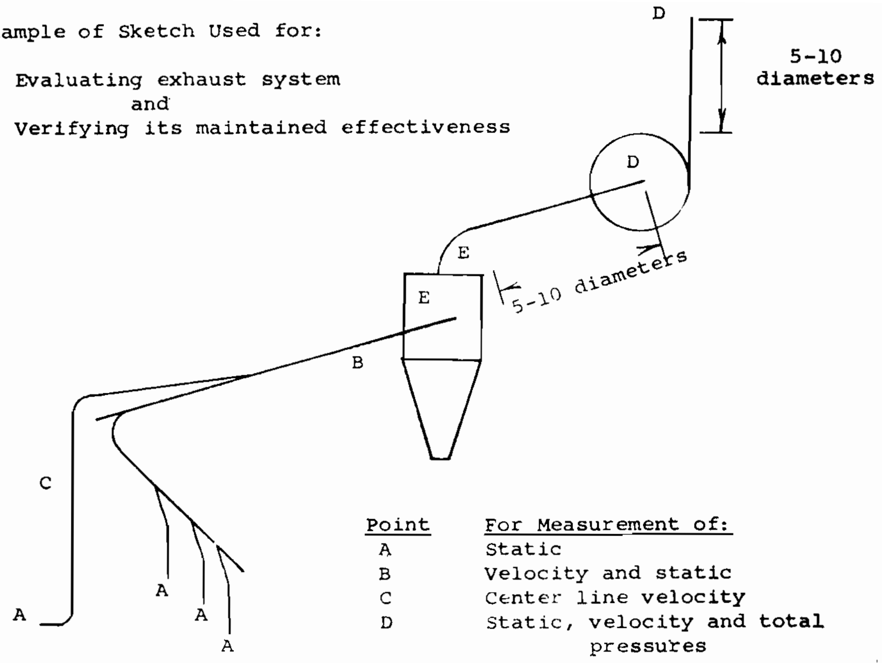
A shows point of operation on a system for two different sized fans. If static raises, volume delivered by large fan drops as shown by B_{LG} but for some static volume loss for small fan is as shown at B_{SM}.

These curves illustrate how important that provision be made for bleed-in to keep system volume up when changing drier or cooler dampers; since changes in dampers change system statics and result in tremendous volume reduction throughout system.

In winter with closed building the system static can change upward and points up desirability for make-up air. Make-up air can be available at $0.65 per hour for 10,000 cfm in Chicago area, when using gas fired make-up air heaters.

Example of Sketch Used for:

Evaluating exhaust system
and
Verifying its maintained effectiveness



Point	For Measurement of:
A	Static
B	Velocity and static
C	Center line velocity
D	Static, velocity and total pressures
E	Static

Figure 7

Blast gates—flow regulating devices to provide adjustments and flexibility in processing or dust control.

Blast gate vs balanced systems —you need blast gates for dryers and coolers to obtain process control. Balanced systems are justified only in hazardous systems to prevent tampering by workmen.

Note extensions to sub-mains on *Fig. 7* — barometric or spring loaded dampers to compensate for reduction of volume in a branch are desirable when drier or cooler dampers are changed — the barometric dampers then bleed in air to keep system volume constant.

Checking and caring for system—Figure 7:

To balance a system start at run of least resistance and work toward that of greatest resistance.

Verify actual vs. design volumes.

Is dust control satisfactory?

Prepare a sketch to show size of ducts, length of runs, fittings, etc. This sketch is a good guide for measurement points, shows up incorrect installation, provides a basis on which to make changes.

Measure statics on each sub branch, volumes on sub mains, cyclone, and fan.

An ammeter on fan motor shows falloff in horsepower which is positive indication that volume handled is dropping. Many people think a fan draws more power with high static or shut off but remember this is untrue. A fan's horsepower requirements vary directly with the weight or volume of air moved.

Good references for planning new or revising systems are:

Industrial Ventilation
Committee on Industrial Ventilation
P.O. Box 453, Lansing, Michigan
By Amer. Conf. of Govt. Industrial Hygienists
or
Engineering Manual for Control of In-Plant Environment in Foundries
American Foundrymen's Society
Des Plaines, Illinois

Conclusion:

In our discussion we've seen that stack losses of raw and finished materials are principally dependent on the design and maintenance of the in-plant exhaust system. The most important single item of the exhaust system in your plant for control of stack losses is the cyclone; it's performance is dependent on keeping the system close to rated volume and keeping the dribble valve tight.

MODERATOR SPILLMAN: Thank you Mr. Henby. The valuable information you have given us on possible reasons for plant food losses from stacks will be very helpful to our membership. It is now 5 P.M. and time to adjourn. Mr. Henby will be around this evening and tomorrow morning. If you have any questions I am sure Mr. Henby will be glad to discuss them with you. I hope you will find time to get acquainted with our panelists who have done a real good job with their respective subjects discussed at this 3 day meeting. Much credit for this program is due to the full cooperation of this membership. I enjoyed moderating this section of the program.

Meeting adjourned at 5.15 P.M. until Friday morning 9 A.M.

Friday Morning Session, Oct. 26, 1962

The Round Table reconvened at nine thirty o'clock a.m., Dr. Vincent Sauchelli, Chairman, presiding.

CHAIRMAN SAUCHELLI: Good morning. It is always a great satisfaction to me at these meetings to see such fresh, tireless faces on the third morning of our sessions.

We have a short business meeting before we resume our regular program. Our Organization is very informal. Some people ask how we're organized and so on. I tell them we have the strongest kind of an organization because it's such an informal type.

We will go right ahead with the meeting. It is usual to consider the minutes of the last meeting. In our case our proceedings are the minutes. I am going to ask if there are any comments on the proceedings? Several people have stated some of the speakers weren't too well pleased with the verbatim report from the tape recording. They wished we had better polishing of the grammar or something like that. Now, let's have some comments. Does anybody have any comments in that respect? You are all familiar with the proceedings. Are you satisfied that we go ahead with the same type of recordings? Apparently there are no comments. We will try to do a little better editing this year and if there are any outstanding errors we will try to polish them off.

The next item will be the Secretary-Treasurer Report.

Housden L. Marshall—Secretary-Treasurer

Your secretarial and treasurer's office continued to function nicely through the year. We sent out three mailings to the membership. One preceding the issuance of the proceedings; another giving the tentative program and a final program mailed during Septemper, 1962. That is our obligation and I hope we fulfilled it sufficiently. Of course, most of you noticed we went high class and printed our final program. We like to do it that way.

I know you are all interested whether we are solvent or not. We have managed to stay in the black. Due to the fact that the meeting this year is in October the financial report only covers 11 months.

Cash on hand October 31, 1961		$ 830.47
Income Oct. 31, 1961 to Sept. 30, 1962		
Registrations — 1961 Meeting.	$3117.50	
Membership Lists — 1961.	261.00	
Sales 1961 proceedings and prior years.	1263.00	
	———	
Total Income.	$4641.50	4641.50
		———
Total cash handled		$5471.97
Expenses Oct. 31, 1961 to Sept. 30, 1962		
Meeting Expense — 1961.	$ 350.44	
Cost Membership List.	215.25	
Transcript and Proceedings Cost.	3070.82	
Mailing, handling, secretarial.	828.13	
	———	
	$4464.64	4464.64
		———
Balance on hand Sept. 30, 1962.		$1007.33

CHAIRMAN SAUCHELLI: Are there any comments or any questions about the report? I have appointed an auditing committee. I don't know whether they have completed their function or not. I assume that they have. Will someone move that this report be accepted as read?

A MEMBER: I move to accept the treasurer's report. Another Member: I second the motion. All in favor? A chorus of "ayes." Opposed? No response.

CHAIRMAN SAUCHELLI: Will the secretary please discuss the dates and places for our 1963 meeting.

SECRETARY MARSHALL: We are booked in this hotel for our next 2 meetings. Nov. 6, 7 and 8, 1963. and Nov. 11, 12 and 13, 1964.

CHAIRMAN SAUCHELLI: We need a motion to authorize Secretary Marshall to confirm these arrangements with the hotel. Let's have a discussion. There is a big problem about finding a suitable meeting place and a meeting time. Up to the present, the group has always indicated its preference was to meet here in Washington. Occasionally we have heard requests we should consider some other central point for our meetings, however, the majority opinion has always been for Washington. It's easily accessable and more fellows like to come to Washington. What is your desire?

MR. CECIL RUSSELL: Let's have it here, Vince.

CHAIRMAN SAUCHELLI: Any other comment? It's difficult to get reservations and accommodations in advance. Some companies have scheduled meetings at this hotel five years in advance in order to make sure that they would reserve the accommodations.

A MEMBER: I think it would complicate the workload of the Executive Committee to have it anywhere other than here. You all have enough problems as it is. Let's not compound them.

CHAIRMAN SAUCHELLI: The secretary, with your okay, will confirm Nov. 6-7-8, 1963, for our 1963 meeting and Nov. 11-12-13, 1964, for our 1964 meeting, at this hotel. Our secretary wishes us to be a little more formal. He is asking for a motion so that we can act.

MR. CECIL RUSSELL: I move that the Secretary be authorized to make arrangements with the Hotel as outlined.

CHAIRMAN SAUCHELLI: Is there a second? The motion was seconded. All in favor. A chorus of "ayes." Opposed. No response. Motion carried.

CHAIRMAN SAUCHELLIS We have been struggling with the idea of how to make our meetings more effective or more efficient, if possible, and it is really a task to try to arrange for a group of this size the mechanics, if you will, that would make the meetings different from what they have recently been. We have had suggestions to separating this group into small segments; have each segment then consider some specific phase of a problem, and then come together after they have had their separate discussions and present the consensus of opinion to the entire group for discussion. It is difficult. Our Round Tables in the early years, with few folks attending, made the task simple; but today with 500 people attending, trying to satisfy them all with separate interests is not easy. We have a few minutes here for discussion. Are there comments or suggestions as to our present type of meetings, the mechanics I'm referring to now? I know that if we get started on this, we may get a great many different suggestions and might get nowhere as a consequence; but I would like a few minutes discussion anyway. We don't want to just force our own ideas on you. Does anybody want to volunteer or suggest something?

Bill Jacoby, are you around? You had some ideas.

(No response.)

I guess Bill Jacoby isn't here.

Does anyone want to volunteer or shall we just go ahead?

GUS MAUTNER: I'll volunteer. I think our main problem in any of these meetings is time. We are always late, we're late starting and we're late finishing. After that excellent presentation of the gentleman from Federal, no one had a chance to ask them a single question, which they would have liked, I know. I think that your planned papers should be of a kind that you have plenty of time left over. We don't get a chance to sound off. Everybody is looking at his watch. I think that the number of papers formally presented should be fewer and there should be more time for discussion, and if they don't discuss them, then you point the finger and say, all right, let me ask you, what do you think of this? Pry them up off their seats somehow and go back to our old way of doing business, because this has become rather formalized, which I dont' think we want. You have to do all your talking in the hall and you should do it in here.

CHAIRMAN SAUCHELLI: Gus, you're right. We have concluded that this next year we are going to do this: We are going to try to have one session devoted to one major topic and different facets of that one major topic discussed. We shall have fewer subjects but thorough discussion and plenty of time for participation from the floor. This day's session will be the sort of pattern for what we have in mind for next year. You will note we have one session devoted to one major topic here this forenoon, and we hope that this pattern is the thing that will make these meetings more effective.

Because, as I keep saying, the essential thing, the thing that makes our meetings different from the usual type of gathering like the Chemical Eengineers and the American Chemical Society meetings, and so on, is the fact that we want participation from the floor. This is your meeting. We don't want to impose the papers on you. The program is organized from suggestions that you give us.

Your Executive Committee acts more or less as an editing committee on your suggestions and on your comments. These meetings represent your thinking, not ours, and that is how we want it to be, and continue to be. We hope you will start thinking about next year and send us in your suggestions.

We are going to select one major subject, maybe we'll take, for example, ammoniation. We have talked about ammoniation for a long time, but we would like to have a review brought up to date on the chemistry, processing, equipment, maintenance and all the other facets that an operating man wants to know about ammoniation. Granulation, we might do the same thing. At any rate it will be something of that order.

I hope we can succeed in making our meetings more effective through frank, informal discussions with more participation from the floor.

Our Secretary wants me to remind you that unless you're registered, you will not be on the mailing list to receive the proceedings. We urge all to register and leave your full, complete address so that there will be no mistake.

It is always the pleasure of your Chairman to welcome visitors from different countries. We are pleased to have visitors from our neighboring countries and from overseas countries. We usually have a fine delegation from our friendly country to the north, and I am going to ask for all visitors from foreign countries and Canada, I'll put it that way because I don't think we consider Canada too much of a foreign country, to just rise. Let's give them a hand.

Thank you. It is a pleasure to greet our friends from overseas.

I hope you make yourselves known to your neighbors because we want you to feel quite at home here.

At this time, too, it is a pleasure to recognize the press. The press always is a great aid to our meetings and they are the busiest people around here. I look around and I see them taking notes and working hard to record our discussions and to make known to the world what we do here for we have become more or less of international interest. I am going to recognize the press. We have some new faces here among the trade press, and I am going to ask them to rise and take a bow. Will you please rise, representatives of the trade press? We have Farm Chemicals, Crop Life, Commercial Fertilizer and Agricultural Chemicals.

I want to take this occasion to thank all the speakers who have participated in our program. I know they work hard. It isn't an easy thing to present papers or prepare papers. To come here means much time and expense. We are truly grateful to you all and I want, on behalf of the Round Table, to thank every one who has participated. I also want to thank, on behalf of this group, Skip Boyd of the Mayflower Management here and the other Mayflower people. They have been very cooperative. They have tried their best to make us comfortable here and to help us in every way to make these meetings a success. I express our appreciation for that effort.

We will now proceed with our regular program. One of the most discussed subjects in the fertilizer industry today is bulk blending. Its appearance on our Round Table agenda this year reflects that interest. The demand for its inclusion in our program has been intensifying year by year to the point that we no longer could put it off. It has been assumed that the new technology involving ammoniation-granulation processes was producing better quality fertilizer having uniformly-sized particles and non-segregating granules was in accordance with the recommendations of agronomists and extension service workers. Now, comes this surge of interest in bulk blending. Investments in modern granulating facilities, representing millions of dollars, were made by many units in the industry based on agronomic recommendations. Were they wrong or is bulk blending a fad: Here today and gone tomorrow? Quien Sabe? Time will tell. Personally, I feel that it is here to stay and that it will advance or increase because farmers like it and want the custom service that goes with it.

The first speaker this morning will tell us about this practice in the Middle West, the region where its growth is significantly big. Following him will be a panel discussion on important phases of the subject and this will be followed by interesting observations and comments on equipment and experience with blending. As I said before, this sort of an arrangement of our program may become the pattern for our future meetings.

It gives me pleasure to welcome Mr. Howard Gaskins, operations manager, plant food division, F. S. Services, Inc., who is going to talk to us on bulk blending in the midwest.

Bulk Blending In The Midwest

Howard Gaskins

THE mixed fertilizer industry is rather like the automobile industry. Both started out with the basic components being known in rather elementary form. When the engine, buggy, and gears were put together, we had an automobile. When nitrogen. phosphates, and potash were put together, we had mixed fertilizers. Better materials and methods have resulted in better automobiles and better mixed fertilizers. We might even compare accessories with the minor elements. Both have added significantly to the effectiveness of the finished product. In both the automobile and a mixed fertilizer, the components need to be balanced to the intended use of the finished product. We therefore find that high powered fertilizers have a high nitrogen content, while big bodied ones are "high in the middle." The potash content, like the gear train in your car, is balanced to the other two.

We might also make another comparison. We can compare the evolution of the automobile to that of the mixed fertilizer plant. The automobile started out as a small, elementary transportation device. The mixed fertilizer plant started out as a shovel-mixing unit. Some of us can remember Georgia buggies. Both the automobile and the mixing plant evolved into high priced, luxury items, more expensive than many consumers needed.

Just as Detroit was making powerful, big, heavy gas hogs, we in the mixed fertilizer business were granulating our mixed fertilizers, wrapping them in beautiful packages, shipping them great distances, sometimes with 3 handling and freight bills.

And, just as Detroit has learned that a third of the automobile users actually prefer something a little less powerful, using less of a cheaper gasoline, and not so dressed up in chrome; we have discovered that a third of the farmers in the Midwest would prefer cheaper fertilizers, without the cost of chemical mixing and granulation, and without the bag. Both the automobile buyer and the fertilizer buyer demand *and get* their money's worth. Some automobile buyers do not need a juggernaut gas hog in order to go from place to place. They can get there in a compact. Neither do some farmers need chemically mixed fertilizers in a bag. They grow their crops with fertilizers from the local bulk blending plant. Both have proven their value in the market place.

It was easy for us to get in the bulk blending business in the Midwest. We had a great deal of acid soil requiring lots of limestone, and we had a program which emphasized the use of bulk rock phosphate. We had lots of trucks and knew how to handle and spread bulk materials on the soil. Bulk blending followed rather naturally.

Bulk blending, as we know it, is custom blending of bulk materials to supply the need of a particular farmer, his fields, and his crops. Custom blending, as we practice it, is a service to individual farmers, and is based usually upon soil tests, the crop history of a field, the crop to be grown, and the expected yield. The custom order takes all these thing into consideration. It is a real pleasure to those of us who have been involved in the pricing of mixed fertilizer to watch an experienced blending plant operator talk to a farmer about his plant food needs in terms of pounds of N, P, and K per acre. It is more a pleasure to realize, after the order has been written for a custom applied, custom blended fertilizer, that at no time did the customer or the salesman ever talk about the price per ton, *or even the analysis.* The analysis is computed only to satisfy the law and the laboratory, and the price per ton may never be computed by either. They have reached complete agreement as to what has been bought and sold, and as to what the price is. We recently took 100 quality control analysis sheets, at random, off the top of the pile, and discovered to our own amazement that there were 83 different analyses. That's 83 out of 100. Such is the nature of custom blending in the Midwest.

The very nature of this custom business determines, to a great extent, the type of local physical facilities. In hilly, wooded country, the fields are generally small, and small blending units serve very well. On the other hand, in the great corn producing areas, the fields are generally larger, the hills not so steep, the spreader trucks are larger, and the blending units are larger.

The size of a blending plant is dependent upon the potential market, the transit time for materials, and, of course, the availability of capital for facilities. Investment will range from less than 35 to over 100 thousand dollars.

We have plants with from 3 to 10 bins, with storage capacities from 450 tons to perhaps 2000 tons. Bins are usually 12 to 15 feet wide and from 40 to 50 feet long. They run 8 to 20 feet high.

Occasionally a plant will have a large bin at one end which may hold as much as 1000 tons, usually for sulfate of ammonia.

You may have gathered by now that no two of our blending plants are alike. In our system, our member companies are independent, and we serve only in an advisory capacity in the construction of a blending plant. They are built with local needs in mind to fit existing layouts, markets and finances. Our function is to advise.

Because of the variety of plants in this system, and because it has grown over a period of a good many years, we have been able to observe the changes and improvements that have been made; and to observe some of the mistakes.

Most of you here are familiar with the details of equipment which can be used, so I'll not burden you with that, but I would like to point out some of the things we have learned:

First, on layout—

Lay out your plant so that your highest tonnage material, usually nitrogen, is closest to your scale. This will shorten those payloader runs.

Lay out your plant so that you can load trucks without going through the mixing unit. There will be a substantial tonnage applied as straight goods. During a busy season this can increase your capacity to serve.

Second, on receiving—

I would suggest that a plant never be built which can receive hopper cars only. While unloading hoppers requires very little labor, the time will probably come when you just can't get a hopper. Box car unloading is real expensive with a shovel, so provide for unloading box cars with a payloader.

Several of our plants have increased their plant's storage capacity by another carload per bin by installing an open bottom screw over the bin to carry material to the front or back of a bin, or both.

Third, on weighing—

Custom mixing requires that all materials be weighed—In fact, our invoices always record the weight of each material in a blend. Weighing will be more accurate, and shrinkage less, if weighing is done in a scale hopper rather than by weighing the payloader and the load on a platform scale. Some of our shrinkage has been attributed to the changing tare weight of a payloader as gasoline is consumed.

Fourth, on the mixing unit—

It has been our experience that rotary mixers, designed to blend dry materials are relatively inexpensive to own, operate, and maintain, and that they will do an adequate job of mixing. Munson and Stedman mixers have been popular, as have concrete mixers.

Box-and-conveyor (either belt or screw) mixers require continual adjustment in custom mixing service, and require a high degree of operator skill. Properly operated, they can do an excellent job of mixing.

We have no expereince with ribbon mixers, pug mills, or gravity mixers in this service, but have reservations about each of them as bulk blenders.

Fifth—on the size of the mixer

Our blenders started out with one ton mixers. It didn't take long for them to discover that larger mixers were required. I believe that most of them now have 6 ton mixers.

Several of them have installed a second mixer so that they can be weighing a batch while one is being mixed and loaded out. This allows almost continuous batch mixing.

Sixth—on loading out

Several of our blending plants have added holding bins for the finished blend, to increase their capacity in the busy season. The mixer is unloaded into these bins, and held for the trucker to load his truck. The bins are usually 8 tons, and will hold a spreader truck load. I might emphasize here that no mixture is ever prepared except to order, and no orders are ever co-mingled. No basing-to-grade is done. In fact, each load of a large order is separately prepared and separately billed. These holding bins allow a full load to be prepared where the mixer does not have the capacity to prepare a full load. They save a lot of waiting time. In addition, they relieve the mixer operator of the job of loading the truck.

Seventh and last, but certainly not least, on the materials used in blending. Blending was real tough a few years ago. There was very little granular sulphate. Ammonium nitrate couldn't be used because of moisture pickup. Triple was too often a high free acid run of pile. Potash was mostly standard, and then, for a while particles were too big.

We could not depend on an adequate supply of well sized raw materials, so we had serious condition problems, and segregation was sometimes painfully apparent.

Today, things are different. All materials can be obtained in a closely sized granular range; Ammonium nitrate is now the most important dry nitrogen carrier for bulk blending; there is an oversupply of good hard cured granular triple and DAP; and the potash industry has an adequate supply of granular potash sized to match other materials. Condition is seldom a problem with bulk blends, and segregation is now a matter for academic discussion and control laboratories. At least it is no longer so painfully apparent to everyone.

In conclusion, we believe that, like the compact car, the custom bulk blending plant is here to stay; that the custom bulk blender can, *and does,* contribute much toward the profitability of farming in the Midwest.

Thank you—you have been a wonderfully attentive audience so early in the morning.

CHAIRMAN SAUCHELLI: We have time for discussion. Are there questions?

MR. WILLIAM HOLZHAUER, Esso Engineering: When you say you need to go from two to three ton mixers up to about six ton capacity, what through-put rate are you talking?

MR. GASKINS: Tons per hour run all the way from 10 to 40, I'd say. We have one blender who has put out 800 tons of the bulk blend in one day, and that's more than we can do in our big East St. Louis plant.

CHAIRMAN SAUCHELLI: If you will please keep your questions, until the end of the panel discussion, we can then provide sufficient time for questions.

I know that the next speaker, who is going to lead the panel, has worked very hard to make this panel discussion comprehensive and thorough. He is a thorough worker himself. He needs no introduction to this audience. He has been with us a number of times and is always ready to cooperate. It gives me great pleasure to present Mr. John O. Hardesty, of the United States Department of Agriculture, who is going to be the panel leader.

Compatibility Of Raw Materials In Blended Fertilizers — Introductory Remarks

John O. Hardesty

AT the 1961 meeting of your Round Table, this subject was approached from the standpoint of "Effects of Particle Size of Raw Materials on their Behavior during the Processing of Mixed Fertilizers." This year it is our purpose to discuss particle size of products used by the farmer. This involves the problems of segregation, flow through fertilizer distributors, and the distribution of fertilizers on the land. The other speakers on this panel were selected on the basis of their valuable contributions to these areas of agricultural research. The wide variation in particle size of many granular and non-granular products makes the problems of segregation, fertilizer analysis, and field distribution worthy of serious study. Uniform distribution of fertilizer on the land has become increasingly important with the increased use of high-analysis granular fertilizers and the increased investment in fertilizer application equipment. The time seems right for consideration of a standard particle size for granular fertilizer and we would like to propose such a standard for your consideration.

Proposed Definition for a Granular Fertilizer

The term "granular fertilizer" has not been officially defined, but is commonly used to describe a fertilizer, the greater part of which passes through a sieve having 4 mm. openings and remains on a sieve having 1 mm. openings. Many granular fertilizers on the market have a narrower particle size range. However, many fertilizers designated as granular have a wider range of particle size. They frequently contain such a high proportion of finely divided material that they are subject to serve segregation of the fine and coarse fractions.

Segregation causes uneven flow through fertilizer drills irrespective of equipment design, uneven application of fertilizer to the crop, and the procurement of non-uniform samples for chemical analysis. The development of a standard particle-size specification for granular fertilizer, therefore, is of direct concern to the makers and blenders of granular fertilizers, the manufacturer of fertilizer distributors, the chemist responsible for analysis of fertilizers, and the farmers who rely on uniform distribution of the fertilizer for best crop production.

Careful consideration and wide-spread discussion of definitions for granular fertilizer should lead to the eventual development of a standard particle-size specification for granular fertilizer products that will be satisfactory to all concerned.

In the intereest of uniformity in trade designation, the following definition of a granular fertilizer is proposed:

Examples

Sieve opening retaining 90% or more of the product			Sieve opening passing the largest particle in the product			Maximum range of particle size
Tyler Mesh	U. S. No.	mm.	Tyler Mesh	U. S. No.	mm.	
20	20	0.841	6	6	3.36	6 to 20
16	18	1.00	5	5	4.00	5 to 16
14	16	1.19	4	4	4.76	4 to 14
12	14	1.41	3½	3½	5.66	3½ to 12
10	12	1.68	3	0.265 in.	6.73	3 to 10
8	8	2.38	⅜ in.	⅜ in.	9.51	⅜ in. to 8

U. S. Fertilizer Laboratory, Beltsville, Maryland

"A granular fertilizer is defined as one in which 90 percent or more of the product remains on any sieve within the range of 8 mesh (2.38 mm. opening) to 20 mesh (0.841 mm. opening), and in which the largest particle passes through a sieve having an opening not larger than four (4) times that of the sieve retaining 90 percent or more of the product."

Chemical Reactions in Fertilizer Blends

Fertilizer materials may be divided into three groups, namely, those that are acid, neutral, or basic in reaction. Superphosphate and monoammonium phosphate are examples of materials that are acid in reaction. Potassium chloride or potassium nitrate are neutral, and calcium cyanamide, limestone, and diammonium phosphate are alkaline. It is well known that chemical reactions may occur in fertilizer mixtures that contain an acid or base or both types of materials. Some of these reactions may be of little importance while others may result in serious loss of nutrients from the fertilizer. Thus, loss of nitrogen may occur when an acid material is mixed with a salt of nitric acid, or a basic material with an ammonium salt.

Urea slowly reacts with moist monocalcium phosphate, the principal constituent of superphosphate, to set free water of crystallization and form urea phosphate and dicalcium phosphate according to the equation:

$$Ca(H_2PO_4)_2 \cdot H_2O + CO(NH_2)_2 \rightarrow CO(NH_2)_2 \cdot H_3PO_4 + CaHPO_4 + H_2O.$$

Frequently, the products of the reaction are deposited in a very finely divided condition and form a plastic mass with the water set free and that already present in the mixture. This plastic mass is subject to severe caking. Neutralization of the superphosphate, prior to or immediately after mixing, corrects this undesirable condition of the mixture.

The following equation represents a double decomposition reaction:

$$NH_4H_2PO_4 + KNO_3 \rightarrow KH_2PO_4 + NH_4NO_3.$$

The products of these reactions, such as ammonium nitrate in this particular case, may be more hygroscopic than either of the original salts used in making the mixture. Moisture content and temperature of the mixture determine the rate of such reactions. Dry mixtures of these materials may remain in good condition for considerable periods of time in storage.

The accompanying selected list of references represents much of the technical literature regarding chemical reactions in fertilizer mixtures.

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To save time I will introduce the panel members first. I think Gus Mautner had a good point this morning when he said we did need to conserve time, therefore, the panel will discuss their subjects, one, two, three, right down the line without any introductions between presentations.

My associates on the panel are Mr. George Hoffmeister, Jr., Chemical Engineer, Applied Research Branch, Division of Chemical Development at TVA. George, will you take your place at the table? George has been in research at TVA for some 20 years. He recently has accomplished considerable research in the segregation of fertilizer materials which he will discuss shortly.

Next, is Mr. Ralph V. Morr, Product Engineer, New Idea Division, AVCO Corporation. AVCO, the "AV" I understand is for aviation, a industry which the company was allied with early in its existance. This company has specialized in making farm equipment since 1899. Ralph is present chairman of the Subcommittee on fertilizer application and he is a representative on the Council of

Fertilizer Application American Society of Chemical Engineers. As many of you know, the Council of Fertilizer Application is under the auspices of American Agronomy Society, American Society Horticultural Science, Farm Equipment Institute, National Canners Association and the NPFI. Ralph has had wide experience in manufacture and use of fertilizer spreaders, which will be his subject for discussion on the second paper of the program. Mr. Rodney L. Maxwell, Cooperative Grange League Federation, Incorporated, Ithaca, New York is a member of the Subcommittee on fertilizer application and has had long experience, I believe more than 20 years, with fertilizer distribution problems. He will discuss this subject .

Finally, at the close of the panel discussion, we should have adequate time for discussion from the floor.

Compatibility Of Raw Materials In Blended Fertilizers — Segregation of Raw Materials

George Hoffmeister

IN the handling and distribution of granular dry blends, segregation seems to be the major technical problem. If you are involved in dry blending, you probably know first-hand how discouraging and exepnsive it can be to take great care in proportioning and mixing a blend only to find that subsequent handling of the blend causes it to become badly "unmixed." Such segregation of course makes it difficult to meet state analysis requirements and also can cause reduced crop response when the material is used.

It is quite appropriate that this problem should be discussed on a panel that is concerned with the "compatibility of raw materials" because the extent to which a blend will withstand handling without excessive segregation depends on the physical properties of the raw materials that go into the blend. It is quite possible to avoid serious segregation by using raw materials with desirable physical properties.

This brings us to the question of which physical properties are important in determining how well a mixture will withstand handling without serious segregation. The properties usually mentioned in this respect are particle size, density, and shape. It frequently has been stated that segregation can be avoided by using raw materials similar in size, shape, and density. However, practically no data have been published to establish the relative importance of each of these properties or to indicate how closely it might be necessary to "match" these properties.

At TVA, we recognized this lack of quantitative information, and consequently undertook some experimental work to see if we could help fill the gap. The overall conclusion from this work is that particle size of the raw materials is by far the most important property that needs to be matched to avoid segregation and further that this matching of size should be quite close to give blends with good handling properties. Our data indicate that variations in the density and shape of fertilizer materials are not likely to have any practical influence on segregation. Now, I would like to spend the rest of my allotted time describing the series of tests that lead to these conclusions.

Our first step was to determine what ranges of size, shape, and density should be studied. To do this, we examined a number of commercial granular fertilizer materials that are commonly used in blending. Figure No. 1 shows some typical results of these examinations.

As you can see, the particle sizes of all these materials fell almost entirely within the 6- to 16-mesh range. However, a very significant thing is that there were wide variations within this range.

Figure No. 1

Size, Density, and Shape of Granular Fertilizer Materials

	Size, Mesh					Particle Density, GM./ML.	Shape
	+6	−6 +8	−8 +10	−10 +16	−16		
Ammonium Nitrates							
Regular Prills	0	6	65	25	4	1.29	Well rounded
High-Density Prills	0	0	8	89	3	1.65	Very well rounded
Granulated	1	35	54	8	2	1.50	Fairly well rounded
Stengel Flake	0	25	43	28	4	1.63	Irregular flakes
Urea Prills	0	1	17	78	4	1.32	Very well rounded
Ammonium Sulfate	0	6	46	41	7	1.64	Irregular flakes
30-10-0 APN	0	5	63	31	1	1.27	Well rounded
18-46-0 DAP	0	5	83	12	0	1.63	Well rounded
Triple Superphosphate	<1	29	56	14	<1	2.12	Well rounded
Potash (A)							
Solution Rounded	0	5	29	58	8	1.93	Fairly well rounded
Potash (B)							
Compacted Type	0	14	65	20	1	1.96	Irregular flakes

For example, one type of ammonium nitrate prills and urea prills were largely in the 10 to 16 mesh range while other commonly used materails, such as 18-46-0 ammonium phosphate and triple superphosphate, had only 12 to 14% in this range. We later found that even much less variation than this can cause serious segregation.

Particle densities varied from a minium of 1.27 grams per milliliter in the case of a 30-10-0 ammonium phosphate nitrate to a maximum of 2.12 for triple superphosphate.

Particle shape varied widely from very well rounded, in the case of material like high-density prilled ammonium nitrate prills, to irregular in the case of Stengel process ammonium nitrate, granular ammonium sulfate, and some types of potash.

Our first tests were made to study the effects of particle size. Figure No. 2 describes the first mixture tested. The ingredients were two sizes of triple superphosphate mixed in equal proportions. The sizes were 6 to 8 mesh and 10 to 14 mesh, which represented materials near the upper and lower ends of the 6- to 16-mesh range. Density and shapes of the two materials were identical. The smaller material was treated with a red dye so that segregation could be observed in our tests.

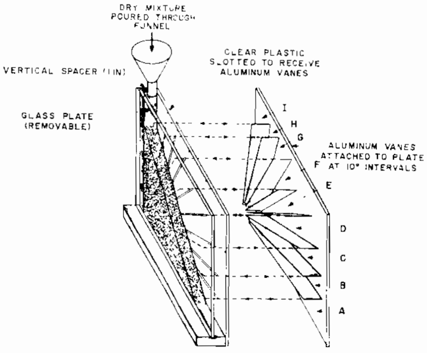
Our first test with this mixture involved dropping it onto a small conical pile on a table. As Dr. Poundstone pointed out yesterday, such "coning" of mixtures is a serious cause of segregation. It occurs not only in building storage piles but also in other operations such as filling bagging hoppers and truck beds. In fact, it is rather difficult to handle mixtures at all without some coning occurring.

Segregation was not very evident from the outside of this pile so our next step was to cut the pile open and look inside. We did this by raising a sheet of clear plastic through a slot in the table.

After the plastic sheet had been raised, the front half of the pile was removed. This provided a cross-section view of the pile interior and it was evident that segregation was severe. The 10- to 14-mesh material was concentrated toward the center of the pile while the 6- to 8-mesh material was largely in a pie-shaped segment extending from the center to the edge.

Like Dr. Poundstone, we found that we did not have to build a whole pile to observe this type of segregation. We obtained the same segregation pattern by building a section of a pile in a narrow plastic box about 14 inches long, and 10 inches high with about a 1 inch spacing between the front and back walls. The mixture was poured in at the upper left. The segregation pattern obtained was the same as in the larger pile.

Our next step was to sample and analyze different parts of this pile to obtain a quantitative measure of the segregation. To do this, we used the device shown in Figure No. 3.



APPARATUS FOR MEASURING SEGREGATION DUE TO CONING

Figure No. 3

The back wall of this clear plastic box was slotted to receive a set of aluminum vanes. After the pile was poured, the vanes were inserted to cut the pile into segments. The box was then turned on its side, one wall of the box was lifted off, and samples were removed for analysis. We chose to use this pie-shaped pattern of sampling because it gave samples that were rather uniform in composition. For example, all the materials in segment A appeared to be of about the same composition, and likewise for the other sections. The analytical data on the first mixture are shown in Figure No. 4.

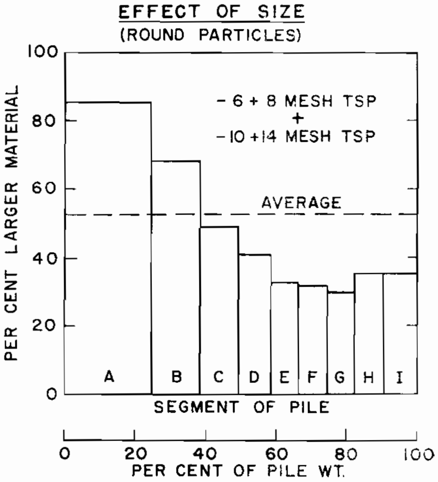


Figure No. 4

This diagram shows the analytical data obtained on the mixture of 6- to 8- and 10- to 14-mesh triple superphosphate. The composition of the material in each segment is shown on the vertical scale as per cent of the larger material. The letters indicate the segments, and the lower scale shows the percent of the total pile weight that was represented by each segment. From this diagram it is evident that there was a high degree of segregation with this mixture. For example, segment A, which was the lowest segment of the pile, contained about 85% large material as compared with 50% in the original mix. In segment E, F, G, H, I, which were in the center portion of the pile, there was only about 30% large material.

We made a simple calculation to see what effect this amount of segregation would have on the grade of a mixture. This calculation showed that if the smaller material in this mix had been urea the average grade would have been 23-23-0, but the grade in segment A would have been 6-40-0 and that in G about 32-14-0.

Figure No. 2

First Mix Used to Study Effect of Size

Ingredient		Percent		Size,	Density,	
Type	Color	Wt.	Vol.	Mesh	G./ML.	Shape
TSP	Gray	50	50	−6+8	2.12	Round
TSP	Red	50	50	−10+14	2.12	Round

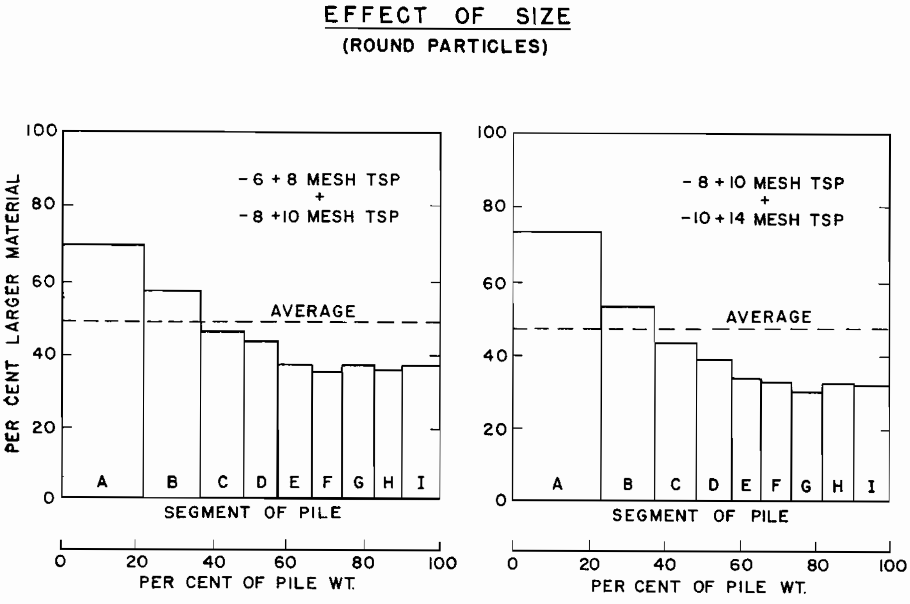

EFFECT OF SIZE
(ROUND PARTICLES)

Figure No. 5

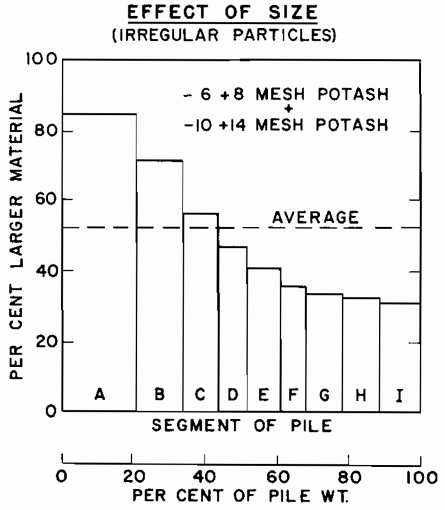

EFFECT OF SIZE
(IRREGULAR PARTICLES)

Figure No. 6

Figure No. 5 shows data from tests of two other mixtures in which the only variable was particle size. They show that even only small differences in particle size can cause serious segregation. The diagram on the left shows that when the size difference was only 6 to 8 versus 8 to 10 the composition of the pile varied from about 70% large material to about 35%. On the right, with a mixture of 8- to 10- and 10- to 14-mesh particles, the variation was from about 75 to 30%.

All the tests that I have discussed thus far were made with well-rounded granules. In regard to the use of granules of irregular shape, there has been two schools of thought. One is that use of irregular particles reduces segregation; the other is that it causes segregation. We tested both theories and concluded that probably neither is correct, because in our tests, irregular granules behaved almost exactly the same as round granules of the same screen size. Evidence that use of irregular granules does not reduce segregation is shown in Figure No. 6.

This mixture was made from two size fractions of an irregular-shaped potash of the compacted and crushed type. The data show the size difference of 6 to 8 versus 10 to 14 mesh caused almost exactly the same degree of segregation as was observed in the tests with round particles.

To determine whether irregular shape of particles can cause segregation, we tested mixtures in which round particles were mixed with irregular particles of equal screen size and density. Results of these tests are shown in Figure No. 7.

The data on the left are for a mixture that contained irregular-shaped, Stengel process ammonium nitrate and well-rounded 18-46-0 diammonium phosphate. These materials had exactly the same density and both were screened to minus 8 plus 10 mesh. As you can see, the composition throughout the pile was rather uniform.

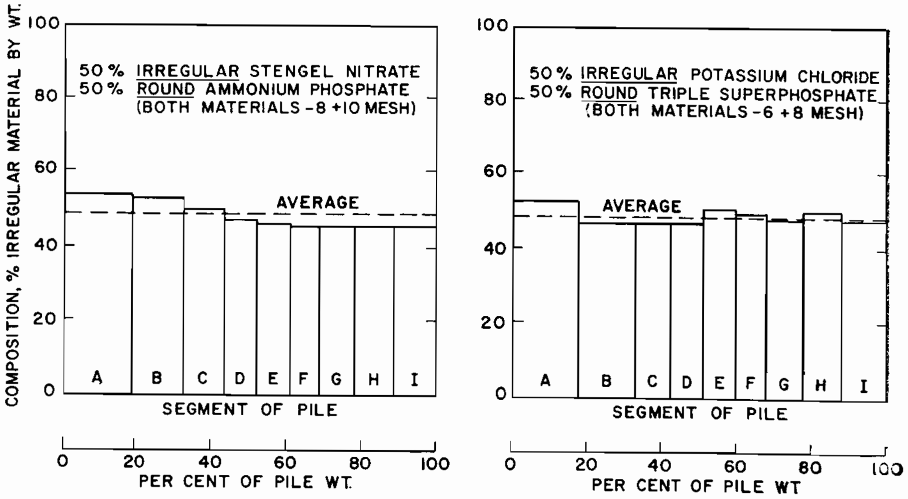
The data on the right show a similar result with a 6- to 8-mesh mixture of irregular potash and round superphosphate.

To study the effect of particle density, we used mixtures of the heaviest and the lightest materials that we encountered. These were triple superphosphate wtih density of 2.12 and 30-10-0 ammonium phosphate nitrate with density of 1.27. Data on these mixtures are shown in Figure No. 8.

The data on the left are for a mixture in which both raw materials were of 6- to 8-mesh size. The data on the right are for an 8- to 10-mesh mixture. Both mixtures were made in the proportion of 50:50 by volume, but because of the density difference the content of dense material, by weight, was about 65%.

Both these diagrams show that, although there was some variation in composition through the pile due to difference in density,

Figure No. 7



EFFECTS OF PARTICLE SHAPE ON SEGREGATION DUE TO CONING

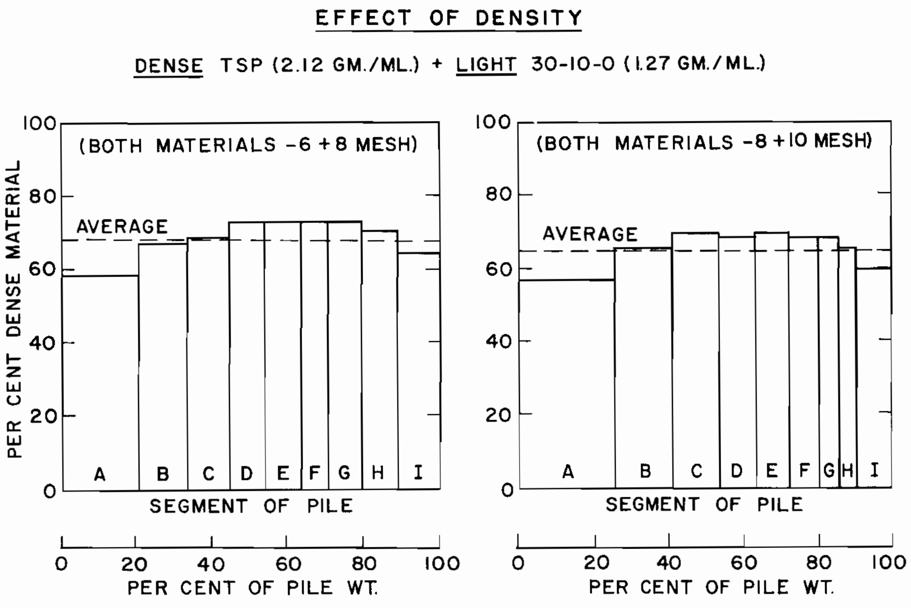


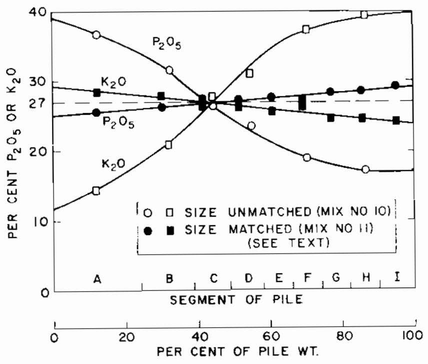
Figure No. 8

these variations were actually rather small. There was some tendency for the dense material to be more concentrated in the center of the pile, but the variations were much less than can be caused by even small differences in particle size. Since the difference in density in these tests were probably the greatest that will be encountered, we can safely say that density differences are not a very significant cause of this type of segregation.

The over-all conclusion from the tests that I have described was that it should be possible to eliminate or greatly reduce segregation of mixtures by simply matching the particle sizes of the raw materials. Of course, it would be impractical to furnish raw materials all in a narrow size range such as 6 to 8 or 8 to 10 mesh. However, it should be possible to obtain the same effect by using raw materials of a wider size range but with matched size distributions. To study this possibility, we made several segregation tests of 0-27-27 grade blends made first with unmatched and then with matched raw materials. Screen analyses (Tyler) of the materials used in the two mixtures were as follows:

	Per cent			
	−6 +8	−8 +10	−10 +16	−16
Unmatched				
Triple superphosphate	30	55	15	0
Potassium chloride	5	29	58	8
Matched				
Triple superphosphate	30	55	15	0
Potassium chloride	30	55	15	0

The mixtures were coned and sampled in the apparatus described; the results are plotted in Figure No. 9.



CONTROL OF SEGREGATION BY MATCHING PARTICLE-SIZE DISTRIBUTION OF INGREDIENTS OF 0-27-27 GRADE DRY BLEND

Figure No. 9

In the case of the unmatched mixture, which is represented by the open data points, the P_2O_5 content in the pile varied from about 38% in segment A to only 17% in sigment I, while K_2O went from about 11% to 40%. With the ingredients of matched size distribution, represented by the solid data points, the picture is much better. Neither the P_2O_5 nor K_2O deviated more than 3 percentage points from the 0-27-27 grade at any point in the pile.

This concludes my discussion of our tests of segregation due to coning. Another type of handling that has been observed to cause segregation of blends is their distribution with fan-type spreaders. We realized that the relative importance of size, shape, and density on this type of segregation might be different than in the case of coning. Therefore, we made a series of spreading tests of different mixtures. I have time only to describe these tests very briefly, but you will see that, as in the coning tests, particle size of the raw materials had much more effect on segregation than did density or shape.

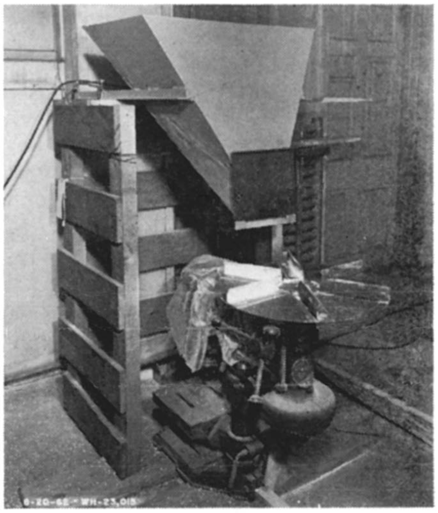


Figure No. 10

Figure No. 10 shows the spreader-fan setup that we used. The fan was 18 inches in diameter and rotated at 500 r.p.m. Test mixtures were placed in the hopper and allowed to flow through an adjustable gate onto the fan. The placement of the material on the fan was adjusted to give the best distribution pattern.

Figure No. 11

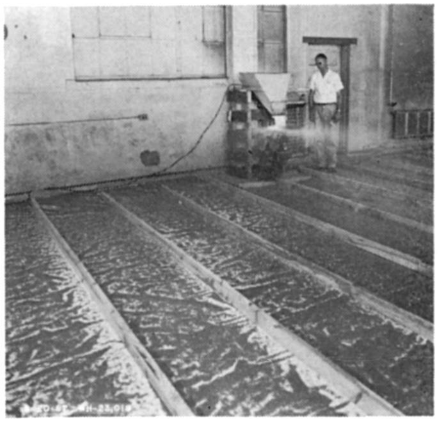


Figure No. 11 shows the arrangement that we used to collect the fertilizer. The spreader was operated in a stationary position, and the fertilizer was collected in a series of 30-inch-wide troughs formed with 2 x 4 lumber. The material in each trough was weighed and analyzed separately. The results of our tests are summarized briefly in Figure No. 12.

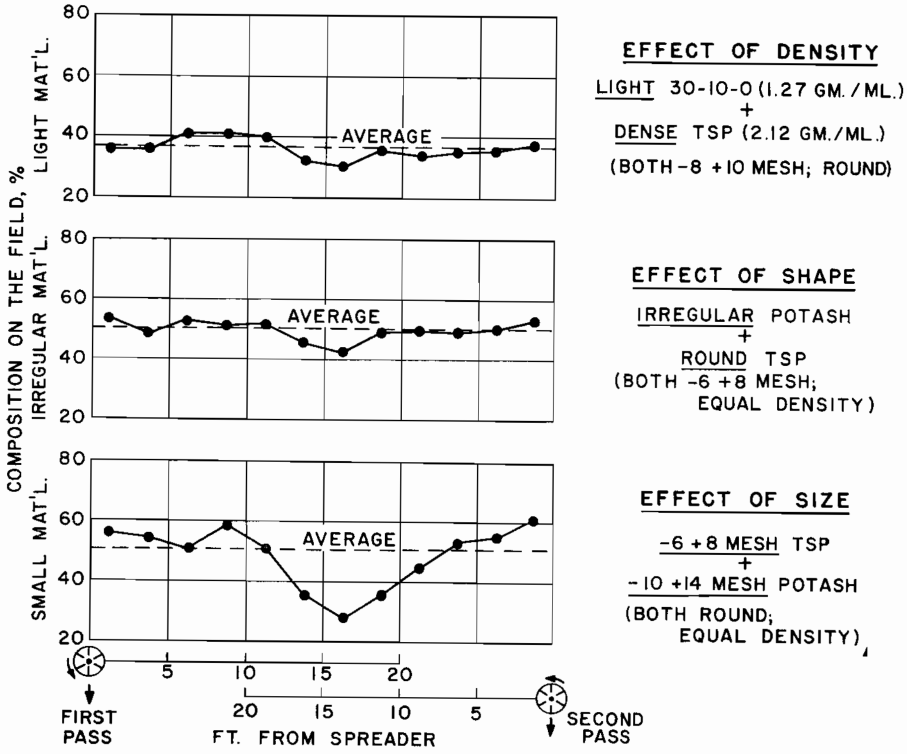


Figure No. 12

These curves show the results of spreading three different mixtures. The composition of the material on the field is plotted against the lateral distance from the spreader fan. The curves are drawn to represent two passes of the spreader with 30 feet between passes. With this spacing, there would be about 10 feet of overlapping.

The bottom curve shows the effect of a size difference of 6 to 8 versus 10 to 14 mesh. Both materials in the mix were of equal density and both were round. The potash was the solution-rounded type. As you can see, there was considerable segregation. The smaller material was not thrown as far as the larger material, with the result that there was a deficiency of small material in the middle area between passes. Similar effects of size have been noted in work by Dr. Cunningham at Virginia Polytech and Dr. Smith at Missouri.

In the test covered by the middle curve, a mixture of two materials of different shapes but equal size and density was used. This did not segregate significantly. The composition was close to the average throughout most of the spread.

In the test covered by the upper curve, the two materials with the greatest probable difference in density, 1.27 versus 2.12, did not segregate significantly.

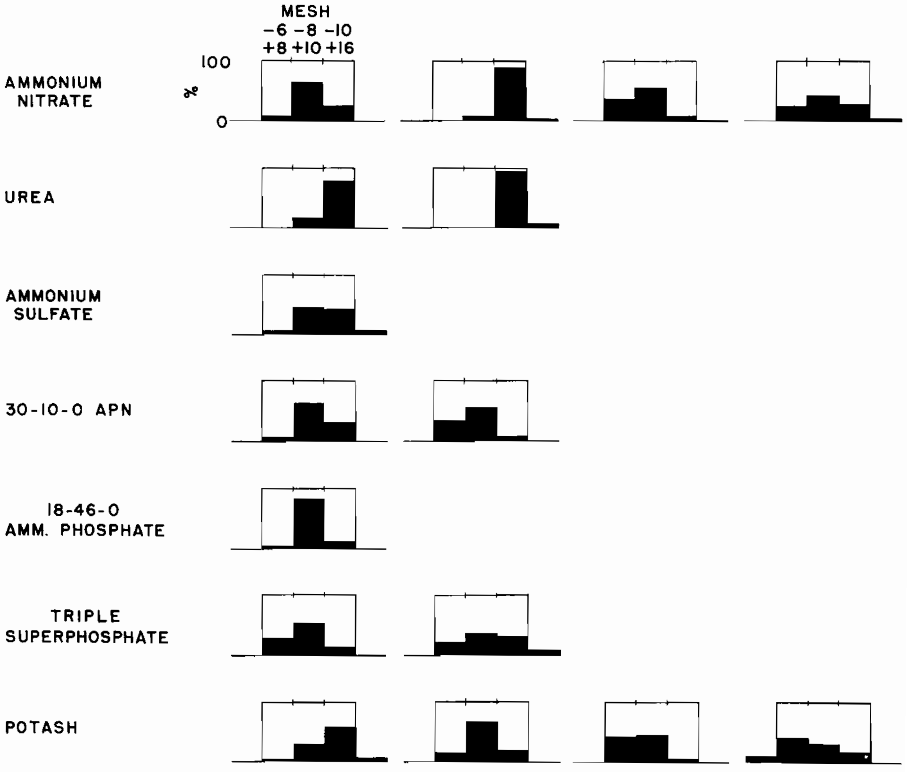
These results lead us to believe that matching size distributions of raw materials can not only practically eliminate segregation due to coning but can also do the same for segregation due to the action of fan-type spreaders.

Since size-matching does seem to be of such importance, I would like to conclude by taking another look at the screen analyses of some of the materials presently available to blenders.

Figure No. 13 shows the screen analyses in graphic form. Each diagram represents material from a different producer. The bars inside the blocks represent the per cent of minus 6- plus 8-, minus 8- plus 10-, and minus 10- plus 16-mesh particles in each material. Materials of matched size distribution will have diagrams of similar shape. Looking at the diagrams, it is obvious that some very poor matches are possible. From the blenders standpoint, it would un-

Figure No. 13

SIZE DISTRIBUTIONS OF SOME GRANULAR FERTILIZER MATERIALS



doubtedly be very desirable to have more uniformity of distribution among the various available materials.

This brings me to my last point; that is, that raw materials themselves are subject to segregation when handled. Thus, a blender may receive a carload of raw material of good size distribution, but if he allows it to cone in a storage bin, the first scoops removed from the bin will differ greatly in size from that removed toward the center of the bin. Figure No. 14 shows an example of this.

This figure shows the size distribution of two samples taken from a bin of potash in a blending plant. It is obvious that the potash in different batches to the mixer could vary considerably in size distribution.

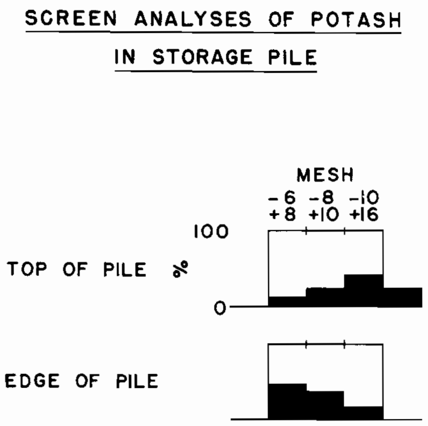


Figure No. 14

Spreading Problems Associated With Non-Uniform Particle Sizes

Ralph V. Morr

A BRIEF review of the farmer's labor problem and his interest in producing more with less labor soon turns up the reasons for the changes now occurring in the handling and spreading of fertilizer. Farmers are no longer interested in paying for, handling, and burning the bags that were required in fertilizer handling of twenty years ago. This used to be the accepted way of getting fertilizer to the farm and transferring it to the fertilizer spreader or grain drill.

The development of pelleted or granulated fertilizer that resisted caking soon changed the requirements for handling fertilizer in a sealed container. Bulk hoppers were developed to transport fertilizer to the farm and then dump into the hoppers of applicating equipment. While this proved to be more efficient, there was still a problem with applicating equipment. More spreading capacity was required, so fertilizer spreaders were merely lengthened another two feet. The limiting factors on spread capacity were then width of farm lanes and gates along with the inconvenience of transporting a wide spreader on an 18-foot highway.

Granulated fertilizer had advantages other than reducing the caking problem, however. It was soon discovered that there was less wind drift and wind loss if another spreading principle was used. The result was the appearance of spinner type spreaders for handling and spreading bulk granulated fertilizer. These come in a variety of sizes and shapes from a small mounted unit to an eight-ton capacity spreader truck. All can be moved on the highway with ease and will go thru any farm lane or gate that other farm equipment will pass thru. It is now possible to purchase fertilizer from a dealer, transport it to the farm, and spread it in 40- or 50-foot widths with no more effort than is required to drive a tractor.

Farmers in our area like the granulated fertilizer so well that they are refusing to buy the powdered form. They like the non-caking, free flowing feature and the fact that they can top-dress without being overly concerned with fertilizer burn. They like to spread their fertilizer with the least effort and as quickly as possible.

Following this, there has been a lot of activity among the manufacturers of fertilizer to be more and more competitive with each other. This has resulted in granulated fertilizer appearing in several forms such as the pellet, the granule, and the semi-granule. In addition, there has been a lot of activity in attenmpting to blend fertilizers by using dry granulated material and mixing them together to form a dry blend. Each of these forms pose a problem to the application equipment manufacturer with the farmer being the one to bear the brunt of the trouble and, in turn, puts the blame on the application equipment.

Granulated fertilizers can be spread uniformly and accurately as long as the particles are of fairly uniform size and bulk density, but other forms are not as easy to cope

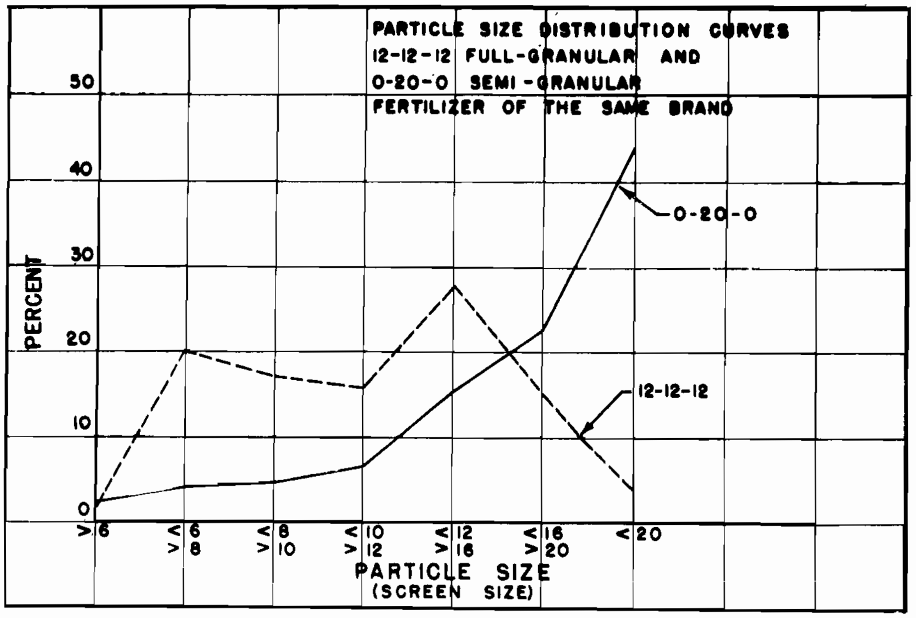


FIGURE 1

with. Two fertilizers of different analysis and made by the same company were purchased from the same dealer the same day. Samples of the fertilizer were taken and graded for particle size to determine the percentage of the fertilizers in different size ranges. Figure 1 showes particle size distribution for both materials. The 12-12-12 was a full granule and graded out with 95 per cent of the granules between a 6 and a 20 mesh screen with a fairly even distribution of particle sizes. The 0-20-0 was a semi-granule with 44 per cent of the particles smaller than a 20 mesh size.

Both fertilizers were then spread the same day using the same spinner spreader with the same spread rate setting. Sample trays 4-feet square were placed side by side across the path of the spreader and samples taken of the actual spread pattern. The trays were equipped with baffles spaced every 4 inches to reduce the bounce of the fertilizer particles. Each sample was weighed, recorded, then charted to determine the distribution pattern. Figure 2 shows the actual spread pattern for both materials for easy comparison. The coefficients of variation "C" were then calculated to determine the relative evenness of the spread pattern. (3)

A zero value for "C" indicates a perfectly even distribution and increasing values show increasing unevenness of distribution. A value of 20 per cent or less is considered acceptable as reported by Cunningham (1). The coefficient of variation was 14 per cent for 12-12-12 and 25 per cent for 0-20-0. Since all conditions were the same for the test runs of both materials, the only conclusion that can be drawn is that the erratic spread pattern for the 0-20-0 is caused by the large variation in particle sizes.

Bulk blends are another problem in the actual spread of a spinner type spreader. Even if there is no segregation in the load, there is segregation in the spread pattern if the particle sizes are not uniform in size and the bulk density of each material is not approximately the same. Figure 3 shows the trajectories of particles of different bulk density which were mixed together in a dry blend and then spread with a spinner type machine. Seg-

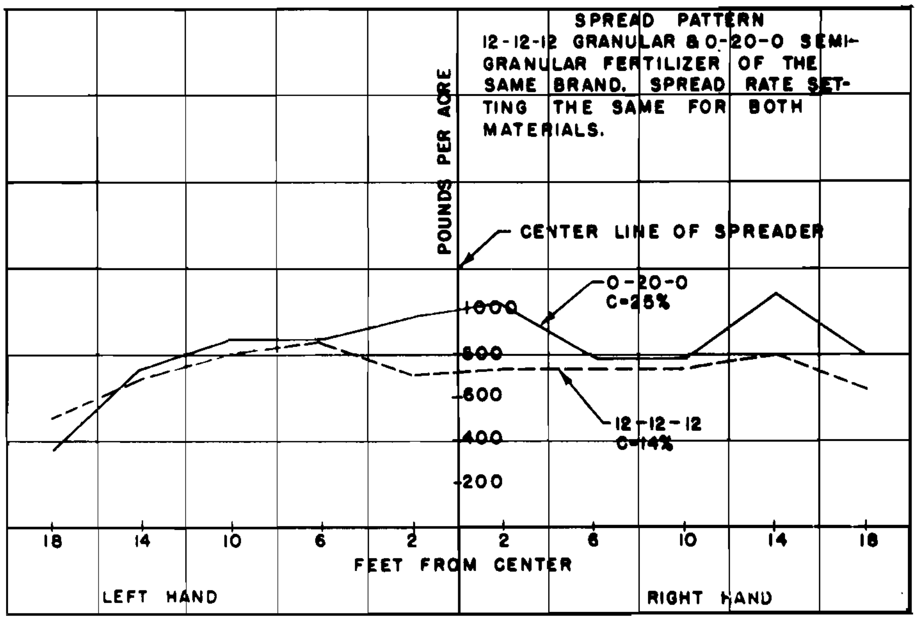


FIGURE 2

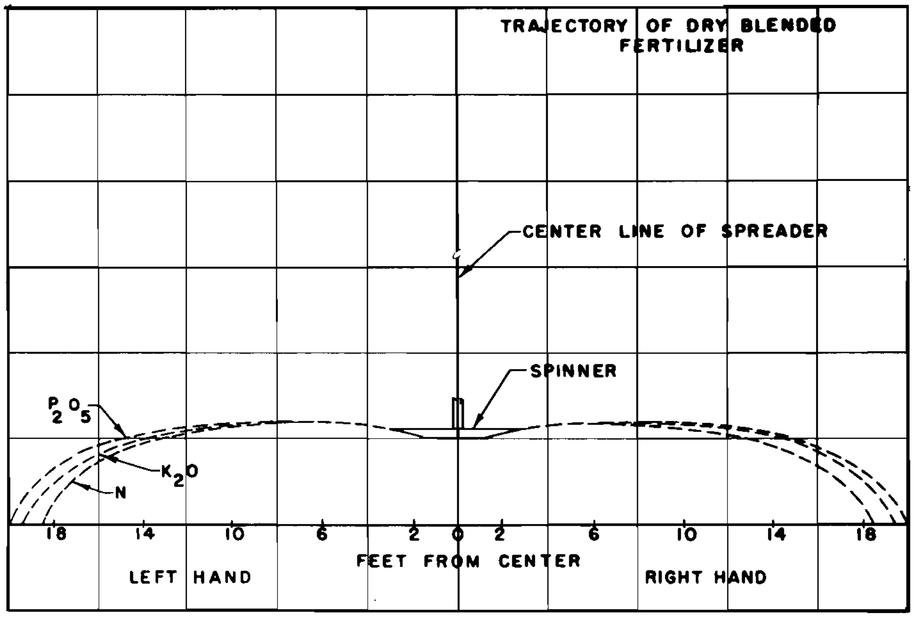


FIGURE 3

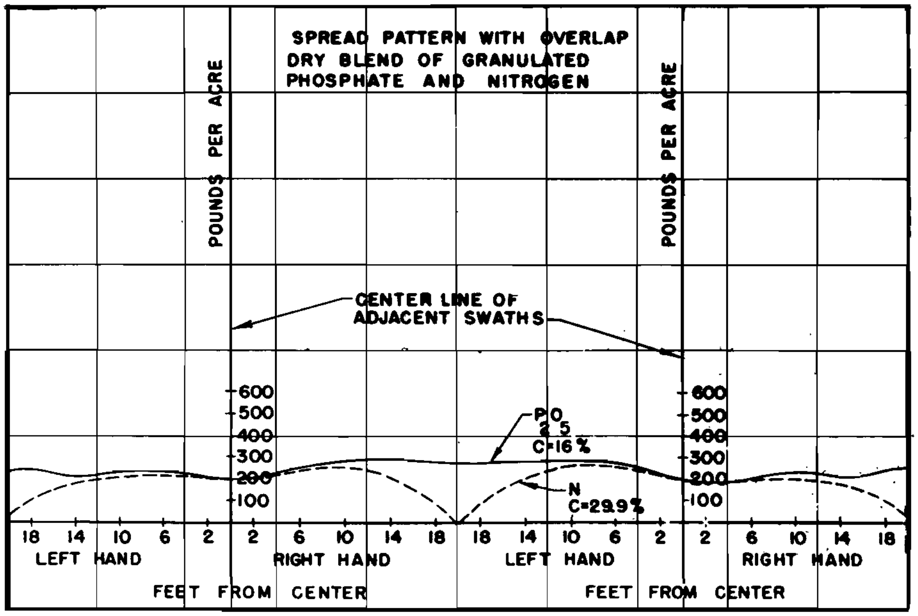


FIGURE 4

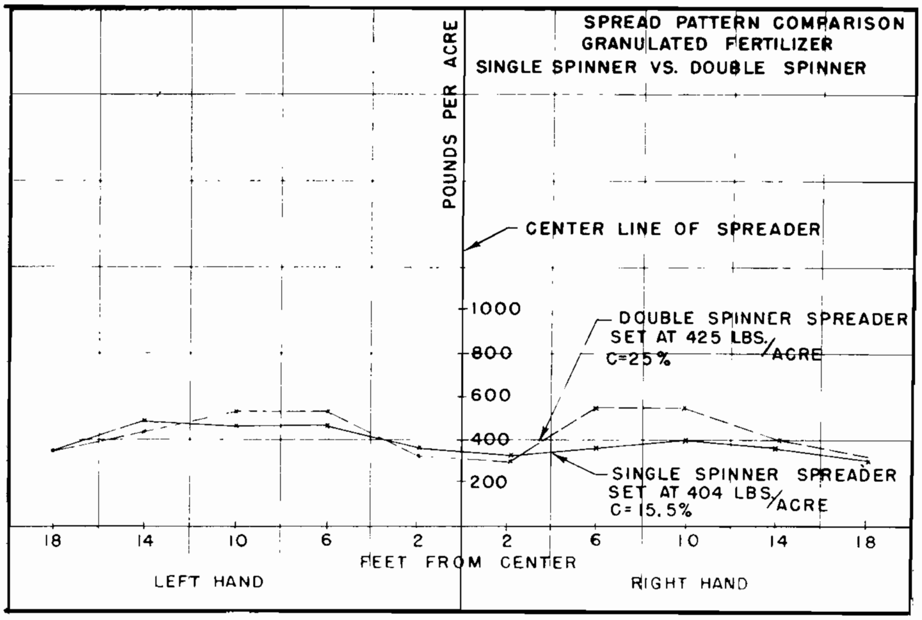


FIGURE 5

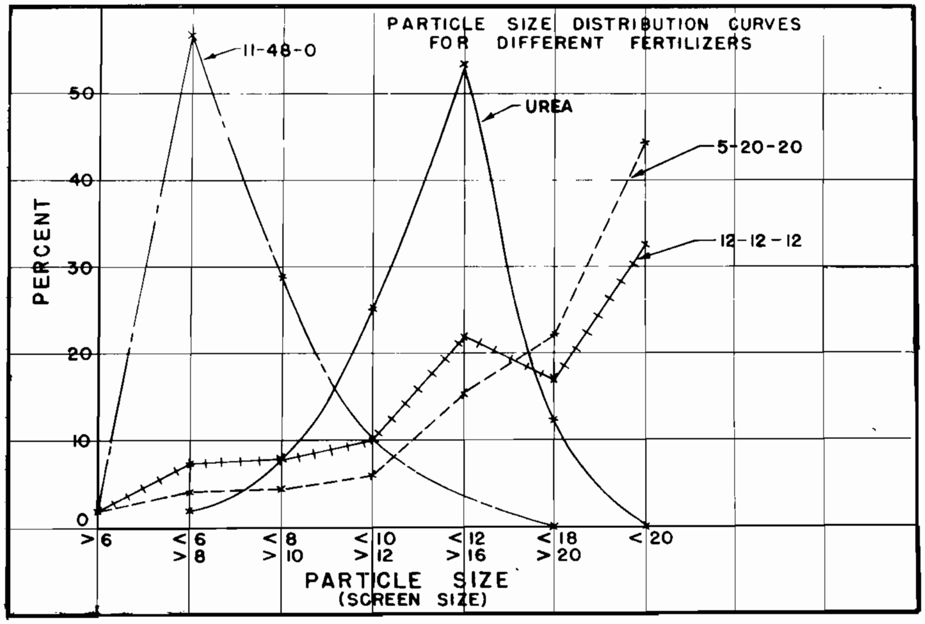


FIGURE 7

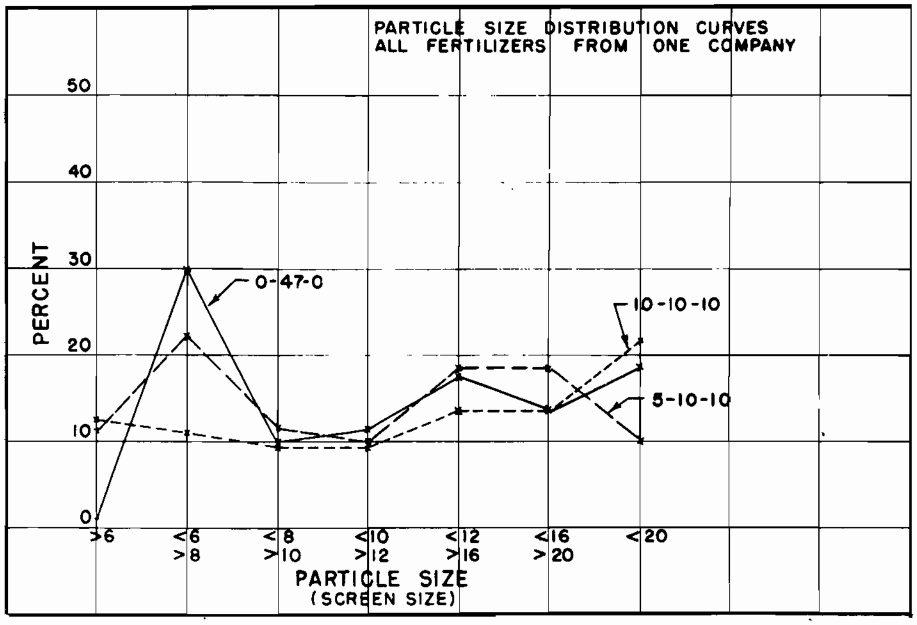


FIGURE 8

regation occurs because the lighter particles do not travel as far as the heavier particles. When this happens it is impossible for the operator to make an overlap to obtain a uniform spread of all materials. Figure 4 shows the actual spread pattern for the phosphate and nitrogen materials across the field. The coefficient of variation is 16 per cent for the phosphate, and 29.9 per cent for the nitrogen.

The use of multiple spinners will not improve the actual spread pattern over a single spinner machine. Research at the University of Missouri (2) has shown that single spinner machines will spread as evenly as multiple spinner machines if the design is right. Figure 5 shows the spread pattern curves for the most popular double spinner spreaders now on the market and a single spinner spreader having the correct design, Spread rates in pounds per acre are nearly the same and can be compared directly. The coefficient of variation for the double spinner spreader is 25 per cent, and is 15.5 per cent for the single spinner spreader.

Variations in spread patterns usually do not show up in affecting the overall yield per acre of a crop as demonstrated in recently published data from the British Isles. However, when the nitrogen is the heavier particle and there is an error in judging the overlap, then results as shown in Figure 6 can be expected. While this does not affect the yield, the farmer will not be convinced and will blame the application equipment and the operator for the non-uniform spread. The result is a dissatisfied customer who tells his neighbors, and all who question the appearance of the field, that the spreader just did not spread evenly.

Figure 6

The problems of handling material of a non-uniform particle size are very difficult to solve. A machine designed to handle one fertilizer will not handle another fertilizer satisfactorily even though it is the same brand purchased from the same dealer. The equipment manufacturers have become aware of the problem and have started activity asking if it might be possible to establish a standard for particle size of granular fertilizers. A survey has been made of some of the fertilizer manufacturers to determine the trend in the manufacture of fertilizers. It was found that the trend is rapidly in the direction of granular material with the granules being graded thru a 6 mesh screen and over a 20 mesh scren. Figuer 7 shows the particle size distribution curves of four fertilizers of different analysis and each the product of a different manufacturer. It is apparent, from this, that there is a wide variation of particle sizes from one brand and analysis of fertilizer to the next. Figure 8 shows the particle size distribution curves of three products made by the same manufacturer showing that it might be possible to produce granulated fertilizer to a standard in particle size.

Fertilizer manufacturers have a problem in making a satisfactory product and remaining competitive and know all the problems associated with its manufacture. The equipment manufacturers, also, have a problem producing equipment that will perform satisfactorily under all field conditions, with all types of fertilizers, and still be competitive. The ultimate consumer is the farmer who must be satisfied with our products. Fertilizers graded for particle size can be spread uniformly and accurately with correctly designed application equipment. Some bright fertilizer producer will find a competitive advantage in advertising to farmers that "This brand of granulated fertilizer is sized for all fertilizer spreaders including the spinner type machines."

(1) Cunningham, F. M., Performnace Characteristics of Bulk Distributors for Granular Fertilizer. Papers presented at the 1962 Annual Meeting of A.S.A.E.

(2) Smith, George E., Bulk Blended Fertilizers. Proceedings of the 11th Annual Meeting Fertilizer Industry Round Table, November 8-10, 1961.

(3) Snedecor, George W., Statistical Methods, Iowa State College Press, Ames, Iowa.

Compatibility Of Raw Materials In Blended Fertilizers — Fertilizer Distribution On The Land

Rodney L. Maxwell

In the G.L.F., we have been spreading fertilizer on a custom basis for over twenty years. It has only been within the past three or four years that I have been aware of any field studies of spreading problems being made by scientific groups such as State Agricultural Colleges, U.S.D.A., etc. I am very happy to see this increase in interest and I am sure that collectively, we can solve many problems and insure the farmer of a better all-around spreading job.

Manpower

Once a custom spreading service is established, the individual operator and his training and experience becomes the most important single factor in getting a qaulity job done. The operator's attitude, knowledge and experience in farming is more important than his truck driving ability. He must understand his equipment and the proper maintenance of it.

We send our operators to a driver training school where they spend a week in the classroom, on the highway, and in the field before they actually start to operate their own trucks. Each summer we hold a series of one-day spreading schools where a small group of drivers bring their spreading trucks and we go over their maintenance program and check the spreading pattern of their equipment.

Equipment

We design and build our own spreading equipment. Basically we use a drag type chain conveyor with very close bar spacings and a double spinner setup to which we have added many devices to enable us to maintain a uniform spreading job.

It is my belief that there is no one way to build a good spreader but the ability of the machine to do a good job will depend on the proper balance of such features as:

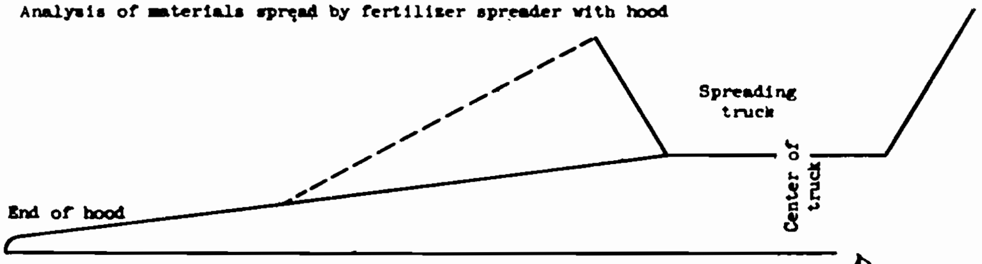
1. Type of conveyor system:
   a. should be geared to the ground speed.
   b. The conveyor system should deliver a uniform ribbon of material to the spinners.
2. Type of metering device:
   It should give uniform flow at any point from lowest to highest desired rates.
3. Number of spinners:
4. Size of spinners:
5. Speed of spinners:
   Should possess the ability to maintain a constant speed which is adjustable to fit the material being spread.
6. Number of spinner blades:
7. Shape of spinner blades:
8. Provisions for adjusting position where material hits spinners:
9. Freedom from obstacles located in path of material leaving spinners.

Segregation

During the past ten years, many changes have taken place in the fertilization practices of this country. Two of these which directly influence the topic which we are about to discuss are:

1. The increasing popularity of the spinner type spreader, both in a custom spreading operation and by the larger farming operations.
2. The increase in the number of manufacturing or mixing procedures used to produce a given analysis of fertilizer or equal amount of plant food. For example, a 10-10-10 fertilizer may be obtained in many variations of the follow ing forms:
   a. *Powdered* (mixed from all powdered or a combination of powdered and liquid ingredients).
   b. *Granular* (where the ingredients are mixed, then

Analysis of materials spread by fertilizer spreader with hood



	Sample L 7	Sample L 6	Sample L 5	Sample L 4	Sample L 3	Sample L 2	Sample L 1
	← 2' →	← 2' →	← 2' →	← 2' →	← 2' →	← 2' →	← 2' →
Chem. analyses							
N	5.21	5.23	5.33	5.29	5.40	5.25	5.21
P	10.33	10.41	10.15	10.38	10.43	10.35	10.05
K	6.18	6.11	6.10	6.15	6.12	6.00	5.91
Sieve Test							
Thru 20	78.4%	80.2%	89.9%	87.6%	86.5%	87.0%	88.4%
100	23.6%	19.4%	17.4%	20.0%	19.2%	19.0%	17.1%

Bagged Mtls used in test
Chemical analysis
N 5.24%
P 10.29%
K 6.17%
Sieve test
20 - 82%
100 - 20.2%

Chart No. I

granulated and the fines are removed and recycled).

c. *Semi-granular*
   (1) Made by same process as the granular except fines are not removed.
   (2) A mixture of powdered and granular ingredients).

d. *Bulk blend* (usually a mixture of all granular ingredients).

With today's extensive use of granular ingredients and various degrees of granulated fertilizers, we

Chart No. II

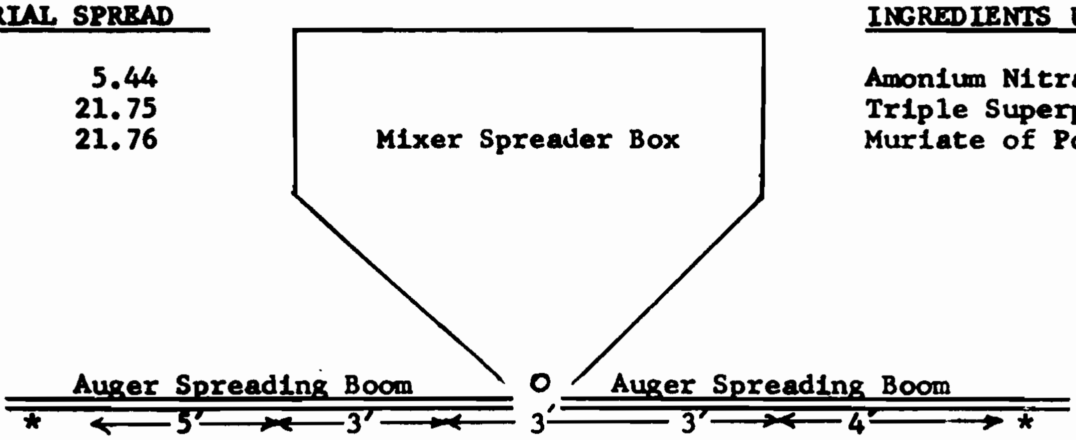
ANALYSIS OF MATERIALS SPREAD

THEORETICAL ANALYSIS OF MATERIAL SPREAD

N.	5.44
T.P_2O_5	21.75
K_2O	21.76

INGREDIENTS USED

Amonium Nitrate
Triple Superphosphate
Muriate of Potash



POSITION

	3	1	C	2	4
N.	4.34	4.81	4.86	4.77	3.52
T.P_2O_5	28.10	22.49	19.46	23.65	35.40
K_2O	15.35	22.48	26.93	20.80	9.82
AMOUNT SPREAD PER 1 FT. OF TRAVEL	115.3 gr./ft.	112.6 gr./ft.	66 gr./ft.	142.7 gr./ft.	66 gr./ft.

Equipment adjusted to spreading the equivalent of 300#/acre of 5-20-20 hear a lot about the problem of segregation. Let us take a look at this problem strictly from the standpoint of the custom-type spreader. In order that we may better understand today's problems, we will first look at Slide No. 1 which shows the equipment used in making Chart No. I.

Chart No. I

This shows the chemical and physical analysis of powdered fertilizer spread with a double spinner spreader equipped with hoods and was made in 1948. Samples were taken every two feet across the spreading pattern and you will note that they showed very ltitle variation in either the chemical analysis or sieve test. In fact, the variations caused by the spreader were much less than the variations due to formualtion and mixing. These samples were taken from a 5-10-5 bag. The problems of segregation were non-existent under these conditions.

Chart No. II

As granular ingredients became more popular, we decided to run some tests on an auger boom-type spreader in order to determine if it was more or less apt to segregate materials than the spinner spreader. For the tests covered by Charts 2, 3, and 4, we used a three-compartment mixer-spreader.

This chart shows the segregation characteristics of the auger boom when used with a blend of ammonium nitrate, granular triple superphosphate and muriate of potash. Notice how rapidly the percent of $T.P_2O_5$ rose as we moved away from center and the exact opposite occurred with the potash.

Chart No. III

Because we were unable to obtain a satisfactory spreading job from the auger boom arrangement, we substituted two spinners for the booms and Chart No. III shows the much improved spreading pattern obtained. Notice in the supper right-hand corner that we were using ammonium nitrate, 20% granular superphosphate and coarse muriate of potash.

Chart No. IV

Spreading recorded on Chart No. IV was identical to Chart No. III except that we substituted regular or fine muriate of potash in place of the coarse muriate of potash. You will notice from this chart that this one change gave us a segregation problem that made this spreading job completely unacceptable.

Charts Nos. V, VI, VII

These charts were made from data accumulated by spreading four different types of fertilizer on the same day by the same equipment. The four types of fertilizer were picked up in bags from stock out of three different fertilizer plants, not all of which were G.L.F. The material was spread under adverse field conditions on a cold, damp day with gusty winds.

No adjustments of any type were made to adapt the spreader to a particular type of material. Spinner speeds and positioning plates remained the same for all materials. It was our purpose to determine how much difference there was in the segregation of the different types of mixed fertilizers.

The spreading equipment was our standard double spinner lime and fertilizer spreader without hoods.

Chart No. III

ANALYSIS OF MATERIALS USED

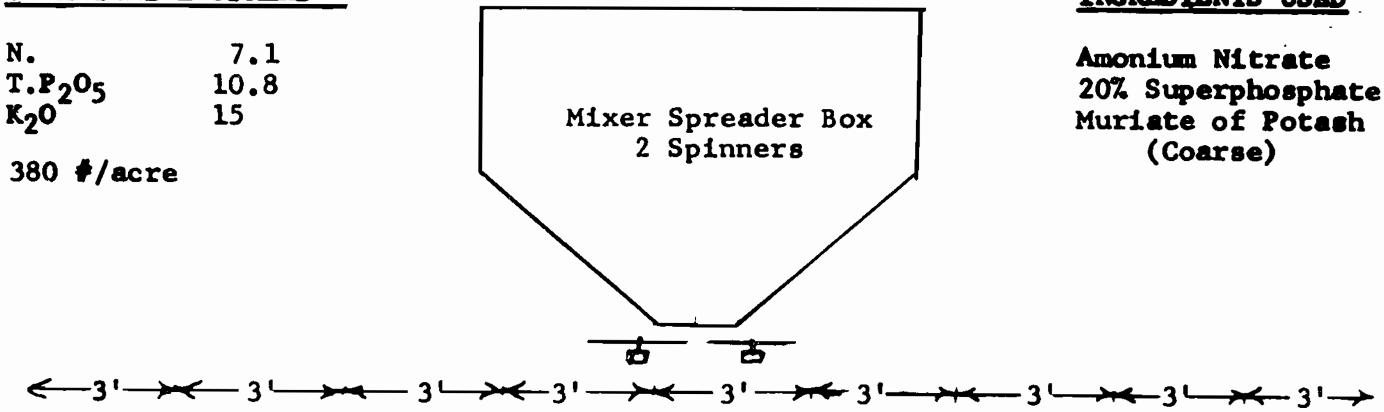
THEORETICAL ANALYSIS OF MATERIAL SPREAD

N.	7.1
$T.P_2O_5$	10.8
K_2O	15

380 #/acre

INGREDIENTS USED

Amonium Nitrate
20% Superphosphate
Muriate of Potash
(Coarse)



POSITION

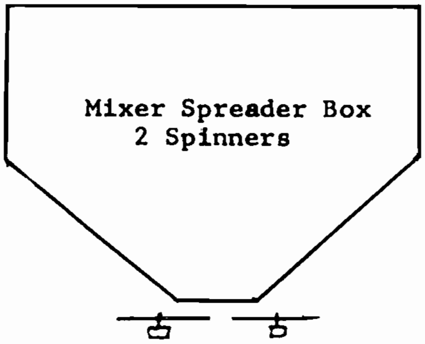
	7	5	3	1	C	2	4	6	8
N.		10.2	8.2	7.7	7.4	7.7	9.3	12.4	
$T.P_2O_5$		8.4	9.9	10.8	10.4	10.1	9.5	9.5	
K_2O		16.6	16.1	15.2	16.7	16.5	17.1	12.2	
Amount Spread in Grams per 4 Ft. of Travel	123	317	414	423	419	425	342	159	30

ANALYSIS OF MATERIALS USED

THEORETICAL ANALYSIS OF MATERIAL SPREAD

N.	7.1
T.P_2O_5	10.8
K_2O	15

380#/acre



INGREDIENTS USED

Amonium Nitrate
20% Superphosphate
Muriate of Potash
(regular or fine)

← 3' →← 3' →← 3' →← 3' →← 3' →← 3' →← 3' →← 3' →← 3' →

	POSITION								
	7	5	3	1	C	2	4	6	8
N.	6.5	14.1	11.1	7.6	7.9	7.4	8.4	12.3	11.8
T.P_2O_5	10.1	10.8	9.9	8.1	7.7	7.3	8.5	10.3	12.7
K_2O	1.0	3.7	10.8	22.1	23.0	24.4	19.3	7.6	2.3
Amount Spread in Grams per 4 Ft. of Travel									
	102	283	427	536	402	410	350	230	139

Chart No. IV

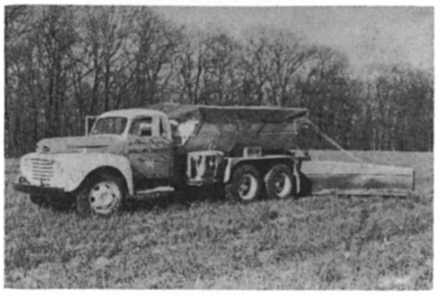
Chart No. V

CHEMICAL ANALYSIS RELATED TO PARTICLE SIZE

MESH	%	N.	T.P_2O_5	K_2O
TEST NO. I - 10-20-20 GRANULAR				
+10	50.3	10.1	22.58	18.73
-10 + 20	39.7	7.59	16.44	25.81
-20	10.0	8.48	20.50	16.33
Analysis before separation		9.31	20.58	20.17
TEST NO. II - 8-16-16 GRANULATED (NOT SIZED)				
+10	33.8	7.36	15.61	16.49
-10 + 20	27.3	7.48	14.42	20.14
-20	38.9	8.32	18.74	7.53
Analysis before separation		7.78	16.51	14.05
TEST NO. III - 8-16-16 SEMI-GRANULAR				
+10	39.4	10.27	26.56	10.73
-10 + 20	23.6	7.53	15.62	31.21
-20	37.0	7.22	15.69	5.98
Analysis before separation		8.63	17.62	13.90
TEST NO. IV. - 8-16-16 BLEND				
+ 10	63.5	4.83	14.81	29.49
-10 + 20	32.1	13.59	15.73	2.26
-20	4.4	15.30	5.66	3.24
Analysis before separation		8.10	13.91	20.39

Chart No. V

Several samples were taken from the bag of each type of fertilizer and the average chemical analysis is shown at the bottom of each type. The samples were run through a sieve test and the percent of prdouct + 10, −10 + 20, and −20 mesh are shown for each type. A chemical analysis is also shown for each class of particle size.



Slide No. 1

Slide No. 1 shows the truck actually spreading a granular fertilizer and the manner in which the samples were collected. Seven 2′ x 2′ square pans covered with ½″ mesh nylon fish netting were set out at 8′ intervals on a line perpendicular to the truck travel. The spreader straddled the center pan as it traveled across this line at a normal spreading speed. The figures on all of the charts are the result of one pass of the spreader coverning a width of 50 ft.

Slide No. 1A

Slide No. 2 shows a test tube comparison of the samples collected from each of the seven pans. The center test tube marked "C" is the sample from the center pan which the spreader straddled. The increase in particle size as one moves away from the center of the spread can be noticed in the test tubes. The red bands on the test tubes represent an approximate 400 lb/acre rate.

Chart No. VI

Chart No. VI shows the chemical analysis of the sample taken at each of seven locations for each type of fertilizer.

- Test No. 1: *Granular*—analysis for N, $T.P_2O_5$ and K_2O all remain nearly uniform.
- Test No. II—*Granular (not sized)* —analysis of N and $T.P_2O_5$ remain nearly as uniform as Test No. 1 but the K_2O starts to vary appreciably.
- Test No. III—*Semi-Granular* — analysis of N shows some greater variation than the preceeding tests while both $T.P_2O_5$ and K_2O show an alarming increase in variation.

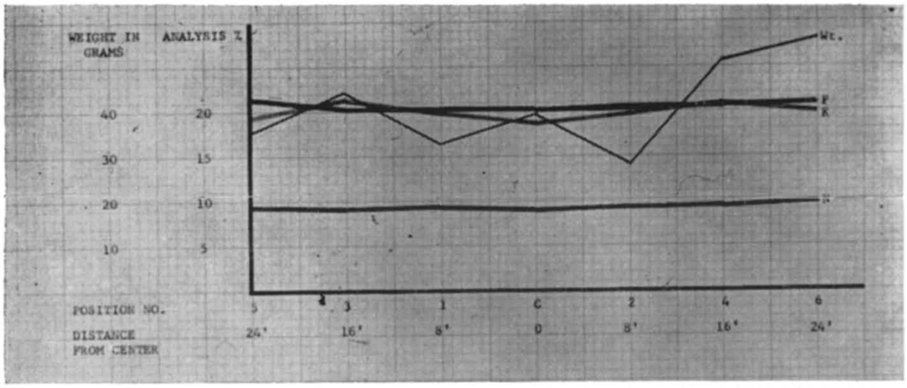
Chart No. VI

CHEMICAL ANALYSES OF SPREADING PATTERN USING 1-2-2 RATIO FERTILIZER MANUFACTURED BY FOUR VARIOUS PROCESSES

	POSITION						
	5	3	1	C	2	4	6
TEST NO. I - 10-20-20 GRANULAR							
N.	9.55	9.25	9.28	9.04	9.08	9.23	9.58
$T.P_2O_5$	21.54	20.49	20.59	20.11	20.35	20.51	20.91
K_2O	19.21	21.10	20.02	18.56	19.78	20.69	20.00
TEST NO. II - 8-16-16 GRANULATED (NOT SIZED)							
N.	7.27	7.44	7.89	7.70	7.93	7.40	7.15
$T.P_2O_5$	15.20	15.62	17.55	16.80	17.68	15.43	15.19
K_2O	17.34	17.61	10.69	11.63	11.75	18.52	16.93
TEST NO. III - 8-16-16 SEMI-GRANULAR							
N.	9.89	8.67	7.98	7.77	7.84	8.70	10.85
$T.P_2O_5$	26.81	15.15	16.23	16.81	15.53	14.89	27.84
K_2O	9.05	22.20	11.08	9.66	12.08	22.18	8.36
TEST NO. IV - 8-16-16 BLEND							
N.	5.04	9.12	9.93	9.14	10.22	9.47	5.05
$T.P_2O_5$	13.23	12.55	12.65	14.05	12.09	11.86	12.64
K_2O	28.61	19.03	16.23	16.49	16.25	17.56	23.90

Graph No. 1

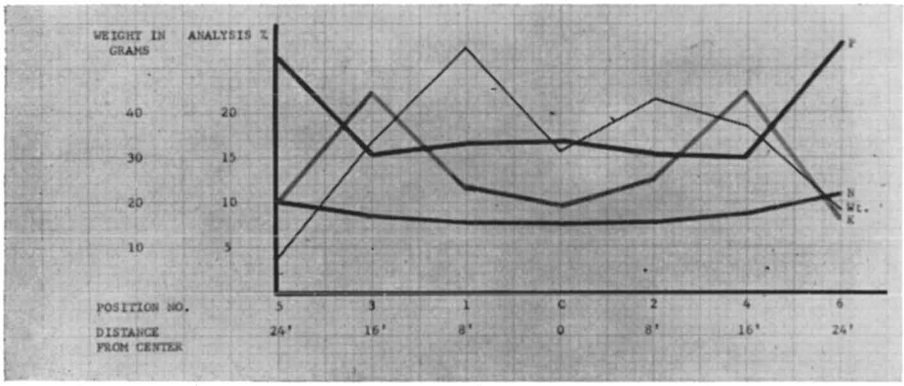
SPREADING PATTERN No. 1 — 10-20-20 GRANULAR



	N.	$T.P_2O_5$	K_2O	SCREEN ANALYSIS	
Average Chemical				+ 6	2.8
Average Chemical				— 6+10	47.5
Analysis of Product	9.31	20.58	20.17	—10+16	33.3
				—16+20	6.4
Weighted Average				—20+28	6.4
Analysis of Spread	9.31	20.58	19.95	—28+60	3.3
				—60	.3

Graph No. 2

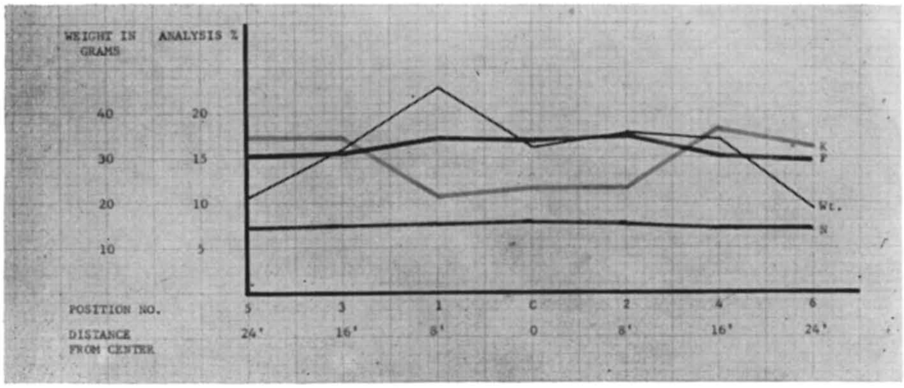
SPREADING PATTERN No. 2 — 8-16-16 GRANULAR — MILL SIZED



	N.	$T.P_2O_5$	K_2O	SCREEN ANALYSIS	
				+ 6	7.6
Average Chemical				— 6+10	26.2
Analysis of Product	7.78	16.51	14.05	—10+16	21.6
				—16+20	5.7
Weighted Average				—20+28	8.4
Analysis of Spread	7.61	16.43	14.46	—28+60	21.2
				—60	9.3

Graph No. 3

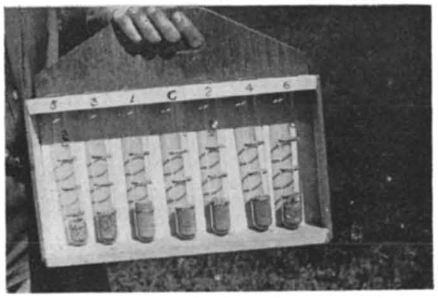
SPREADING PATTERN No. 111 — 8-16-16 SEMI-GRANULAR



	N.	$T.P_2O_5$	K_2O	SCREEN ANALYSIS	
				+ 6	3.1
Average Chemical				— 6+10	36.3
Analysis of Product	8.63	17.62	13.90	—10+16	18.9
				—16+20	4.5
Weighted Average				—20+28	5.1
Analysis of Spread	8.42	17.06	14.18	—28+60	13.6
				—60	18.5

Test No. IV—*Bulk Blend*—our analysis of N showed the widest variation of any of the tests. $T.P_2O_5$ shows considerable less variation than Test No. III, but more than either Test I or Test II. Variations in K_2O were less than Test No. III, about equal to Test No. II, and far greater than in Test No. I.

If we refer back to Chart V, we notice that 63.5% of the bulk blend product was +10 mesh with a very low N and very high K_2O anslysis. This analysis is almost identical to the material spread at the edges of the spreading pattern.



Silde No. 2

Graphs I, II, III and IV

The N, $T.P_2O_5$ and K_2O of each of the four tests are represented by colored lines. The actual weight of material spread is represented by the finer black line.

In Test No. I, all of the colored lines are very straight; in Test No. II, the red K_2O line becomes quite variable; in Test No. III, both the red K_2O line and the brown $T.P_2O_5$ line show a high degree of variation. In Test No. IV, all of the lines show considerable variation.

Chart No. VII shows a summary of variations due to segregation of materials of the four types of fertilizer spread, expressed in percentage of average product analysis.

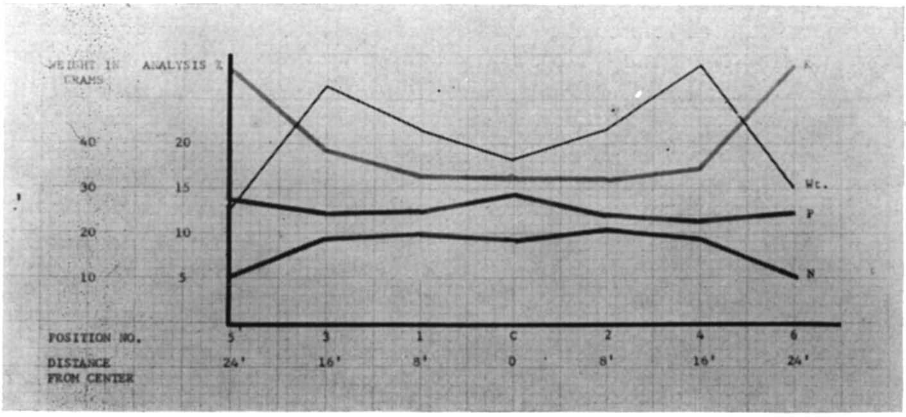
Conclusions

It should be again pointed out that a few good spreader operators could have adjusted this machine to each individual type of fertilizer and have done a somewhat better job. For experimental purposes, we wanted to spread them all under the same conditions.

Under today's conditions, it appears certain that the custom

Graph No. 4

SPREADING PATTERN No. IV — 8-16-16 GRANULAR INGREDIENTS



	N.	T.P_2O_5	K_2O	SCREEN ANALYSIS	
				+ 6	.7
				6+10	62.8
Average Chemical Analysis of Product	8.10	13.91	20.39	—10+16	28.9
				—16+20	3.2
				—20+28	2.6
Weighted Average Analysis of Spread	8.70	12.62	19.47	—28+60	1.3
				—60	

spreader operator will do a more uniform job of distribution of plant food if he spreads either powdered fertilizer under the hoods or a granulated fertilizer that has been screened (no hoods required). Certainly none of us would like to go back to the other problems inherent with powdered fertilizer and hoods.

I believe it is possible that at some time in the future we may have fertilizer ingredients that are sized to where they are compatible in a spreading mixture. For spreading purposes, it does not appear that all fertilizer particles will have to be of the same exact size, but rather, the range of sizes in each ingredient should be compatible with the range in size of the other ingredients with which it is mixed. We need an end product which, when separated into two or three screen sizes will have a similar analysis of each screen size.

MR. HARDESTY: The program says "Summary," but I think these presentations have been excellent and I don't think they need a summary. Gentlemen, we thank you. We will dispense with the summary.

The preceding speakers have shown that one of the properties that the technologists call an attribute of the product is the distribution of particle size in the product that will foster uniform sampling, and uniform application of fertilizer to the crop. The farmer benefits by the use of a uniform product. The spreader manufacturer needs such a product in order to build a machine that will distribute granular fertilizer satisfactorily. The fertilizer analyst needs a standardized particle size and uniform samples in order to fulfill his responsibility of determining the correct analysis of fertilizers.

I think it was U. S. Grant who had a note on his desk that said, "When we're talking, we're not thinking," and the definition for a granular fertilizer that we're talking about needs some real thought to make it work in practice.

I have a box here and this box has samples in it such as those we are talking about in the definition. I am going to pass the box around for you to notice the one on the right hand side which has 10 percent of fines in it. Now, you can't see those fines. Shake the sample case. Now you do. This illustration is just to help you visualize the size of the material that we are talking about in this granulation definition.

If you will notice the samples carefully you will see the type of segregation that George Hoffmeister talked about. Even in these samples that we are passing around, there is some segregation in the particle size range that we are proposing as a definition for a gran-

Chart No. VII

SUMMARY OF VARIATIONS OF CHEMICAL ANALYSIS % OF AVERAGE PRODUCT ANALYSIS

	TEST NO. I		TEST NO. II		TEST NO. III		TEST NO. IV	
	GRANULAR		GRANULATED (NOT SIZED)		SEMI-GRANULAR		BLEND	
	Low	High	Low	High	Low	High	Low	High
N.	97.1	102.9	94.0	104.2	92.3	118.8	57.9	117.4
T.P_2O_5	97.7	104.6	92.5	107.6	87.3	163.2	94.0	111.3
K_2O	90.0	104.6	73.9	128.1	68.1	156.6	83.6	148.4

ular fertilizer. I think George's demonstration shows that you can get segregation even in very closely sized materials. Sizes even closer than 6 to 20 mesh that we are advocating here, but we must have some sort of a practical distribution of granule size if we are going to produce a granular fertilizer economically.

In presenting this definition, we are thinking about performance of the product rather than conformance to any set of standards or any particular set of specifications. In other words, I want to emphasize, we are thinking about performance of the product instead of conformance to a definition.

In our discussion period I would like to hear some comments from you on whether you think this definition refers to the particle size of fertilizer materials that we all think about when we say granular fertilizers. We would like to have some discussion on it.

MR. SAUCHELLI: Thank you John and your panel. I certainly want to commend the members of this panel for the excellent job they have done in presenting their various segments to us. It represents a lot of hard work and very good thinking, and, as I said previously, I believe that this is the pattern for our future sessions; that is, have one subject thoroughly discussed and give us some time for discussion.

As to definitions, it's good to talk about them, but it isn't the policy of the Round Table to record its thought on matters of this kind. We had something on standardization of particle size last year from the consumer's viewpoint and the producer's viewpoint. We have been told that many of the producers believe that the market places will decide on the best particle size and the best definition, but I think it's all right to think about it, but I don't think we can take any official action. The Round Table doesn't do that.

We do have here an opportunity now to throw some questions at the panel speakers. Even though they have done a very good and thorough job of coverage, there may be some points in your minds that might require clarification, so let's get in to this question and answer period.

Who has the first question or any comment with reference to the discussions of the panel- Here's a question: Mr. Hugh Grayson of Australia: This has been an interesting one for me because in Australia, in our particular state, something like 60 per cent of our total output goes on pastures through spinner distributors. Earlier in the session Mr. Hoffmeister showed us, I think quite clearly, what happens in the case of different size particles as far as segregation in a hopper is concerned. The gentleman who talked about the spreaders, and I must say we have done a lot of work ourselves going back to about 1930 on performance of spinner distributors, has given quite a good coverage of what you can do about the design of a spinner. The thought that I have and the question I wanted to ask was: have they given any thought to methods of overcoming the segregation which actually occurs in the hopper preceding the spinner? In other words, you can design a spinner to spread about any product but you have segregation occurring within the hopper of the spinner truck, and any design that you have can only be matched to one size of granular, not to the range of sizes occurring and coming out of the hopper truck. I know some work has been done on that, some spinners have been designed, and some trucks have been designed to overcome this segregation problem within the hopper of the spreader truck. I just wondered what these gentlemen think of it.

CHARIMAN SAUCHELLI: Do you direct that to any particular person? Maybe Mr. Maxwell who has had experience with this, or Mr. Gaskins.

MR. MAXWELL: We haven't done any particular work on design of a hopper with this in mind. We have thought that the segregation in the hopper occurs more in the manner of filling the hopper. We probably have relatively short hauls as compared with some other sections of the world. We felt that the problems of segregation in spinners themselves was much greater and needed attention more than the segregation that occurs en route. We tried to correct it at the time of loading and at the time of spreading, figuring that those were the two major problems. If we had all the answers to those, maybe we'd be spending more time on what happened en route. Our average haul is relatively short.

MR. GRAYSON: I'm sorry. I should have qualified that. The thought was going through my mind here that Mr. Hoffmeister showed when a hopper empties the fine material, which is in the center of the hopper, runs out first, the coarse material, which is over to the sides of the hopper, comes out last. This is the thought that I had.

CHAIRMAN SAUCHELLI: Any further questions on this? Cecil Russell, Monsanto. Dr. Cunningham of VPI recommends keeping the load leveled off to prevent the segregation in the hopper of the truck.

CHAIRMAN SAUCHELLI: Mr. Russell said keep the load level and uniform.

MR. RUSSELL: He referred to Dr. Cunningham, VPI, who has done some very interesting research on this whole problem.

MR. GASKINS: Dr. Sauchelli, I know that they do use hoses to distribute the material in the trucks, instead of letting it cone in the middle, to spread it out and keep it level.

CHAIRMAN SAUCHELLI: Any other comments? Anyone want to comment on this or any part of this whole subject?

DR. L. J. PIRCON: We conducted some work on this in the laboratory as well as in the field. We built a pilot-sized model of a truck which had geometric similitude; in other words, it was built to scale and we used transparent walls on it. We used fluorescent particles in order to observe the trajectory of these particles with that vibration that you actually have in the hopper in the transport.

We also studied this effect of draining of the material onto the conveyor prior to getting to the spinner and there are many factors involved, but the principal factors that we observed correlated with the motion and the type of particular motion during the laboratory movement imposed was the same as that which occurs under static conditions when you are piling or when you are getting this coning effect. We did find that the greatest single factor was during the loading especially if you did cone load. We used an elephant nose and imposed a motion on it such that you would get in loading which would give you uniform surface. Under those conditions, of course, you got minimum segregation. Even the type of wall that you use in that truck body has a very definite effect on the extent of segregation that will occur, and, of course, the volume of the material with respect to the size of the truck —in other words, what I am saying is that if you have a lot of surface area as compared to the total volume, this is also a factor. In other words, if you have a big truck with a lot of volume, small surface area, then it becomes less distinguishing.

Using chemical engineering principles, we developed relationships the same as the fellows yesterday that were talking about particles falling out of moving air in dust collecting systems where you have Stokes relationships. In other words, you have gravitational force pulling down and a frictional drag opposing it. You also have these types of opposing forces to the motion of the particle within the bed.

We found that when we correlated these, when we developed these relationships, we could predict fairly accurately what would happen on loading into a pile and what would happen in transport in the vibration.

We measured the types and the amplitude, the type of vibration in the field, and then we reproduced this in our laboratory because we had to run something over 200 truckloads over varying distances anywhere from 5 to 25 mile hauls.

This kind of research gives you a background on this, but essentially what it boils down to is that if you correlate this friction factor for each of the individual ingredients and equate that particular physical property, then something like 94 out of a hundred truckloads would not segregate to an extent exceeding five-tenths of a unit of each of the plant food nutrients. But if you just took a random material, as supplied presently, this in transit segregation could occur as much as 56 out of a hundred truckloads segregating to the extent where you could have difficulty in excess of the restricted variances allowed.

Does this pretty much answer the question?

CHAIRMAN SAUCHELLI: Tell us, Doctor, where is the data you have accumulated which I understand is very interesting and very important. When is it to be published?

DR. PIRCON: We're preparing the manuscript presently and, of course, we're discussing with various people as to the best publication to release in.

CHAIRMAN SAUCHELLI: You haven't decided yet on which publication?

DR. PIRCON: No.

DR. PIRCON: Oh, one thing more that might be of interest to you. We noticed as these particles would move within the truck body it was almost as if you had water which was churning and followed a very definite pattern, and, in fact, when you would stop the truck you could notice the effect of these ripples on the surface of that truck load, so it's not just a matter of the particle itself, that is, its relative motion to the other particles, but it's a matter of associated motion as well.

CHAIRMAN SAUCHELLI: Mr. Maxwell, when we were doing this in 1940, we didn't anticipate all these particular complexities and so on, so life gets more complicated as we get along. Any other comments?

MR. HARDESTY: I think here today we have recognized the probleb but I think there is a school of thought that says, well, now, just what does this non-uniform distribution mean to the growing plant?

If you have a 10-1010 fertilizer, is it just as well that you put on an 8-10-12 in one part of a field and a 12-10-8 in another part of the field and expect that the difference in the crop response will even out and that it doesn't make any difference if you get non-uniform distribution? I think there is a school of thought like that. We don't know the answer and I think our agronomy has not given us a definite answer as to just how far you can have segregation and still have good response to the fertilizer.

I have a copy of a reprint here entitled "Inefficiency of Fertilizer Use Resulting From Non-uniform Special Distribution" written by Don Jensen and John Pestk of the Iowa State Experiment Station published in "Soil Science Society of American Proceedings" 26, pages 170-192 (1962) and I wonder if either of those folks are here. (No Response). The gist of that publication, as I understand it, is that there is a definite poor crop response to the fertilizer if you get a difference in distribution of nutrients such as I mentioned; that is, an 8-10-12 or a 12-10-8 on the land. That's the point of the problem. Do these differences in spacial distribution even out or is there actually a poor crop response?

CHAIRMAN SAUCHELLI: Missouri and Illinois and others have made quite a number of agronomic studies. I think that it is important. The farmers apparently are satisfied that they are getting fairly good returns in harvests, but I don't think that we can be satisfied with just partial knowledge. I think these studies should go on and it is remarkable what has happened within the last three or four years in the way of intensified research into this problem of dry mixtures, call them bulk blends, if you will, and their influence on crops. I think we will have to proceed with our program. I remember what Gus said. I am sorry, Gus, but we will have to go on.

I want to thank again John Hardesty and his panel for their fine preparation.

The next subject is very intriguing. It just shows what ingenuity will do in trying to meet these problems. We have on our program a discussion on blending equipment to be presented by Oliver Haley of Continental Sales Company. Mr. Haley asked H. E. "Cotton" Graham, Jr. to discuss this paper.

Blending Equipment

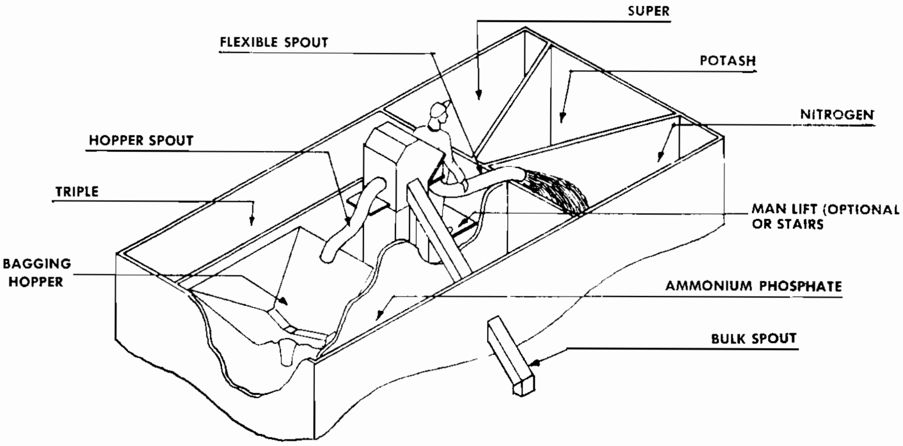
Herbert E. Graham, Jr.

MR. Oliver Haley, President of our Company made a dream come true. He developed a fertilizer mixer which mixes and meters dry raw material to a com-

Slide No. 1

CONTINENTAL FERTILIZER COMPANY, Nevada, Iowa, Oliver Haley, Pres. This HOME BLEND-O-MIXER PLANT has 30° SLOPING FLOORS & AIRTIGHT BINS 26 feet tall. All five storage bins comfortably HOLDS TWO CARLOADS EACH. Four 15 TON HOLDING BINS serve multi-purposes, as does the huge MULTI-PURPOSE LEAN-TO shelter.

Cut-a-way view of top of factory



Slide No. 3

plete analysis on a continuous process at the rate of 20 tons per hour.

After perfecting the Blend-O-Mixer a building was designed to feed the mixer by gravity or a vibration system. This building has 5 bins with total holding capacity of 400 to 1000 tons.

For unloading the under-track systems are used. A water proof concrete trough houses either auger, conveyor belt or vibrator. For charging the bins either steel or wood elevator legs are used. Capacities 30 to 70 tons per hour.

For bulk loading a direct spout to the truck or from 4 fifteen ton holding bins are used.

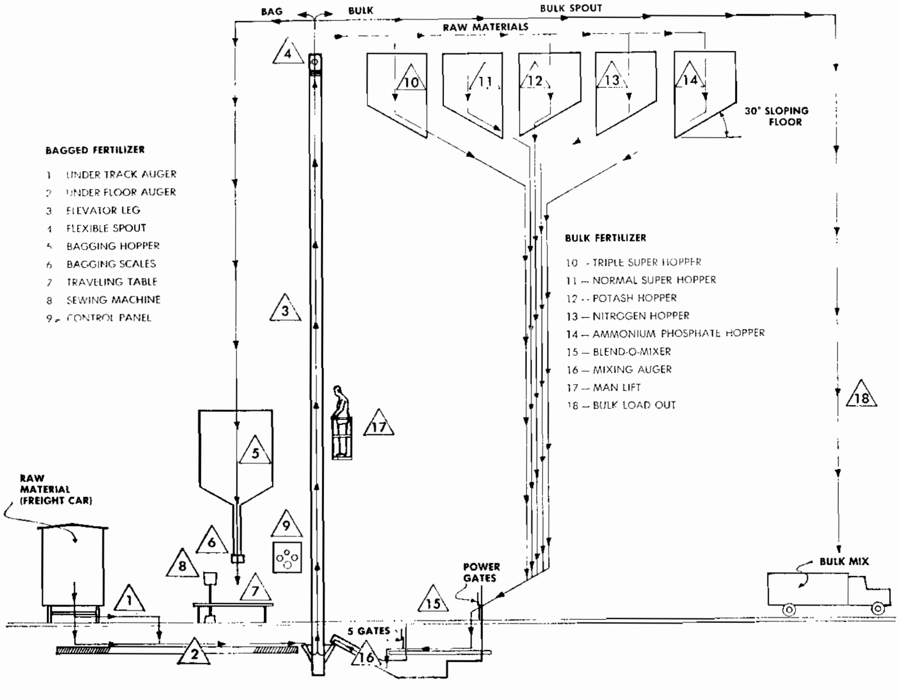
For bagging semi-automatic scales with sewing machine and traveling table direct to the trucks or bag warehouse is being used.

Platform scales, office building, bulk holding hoppers, bag warehouse, automatic control systems, insecticide attachment, trace mineral bins and meters are all offered as optional's.

This compact plant is flexible enough to meet the demands in any area large or small.

Slide No. 2

Flow Diagram of Blend-O-Mixer Factory



Continental "Blend-O-Mixer" Plants are now operating in 24 States with tremendous results.

I am General Sales Manager of Continental Sales and Fertilizer Company.

Slides:

1—Continental Fertilizer Co. operation. Nevada, Iowa.

2—Flow Diagram—Blend-O-Mixer Factory

3—Cut-a-way view of Top of Factory.

CHAIRMAN SAUCHELLI: Thank you, Mr. Graham.

We want to continue. I assume from what Mr. Graham said that most of you fellows have already seen the little model up in their room. We simply have to get along with our program and we will have to dispense with any questions at this time.

The last paper this morning — "Experience with Blending Equipment" will be discussed by Warren Upton of Upton-Rich Company.

Actual Experience Bulk Blending Operation

Warren Upton

MR. Chairman, Fellow Members of the Round Table.

Thanks for the opportunity to address this Round Table. I hope that our short experience in Blending, in the North East, will help to acquaint you with some of our problems, which are really the same problems we have found in this industry for many years, viz: sales, credits, labor, seasonal peaks and pricing.

The difference between the "Blender" and other plant food manufacturers are: (1) More local in scope. Blenders are mainly local and this makes some of our operations easier for sales, traffic and credits. It also makes our business more hazardous. Crop failure over the local area can hurt us more than if our business was spread out over wider areas and markets. Our own market is within 20 miles of our blending plant. I think this is about as far as one can operate, depending on his area, of course, and the concentration of crops. (2) More personal service to growers. By this I mean that we rarely spend more than a day or two without seeing most of our important customers. This means we are easily available for agronomic help, quick delivery, and all business is purely personal contacts. I think I would have to agree that Blenders are actually like large dealers, but that our knowledge and agricultural background must be as well rounded as that of any manufacturer, perhaps more so, because we must live and prosper locally and cannot afford a mistake.

Some things are very necessary for the Blender, as indeed, all other of our business people. He has yet to earn his reputation and the confidence of his customers. Efficient operation, good physical structure of his product and adequate financing is most important.

Our principal problem in blending is the sizing of our raw materials.

To get into a discussion of our own experience, perhaps, I can give you a resume of my own Industry experience and a discription of our facilities and our market. Then, if anyone has any question at any time, please wave your hand and I will try to answer.

I have a farm background, chemical and ag-education, two years in pesticide business and 23 years in the Pesticide and Fertilizer sales and agronomic work. Our plant is a Continental Blend-O-Mixer. We own a 15,000 square foot warehouse for finished product storage, loading and bagging area. We are located in Savannah, N. Y.

We use our products on all types of crops except citrus fruits, cotton, rice and tobacco.

Materials used in our plant are: 18-46-0, 0-46-0, 0-20-0, 0-0-60, 21-0-0, 45-0-0 (some) and 33.5-0-0 (some). We make special mixes with Copper sulfate, Borax, Magnesium, Mingareal and Sulfur.

The services we offer are soil analysis (through the State), Bulk delivery and spreading, special mixes at any time and very fast and efficient loading.

The aids we have are technical services from suppliers and their knowledge and cooperation and the Agricultural services and advice from our State College people and extension men.

CHAIRMAN SAUCHELLI: Thank you, Mr. Upton.

We have time for a few questions. I am not going to hold you too long. I know you are getting restless, but if there are any questions here relating to any part of this morning's program, we would be glad to entertain them now.

Does anybody have anything to say for the good of the Order?

(No response).

We certainly have had a grand meeting here, bigger and better, and we look forward to seeing you all next year.

We stand adjourned. Thank you all.

(Applause.)

(The Round Table adjourned at twelve-fifteen o'clock p.m.)

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