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MARKETING ADVANTAGES OF USING  
SOLID MATERIALS IN SUSPENSIONS

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## MARKETING ADVANTAGES OF USING SOLID MATERIALS IN SUSPENSIONS

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### Introduction

The advantages of fluid fertilizer are well known - ease of handling, uniformity of application, the ability to mix and apply pesticides uniformly, etc. Until the advent of suspension fertilizer, fluids were at a considerable disadvantage to solids because of their low analysis and high raw material costs. The fluid mixer not only had to pay high prices for raw materials, but also for equipment and labor to transport large quantities of water to the farmer's field.

The high cost of transportation and application from the mixer to the farmer has been reduced by suspensions. However, in many cases the cost of materials for suspensions has increased because of the high freight charges on dilute materials such as aqua ammonia, suspension base, urea-ammonium nitrate solution, and phosphoric acid. Rates on phosphate fertilizer solution shipped from the TVA plant at Sheffield, Alabama, (table 1) have increased up to 64 percent in the last 3 years. Fertilizers moved under favored freight rates until 1974, but these are now discontinued, and fertilizers now move at the same rates as other commercial products. In addition, liquids are charged a premium over solids.

Because of the rapid increase in freight rates, savings in using solid materials in fluid fertilizer production are becoming substantial. Also, solid ammonium phosphate bases can be purchased at prices lower than fluid ammonium phosphate bases because the solids can be manufactured from low-grade phosphoric acid. Equipment for handling solids efficiently is available and most fluid mixers are familiar with handling at least one solid, potash. The conversion to handling one or two more solids is usually not difficult if savings in material costs justify the extra expense.

Monoammonium Phosphate (MAP)

Monoammonium phosphate is the most common solid material (other than attapulgite clay and potash) used in production of suspension fertilizers. A good supply of MAP and attractive delivered prices are responsible for increasing use of this product in United States suspension plants.

Grades of suspensions which can be made from monoammonium phosphate vary with the purity of the acid from which the MAP is produced. An 11-33-0 grade base can be produced from monoammonium phosphate made from relatively pure wet-process acid. However, some MAP is produced from low-grade acids not suitable for any other product and suspensions made from such material may be limited to grades as low as 8-24-0.

Adequate agitation is required in suspending the powdered MAP or to reduce and suspend the granulated product. Also, aqua or anhydrous ammonia must be added to ammoniate the phosphate to the  $N/P_2O_5$  ratio of 0.333. This can be a problem in some locations where the storage of ammonia is not permitted. The solubility of ammonium phosphates at various  $N/P_2O_5$  ratios is shown in figure 1. The eutectic point for ammonium orthophosphates is at the  $N/P_2O_5$  ratio of 0.307. However, tests at TVA show that the 0.333 ratio produces a superior suspension because the impurities do not gel as badly at that ratio. A typical plant for the production of suspensions from monoammonium phosphate is shown in figure 2.

TVA Ammonium Polyphosphate (APP), 12-54-0

TVA is producing a granular ammonium polyphosphate product (12-54-0) by ammoniating merchant-grade, wet-process phosphoric acid in a pipe reactor. The melt from the reactor is granulated in a pugmill and the product contains

15-30 percent of polyphosphate. A satisfactory 11-33-0 suspension which will store for about 3 months can be made from this material by using equipment and techniques similar to those used to produce suspensions from monoammonium phosphate. Usually less agitation is required than with monoammonium phosphate because the polyphosphate in the 12-54-0 goes quickly into solution, resulting in disintegration of the pellets and suspension of the residue. Also, the polyphosphates in the 12-54-0 sequester part of the impurities and keep them in solution.

Because it will store, the 11-33-0 suspension can be produced during slack periods and stored until it is needed to produce final grades. A typical formula for 11-33-0 is shown in table 2 and several grades which can be mixed by using it as a base are shown in table 3.

#### Diammonium Phosphate (DAP), 18-46-0

Suspensions can be made from granular diammonium phosphate. Procedures and equipment are similar to those used for monoammonium phosphate and 12-54-0. Phosphoric acid and some ammonia are usually added to produce heat and liquid phase to break down the granules and to adjust the  $N/P_{2O_5}$  ratio to 0.333. A list of grades and formulas for making these grades from 18-46-0 and wet-process acid are shown in table 4. The  $N/P_{2O_5}$  ratio of 0.333 is chosen for diammonium phosphate suspensions for the same reason it was chosen for the monoammonium phosphate and 12-54-0 suspensions.

#### Mixtures of Monoammonium Phosphate and Diammonium Phosphate

If a suspension is made by obtaining one-half of the  $P_{2O_5}$  from the usual grades of monoammonium phosphate and one-half from diammonium phosphate (18-46-0), a mixture will result with an  $N/P_{2O_5}$  ratio very near the eutectic point for ammonium orthophosphates ( $N/P_{2O_5}$  ratio 0.286). When

the two are mixed, some heat of reaction will be developed and if sufficient agitation is available, a satisfactory suspension can be made. It has been reported in the literature that a satisfactory 12-12-12 suspension can be made using these materials. However, it is difficult and only small batches should be produced until the technique has been mastered.

#### Diammonium Phosphate and 12-54-0

Suspensions similar to those made by mixing diammonium phosphate and monoammonium phosphate have been prepared from diammonium phosphate and TVA 12-54-0 on a small scale. It appears that a satisfactory suspension can be made by mixing these two materials, when agitation is adequate. The polyphosphate in 12-54-0 helps to produce a good suspension by sequestering part of the impurities from the wet acid used to manufacture the two solids.

#### Solid Urea

As the supply of urea increases, it is likely that its delivered price will become competitive with urea-ammonium nitrate solution and its use as a supplementary nitrogen source in suspension fertilizers will increase. The ammonium nitrate in urea-ammonium nitrate solution reacts with potash in suspension fertilizers to produce potassium nitrate and ammonium chloride. Potassium nitrate is relatively insoluble at ordinary temperatures and its presence in suspensions decreases the weight of salts in solution and increases the weight of solids that must be suspended.

Urea alone usually does not give maximum solubility. In high potash grades maximum solubility is obtained when about 90 percent of the supplementary nitrogen is obtained from urea and 10 percent from ammonium nitrate. This presents the possibility of using combinations of urea and

urea-ammonium nitrate solution as supplementary nitrogen to obtain maximum analysis.

#### TVA Granular Urea-Ammonium Phosphate (UAP)

TVA is producing two grades of urea-ammonium phosphate, 28-28-0 and 35-17-0, on a demonstration scale. The product is made by reacting anhydrous ammonia with wet-process phosphoric acid in a pipe reactor and discharging the resulting melt into a pugmill where urea melt is added. The 28-28-0 grade contains 80 percent of the nitrogen as urea nitrogen and 20 percent as ammonia nitrogen. Twenty to thirty percent of the  $P_2O_5$  is in the polyphosphate form. The 35-17-0 contains 90 percent of the nitrogen as urea nitrogen and 10 percent as ammonia nitrogen, with 20 to 30 percent of the  $P_2O_5$  in the polyphosphate form. Both of these grades produce satisfactory suspension fertilizers. The  $N/P_2O_5$  ratio, however, is the same as that of 12-54-0 and must be ammoniated to the 0.333-N/ $P_2O_5$  ratio in the production of satisfactory suspensions. Grades such as 15-13-13, 20-10-10, 21-7-7, and 16-15-0 have been produced, chiefly from 28-28-0.

#### Use of Solid Materials to Produce Tobacco Suspension Fertilizer

Until recently the requirements for tobacco fertilizer were so stringent that it was difficult for the fluid producer to meet them. For example, the law required a maximum of 2 percent chloride and a minimum of 2 percent MgO. Also, although usually not a legal requirement, most land-grant universities recommended that 50 percent of the nitrogen be in the nitrate form. These were extremely difficult requirements for fluids. They essentially eliminated potassium chloride as a potassium source and the magnesium requirement was especially difficult. Magnesium reacts with phosphate in ammonium phosphates to produce magnesium-ammonium

orthophosphates or magnesium-ammonium pyrophosphates which precipitate from fluid fertilizers, causing difficulty in storage and application. Also, most suspension bases available, such as 10-34-0 or 11-37-0, were already ammoniated to such a degree that, if all of the phosphate was obtained from them, the maximum ammonia-nitrogen requirement would be exceeded.

Recent changes in some state laws have eliminated the magnesium requirement and the nitrate-nitrogen requirement has been modified, although it is still desirable to have as much nitrate-nitrogen as possible. These changes have made it possible for the suspension fertilizer producer to get a portion of the lucrative tobacco market. However, because the low chloride requirement still remains as a state law in tobacco-producing states, some potassium source other than the chloride is required. Usually as much potassium nitrate as possible is used to raise the nitrate-nitrogen to the maximum level. The balance of the  $K_2O$  is usually obtained from potassium sulfate. Some potassium chloride can be used if the 2 percent maximum chloride requirement is not exceeded. Satisfactory suspensions containing about 40 percent of the nitrogen in the nitrate form and less than 2 percent chlorine can be made from these materials, if the solids are finely divided. The usual requirement is the same as that for potash; that is, 100 percent of the solid should pass through a 20-mesh screen and 90 percent through a 35-mesh screen.

#### Calcium Phosphate

A limited amount of calcium phosphate, mostly dicalcium phosphate, is available as a byproduct from industry. Successful non-nitrogen suspensions have been produced from this material. Grades such as 0-14-0, 0-11-11, 0-9-18, and 0-6-29 have been produced from the byproduct calcium phosphate

and orthophosphoric acid. Further work with calcium phosphate is needed to give the fluid fertilizer producer an opportunity to participate in the fertilizer market for crops which do not require nitrogen.

### Red Potash

Potassium chloride is the most familiar potassium solid used in the production of suspension fertilizers. All suspension plants, except satellite-type plants, use solid potash. Most familiar is liquid-grade white potash manufactured to specifications especially suited to the production of fluid fertilizers. Fine grades of red potash have been used at times; however, some problems have been encountered. The impurities in red potash tend to form gels which thicken the fluid and usually the ratio produced must be at least one grade lower than can be made with liquid-grade white potash. Red potash is 2 to 2-1/2 percent lower in plant food than white potash. It must be remembered that a grade made from red potash will contain 2 to 2-1/2 percent more solid and 2 to 2-1/2 percent less water than the same grade made with white potash. If this is not considered, thick mixes result which set up in application equipment and storage tanks.

### Micronutrients

Generally, solid micronutrient sources are more economical than the liquid or chelated sources. However, there are a large number of solid sources containing varying amounts and kinds of impurities available. Reactions sometimes occur between the micronutrient source and other materials which are not easily predicted, especially if more than one micronutrient is added. Solid micronutrient materials and their use in

suspension fertilizer have been well documented and need not be covered in detail. However, care should be taken in selection of the micronutrient material.

### Conclusion

Unless the trend to higher freight rates is reversed (which is unlikely), it is going to become more expensive to ship water and the savings in using solids to produce suspensions will increase. This should accelerate the shift from fluid materials to solids, especially at plants distant from the basic supplier. Equipment capable of producing suspensions from solids has been developed. At this date few plants are equipped for handling solids, but the savings are so great that many operators are considering redesigning their plants and installing equipment for handling solids.

The suspension fertilizer plant of the future may resemble a bulk blend plant with bins for raw materials and a mix tank instead of a dry mixer.

Table 1

Increases Since April 21, 1971, of Commodities As Shown in  
Various Fertilizer Tariffs

<u>Date</u>	<u>Ex Partee</u>	<u>Increases</u>
4/12/71	X267B	Fertilizer compound - 6%, Sheffield to South 12%, Sheffield to other territories
		Superphosphate - 6%, Sheffield to other territories
		Nitrogen fertilizer solution - 6%, Sheffield to all territories except 3%, Sheffield to South on 100,000 lb minimum shipments
		Urea - 6%, Sheffield to South 12%, Sheffield to other territories
		Phosphatic fertilizer solution - 6%, Sheffield to South 12%, Sheffield to other territories
11/12/72	X281B	Fertilizer compounds) Nitrogen fert. soln.) 3%, Sheffield to South and other Urea ) territories
		Superphosphate ) Phosphate fert.soln.) No increase
8/19/73	X295	All commodities - 3%, Sheffield to all territories
10/1/73	X299	All commodities - 1.9%, Sheffield to all territories All commodities - 2.6%, Sheffield to all territories (Cancels 1.9% effective 1/1/74) All commodities - 2.8%, Sheffield to all territories (Effective 3/16/74. Cancels 2.6%)
1/31/74	X301	All commodities - 2.1% surcharge, Sheffield to all territories 2.5% surcharge (Canceled 2.1% effective 3/9/74) 2.8% surcharge (Canceled 2.5% eff. 4/1/74) 3% surcharge (Canceled 2.8% eff. 5/1/74)
6/5/74	X305	All commodities - 3%, Sheffield to all territories (Canceled 3% surcharge under X301 series)
6/20/74	X305A	All commodities - 3.3% plus 10%, Sheffield to all terri- tories (Canceled 3% under X305)
4/27/75	X310A	All commodities - 7%, Sheffield to all territories
10/11/75	X313	All commodities - 2.5%, Sheffield to all territories
3/21/76	X318	All commodities - 7%, Sheffield to South and East

Table 2

11-33-0 Base Suspension for TVA Ammonium Polyphosphate  
(12-54-0)

<u>Raw Material</u>	<u>Formula A</u> <u>Lbs/Ton Product</u>	<u>Formula B</u> <u>Lbs/Ton Product</u>
Aqua ammonia (20-0-0)	367	-
Anhydrous ammonia (82.25-0-0)	-	90
Ammonium polyphosphate (12-54-0)	1222	1222
Water	381	658
Clay	30	30

Table 3

Popular Grades Made from 11-33-0 Base Suspension

<u>Grade</u>	<u>4-12-24</u> <u>Lbs/Ton Product</u>	<u>6-18-18</u> <u>Lbs/Ton Product</u>	<u>13-13-13</u> <u>Lbs/Ton Product</u>	<u>16-8-16</u> <u>Lbs/Ton Product</u>
<u>Raw Material</u>				
11-33-0 base suspension	728	1091	788	485
Urea-ammonium nitrate solution (32-0-0)	-	-	542	834
Potash (0-0-62)	775	581	420	517
Clay*	20	14	19	23
Water	477	314	231	141

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\* Amount of clay added must be adjusted to suit situation (for storage, for direct application, low ambient temperature, etc.)

Table 4

Formulations With Diammonium Phosphate, Phosphoric Acid,  
Ammonia, Urea-Ammonium Nitrate Solution, and Potash

<u>Material</u>	<u>18-6-6</u>	<u>16-8-8</u>	<u>12-12-12</u>	<u>8-16-16</u>	<u>6-18-18</u>	<u>8-24-8</u>
	<u>Lbs/Ton Product</u>					
Ammonia	9	11	16	21	26	35
DAP (18-46-0)	183	243	365	487	548	730
Phosphoric Acid (54% P <sub>2</sub> O <sub>5</sub> )	67	89	133	178	200	267
UAN (32% N)	1000	834	503	172	-	-
Potash (62% K <sub>2</sub> O)	194	258	387	516	581	258
Clay	40	40	40	40	40	40
Water	507	525	556	586	605	670

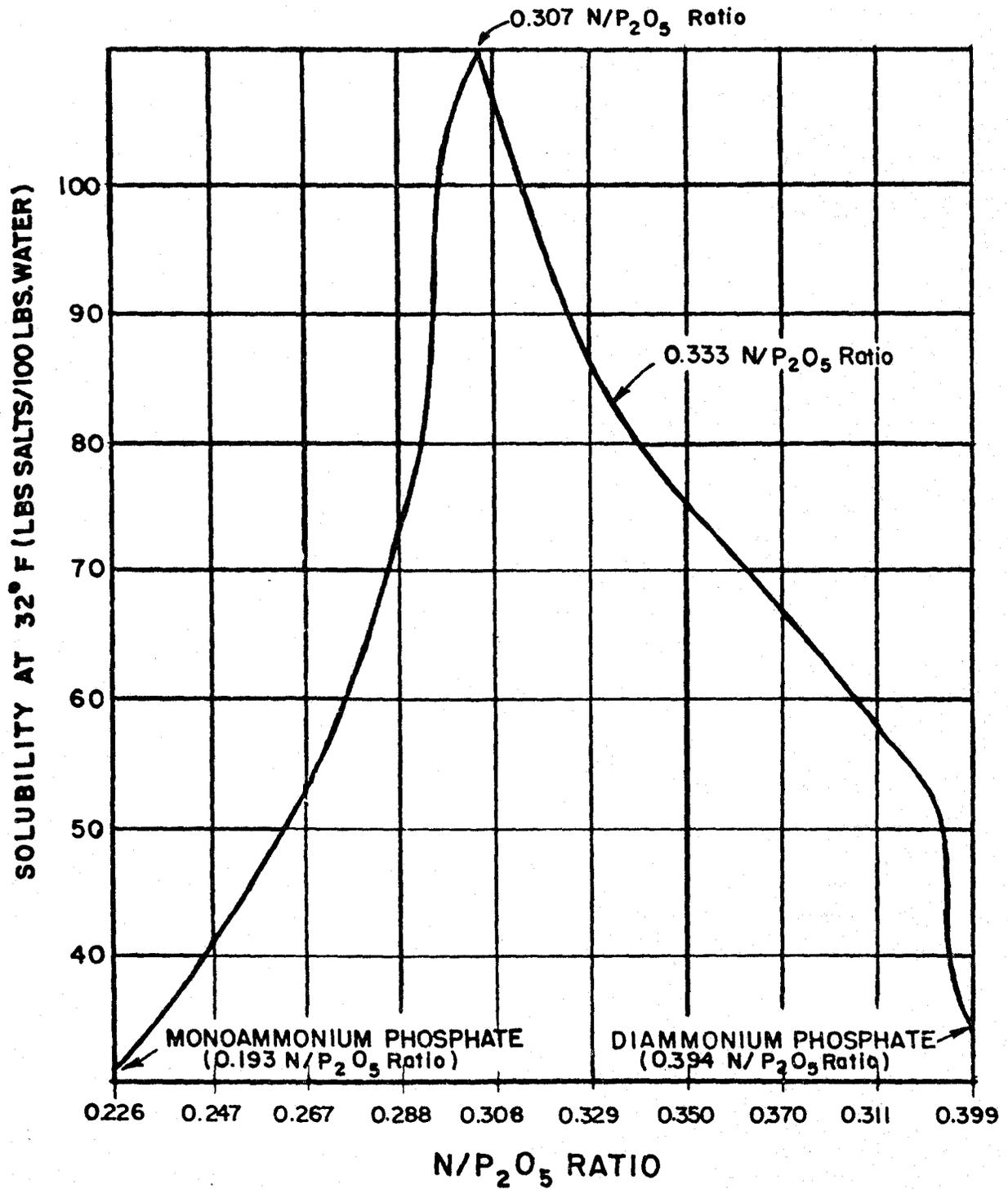


FIGURE I  
 SOLUBILITY OF SATURATED AMMONIUM  
 PHOSPHATE SOLUTION

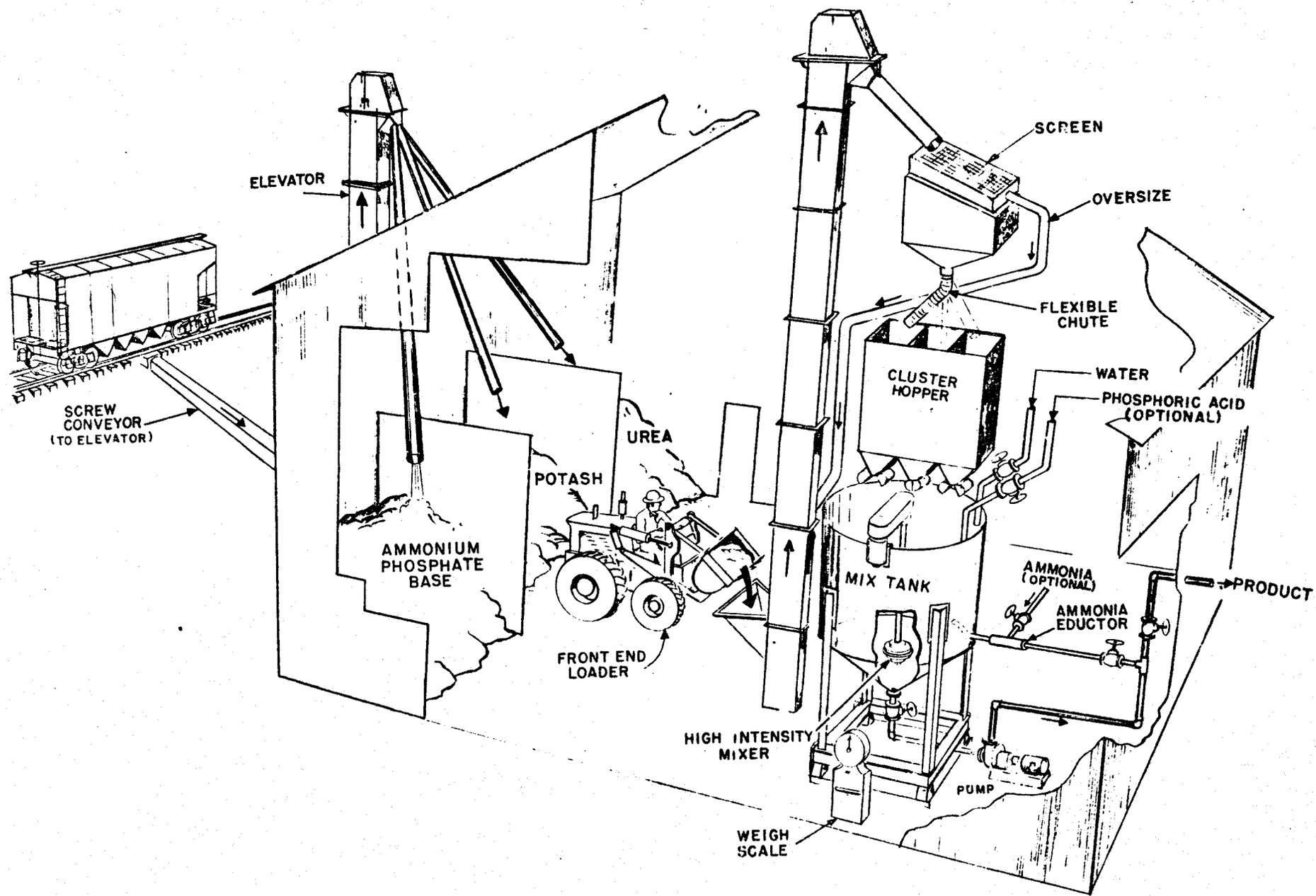


FIGURE 2

TYPICAL PLANT FOR PRODUCTION OF SUSPENSIONS FROM SOLIDS