Fluid Fertilizers: Properties and Characteristics

Dale F. Leikam

Fluid Fertilizer Foundation
www.FluidFertilizer.com

Dale.Leikam@sbcglobal.net
785-776-0273
785-770-0009

Fluid Fertilizer Foundation

Indianapolis Marriott East

Wednesday, December 8, 2010

8:00	8:15	- - - Welcome and Announcements - - -
8:15	9:00	- - - - - Fluid Fertilizer Solutions and Opportunities (D. Fairchild) - - - - -
9:00	9:45	- - - National/Global Fertilizer Outlook and Trends (T. Erny) - - -
9:45	10:10	- - - - - - - - - - - Break - - - - - - - - - - - -

		Session A	Session B
10:10	11:00	Operation Issues/Maintenance (C. Schultze)	Basic Fluid Characteristics, Salt-out, Solubility, Etc. (D. Leikam)
11:00	11:50	Storage Tank Inspection, Maintenance & Failure (C. Brooks)	Use of VRT Programs In Dealer Research (M. Wiebers)
11:50	1:00	Lunch	Lunch
1:00	1:50	DOT Rail Tank Car Certification (M. Orr)	Urea Volatilization: How Large Is The Issue and Losses (D. Kissel)
1:50	2:40	↓	New Technologies: Products and Additives (D. Leikam)
2:40	3:30	↓	Statistics: How They Are Used and Mis-used (S. Staggenborg)
3:30	3:50	- - - - - - - - - - - - Break	- - - - - - - - - - - -
3:50	4:40	UAN Management: Corrosion, Composition, etc (R. Satterfield)	Fertigation: Equipment and Agronomics (J. Schepers)
4:40	5:30	Formulation Issues At The Plant (M. Orr)	Fluid Starter Fertilizer Sources **(D.. Zabel)**
6:00	7:30	- - - - - - - - - - - - Social Time / Reception	- - - - - - - - - - - -

Thursday, December 9, 2010

8:00	8:10	- - - - - - - - - - - Announcements, Housekeeping - - - - - - - - - - -
8:10	9:00	- - - - - - - - What's New In Washington? TFI Update (F. West) - - - - - - - -

		Session A	Session B
9:10	9:50	Micronutrient Compatibilities (A. Robinett)	High Yield Systems; Fertility Programs For the Future (M. Alley)
9:50	10:10	- - - - - - - - - - - - Break	- - - - - - - - - - - -
10:10	11:00	Regulatory Update and Other Issues. (J. Payne)	Five Factors To Improve The Odds For High Yields (M. Bauer)
11:00	11:50	Fluid Storage and Shelf Life Issues (J. Walker and Panel)	High Yield Systems: Role of Placement and Timing (S. Murrell)
11:50	12:00	- - - - - - Wrap-Up, Thank You, Have a safe trip home!!	- - - - -

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NEWS & NOTES

High Soil Test P Essential for Maximum Corn Yields and Profits

Don't Forget Starter Fertilizer - Especially Now

10-34-0 Storage and Handling

MORE

EVENTS

2011 Fluid Forum
Feburary 20-22, 2011
Scottsdale Plaza Resort
Scottsdale, AZ
Phone: 480-948-5000

Fluid Technology Roundup
Indianapolis, IN,
December 8-9, 2010.
Wednesday, December 8, 8:00am -
Thursday, December 9th, 12:00 p.m.
Indianapolis Marriott East
7202 East 21st St.
Indianapolis, IN 46219.
Phone: 317-352-1231
Program • Letter • Registration

North Central Extension-Industry Soil Fertility Conference
November 17-18, 2010
Holiday Inn Airport
Des Moines, IA

Welcome to the Fluid Fertilizer Foundation Website!

Fluid Journal Articles

Fall 2010 Issue:

Are Current Fertilizer Recommendations Adequate?

Corn being a primary responder, yield goals in the next 20 years are targeted at 250 to 300 bu/A by some in the seed industry.

Dr. Gyles Randall

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2010 • Vol. 18, No. 4, Issue #70

***Summary:** Challenges undoubtedly face the fertilizer and nutrient management industry as crop yields and potential demand escalate. Are today's nutrient recommendations appropriate for the future? Will they enable these ever-increasing yields to be realized or will they become yield-limiting? Do we have the research in place to develop nutrient best management guidelines for these very high yields? If not, where do we start and what are the nutrient/crop priorities? What are the economic and environmental consequences of this extraordinary high-yield production system? Will time of application and placement method guidelines need to be reevaluated? How will the logistics and capabilities of the farmer and the dealer fit into these "new" nutrient management guidelines?*

Current status

Aging recommendations. Many of the current recommendations are based on research conducted in the '70s and '80s, and even earlier. Back then U.S. average yields ranged from 80 to 120 bu/A, and it is likely that yield in many of the calibration research trials seldom exceeded 175 bu/A. Yield response probabilities and critical levels are currently based on these calibration studies. In some states, little phosphorus (P) and potassium (K) calibration research has been conducted since. In other states, notably Iowa, some perceptive scientists began long-term P and K response trials that have been most helpful for updating nutrient rate recommendations. Recently, the University of Nebraska changed its longtime soil test P (STP) critical level from 15 ppm to 25 ppm for corn after corn, based on current high-yield data.

Logistical concerns. Soil testing is critical to the implementation of sound nutrient rate recommendations. But, soil testing has its share of uncertainties and a vigorous research and extension effort is needed to complement new fertilizer recommendations.

Variable rate application has come a long way since its inception. With improved technology and information, it will be desirable to apply variable rates of P and K to the soil to obtain very high and profitable yields with reduced risk of insufficient P or K.

Time and labor are substantial issues facing farmers and fertilizer suppliers, especially as farm operations get larger and the territory served by fertilizer dealers expands. Fertilizer applications that require more time, management and specific placement equipment often are passed over in favor of broadcast application as a farmer's acreage grows. With increased emphasis on early and timely planting, larger farm operations often pass on application methods that slow or delay planting. Storage space also becomes an issue for the dealer if non-traditional nitrogen (N) and P products are desired. Some of these products may have increased efficiency attributes desired by the grower, but extra storage needs for these products can be a negative issue for the dealer. Regardless, timing and fertilizer placement choices are influenced by the dealer's and grower's needs, and they require consideration by the nutrient research community as research is developed and prioritized.

Risk of yield loss is a concern that faces both dealers and farmers. The possibility that yield is left in the field due to inadequate nutrient availability or supply is unthinkable for growers attempting to maximize return on their fertilizer dollar. As farmers work with their dealers and/or agricultural advisors to arrive at a nutrient application game plan, risk plays a key role in arriving at the final decision. Researchers, working to provide adequate nutrient supply for high and very high yield conditions, need to keep economic and environmental risks in mind.

Land tenure. Whether the land to be fertilized is owned or is rented can and perhaps should play an important role in decisions on fertilizer rate and placement. To date, this factor has not been included in fertilizer guidelines provided by most universities. Kansas State University has led the way in developing P recommendations based in part on land tenure. Farmers who own land to be fertilized generally have a long-term vision for that land that

A Further Look into Fertilizer Recommendation Adequacy Regarding Phosphorus and Potassium

Farmer-specific goals should be incorporated into the decision-making process.

Drs. Dale Leikam, Gyles Randall, and Antonio Mallarino

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2010 • Vol. 18, No. 4, Issue #70

***Summary:** There are several logical and appropriate approaches to managing phosphorus (P) and potassium (K) fertility. Within the bounds of environmental stewardship, it should be up to the individual producers to determine the appropriate fertility approach suitable for their production system. Nutrient sufficiency programs generally minimize fertility inputs in the early years but have increased risk of P or K limiting crop growth and long-term profitability. Build/maintenance programs may cost more in the initial years if soil tests must be built up, but they generally provide for maximum yield and long-term profitability while increasing fertilizer management flexibility in the coming years. In addition, an individual producer's attitude toward managing risk, the producer's long-term viewpoint in making investments in soil fertility, expected land tenure, and other farmer-specific goals and objectives should be incorporated into the decision-making process for determining the P and K fertility management program that best suits an individual producer's needs. To continue to increase crop yields in the future, it is important to note that research has shown that annual fertilizer applications may not fully substitute for high P and K soil fertility. Highest crop yields are often associated with soil tests greater than the established critical value. There may be a severe economic penalty associated with low P or K soil tests even when fertilizer is applied--especially in years/situations with high-yield potential.*

Profitable crop production requires adequate crop nutrition and there are few fields that do not require the addition of supplemental crop nutrients. As a result, there has been much investment in time, expertise, and money devoted to developing reliable soil tests that are well correlated to crop nutrient uptake and crop yield response. Once a reliable soil test is developed, the test is then calibrated to estimate the nutrient application rate required for optimum crop growth at various soil test levels. Historically, the soil test value and crop to be grown have been the main, and often only, factors used in making nutrient rate recommendations--although there are sometimes adjustments made for factors such as expected crop yield, soil type, and/or soil association. However, there are many other factors that affect crop growth, nutrient availability, nutrient uptake, and crop production efficiency that need to be taken into consideration in order to arrive at a nutrient management program that best fits a specific field. The cultural and tillage system used, planting dates, soil/environmental condition, equipment availability, an individual farmer's long-term approach to managing risk and land investment, crop fertilizer prices, and other factors are not estimated by soil testing but they generally influence crop nutrient rate decisions.

While plant-available nitrate and/or ammonium nitrogen (N) soil testing historically has been used for N recommendations in lower rainfall areas, such as the Great Plains and other western states, N soil testing has generally not been used in more humid regions such as the Corn Belt and southeastern states. Higher rainfall in these areas causes much more weather-induced variability in inorganic soil N supplies and much less reliability in assessing available N supply to the growing crop.

P, K interpretation

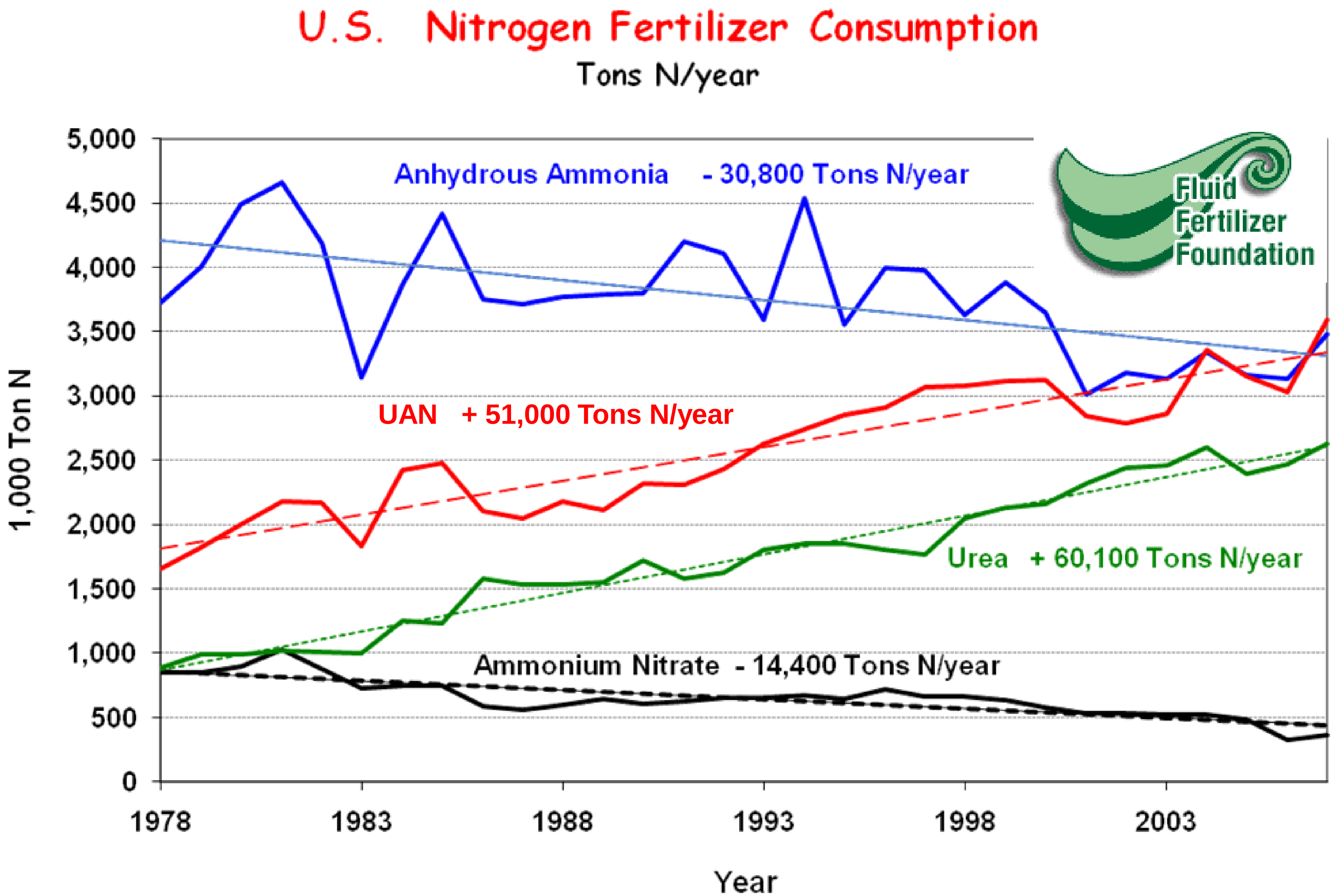
Nutrient recommendations. As cropping systems change with the increased adoption of reduced and no-till systems, it is possible that nutrient recommendations may also need to change as compared to those developed with past conventional, aggressive tillage. Additionally, as crop yields continue to increase year after year, the overall amounts of crop nutrients required and rate of crop nutrient uptake are also increasing. As yields continue to climb, farmers need to consider the total amount of nutrients required by these higher yielding crops and the daily nutrient requirements, especially at critical stages of crop development. Table 1 presents the very large total nutrient uptake and daily nutrient requirements of high-yielding corn and soybeans in a Rutgers University study. Since most P and K moves to the root surface across only very short distances by diffusion, questions sometimes arise about the adequacy of many current crop nutrient recommendations developed at much lower yield levels than are currently obtained by top producers.

Soil tests for P and K do not directly tell how much of a nutrient is available to a crop--nor do they accurately predict precisely how much of a nutrient to apply to a specific field situation. Instead, what soil tests do much better is estimate the soil's relative ability to supply a nutrient to a growing crop. This provides an index

Fluid Fertilizers

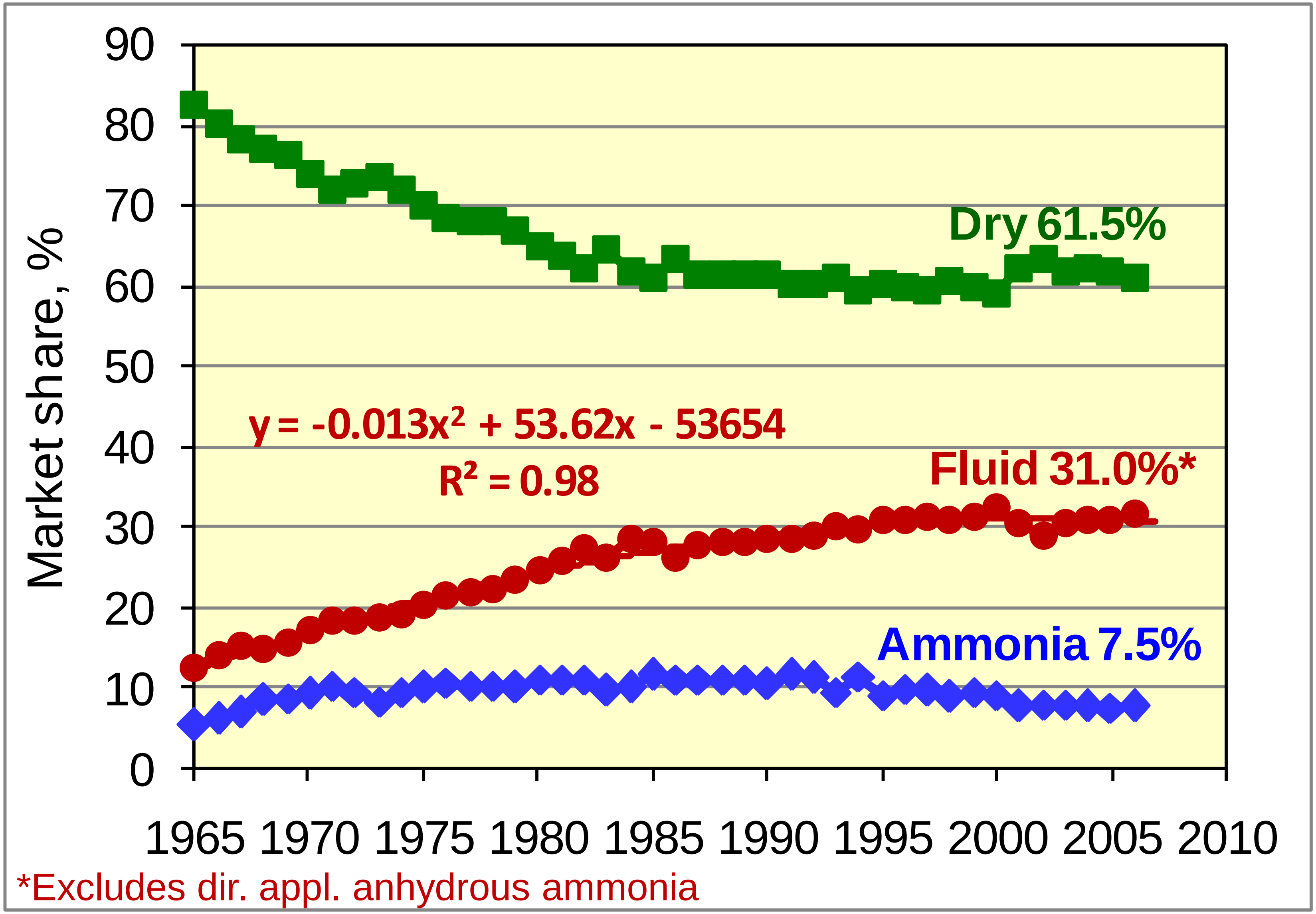
- Increasing in popularity in U.S. and elsewhere
- Advantages include
  - ✓ Flexibility and versatility in application
  - ✓ Efficiency and adaptability
  - ✓ Benefits of continuous bands
  - ✓ Ease of handling
  - ✓ Does not segregate
  - ✓ Flexibility, etc.

- Limitations
  - ✓ Often higher purchase price than solid fertilizers **
  - ✓ Salt-out and precipitate formation potential with certain products and blends



U.S. Nitrogen Fertilizer Consumption
Tons N/year
Anhydrous Ammonia - 30,800 Tons N/year
UAN + 51,000 Tons N/year
Urea + 60,100 Tons N/year
Ammonium Nitrate - 14,400 Tons N/year
Fluid Fertilizer Foundation
1,000 Ton N
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1978
1983
1988
1993
1998
2003
Year

USA fertilizer market share by class.



Data source: Commercial Fertilizers, AAPFCO & TFI

Fluid Fertilizers

Terminology, Solubility, Density and N Solutions

Solution – All salts totally dissolved in water. No solids allowed!

Slurry – Fluid product containing water, dissolved salts and undissolved salts. Settles out quickly. Not Common.

Suspension – Fluid product containing water, dissolved salts, fine undissolved salt crystals and a suspending agent – normally attapulgite clay.

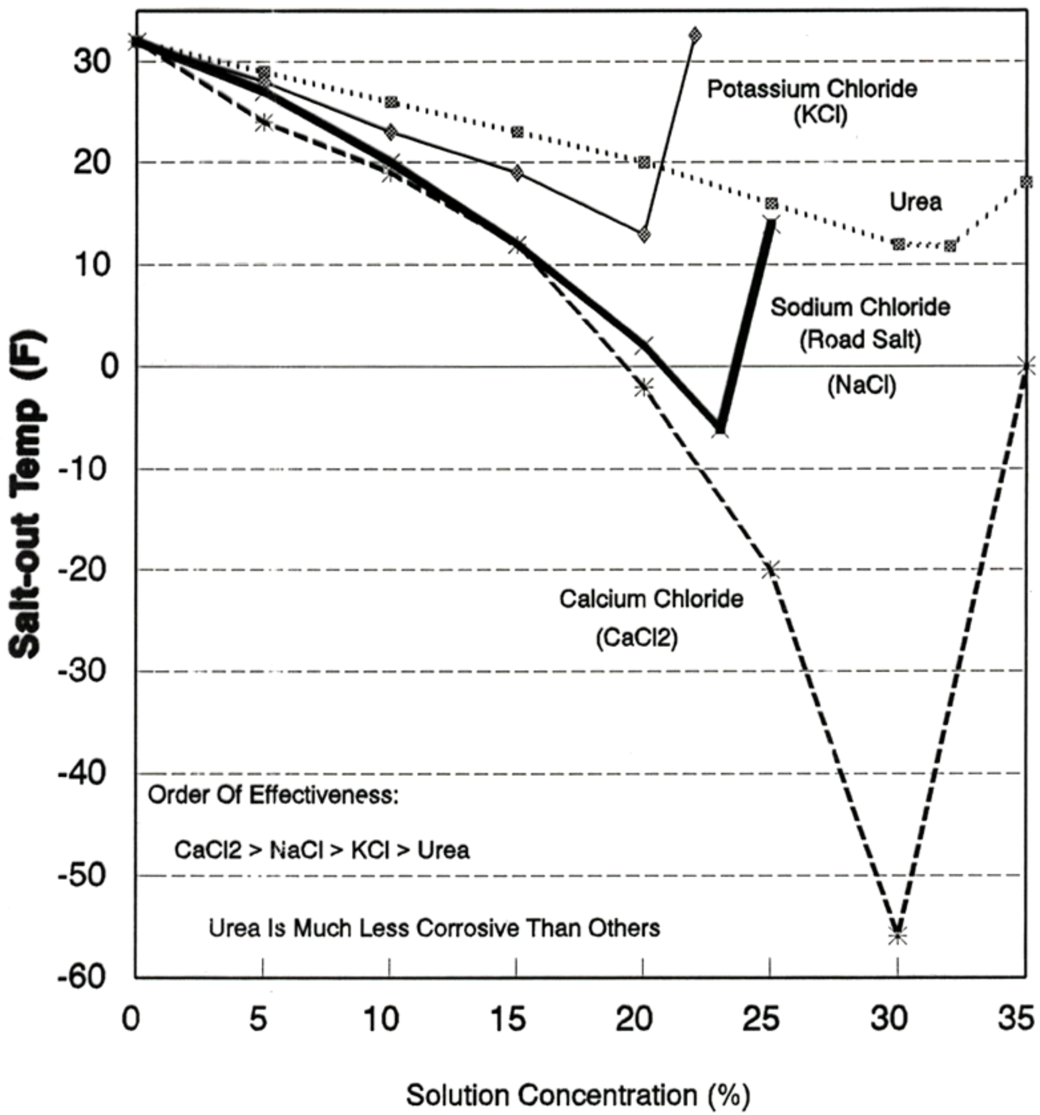
Muddy Water – Solutions with undissolved solids or suspensions containing too few undissolved salt crystals. Not a good range to try and operate in!!.

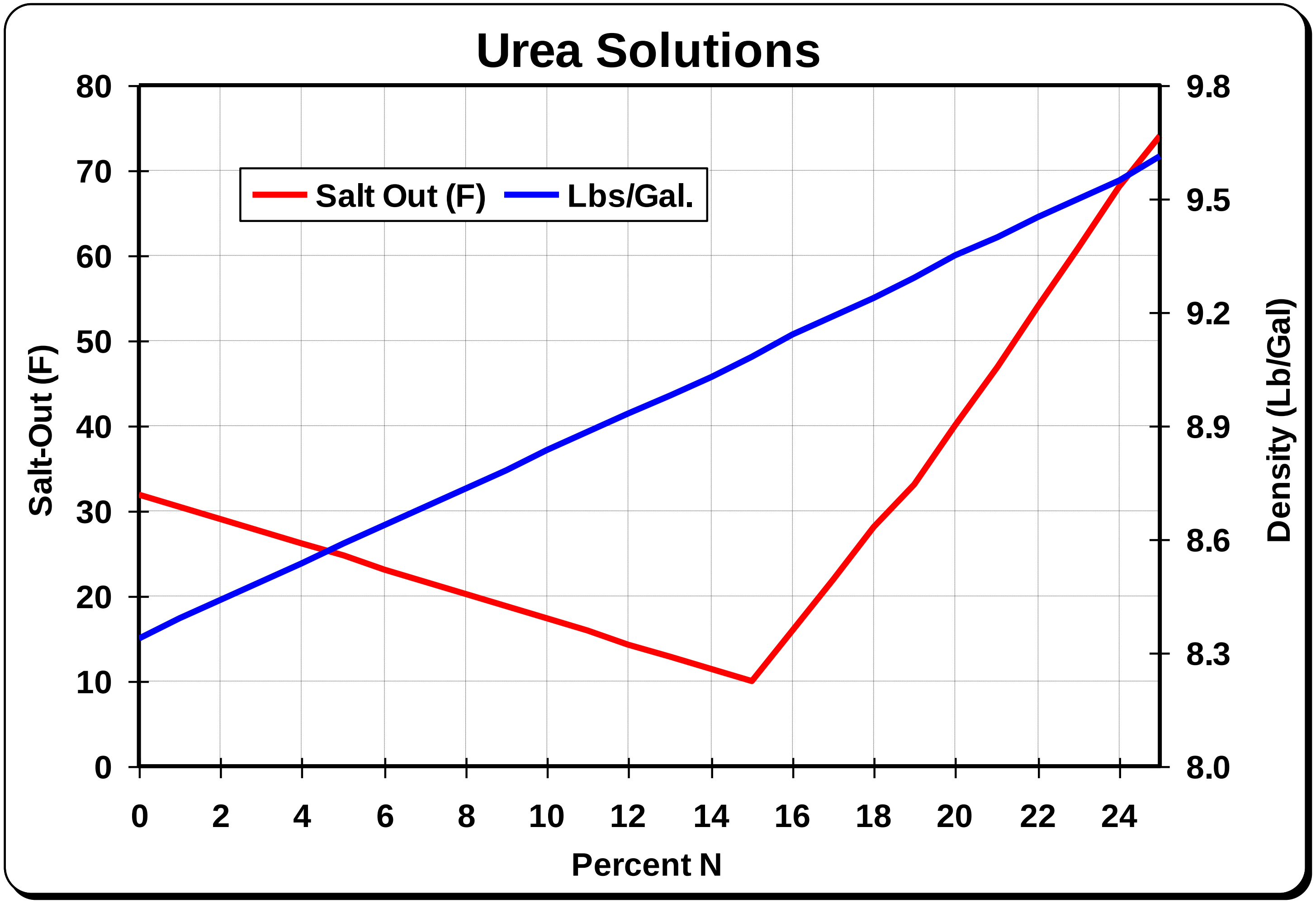
Falling Out Of Solution – No such thing.

Salt-Out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

Precipitate Formation – Non-crystalline mass forms which has much lower solubility than original ingredients in solution. Example; Improperly stored fluid phosphates

EFFECT OF SALTS ON FREEZING POINT





Urea Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
Density (Lb/Gal)
Percent N
0
10
20
30
40
50
60
70
80
8.0
8.3
8.6
8.9
9.2
9.5
9.8
0
2
4
6
8
10
12
14
16
18
20
22
24
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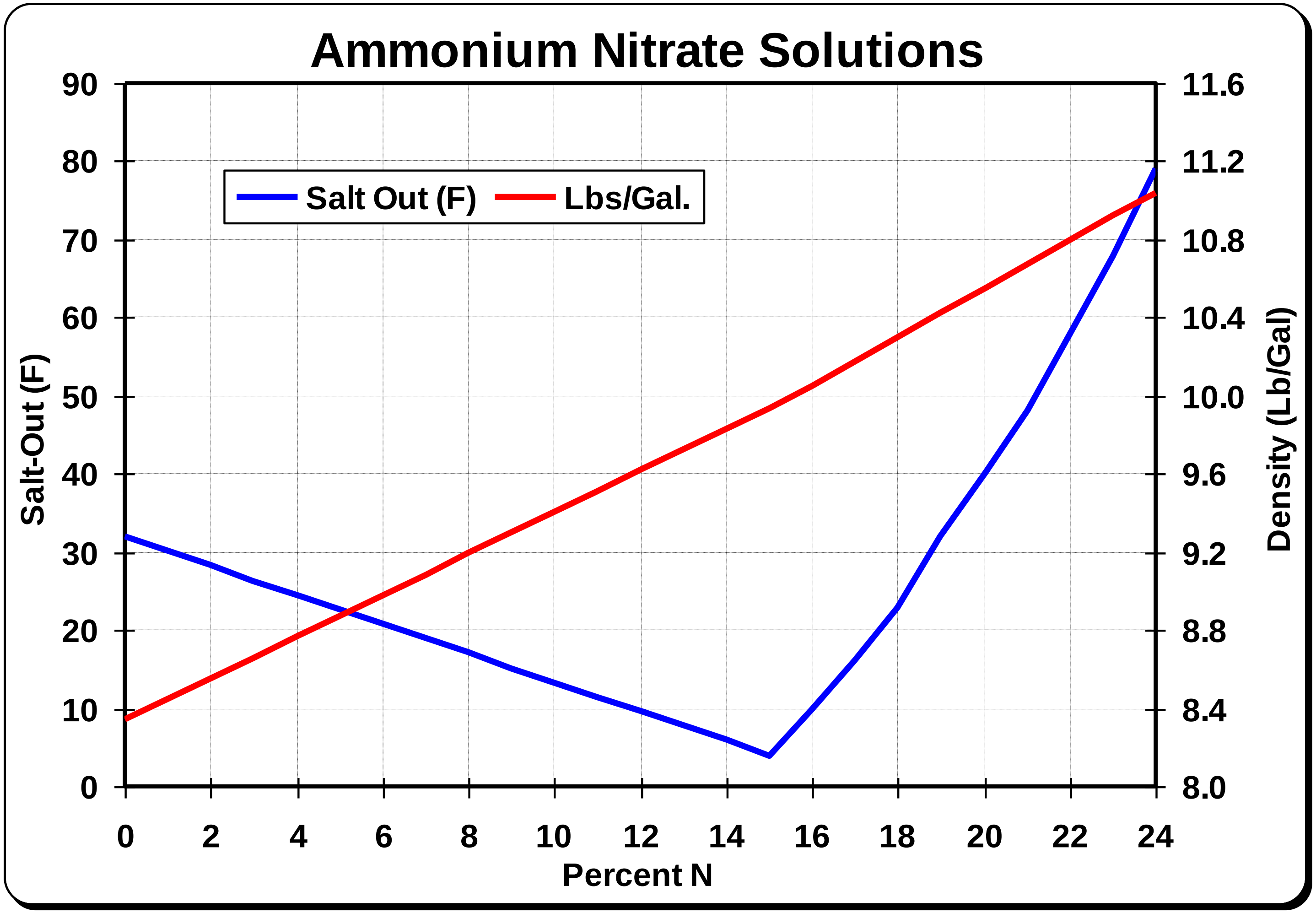
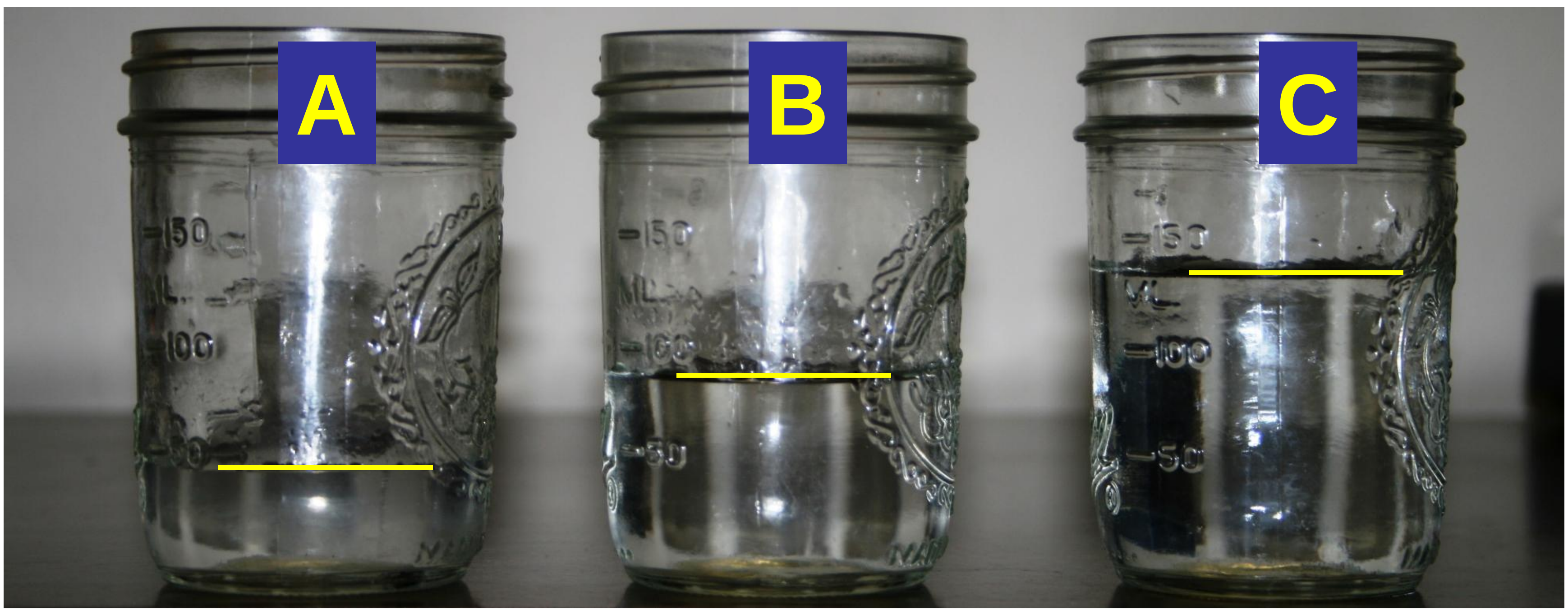
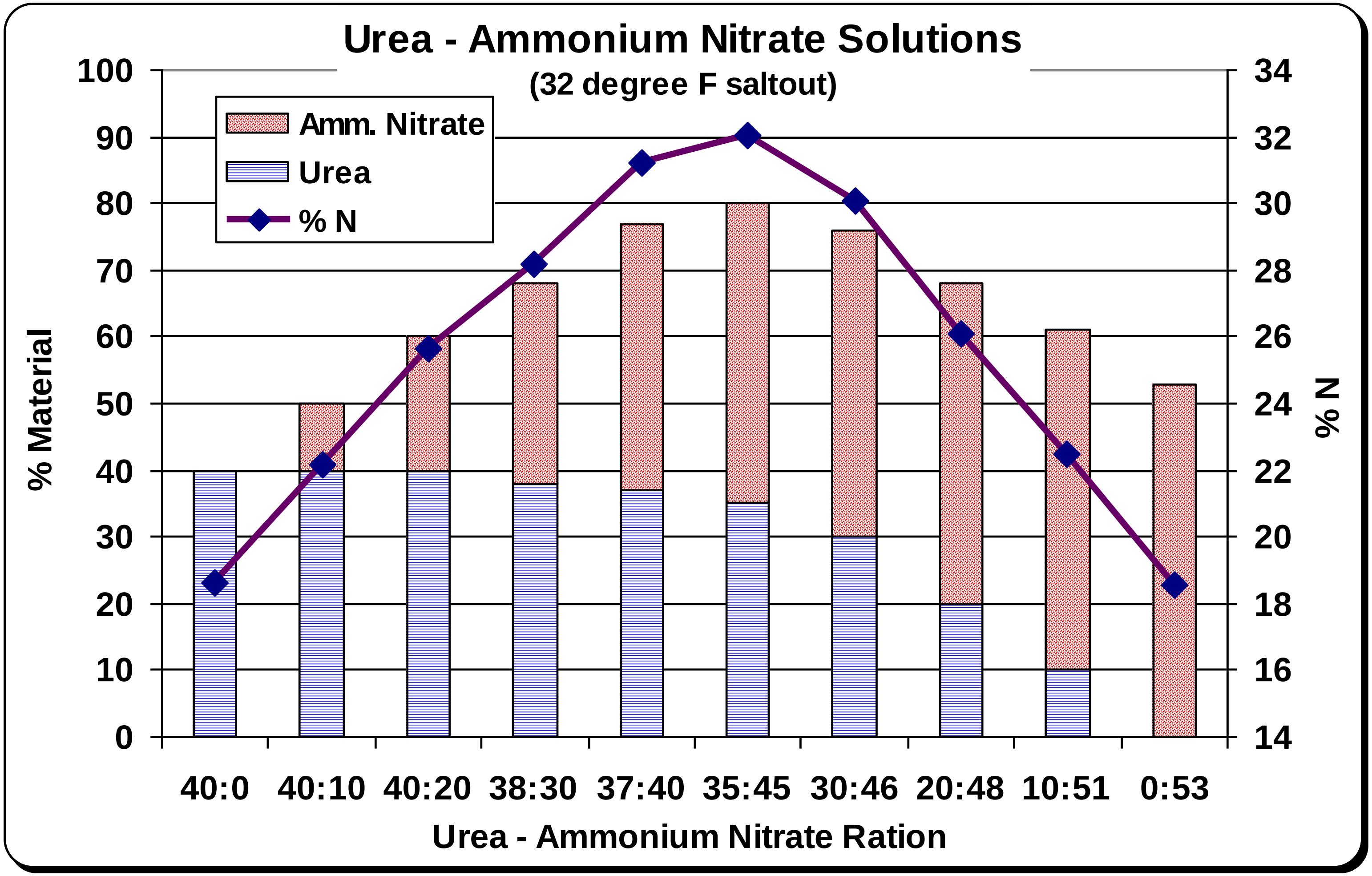

Ammonium Nitrate Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
Density (Lb/Gal)
Percent N
0
10
20
30
40
50
60
70
80
90
8.0
8.4
8.8
9.2
9.6
10.0
10.4
10.8
11.2
11.6
0
2
4
6
8
10
12
14
16
18
20
22
24

To Make 32-0-0 UAN Solution – How Much Water Is Needed ?





Eutectic Point – point of maximum solubility

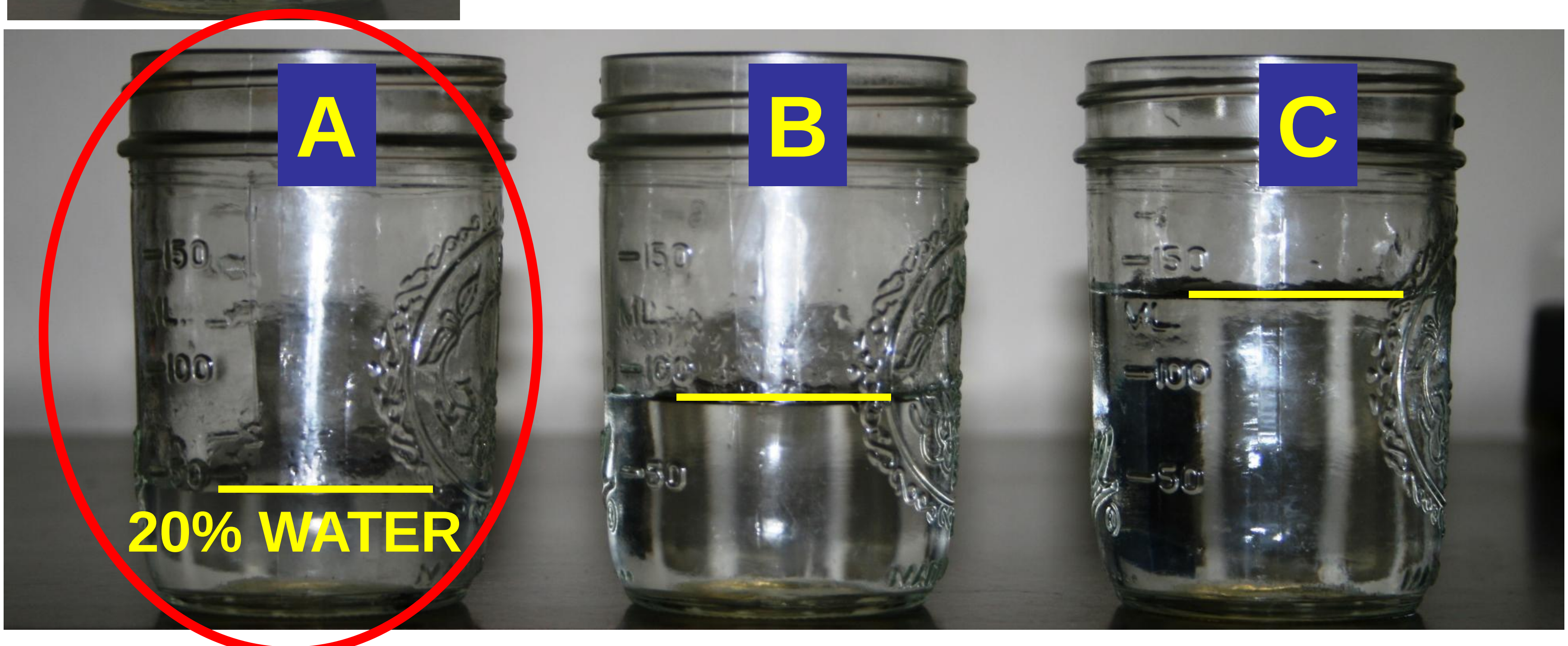
32% UAN contains:

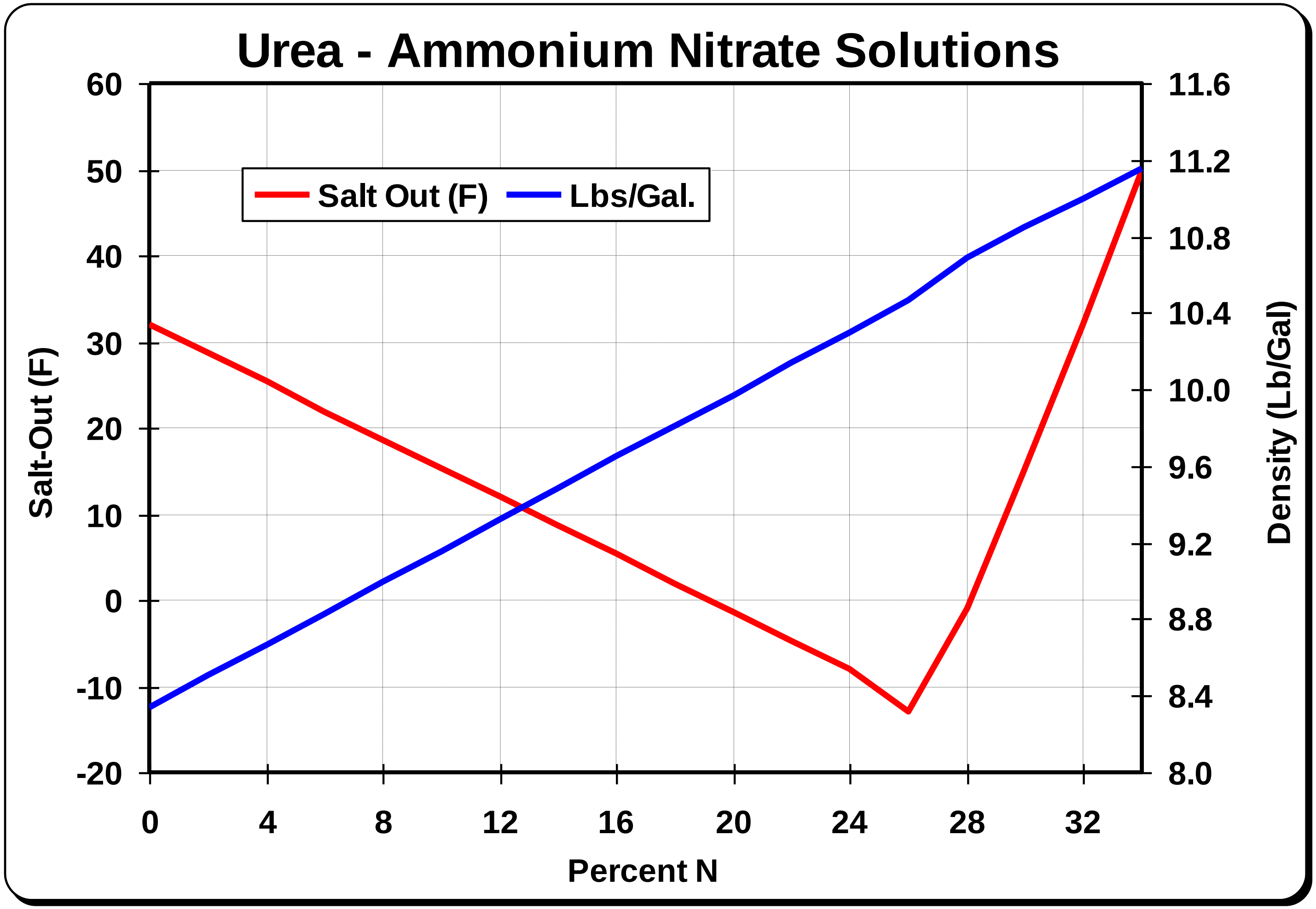
- **approximately 35% ammonium nitrate, 45% urea and 20% water at eutectic point**

28% UAN contains 30% water

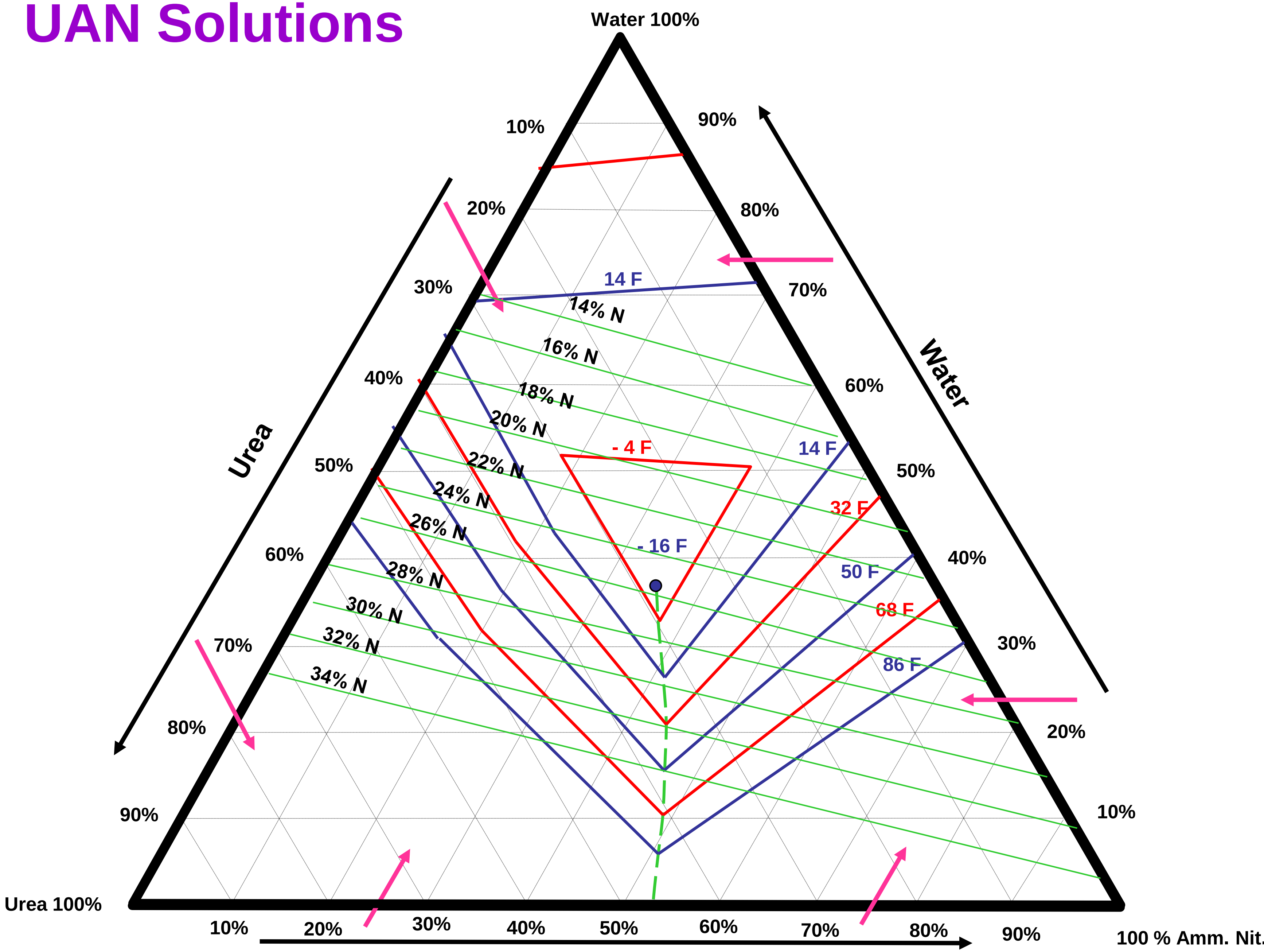
To Make 32-0-0 UAN Solution –

How Much Water Is Needed ?




Urea - Ammonium Nitrate Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
60
50
40
30
20
10
0
-10
-20
Density (Lb/Gal)
11.6
11.2
10.8
10.4
10.0
9.6
9.2
8.8
8.4
8.0
0
4
8
12
16
20
24
28
32
Percent N

UAN Solutions



UAN Solution

- Salt-out is an issue in many environments
  - ✓ There is very little water in UAN solution.
  - ✓ Warm water has ability to dissolve more salts than cold water
  - ✓ Salt-out occurs when salt content exceeds solubility at a given product temperature
  - ✓ Crystals form on tank walls as temperature cools
  - ✓ Eventually salts accumulate at tank bottom
  - ✓ Salts will re-dissolve with sufficient heat and recirculation

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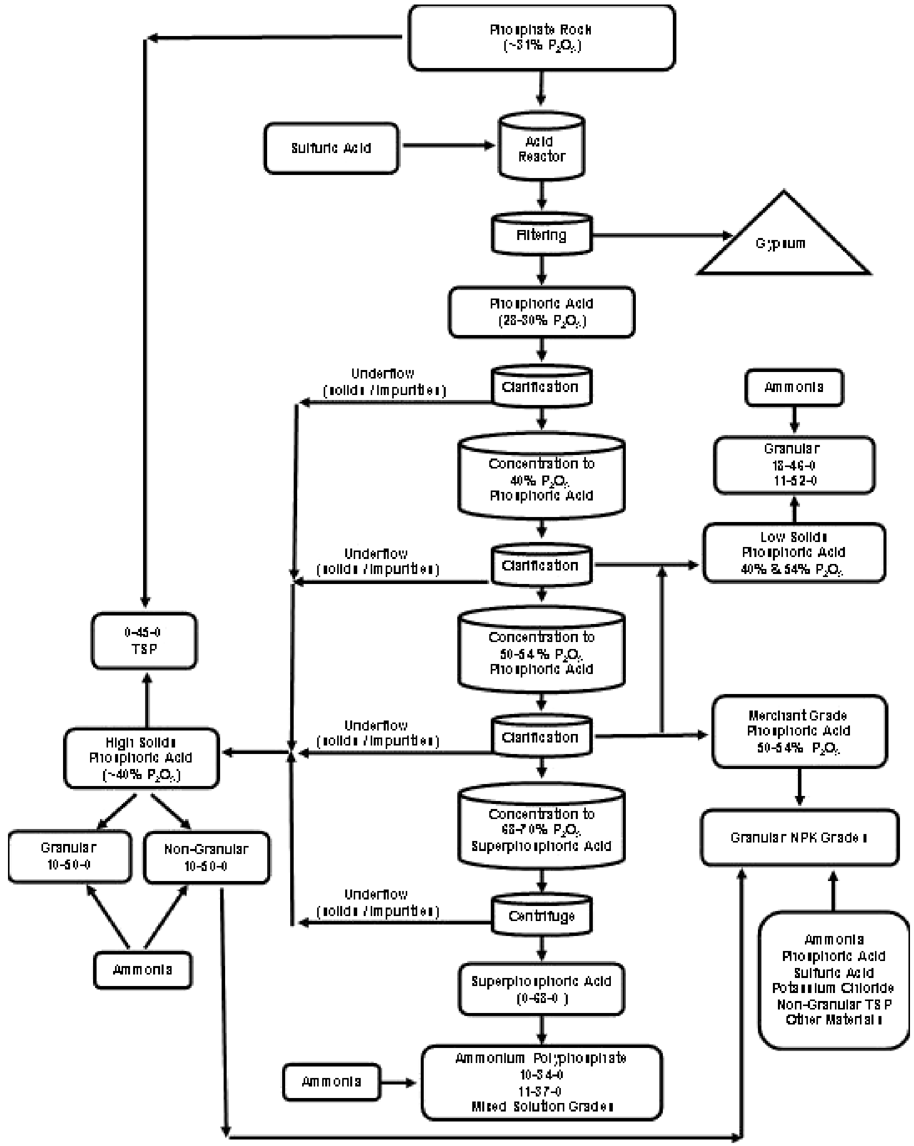
Lowering Water Freezing Temperature With UAN Solution

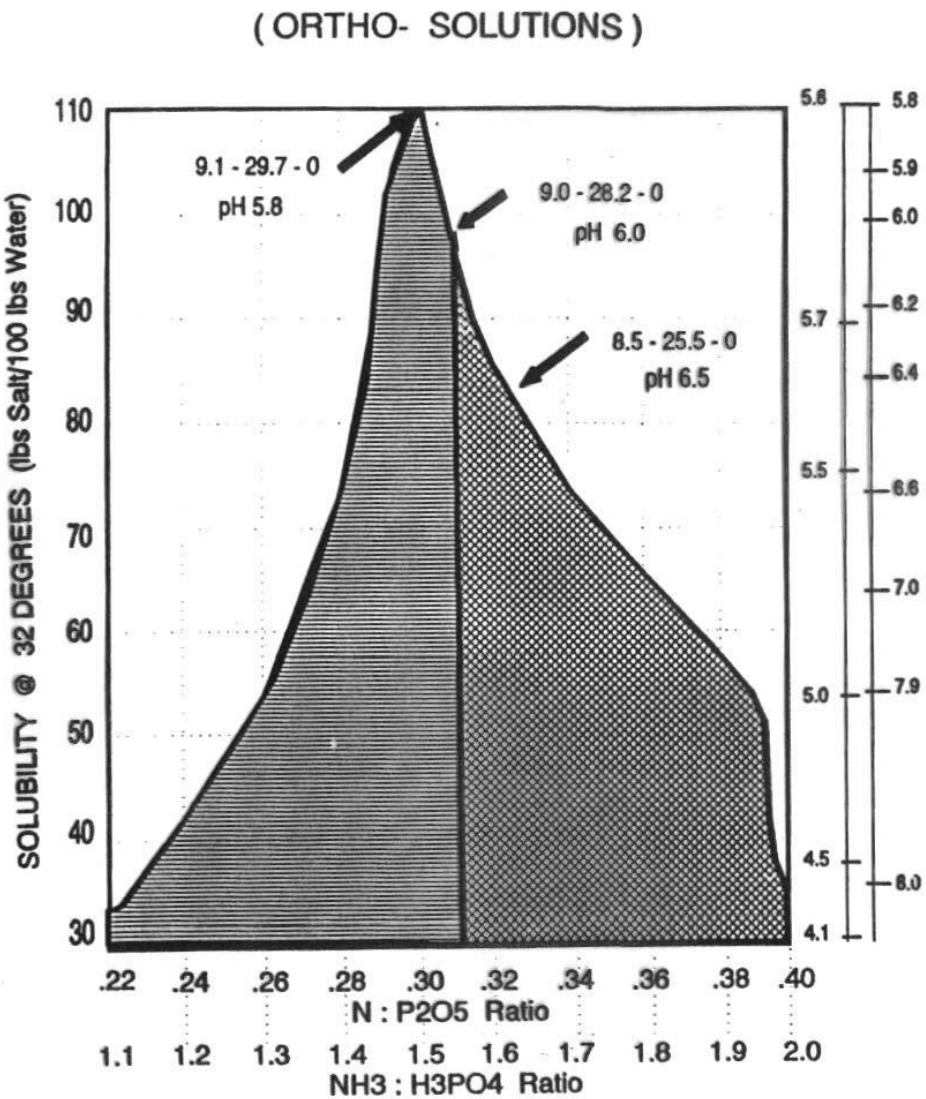
% N	Freezing Temperature F	28-0-0	32-0-0
		gal per 100 gal water	
0	32	0	0
2	27	6.1	5.2
4	23	13.1	11.2
6	18	21.5	18.2
8	14	31.5	26.2
10	9	43.7	35.6
12	5	59.0	47.2
14	0	78.7	61.2

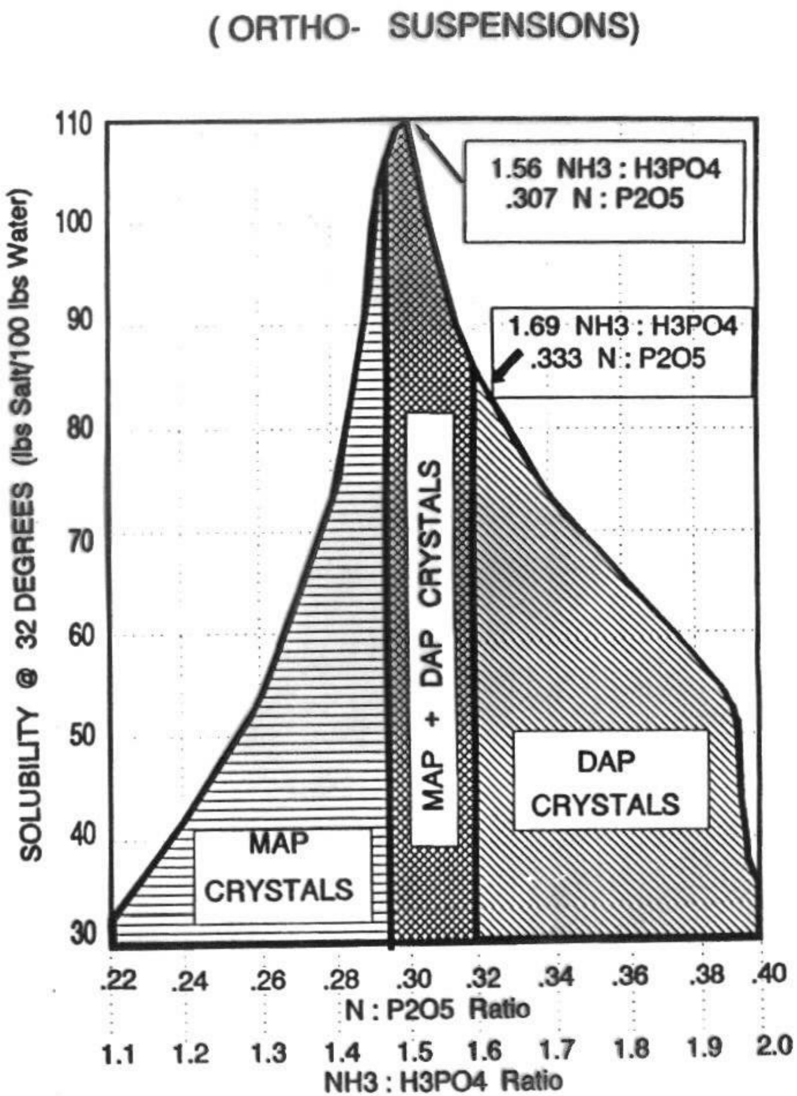
Liquid Phosphate Products

Fluid Phosphate Products and Characteristics



SOLUBILITY OF AMMONIUM PHOSPHATES





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Phosphoric Acid

Wet-Process Acid

- Black, brown, green (calcined)
- Contains many rock impurities
- Used in fertilizer industry

Furnace, food-grade acid

- Clear
- No impurities
- Food and industrial processes

Orthophosphoric Acid Examples

Source	Acid 1	Acid 2	Acid 3	Acid 4
P2O5	61	53.2	52.8	57
MgO	0.3	1.2	1.1	0.2
Fe2O3	0.35	0.5	1	0.32
Al2O3	0.18	0.4	0.5	0.16
F	0.3	0.4	2.1	0.1
Solids	0.5	0.1	0.1	Nil
Visc.@100F	40	90	100	27
P/F	89	58	46	248

Source: Texas Gulf

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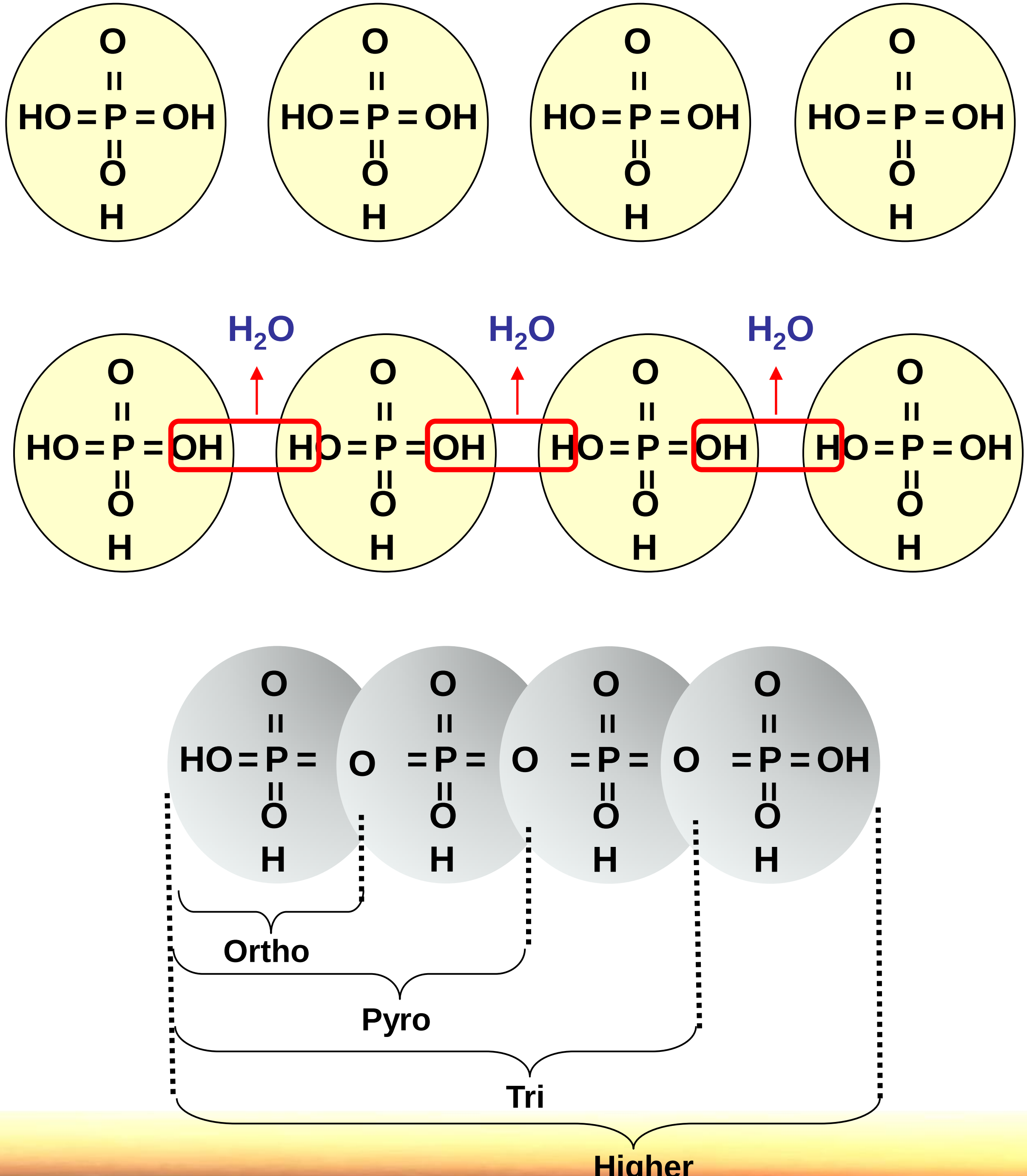
Ammonium Polyphosphate

- Primary P source for much of fluid industry
- Many NPKS products made from APP
- Produced from ammonia, superphosphoric acid and water
- Generally equal agronomic performance as compared to solid fertilizers
  - ✓ If applied at equal P rates in similar manner
  - ✓ Potentially superior to solids if discontinuous bands result from with solid fertilizer band applications
- Contains most P as polyphosphate

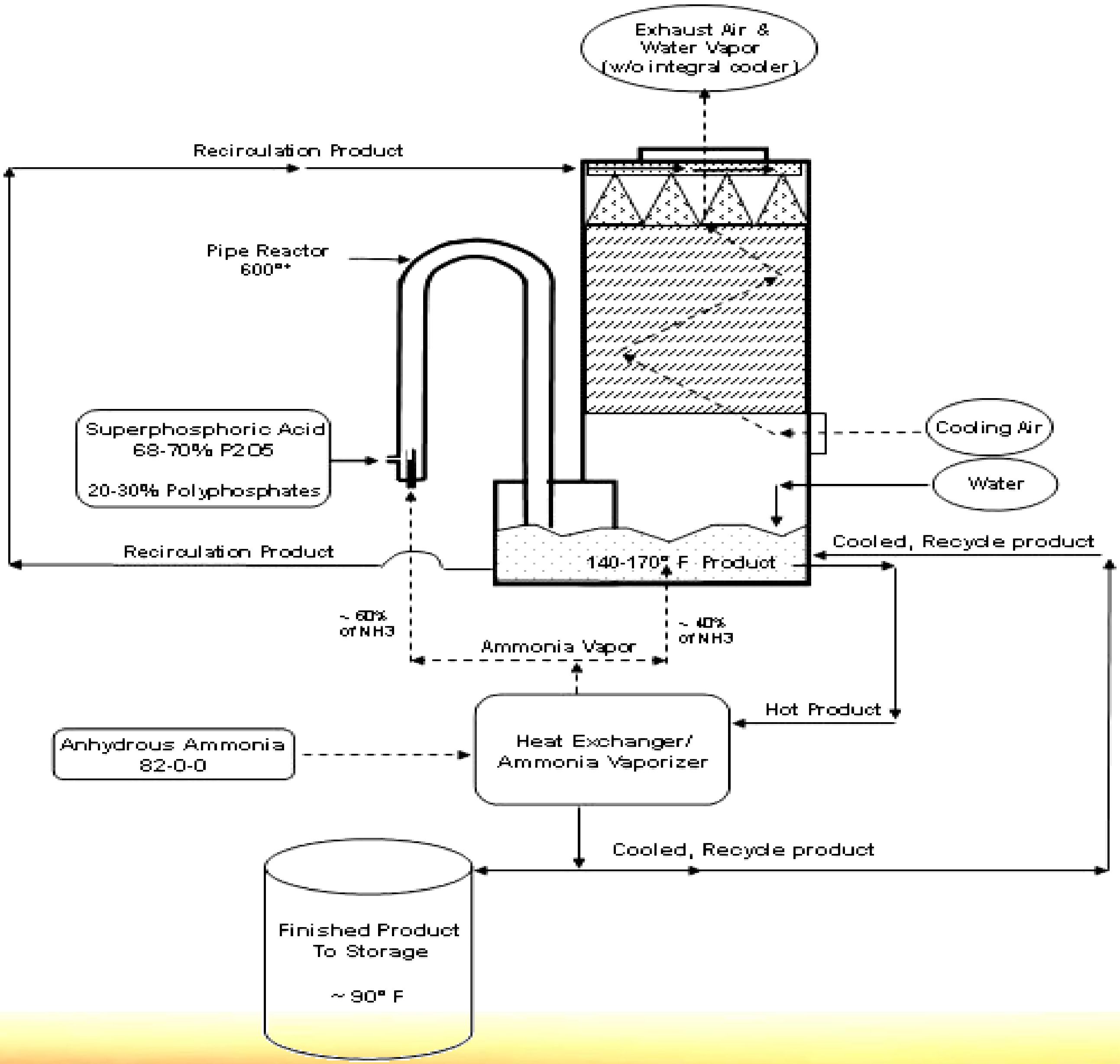


Heat links phosphates by removing chemically bound water

Heat comes from chemical reaction of reacting phosphoric acid with ammonia

Flow Diagram For Ammonium Polyphosphate Production

10-34-0 & 11-37-0



Why Do We Want Polyphosphates ?

- Not necessarily for agronomic reasons
- Manage sludge problems in fluid P products
  - ✓ Polyphosphates sequester metal cation impurities in the product (especially Mg) to form relatively insoluble precipitates
  - ✓ Provides superior storage qualities
- Increased analysis compared to orthophosphate
- Provides ability to include higher amounts of micronutrients in product (not Ca or Mg)

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Hydrolysis Of Polyphosphate To Orthophosphate

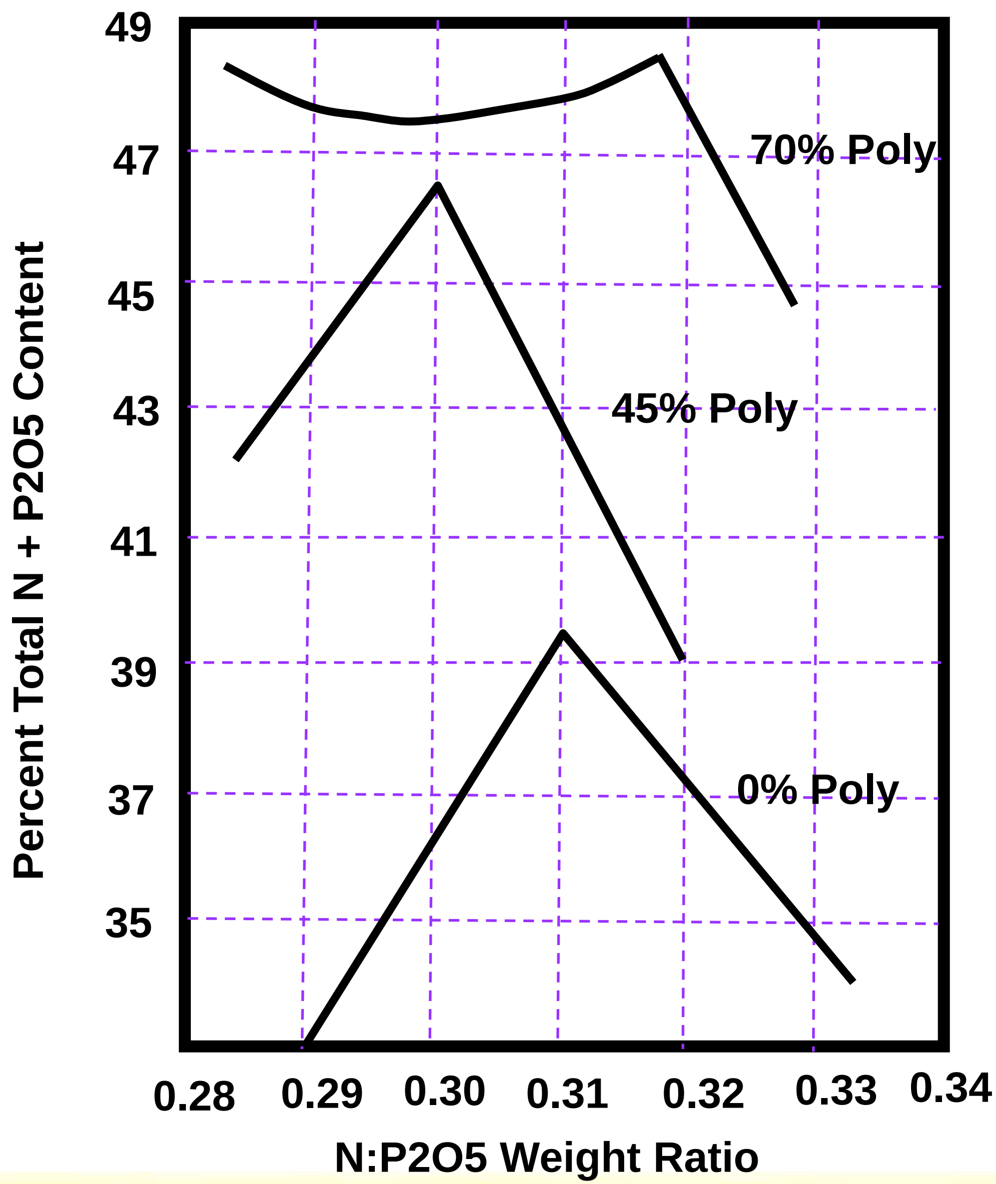
Soil Temperature	24 Hour Polyphosphate Hydrolysis (%)
41 F	30-40 %
68 F	50-60 %
95 F	80-90 %

Chang and Racz, 1977

After application to soils, polyphosphate is quickly converted to orthophosphate by abundant soil enzymes

Plants utilize orthophosphates

Effect of Poly Content and N:P2O5 Ratio On Solubility



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- Provides ability to include higher amounts of micronutrients in product (<u>not</u> Ca^{++} or Mg^{++})

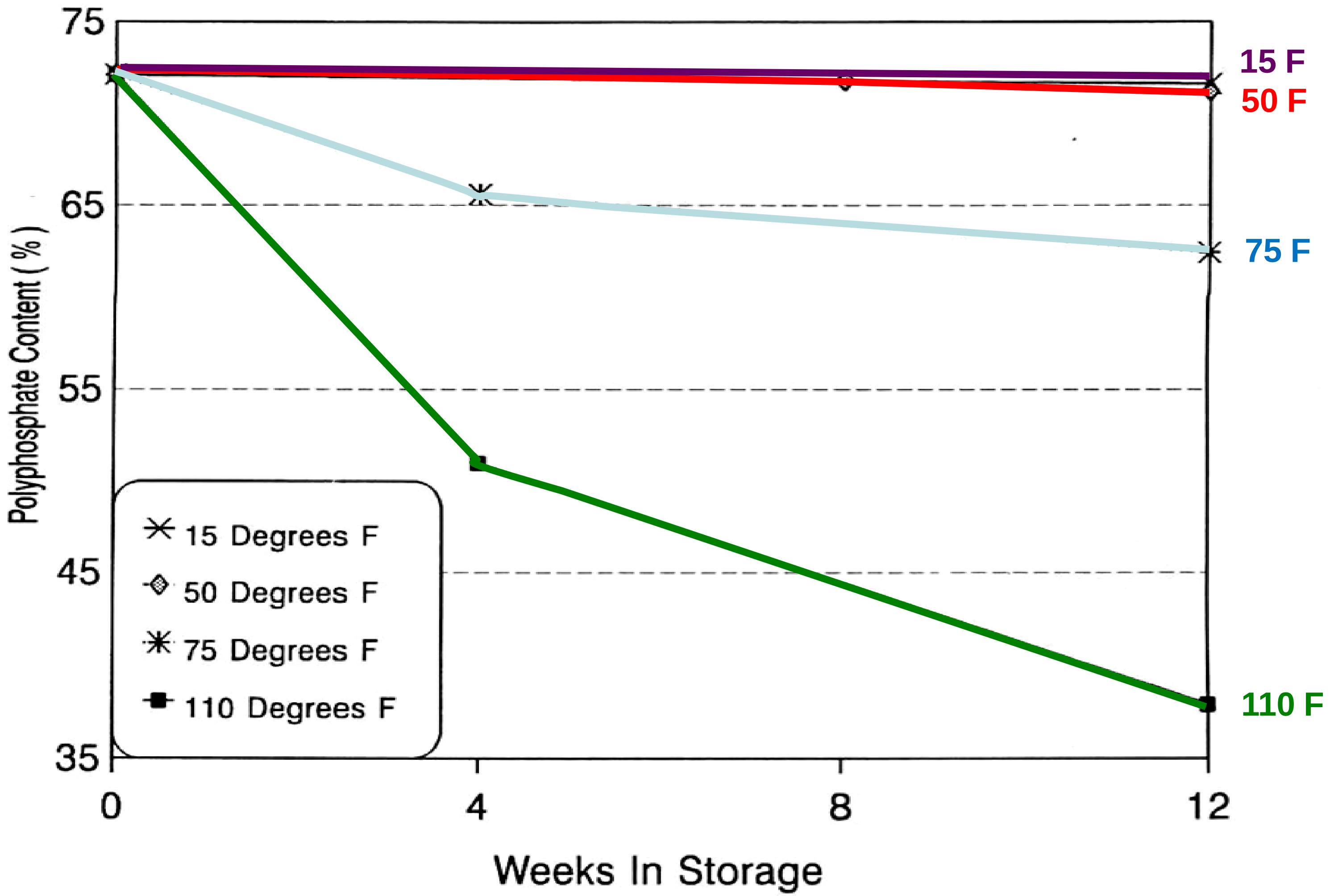
Zinc Sequestering By 10-34-0

Zinc Sources

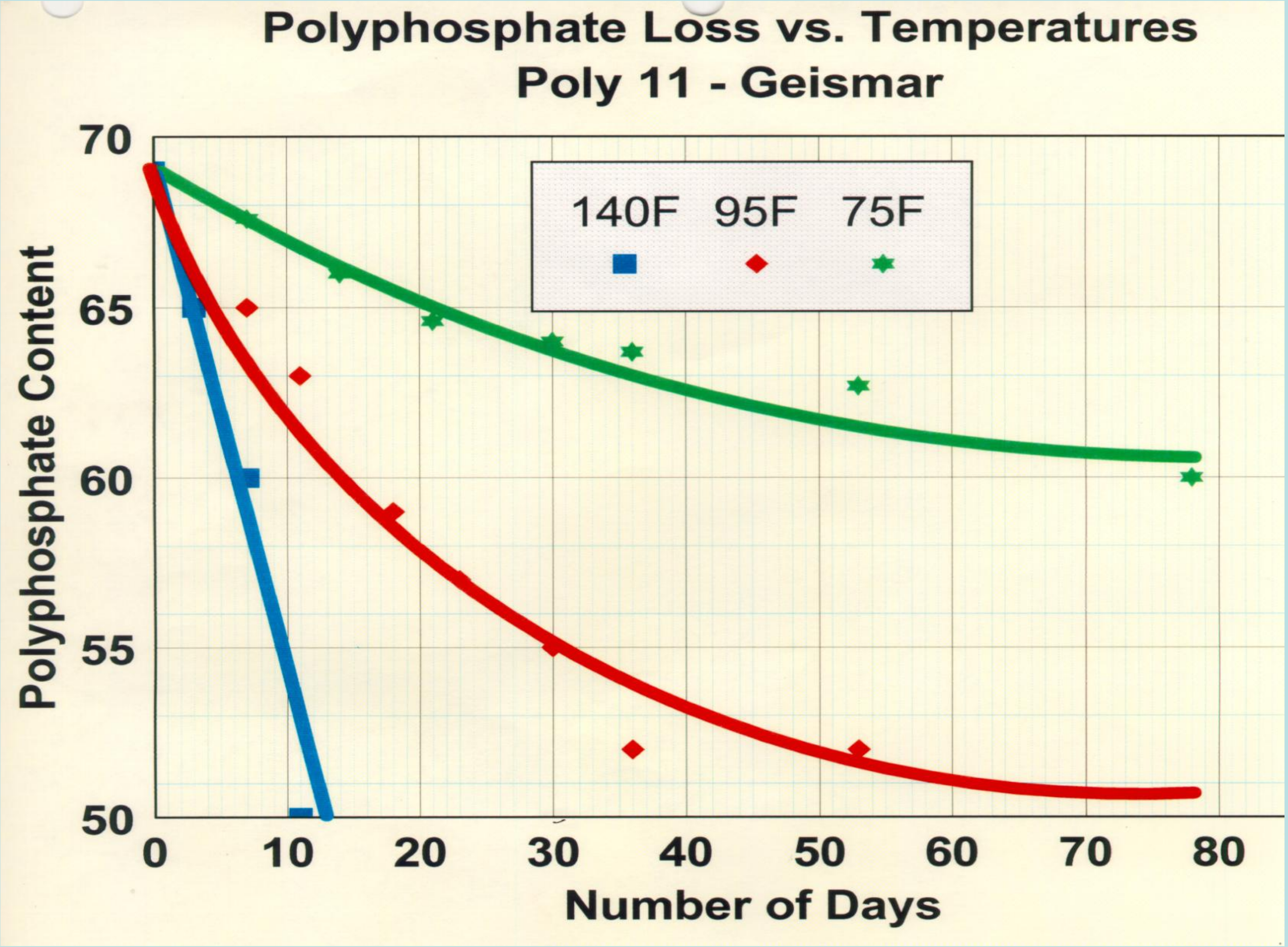
Original Zinc Source	% Zinc Remaining As Original Source	% Zinc Sequestered By Polyphosphate
Zn EDTA	100	0
Zn Sulfate	4	96
Zn-NH3 Complex	8	92
Zn Phenolic Acid	11	89
Zn Citrate	8	92
Zn Nitrate + UAN	15	85
Zn HEIDA	19	81

Values Are For 4 Minutes After Mixing - U of Neb.

Temperature Effect On 10-34-0 Quality



Source: Farmland Industries



Polyphosphate Loss vs. Temperatures
Poly 11 - Geismar
140F
95F
75F
Polyphosphate Content
70
65
60
55
50
0
10
20
30
40
50
60
70
80
Number of Days

Factors Impacting Precipitate Formation In Storage

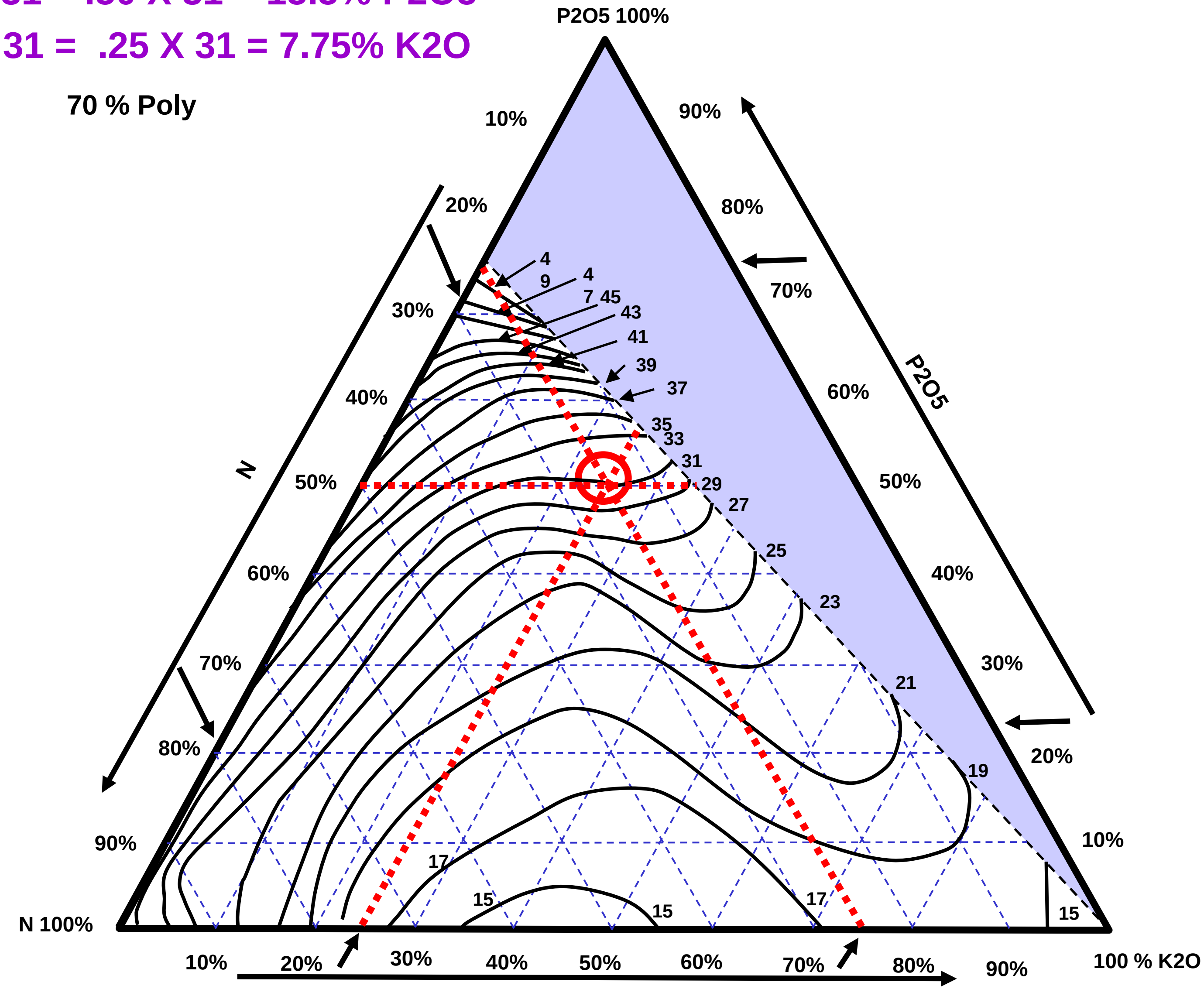
- Amount of polyphosphate initially present
- Amount of impurities in super-acid
- Other 'impurities' added to product
  - ✓ Zinc
  - ✓ Previous product sludge
- Temperature of stored product
- Length of time product stored

APP Storage and Housekeeping Suggestions

- Do not store longer than necessary
- Avoid storage in summer months
- Completely empty and clean tanks regularly
- Know the quality of remaining product before adding additional product to tanks
- Do not contaminate with products/impurities that may affect storage properties
- Never mingle any calcium or magnesium with product or mix plant
- Make sure that farmers and dealers lines, tanks and equipment are completely cleaned after use

- **Final maximum grade May Contain <u>31</u> Total Plant Food Units.**
  - N = 25% of 31 = .25 X 31 = 7.75% N
  - P_2O_5 = 50% of 31 = .50 X 31 = 15.5% P2O5
  - K_2O = 25% of 31 = .25 X 31 = 7.75% K2O

70 % Poly



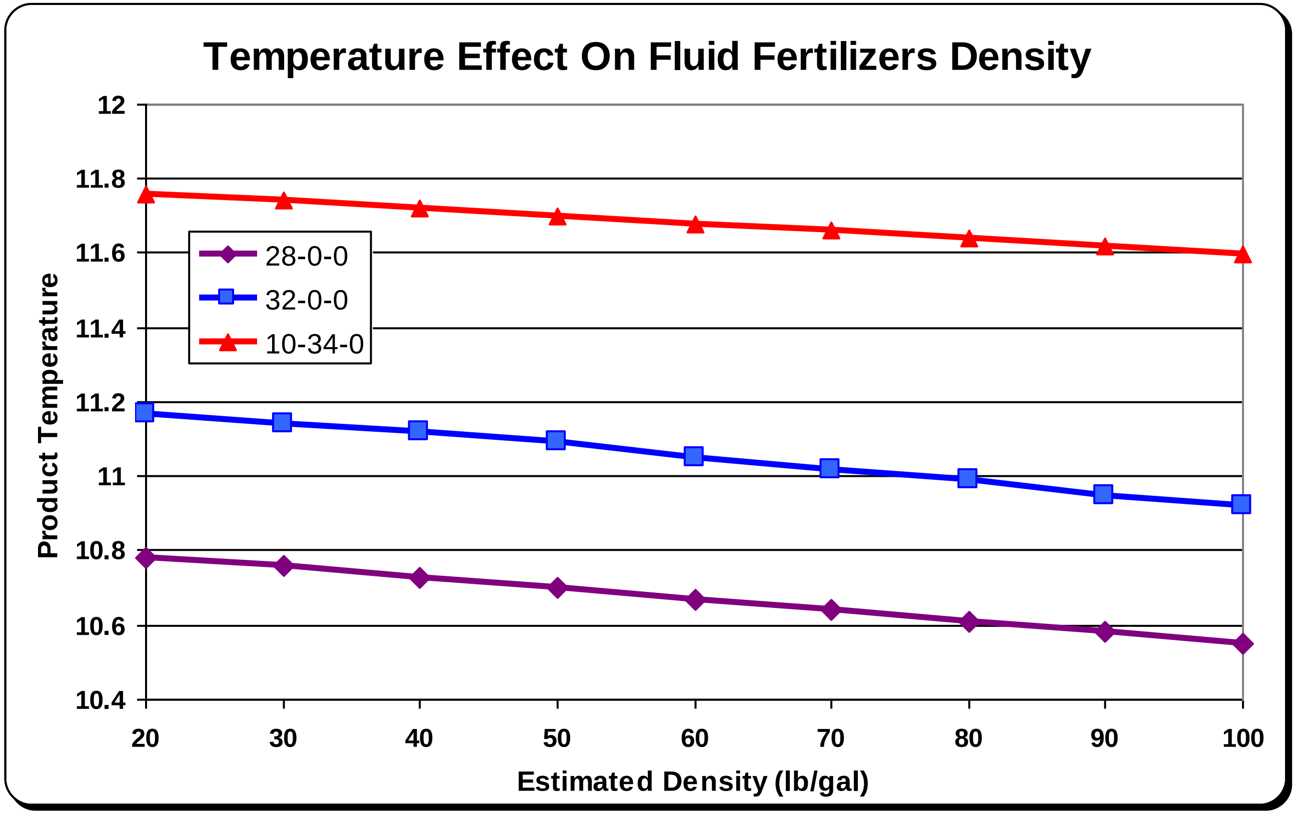
Solution Grades For UAN Solution (28-32% N), Potassium Chloride (0-0-62) and Ammonium Polyphosphate (10-34-0, 11-37-0) System

N:P_2O_5:K_2O Ratio	Solution Analysis (32 F Saltout)
1-0-1	7-0-7
1-0-2	5.5-0-11
1-0-3	4.3-0-12.9
1-1-0	19.5-19.5-0
1-1-1	7.3-7.3-7.3
1-1-2	5.3-5.3-10.6
1-1-3	4.2-4.2-12.6
1-1-4	3.5-3.5-14
1-1-5	2.9-2.9-14.5
1-2-0	15.3-30.6-0
1-2-1	7.7-15.4-7.7
1-2-2	5.1-10.2-10.2
1-2-3	3.8-7.6-11.4
1-2-4	3.2-6.4-12.8
1-2-5	2.7-5.4-13.5
1-2-6	2.3-4.6-13.8
1-3-0	12.5-37.5-0
1-3-1	7.4-22.2-7.4
1-3-2	4.7-14.1-9.4
1-3-3	3.5-10.5-10.5
1-3-4	2.9-8.7-11.6
1-3-5	2.5-7.5-12.5
1-3-6	2.2-6.6-13.2

N:P_2O_5:K_2O Ratio	Solution Analysis (32 F Saltout)
3-0-1	13.5-0-4.5
3-0-2	8.4-0-5.6
3-0-4	6.6-0-8.8
3-1-0	24.6-8.2-0
3-1-1	12.6-4.2-4.2
3-1-2	8.7-2.9-5.8
3-1-3	6.9-2.3-6.9
3-1-4	6-2-8
3-2-0	21.6-14.4-0
3-2-1	12-8-4
3-2-2	8.7-5.8-5.8
3-2-3	6.9-4.6-6.9
3-2-4	6.3-4.2-8.4
3-2-5	5.7-3.8-9.5
3-3-1	11.7-11.7-3.9
3-3-2	8.4-8.4-5.6
3-3-4	6.3-6.3-8.4
3-3-5	5.7-5.7-9.5
3-4-1	11.4-15.2-3.8
3-4-2	9-12-6

Typical Characteristics Of Several Fluid Fertilizer Products

Source	Analysis	Density	Salt-Out	General Comments
	N-P_2O_5-K_2O	*Lbs/gal*	*º F*	
UAN	**28-0-0**	**10.67**	**0**	**~ 30% water**
UAN	**32-0-0**	**11.06**	**28 - 32**	**~ 20% water**
ATS	**12-0-0-26S**	**11.04**	**<20**	**Fluid S Source of Choice**
APP	**10-34-0**	**11.65**	**<10**	**11-37-0 grade also**



Estimated Density Of Fluid Products

Product Temperature	28-0-0	32-0-0	10-34-0
	- - -	lb / gal	- - -
20	10.78	11.17	11.76
30	10.76	11.14	11.74
40	10.73	11.12	11.72
50	10.7	11.09	11.7
60	10.67	11.05	11.68
70	10.64	11.02	11.66
80	10.61	10.99	11.64
90	10.58	10.95	11.62
100	10.55	10.92	11.6

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Salt-out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

Precipitate formation – Non-crystalline mass forms which has much lower solubility than original ingredients in solution. Example; Improperly stored fluid phosphates

Heat generator – Generates chemical heat when producing solutions. Examples; ammonia + phosphoric acid; dilution of sulfuric acid)

Fume generator – Generates fumes which can be safety hazard. Example; UAN solution + Potassium carbonate → ammonia fumes.

$$2NH_4NO_3 + K_2CO_3 \rightarrow 2KNO_3 + (NH_4)_2CO_3$$

$$(NH_4)_2CO_3 \rightarrow 2NH_3\uparrow + H_2CO_3$$

$$H_2CO_3 \rightarrow H_2O + CO_2\uparrow$$

UAN in Irrigation Water ?

UAN in Irrigation Water ?

Urea N Volatilization ?

$$2NH_4NO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + (NH_4)_2CO_3$$

$$(NH_4)_2CO_3 \rightarrow \uparrow 2NH_3 + H_2CO_3 \uparrow$$

$$H_2CO_3 \rightarrow H_2O + CO_2$$

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Caution: This chart contains information based on the opinions of people in the fluid fertilizer industry. This information has been compiled as a general guide only. Neither the Fluid Fertilizer Foundation or contributors guarantee the accuracy of the information. Please refer to manufacturer/supplier product information and also Perform a small jar compatibility test prior to final mixing.

- (green) 'Compatible', results in relatively stable mixture.
- (yellow) 'Limited Compatibility', generally compatible within solubility limits.
- (blue) 'Very Limitied Compatibility', generally unsuitable mixtures.
- (red) 'Incompatible', unsuitable mixture and/or hazardous combination.
- Δ Significant heat generated.

Fluid Fertilizer Foundation

2805 Claflin Road, Suite 200

Manhattan, KS 66502

785-776-0273

FluidFertilizer@sbcglobal.net

	Ammonia	Aqua Ammonia	Urea Solution	Amm. Nitrate Solution	UAN Solution	Ammonium Sulfate Solution	Ammonium Polyphosphate Solution	Ammonium Chloride Solution	Ammonium Thiosulfate	Potassium Thiosulfate	Calcium Thiosulfate	Magnesium Thiosulfate	Calcium-Ammonium Nitrate Solution	Calcium Nitrate Solution	Potassium Carbonate Solution
Anhydrous Ammonia	black														
Aqua Ammonia; 20-0-0	blue Δ	black													
Urea Soln; 23-0-0	blue Δ	green	black												
Ammonium Nitrate Soln; 20-0-0	blue Δ	green	green	black											
Urea Ammonium Nitrate Soln; UAN 28/32-0-0	blue Δ	green	green	green	black										
Ammonium Sulfate Soln; 8-0-0-9S	red Δ	red Δ	green	green	green	black									
Ammonium Polyphosphate Soln; 10-34-0	red Δ	red Δ	green	green	green	green	black								
Ammonium Chloride Soln; 6-0-0-16Cl	blue Δ	yellow	green	yellow	green	yellow	green	black							
Ammonium Thiosulfate Soln; 12-0-0 26S	blue Δ	green	green	yellow	green	red	green	yellow	black						
Potassium Thiosulfate; KTS 0-0-25-17S	red	yellow	green	yellow	yellow	red	green	yellow	green	black					
Calcium Thiosulfate; CaTS, 6%Ca 10%S	red	green	green	green	green	red	red	?	red	yellow	black				
Magnesium Thiosulfate; MgTS, 10%S 4%Mg	red	red	yellow	red	green	red	red	?	yellow	green `	red	black			
Calcium-Ammonium Nitrate Soln; 17-0-0 8.8Ca	red	yellow	green	green	green	red	red	red	red	blue	blue	red	black		
Calcium Nitrate Soln; 9% N, 11% Ca	red	red	green	green	green	red	red	?	red	blue	blue	blue	green		
Potassium Carbonate Soln; 0-0-32	red	red	green	yellow	yellow	red	green	?	yellow	green	red	red	red	red	black
N-pHuric 28/27; 28-0-0 9S	red	yellow Δ	green	red	red	green	red	red	red	red	red	red	red	red	red
N-pHuric 15/49; 15-0-0 16S	red	yellow Δ	green	red	red	green	red	red	red	red	red	red	red	red	red
N-pHuric 10/55; 10-0-0 18S	red	yellow Δ	green	red	red	green	red	red	red	red	red	red	red	red	red
Water	yellow Δ	green	green	green	green	green	green	green	green	green	green	green	green	green	green
Nitric Acid	red Δ	yellow Δ	yellow Δ	yellow Δ	red	yellow Δ	yellow Δ	red	red	red	red	red	red	red	red
Phosphoric Acid (white)	red Δ	yellow Δ	yellow Δ	red	red	yellow Δ	yellow Δ	red	red	red	red	red	red	yellow Δ	red
Phosphoric Acid (green)	red Δ	yellow Δ	yellow Δ	red	red	yellow Δ	yellow Δ	red	red	red	red	red	red	yellow Δ	red
Sulfuric Acid	red Δ	yellow Δ	yellow Δ	red	red	yellow Δ	blue Δ	red	red	red	red	red	red	red	red
Urea; 46-0-0	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Ammonium Nitrate; 34-0-0	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	red	yellow	yellow	yellow
Calcium Nitrate; 15.5-0-0-19Ca	red	yellow	yellow	yellow	yellow	red	red	red	red	blue	yellow	yellow	yellow	yellow	red
Potassium Chloride; 0-0-62	red	yellow	yellow	yellow	yellow	blue	yellow	yellow	yellow	red	yellow	yellow	yellow	yellow	yellow
Potassium Nitrate; 13-0-46	red	yellow	yellow	yellow	yellow	red	yellow	?	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Magnesium Nitrate; 10%N 9%Mg	red	yellow	yellow	yellow	yellow	blue	red	?	yellow	yellow	yellow	yellow	yellow	yellow	red

	N-pHuric 28/27	N-pHuric 15/49	N-pHuric 10/55	Water	Nitric Acid	Phosphoric Acid (white)	Phosphoric Acid (green)	Sulfuric Acid	Urea	Ammonium Nitrate	Calcium Nitrate	Potassium Chloride	Potassium Nitrate	Magnesium Nitrate
N-pHuric 28/27; 28-0-0 9S	black													
N-pHuric 15/49; 15-0-0 16S	yellow	black												
N-pHuric 10/55; 10-0-0 18S	yellow	green	black											
Water	green	green	green	black										
Nitric Acid	red	red	red	green Δ	black									
Phosphoric Acid (white)	yellow	green	green	green Δ	green	black								
Phosphoric Acid (green)	yellow	green	green	green Δ	green	green	black							
Sulfuric Acid	red	yellow	yellow	yellow Δ	green	green	green	black						
Urea; 46-0-0	red	yellow	yellow	yellow	red Δ	yellow Δ	yellow Δ	yellow Δ	black					
Ammonium Nitrate; 34-0-0	red	red	red	yellow	yellow	yellow	yellow	red	Dry	black				
Calcium Nitrate; 15.5-0-0-19Ca	red	red	red	yellow	red	red	red	red	Dry	Dry	black			
Potassium Chloride; 0-0-62	red	red	red	yellow	red	red	red	red	Dry	Dry	Dry	black		
Potassium Nitrate; 13-0-46	red	red	red	yellow	red	yellow	yellow	red	Dry	Dry	Dry	Dry	black	
Magnesium Nitrate; 10%N 9%Mg	red	red	red	yellow	red	blue	blue	red	Dry	Dry	Dry	Dry	Dry	black

Thank You And Enjoy The Roundup

Dale F. Leikam

Fluid Fertilizer Foundation

www.FluidFertilizer.com

Dale.Leikam@sbcglobal.net
785-776-0273
785-770-0009