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 Marketing and Technology Workshop

Sheraton Tampa Riverwalk Hotel - Tampa, FL

Fluid Fertilizer Foundation

Fluid Fertilizer Foundation
2805 Claflin Rd., Ste. 200
Manhattan, KS 66502

Phone: 785-776-0273
E-mail: fluidfertilizer@sbcglobal.net
Website: www.fluidfertilizer.com

Tuesday, December 8, 2009

		Session A	Session B
12:30	12:45	Welcome and Announcements **(B. Easterwood)**	
12:45	1:15	Fluid Fertilizer Solutions and Opportunities **(A. Campos)**	
1:15	2:00	Southeast/Global Fertilizer Outlook and Trends; 2010 and Beyond	
2:00	2:15	Break	
2:15	3:15	Local Plant Operation/Maintenance **(T. Scoble)**	Advanced Production Systems For Citrus **(A. Schumann)**
3:15	4:00	Florida Nutrient Criteria Issues: A Precedent For the Rest of the Nation? **(J. Brown)**	Production, Characteristics, Salt-out, Precipitate Formation, etc. For Common Fluid Fertilizers **(D. Leikam)**
4:00	5:00	Storage Tank Failures & Maintenance **C. Meyers)**	Compatibilities, Formulation With ATS, CaNO3, K2CO3, KNO3, etc. **(M. Orr)**
6:00	7:30	Social Hour / Reception	

Wednesday, December 9, 2009

		Session A	Session B
8:00	9:00	Urea Volatilization: Mechanisms, Magnitude and Management **(D. Kissel)**	
9:10	10:10	Fertigation/Maintenance of Fertigation Systems **(B. Hobbs)**	Micronutrient Sources & Performance: Where They Fit **(A. Robinett)**
10:10	10:30	Break	
10:30	11:30	Production Issues For Fluid Products (**D. Plank)**	Foliar Nutrient Application Update and Opportunities
11:30	12:15	Specialty Fertilizer Law/Issues **(M. Hartney)**	Modern Products, Techniques and Equipment **(G. Harris)**
12:15	12:30	Wrap-Up, Thank You, Enjoy The Mosaic Tour, Have a Safe Trip Home!!	
1:00	7:00	Tour of Mosaic Phosphate Mine **(Mosaic Company)**	

Olsen's Agricultural Laboratory, Inc.
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Office: (308) 345-3670 Fax: (308)345-7880

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DR. GYLES RANDALL AND JEFF VETSCH

NPKS Starters Improve Profitability On High-Testing Soils

Studies conducted at Southern Research and Outreach Center in Waseca, Minnesota.

Historically, starter fertilizers have not been commonly recommended for corn production on high or very high P-testing soils due to poor yield response even though early growth responses may be seen. However, we've seen renewed interest in starter (band-placed) fertilizers as 1) corn yields continue to increase, 2) tillage intensity tends to decrease, and 3) corn planting comes earlier. With this renewed interest, questions have been raised regarding the inclusion of K and S in the fluid starter, as well as about optimum placement (in-row with seed vs. bands 2 inches from the seed or bands dribbled on the soil surface). Objectives of the research in this report were:

- Determine the effect of various combinations and rates of N, P, K and S as starter fertilizers for improving corn production and profitability on high P- and K-testing soils
- Evaluate starter placement positions for NPKS fluid fertilizers for corn grown on high P- and K-testing soils
- Provide to corn producers, crop advisors, and the fertilizer industry management guidelines on fluid starter fertilizer rates and placements for corn grown on high P- and K-testing soils with reduced tillage.

Concentration

Concentrations of N, P, K, and S in the whole small plant at the V6 stage were inconsistently affected by NPKS treatments (Table 1). This was particularly true for N and P where statistically significant differences were found but there was no clear effect of rate or placement and no interaction between rate and placement. Whole-plant K concentrations were not affected by starter P and K treatments. Whole-plant S concentration was increased by the 2 x 2 and 2 x 0 treatments that received S. Concentrations of NPKS were similar between 2 x 0 and 2 x 2 placement.

Dry matter

Dry matter accumulation at V6 was affected by the starter P

Fluid Fertilizers

- Increasing in popularity in U.S. and elsewhere
- Advantages include
  - ✓ Flexibility and versatility in application
  - ✓ Efficiency and adaptability
  - ✓ Potential benefits of continuous bands
  - ✓ Ease of handling
  - ✓ Does not segregate
  - ✓ Etc.
- Limitations
  - ✓ Generally higher purchase cost than solid fertilizers
  - ✓ Salt-out and precipitate formation potential with certain products and blends

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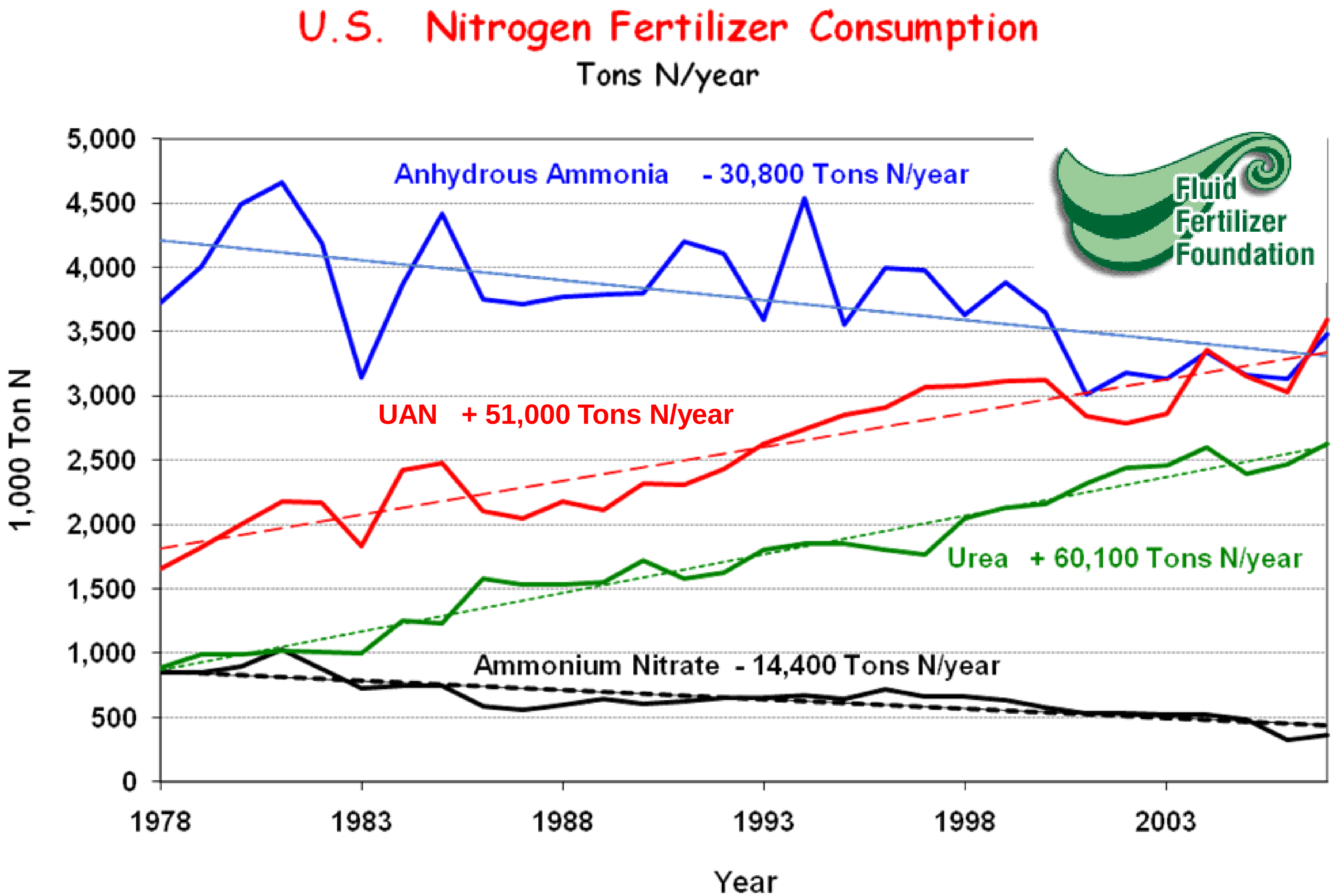

U.S. Nitrogen Fertilizer Consumption
Tons N/year
Anhydrous Ammonia - 30,800 Tons N/year
UAN + 51,000 Tons N/year
Urea + 60,100 Tons N/year
Ammonium Nitrate - 14,400 Tons N/year
Fluid Fertilizer Foundation
1,000 Ton N
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1978
1983
1988
1993
1998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

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.

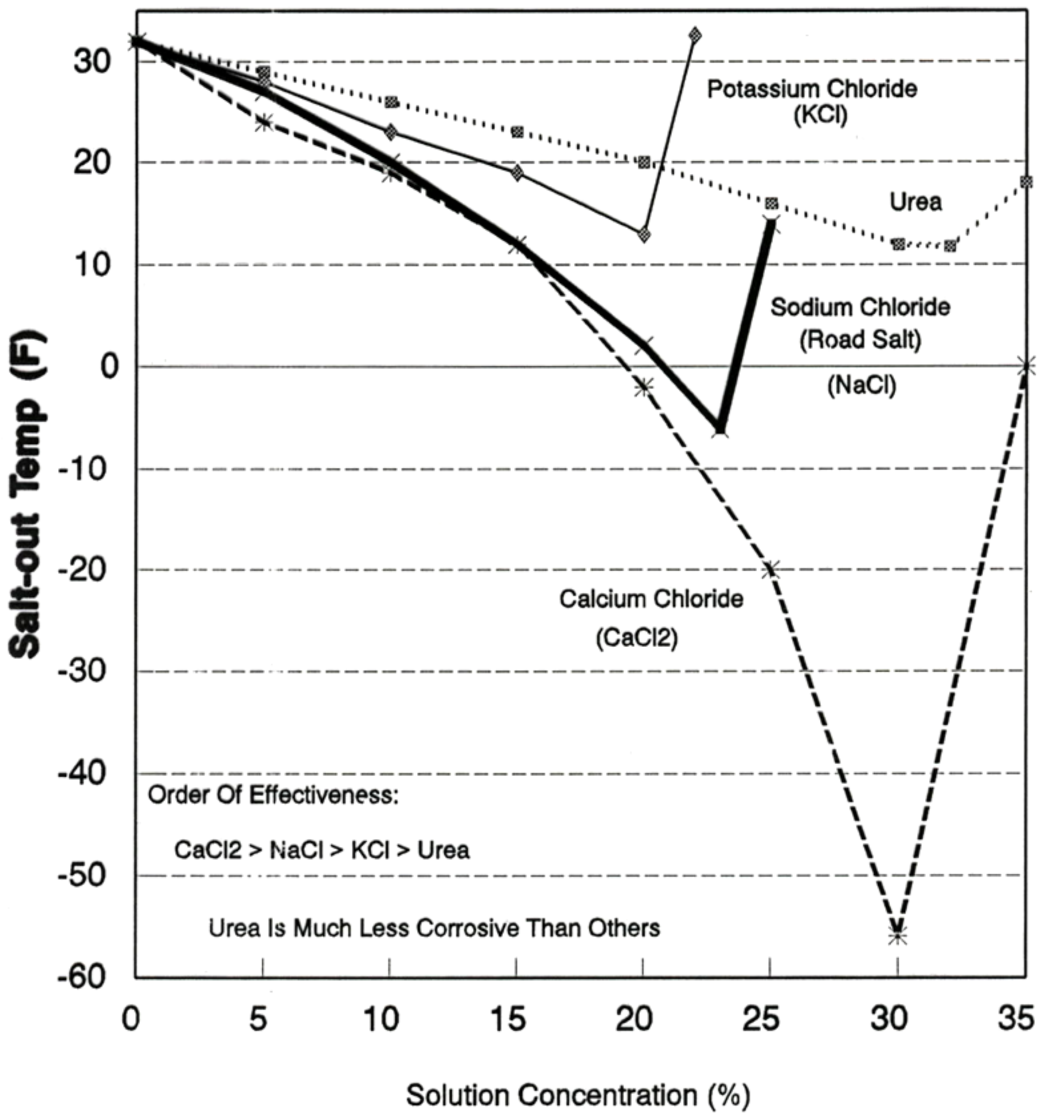
Muddy Water – Solutions with undissolved solids or suspensions containing too few undissolved salt crystals. Not a good range to try and operate in!!.

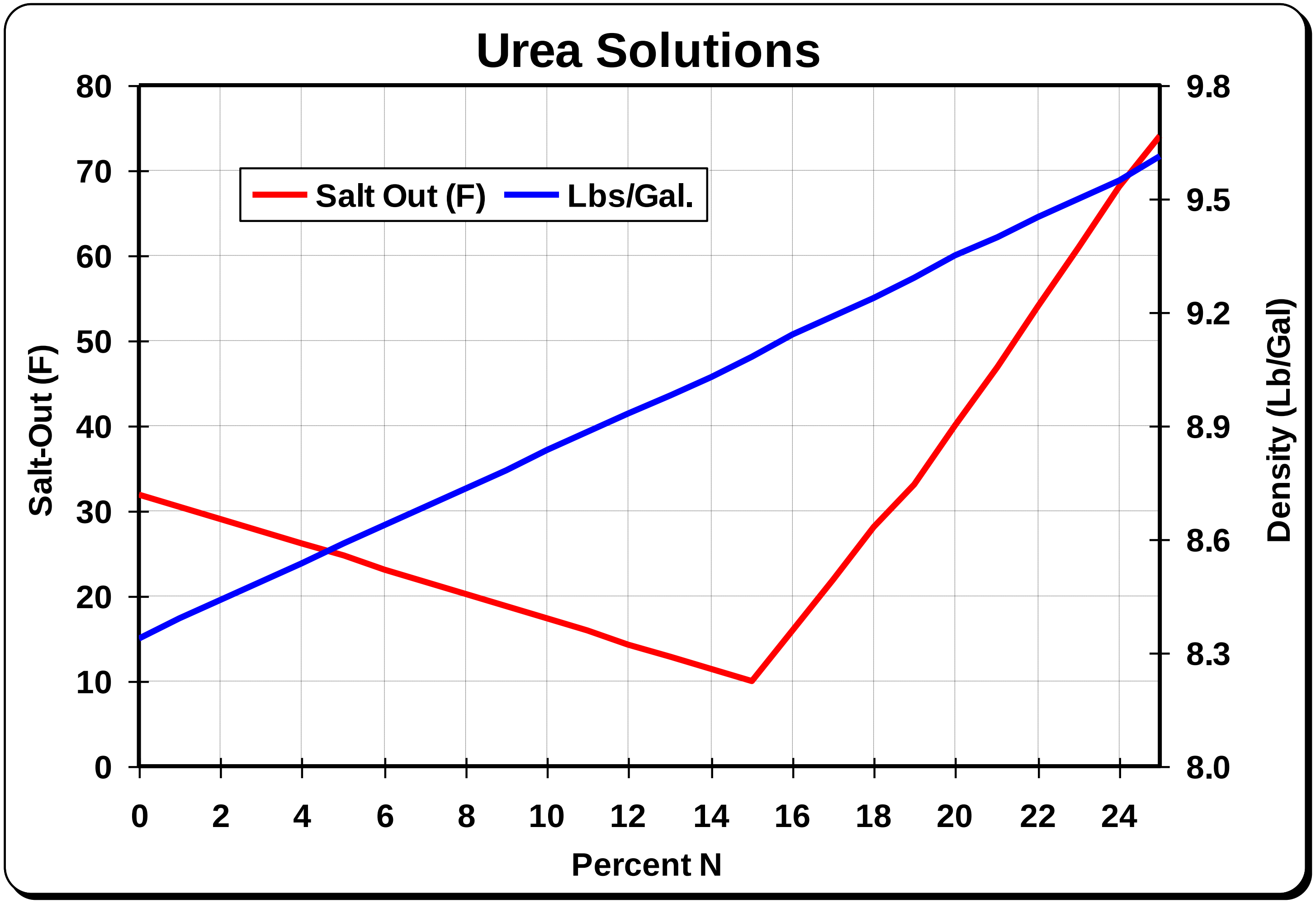
Falling Out Of Solution – No such thing.

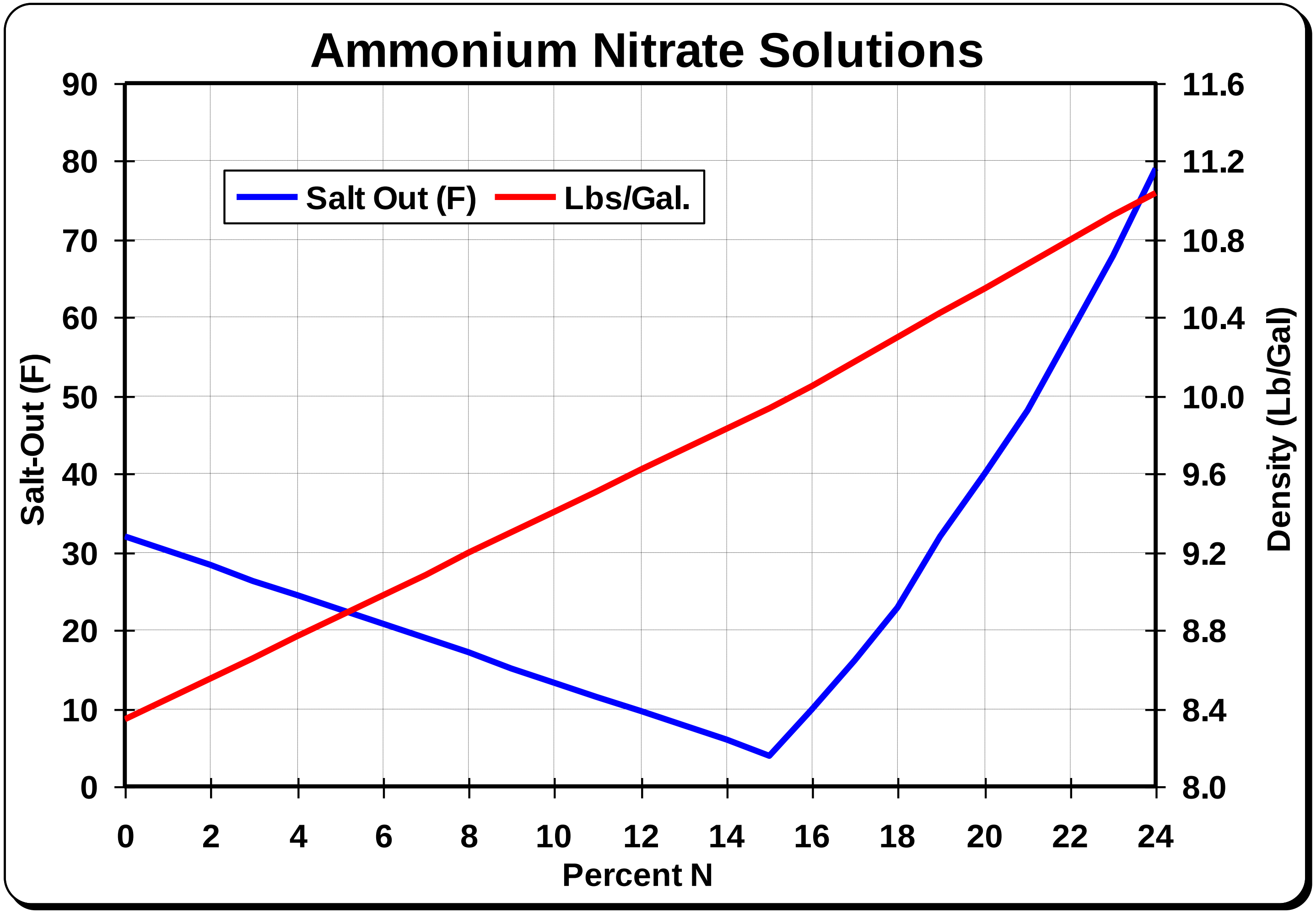
Salt-Out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

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

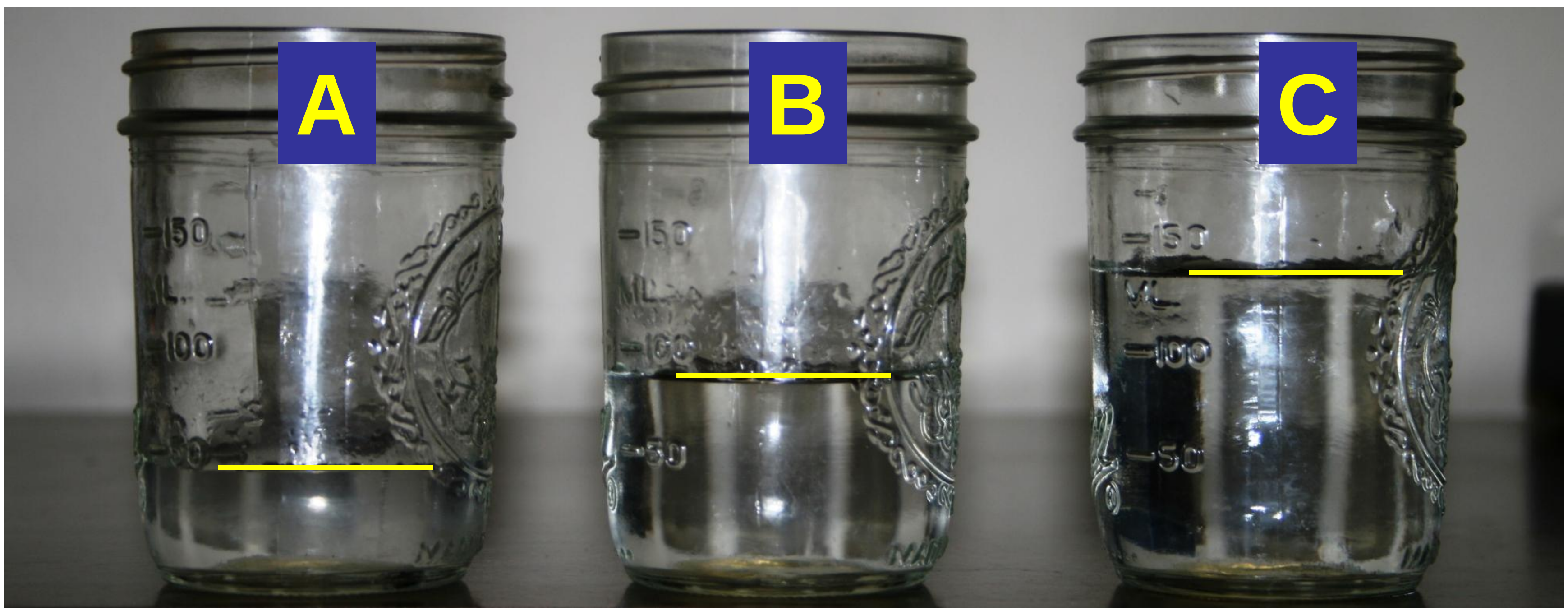


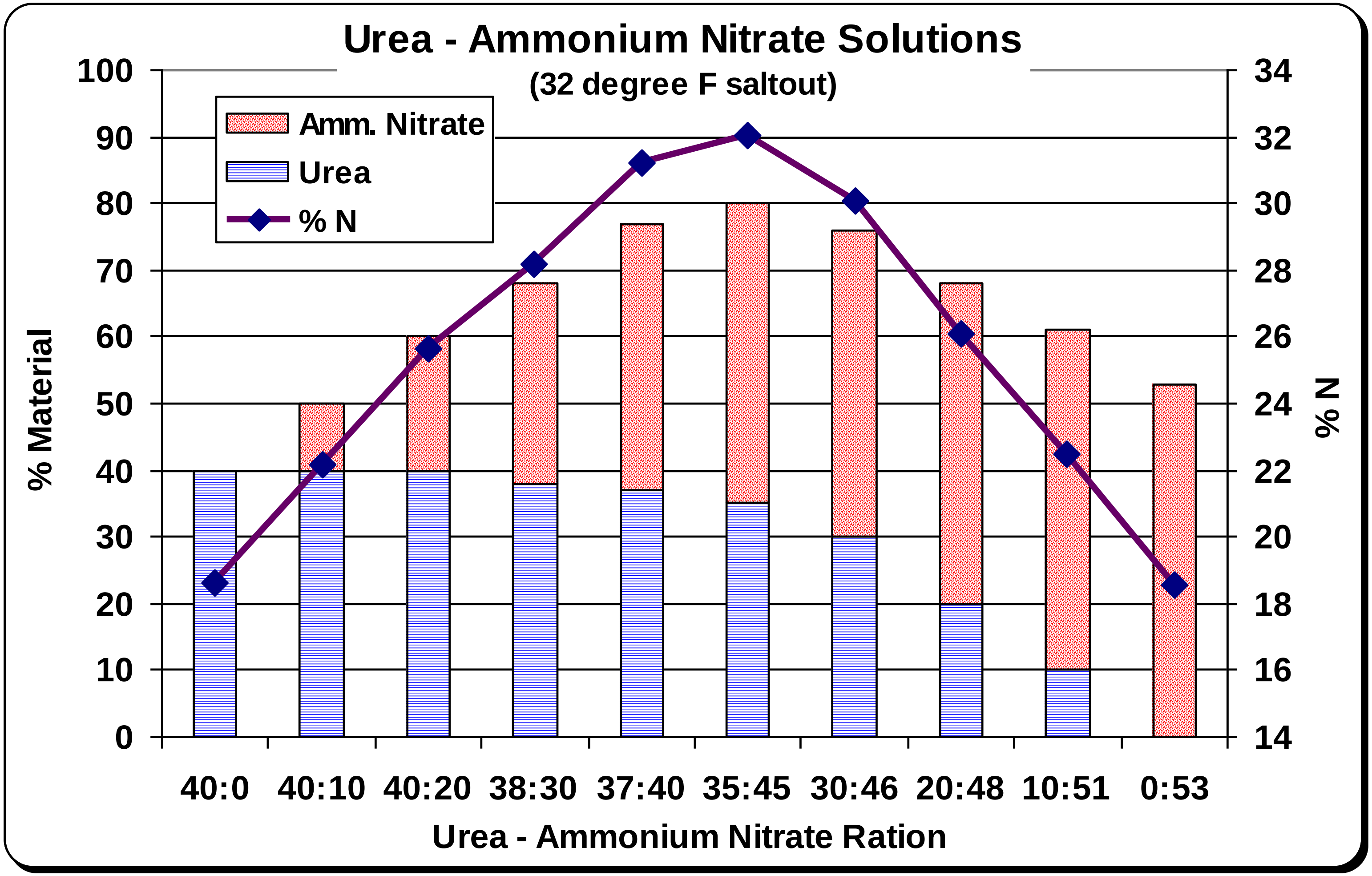

Urea Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
Density (Lb/Gal)
Percent N
0
10
20
30
40
50
60
70
80
8.0
8.3
8.6
8.9
9.2
9.5
9.8
0
2
4
6
8
10
12
14
16
18
20
22
24



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 ?





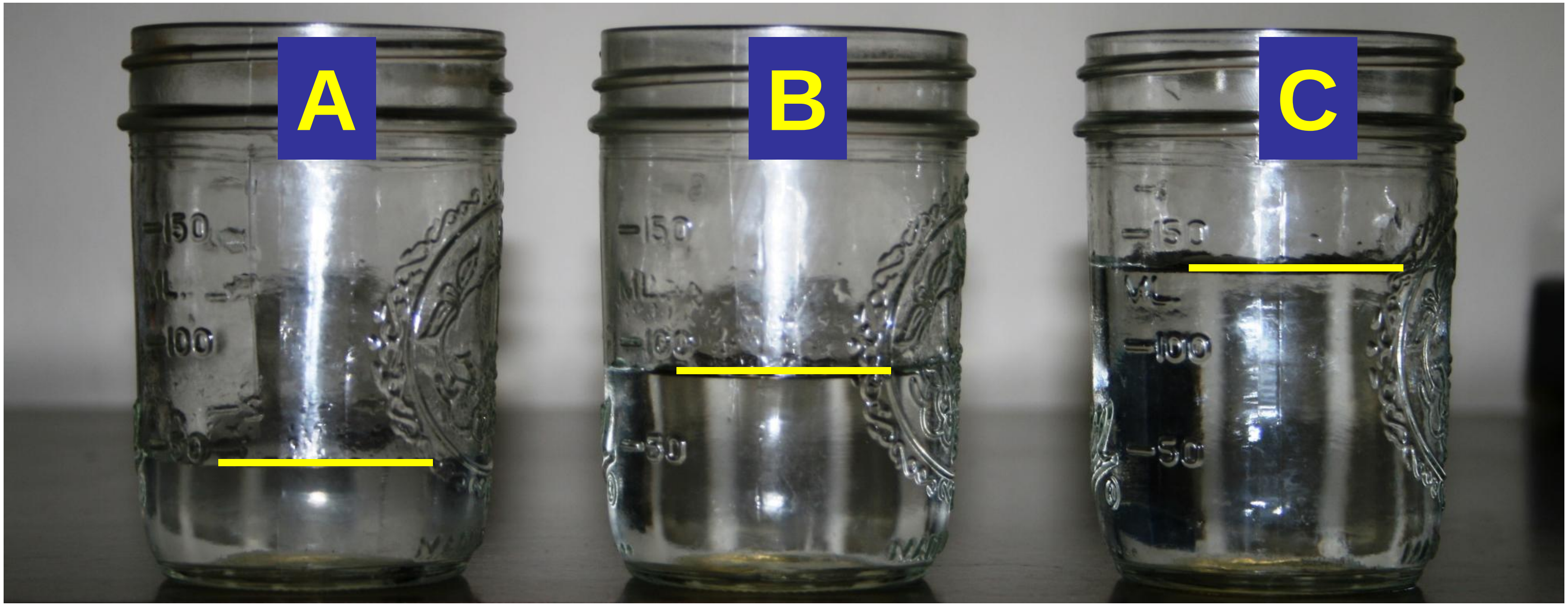
Eutectic Point – point of maximum solubility

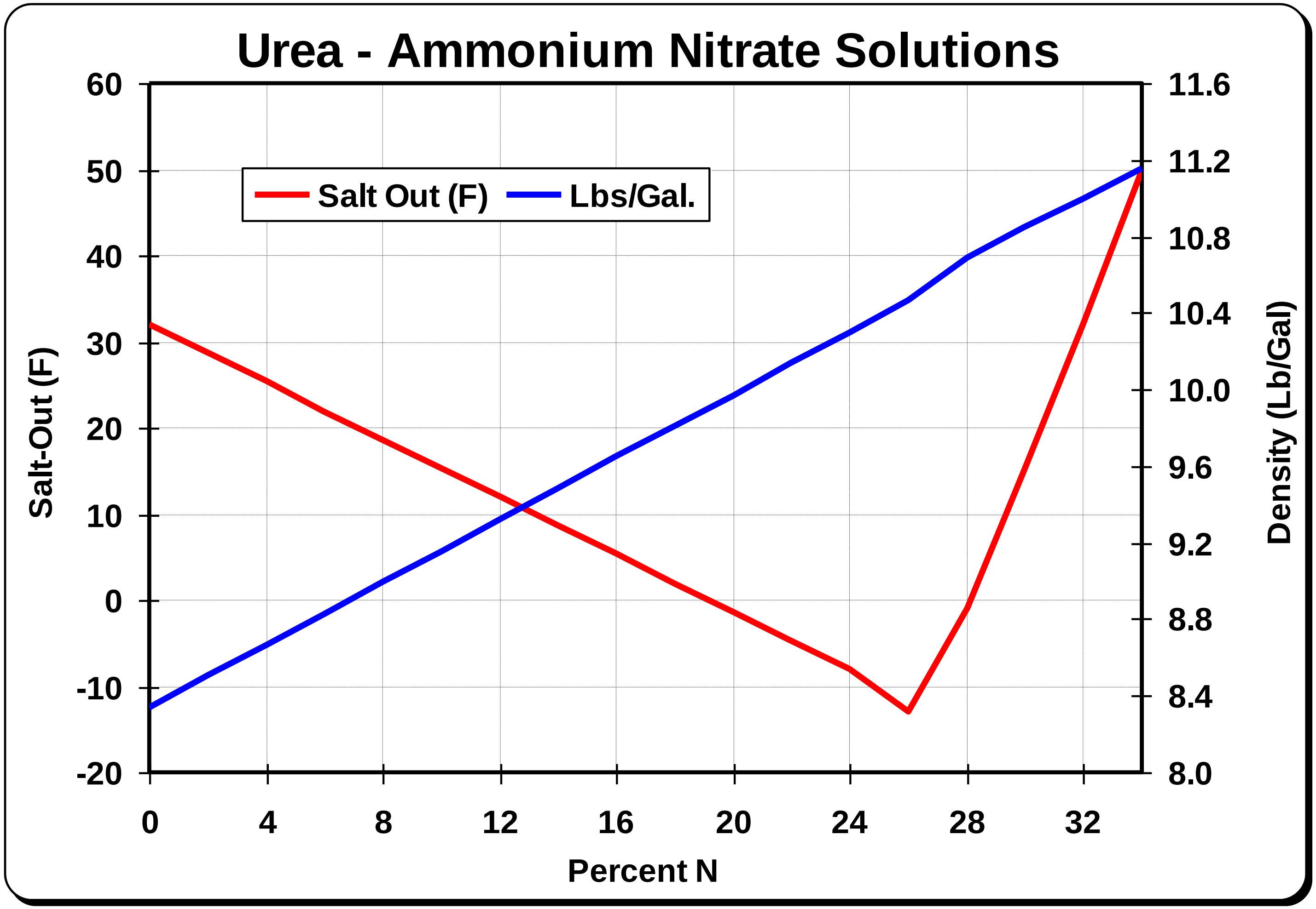
32% UAN contains:

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

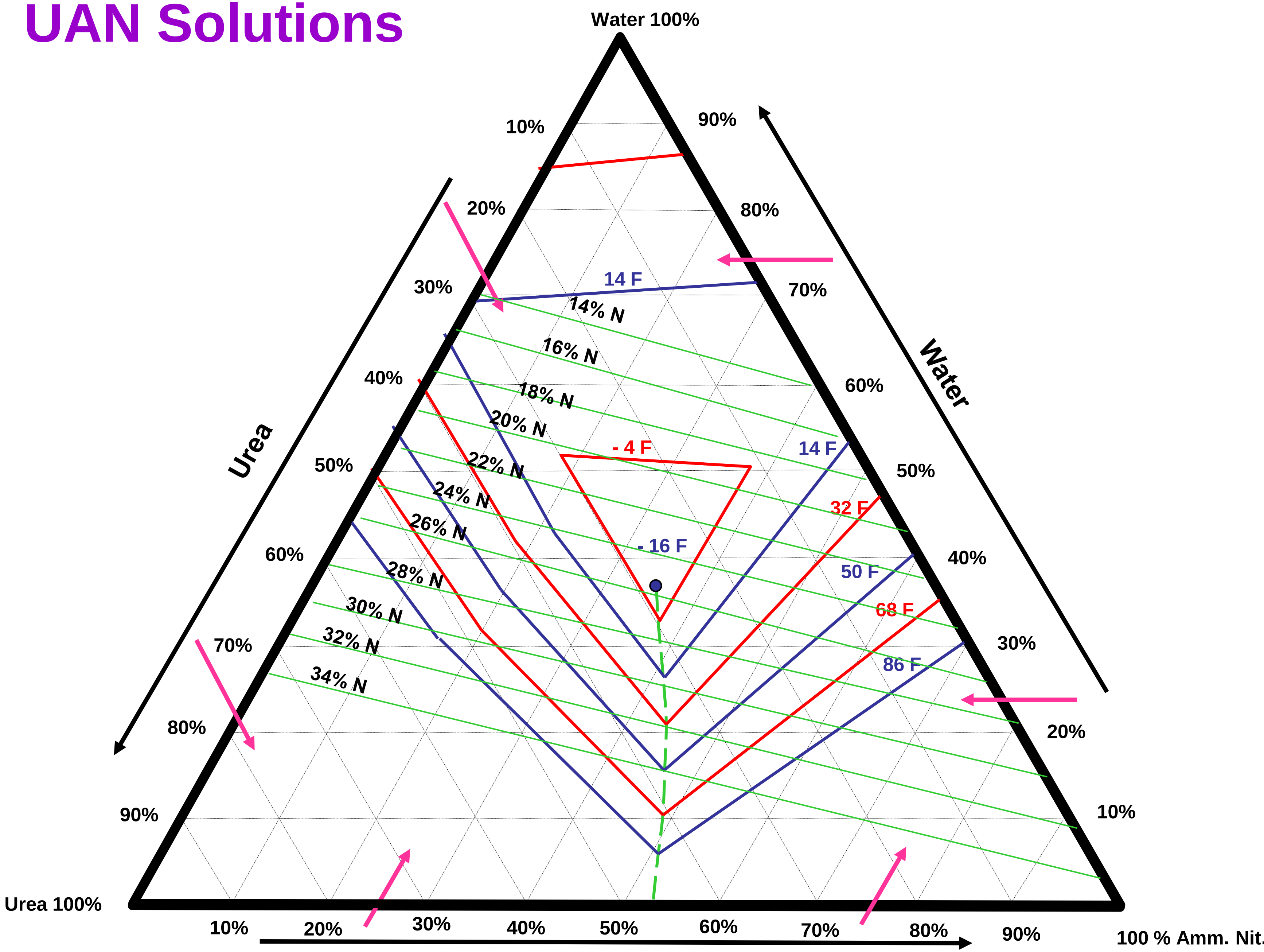
28% UAN contains 30% water

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




Urea - Ammonium Nitrate Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
Density (Lb/Gal)
Percent N
60
50
40
30
20
10
0
-10
-20
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

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

Lowering Water Freezing Temperature With UAN Soulution

% 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

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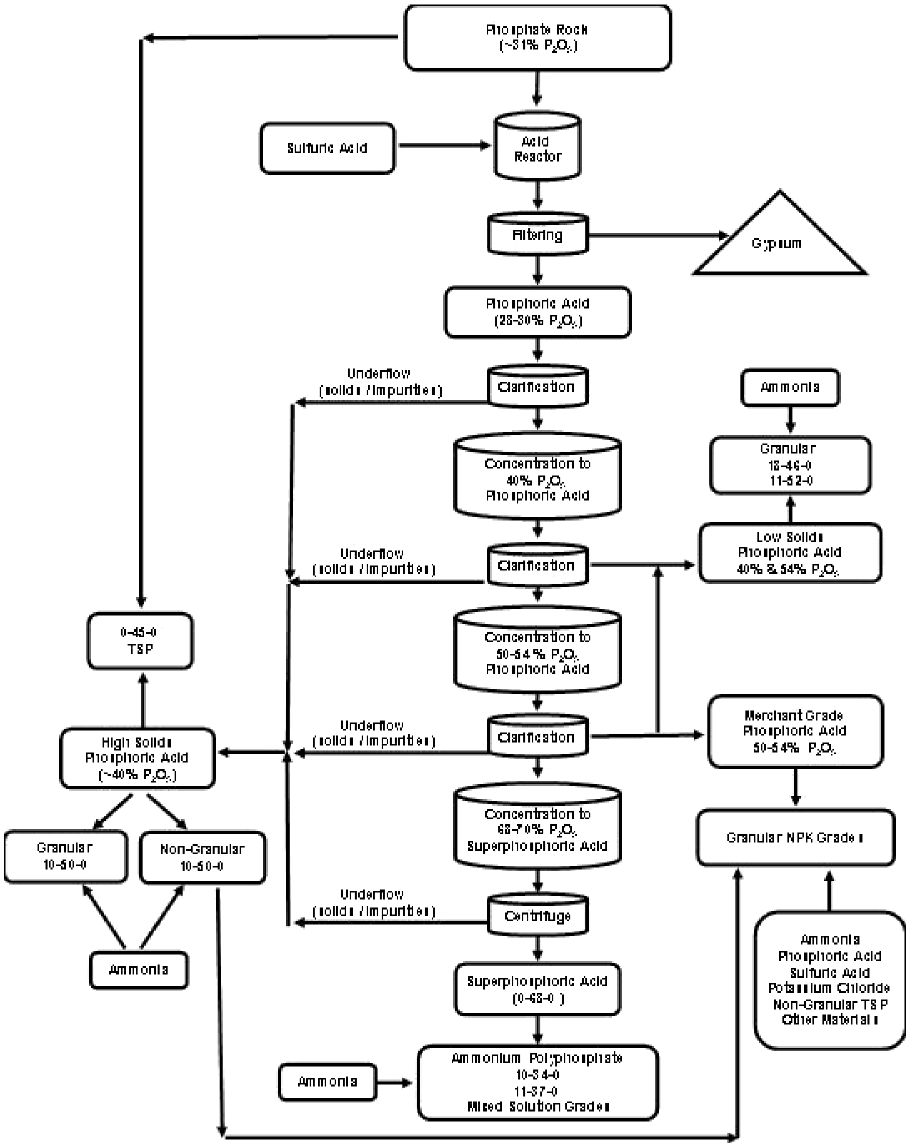
Liquid Phosphate Products

Fluid Phosphate Products and Characteristics



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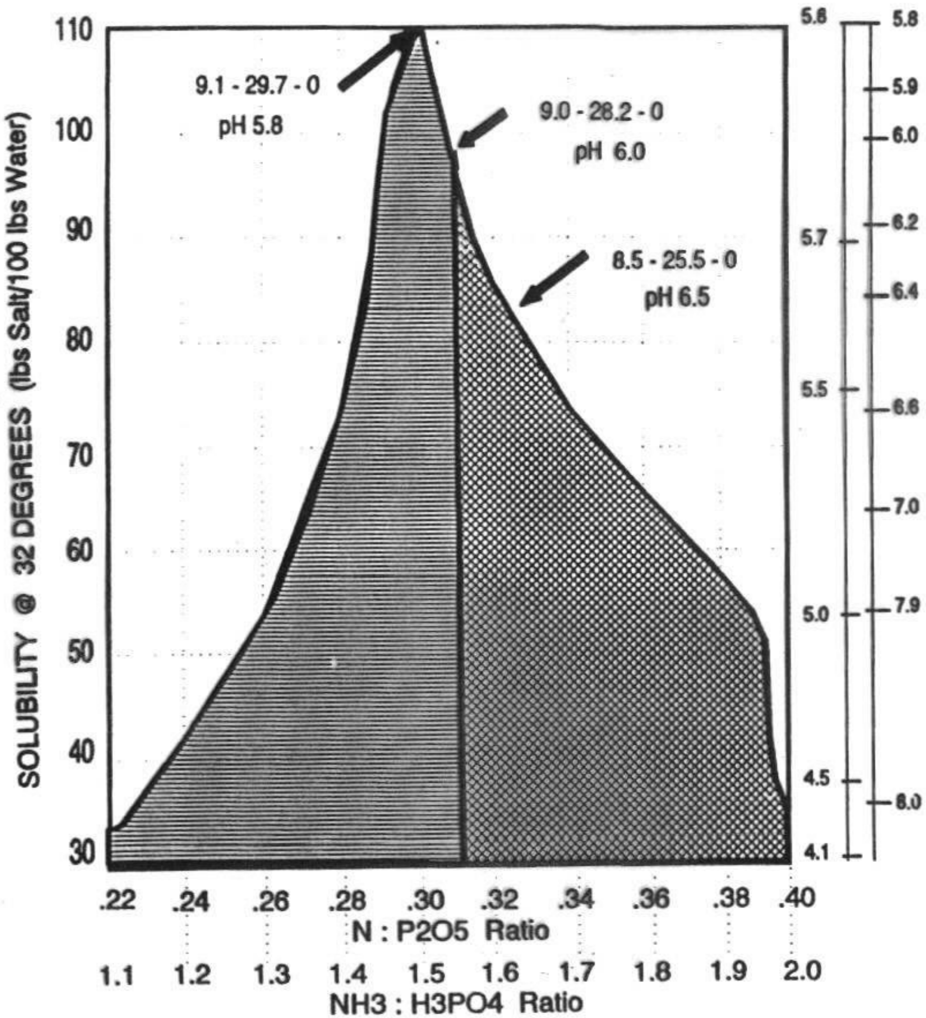
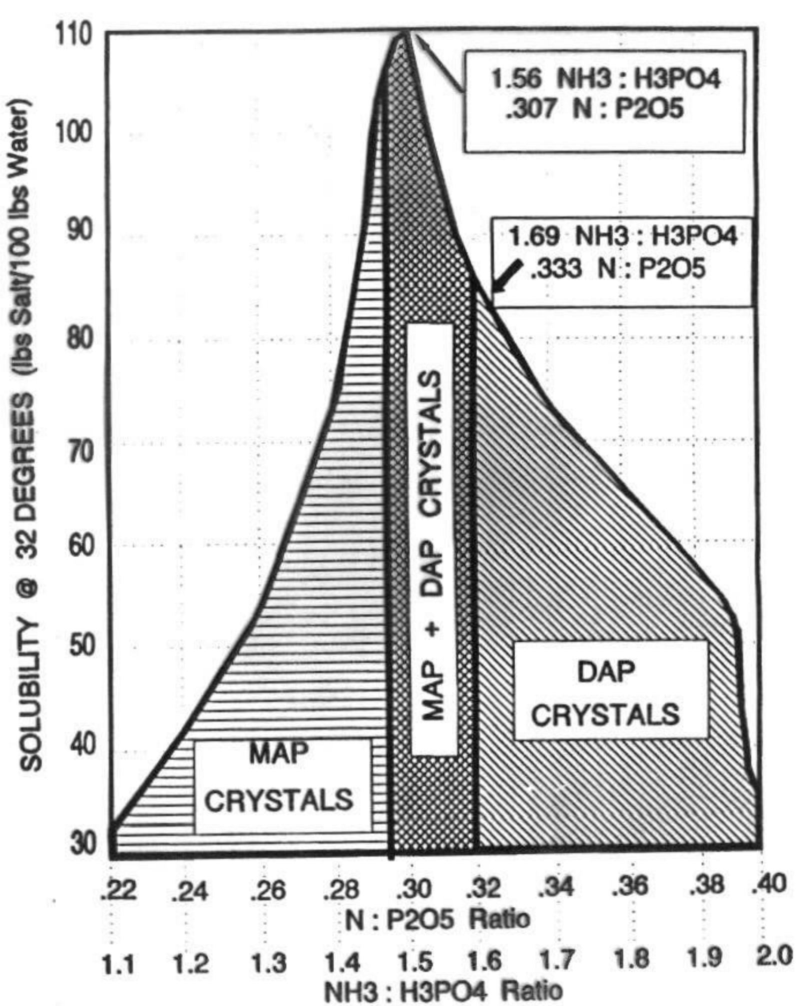
SOLUBILITY OF AMMONIUM PHOSPHATES

(ORTHO- SOLUTIONS)



(ORTHO- SUSPENSIONS)



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

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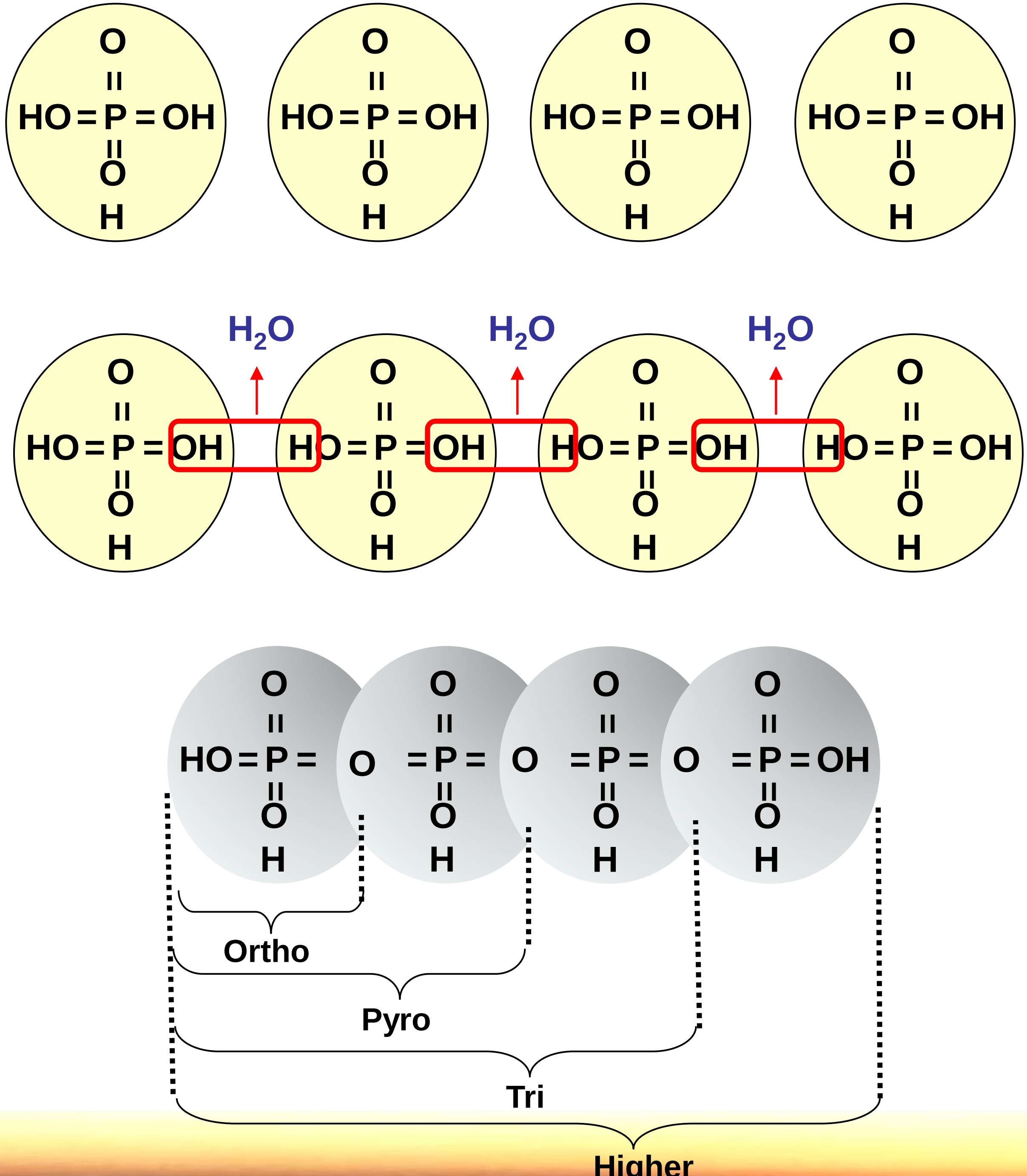
Orthophosphoric Acid Examples

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

Ammonium Polyphosphate

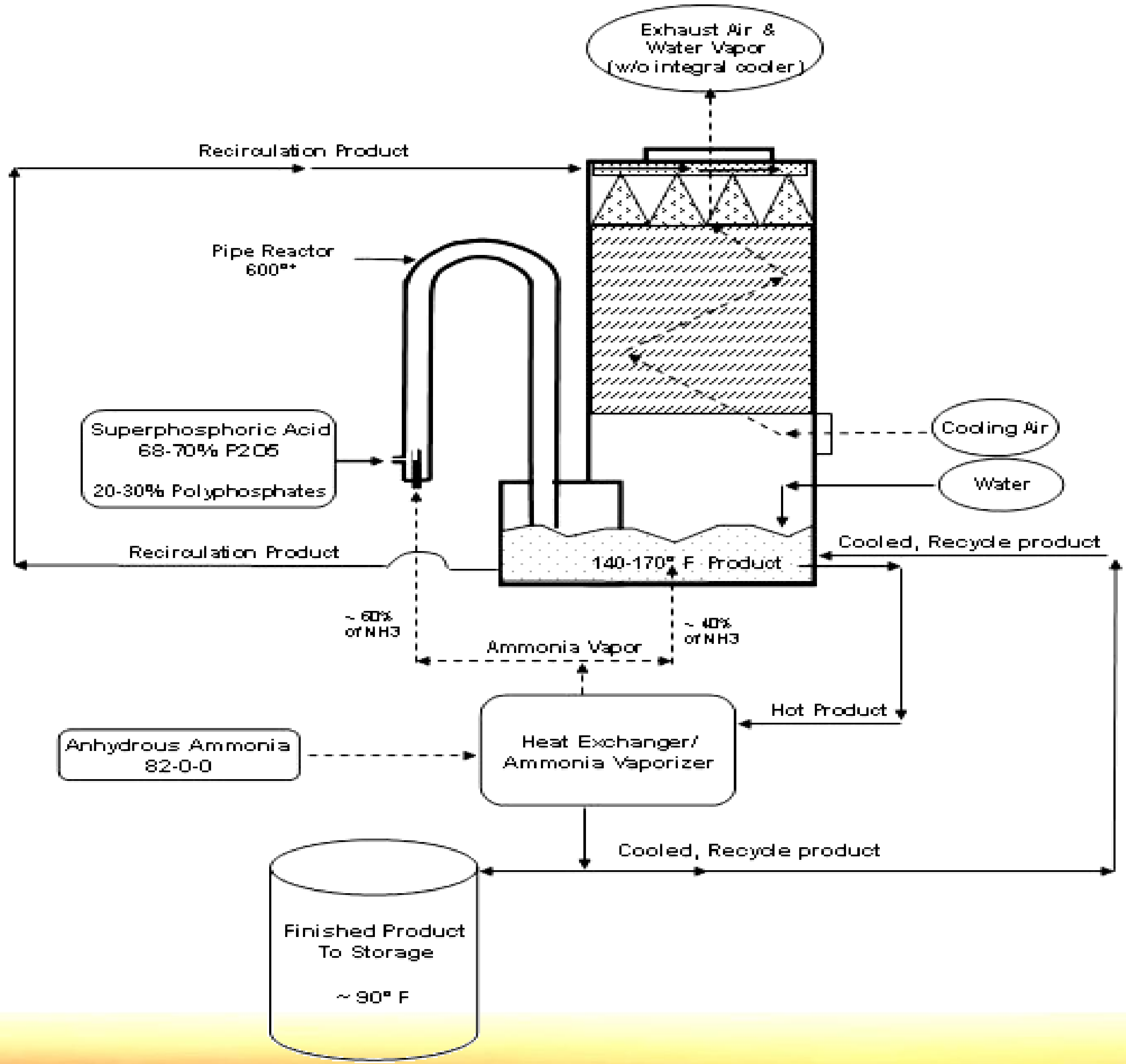
- Primary P source for much of fluid industry
- Most NPKS products made from APP
- Produced from ammonia, superphosphoric acid and water
- Generally equal agronomic performance as compared to solid fertilizers
  - ✓ If applied at equal P rates in similar manner
  - ✓ Potentially superior to solids if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



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

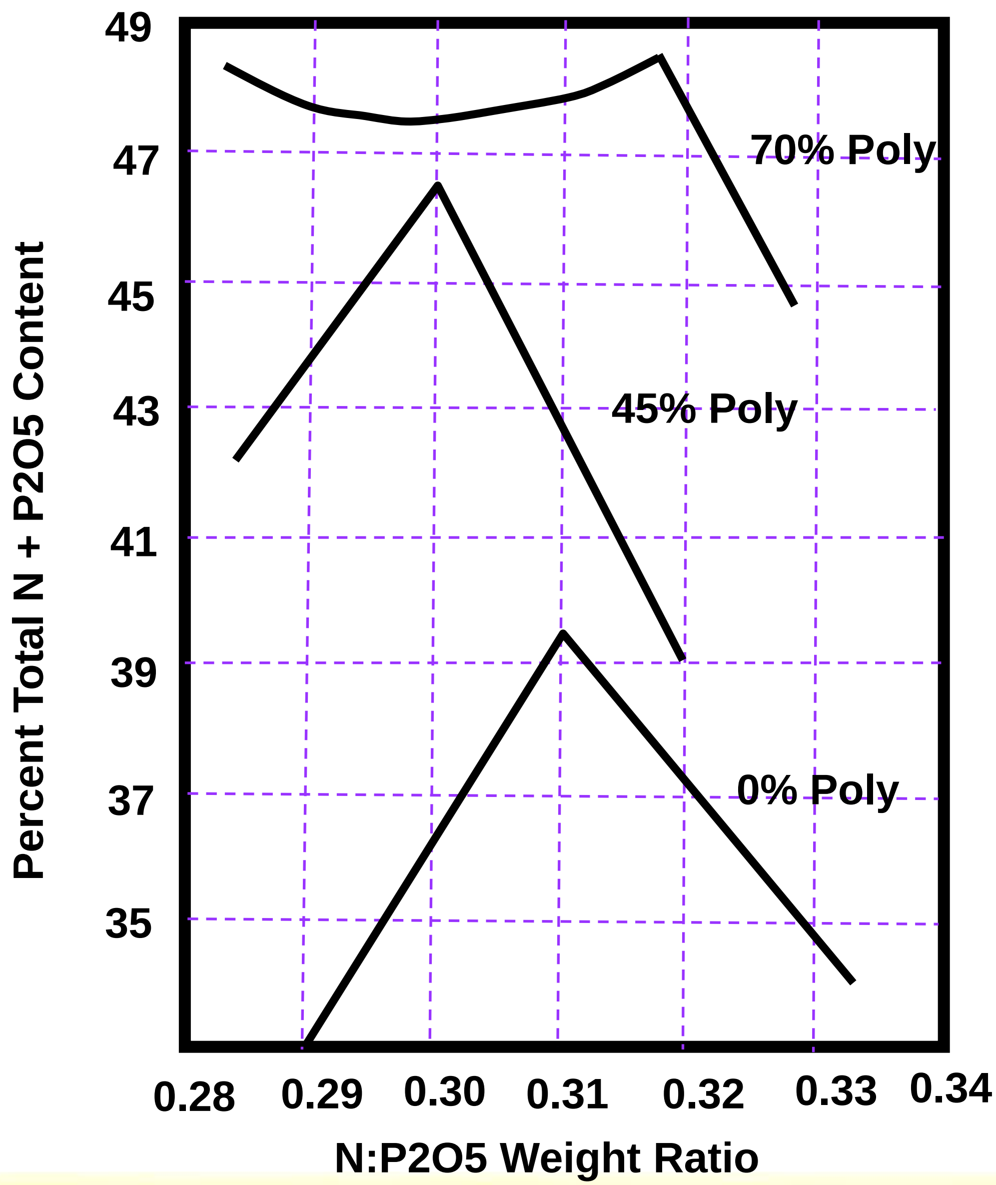
Soil Temperature	24 Hour Polyphosphate Hydrolysis (%)
41 F	30-40 %
68 F	50-60 %
95 F	80-90 %

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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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.

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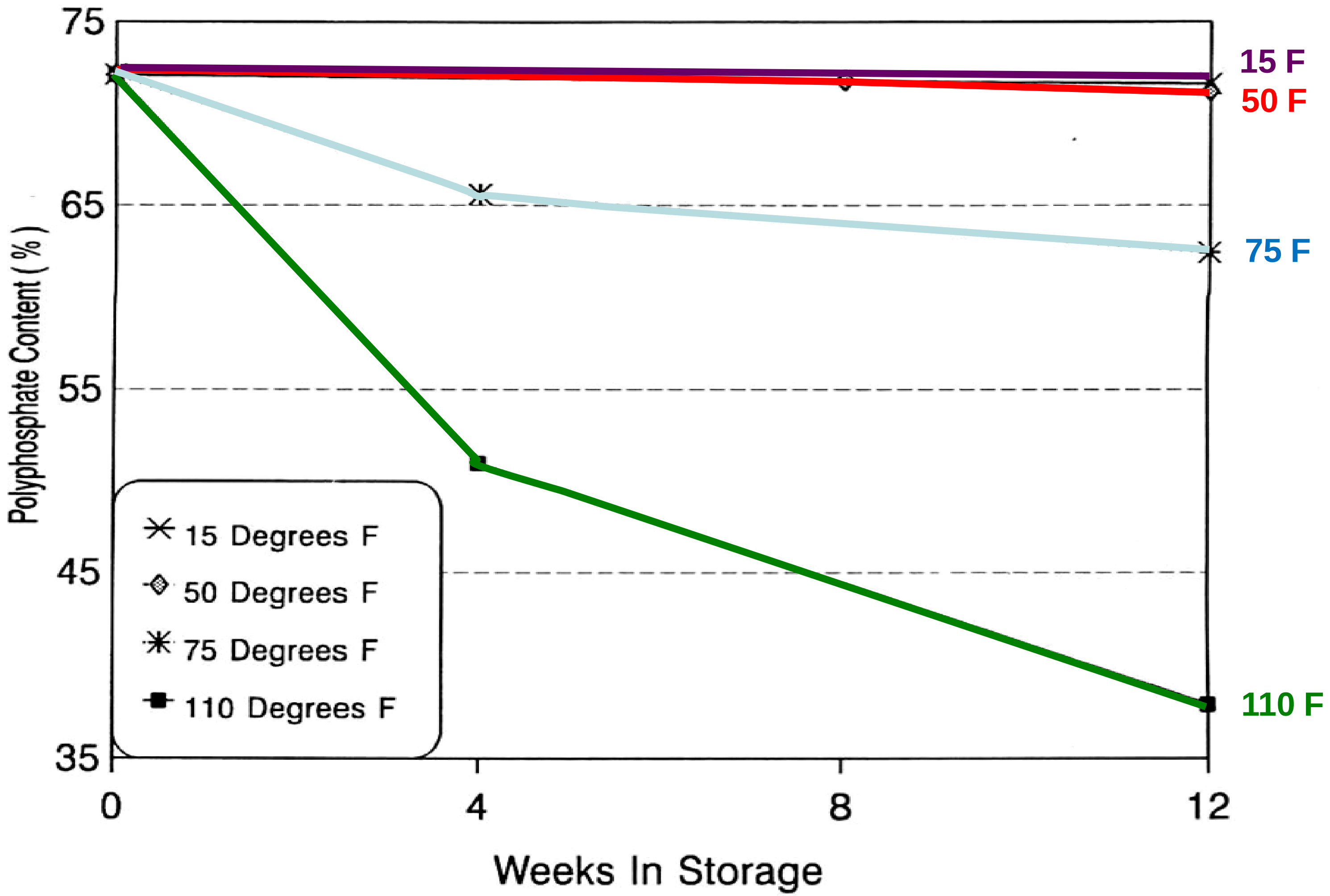
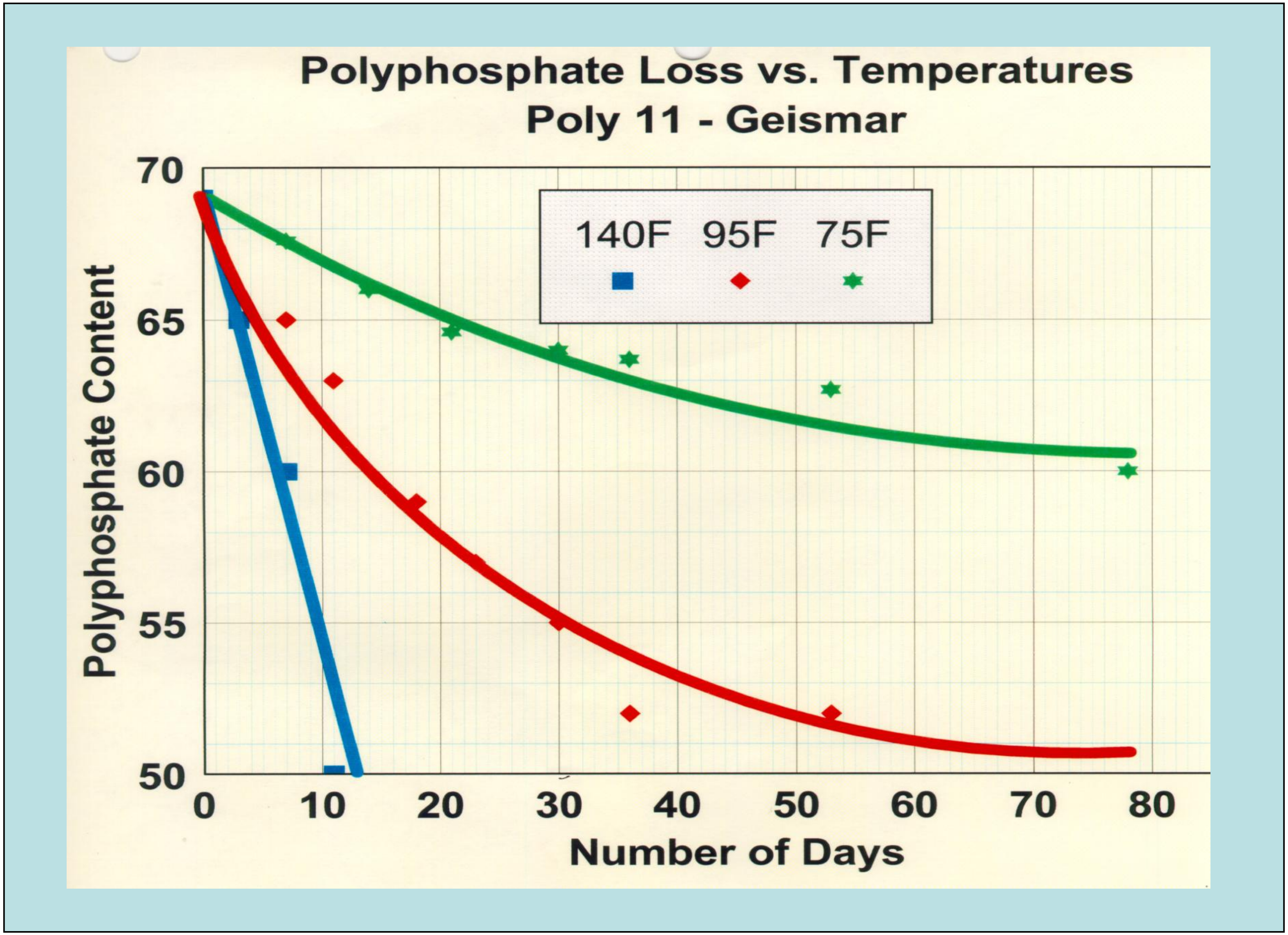
Temperature Effect On 10-34-0 Quality



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

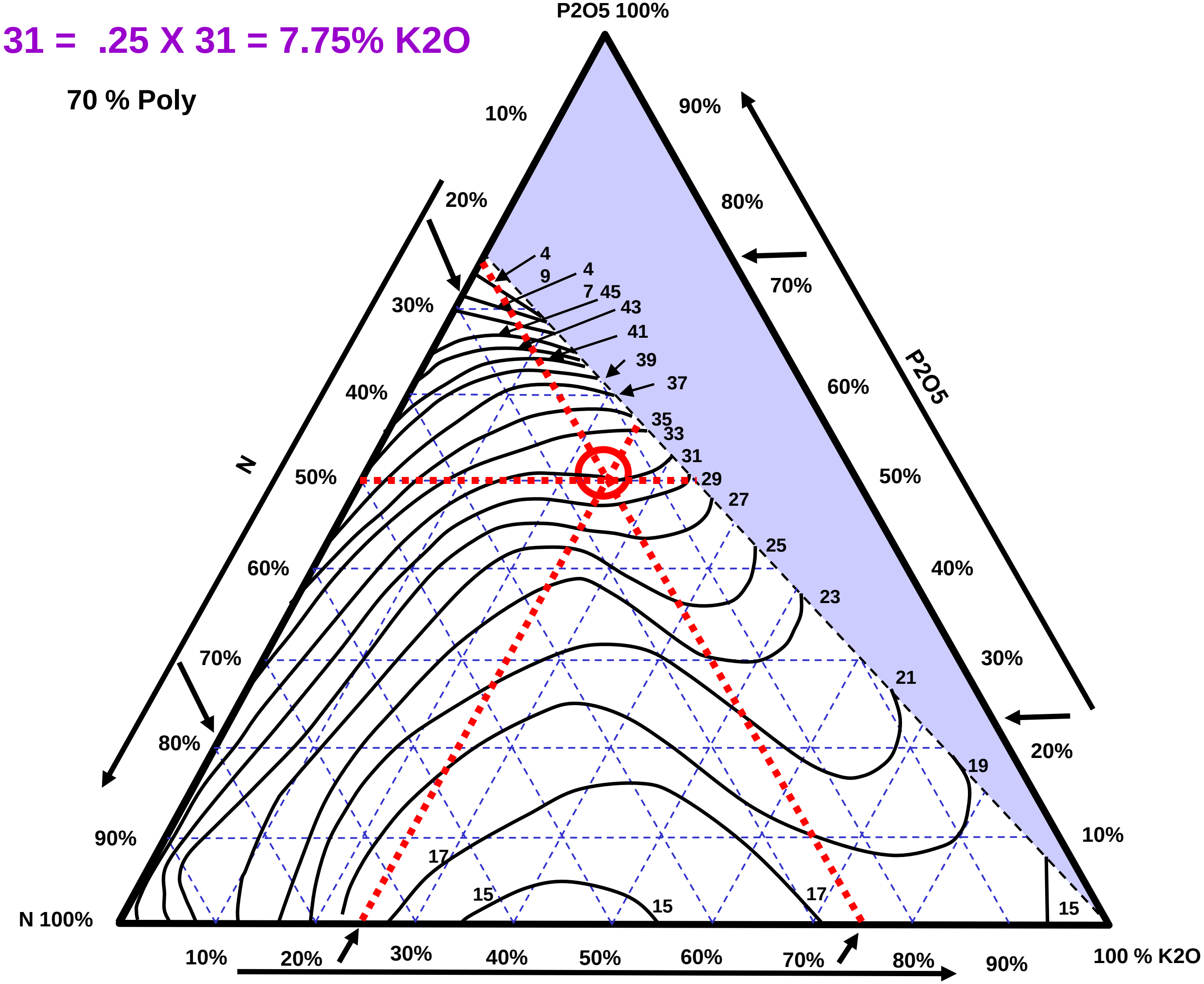
- Amount of polyphosphate initially present
- Amount of impurities in super-acid
- Other 'impurities' added to product
  - Zinc
  - Previous product sludge
- Temperature of stored product
- Length of time product stored

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 31 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



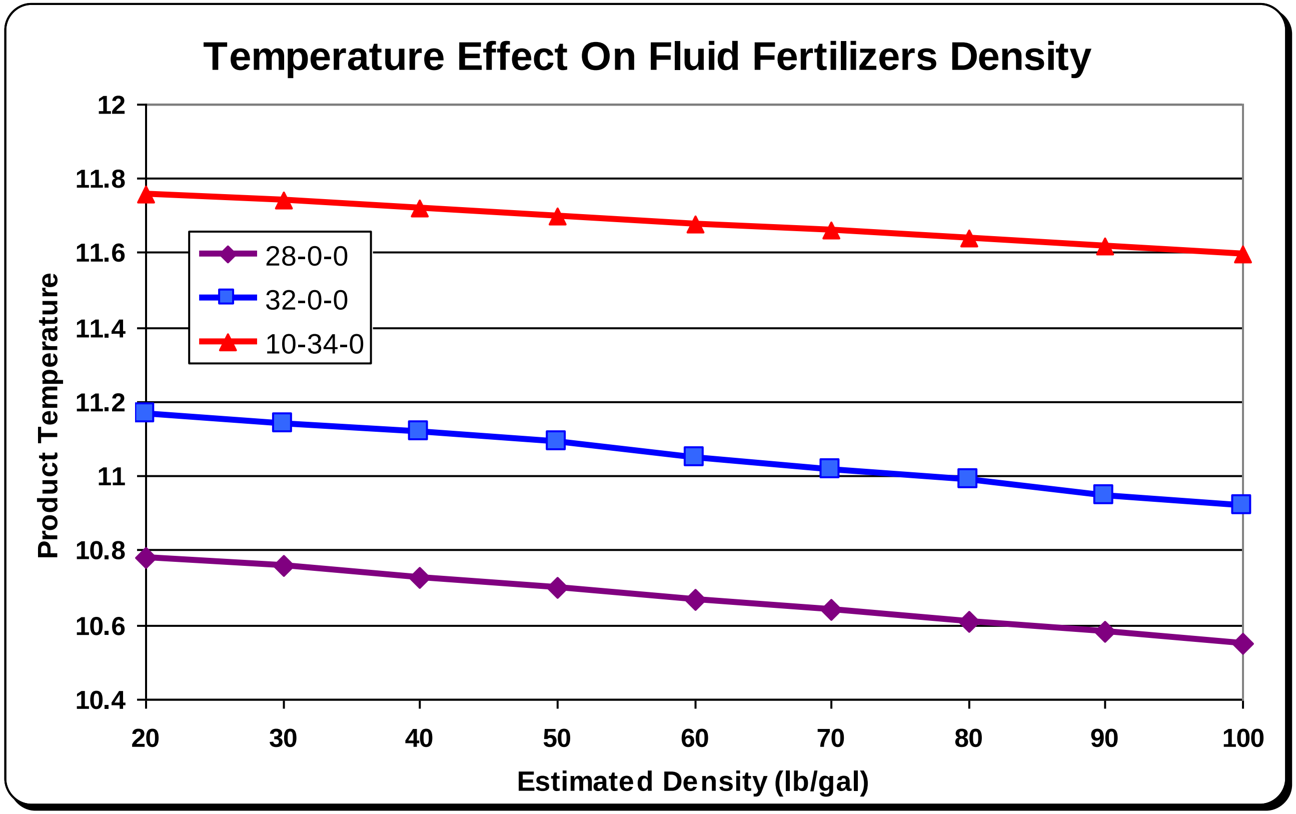
Solution Grades For UAN Solution (28-32% N), Potassium Chloride (0-0-62) and Ammonium Polyphosphate (10-34-0, 11-37-0) System

$N:P_2O_5:K_2O$ 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 ?

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

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

$$H_2CO_3 \rightarrow H_2O + CO_2$$

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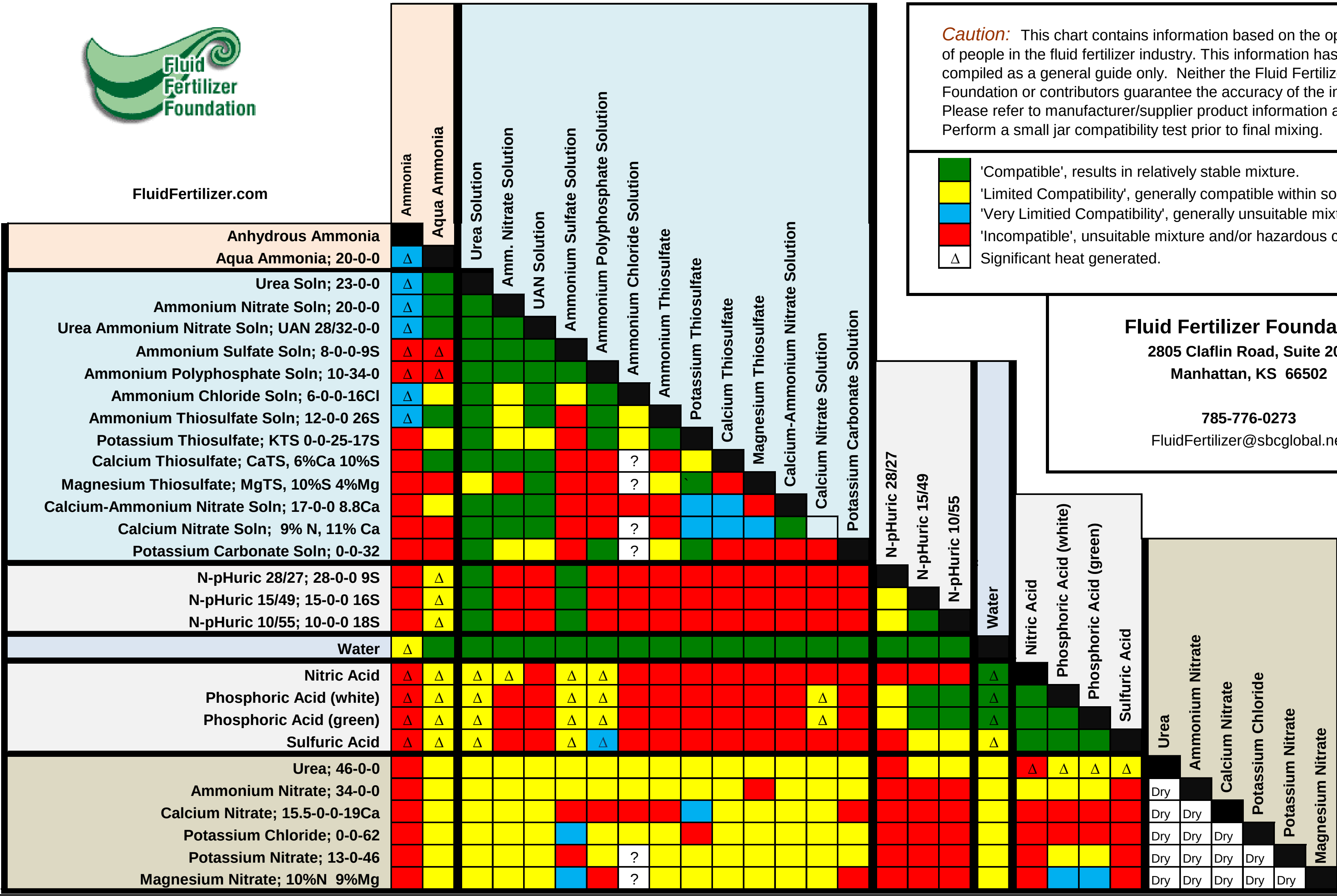

Caution: This chart contains information based on the opinions of people in the fluid fertilizer industry. This information has been compiled as a general guide only. Neither the Fluid Fertilizer Foundation or contributors guarantee the accuracy of the information. Please refer to manufacturer/supplier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

- 'Compatible', results in relatively stable mixture.
- 'Limited Compatibility', generally compatible within solubility limits.
- 'Very Limitied Compatibility', generally unsuitable mixtures.
- '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

Thank You And Enjoy The Conference

Dale F. Leikam

Fluid Fertilizer Foundation
www.FluidFertilizer.com

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