Fluid Fertilizers: Properties and Characteristics

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Western Fluid Fertilizer Technology Workshop

Piccadilly Inn Airport

Fresno, CA

Fluid Fertilizer Foundation

Tuesday, December 9, 2008

12:30	12:45	Welcome and Announcements **(R. Hopkins)**
12:45	1:15	Fluid Fertilizer Solutions For Crop Production **(L. Murphy)**
1:15	2:00	West Coast/Global Fertilizer Outlook and Trends; 2009 and Beyond **(J. Yost)**
2:00	2:15	Break

		Session A	**Session B**
2:15	3:15	Local Plant Operation/Maintenance Issues **(L. Lankenau)**	New Products, Techniques and Equipment **(R. Mikkelsen)**
3:15	4:15	Properties, Characteristics, Salt-out, precipitate formation of common fluid fertilizers **(D. Leikam)**	Fluid Sulfurs: Essential crop nutrition and soil amendment **(T. Fairweather)**
4:15	5:15	Compatibilities, formulation of ATS, CaTS, MgTS, K_2CO_3, KNO_3, etc. **(C. Louie, R. Satterfield, etc)**	Chelates: What they are and how/where they fit **(V. Jurin)**

Wednesday, December 10, 2008

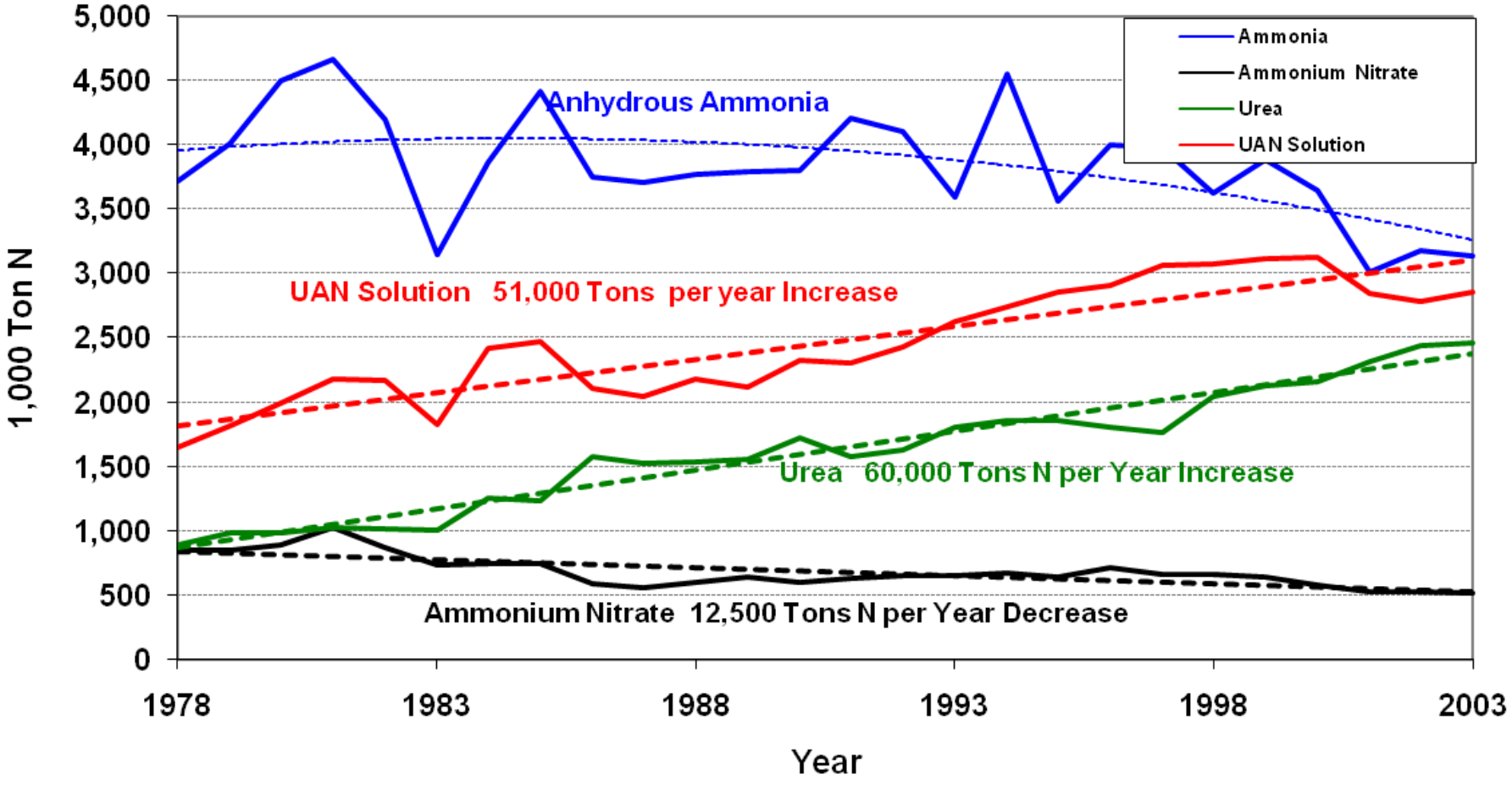
		Session A	**Session B**
8:00	9:15	Advances In Drip Systems and Nutrient Management **(A. Lobato, Chile)**	
9:15	10:00	Producing Urea, K_2CO_3, KNO_3 and 10-34-0 Solutions: Plant Operation Issues. **(M. Orr, R. Satterfield, etc.)**	Nutrient/Water Application Uniformity via Fertigation **(L. Schwankl)**
10:00	10:20	Break	
10:20	11:20	Storage Tank Failures and Maintenance **(C. Kominski)**	Drip Systems: Soil P Movement Of Various P Sources **(C. Krauter)**
11:20	12:00	Soil & Water Protection: Regulatory Update & Issues **(R. Pinel)**	Foliar Nutrient Application Update: Opportunities & Solutions **(P. Brown)**
12:00	12:20	Fertilizer Chain of Custody, Other Operation Issues, Questions and Discussion. **(Group)**	
12:20	12:30	Wrap-Up, Thank You, Have a safe trip home!!	

Fluid Fertilizers

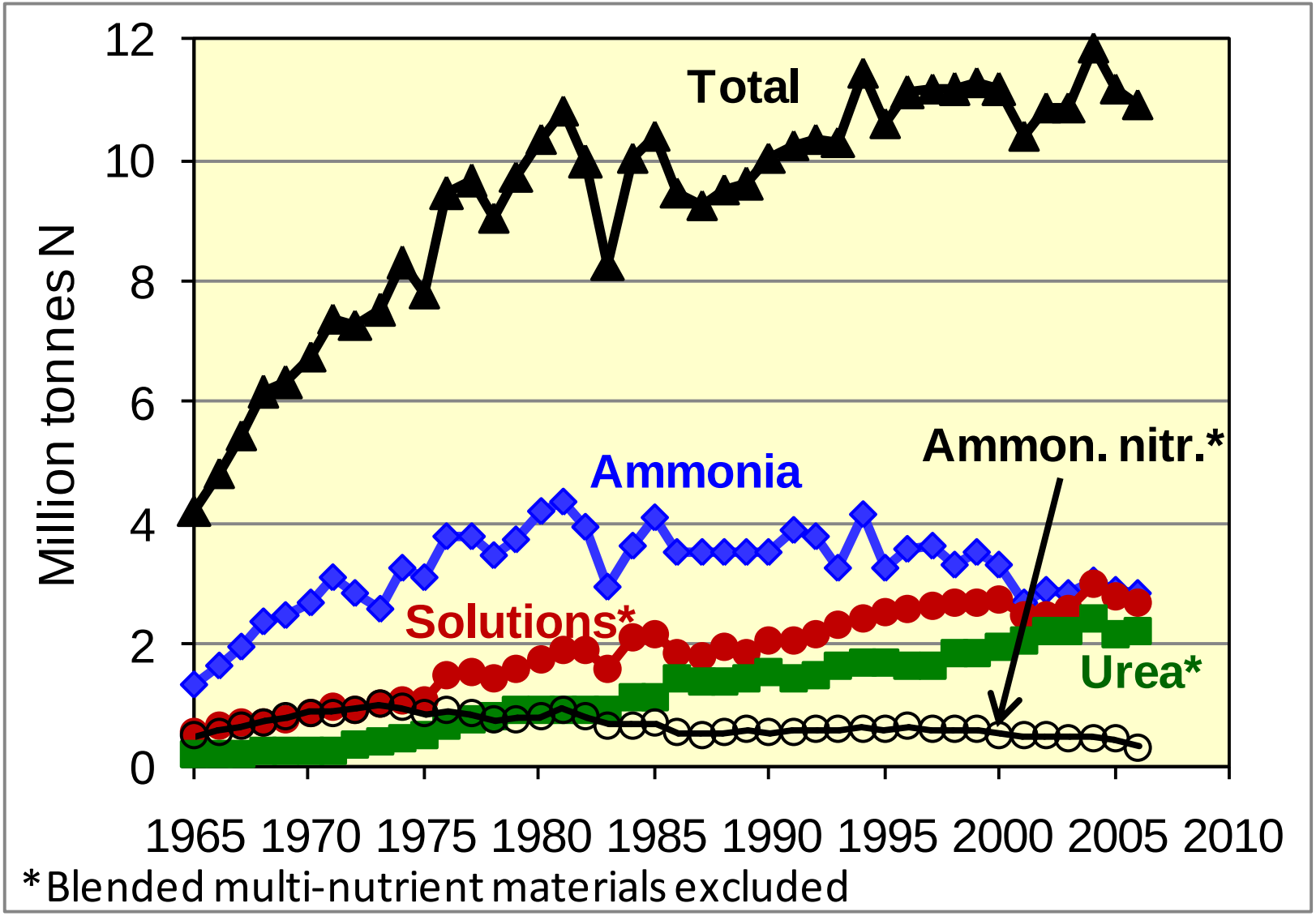
- Increasing in popularity in U.S. and elsewhere
- Advantages include
  - ✓ Flexibility and versatility in application
  - ✓ Efficiency and adaptability
  - ✓ Potential benefits of continuous bands
  - ✓ Ease of handling
  - ✓ Does not segregate
  - ✓ Etc.
- Limitations
  - ✓ Generally higher purchase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

U.S. Nitrogen Fertilizer Consumption

Tons N/year

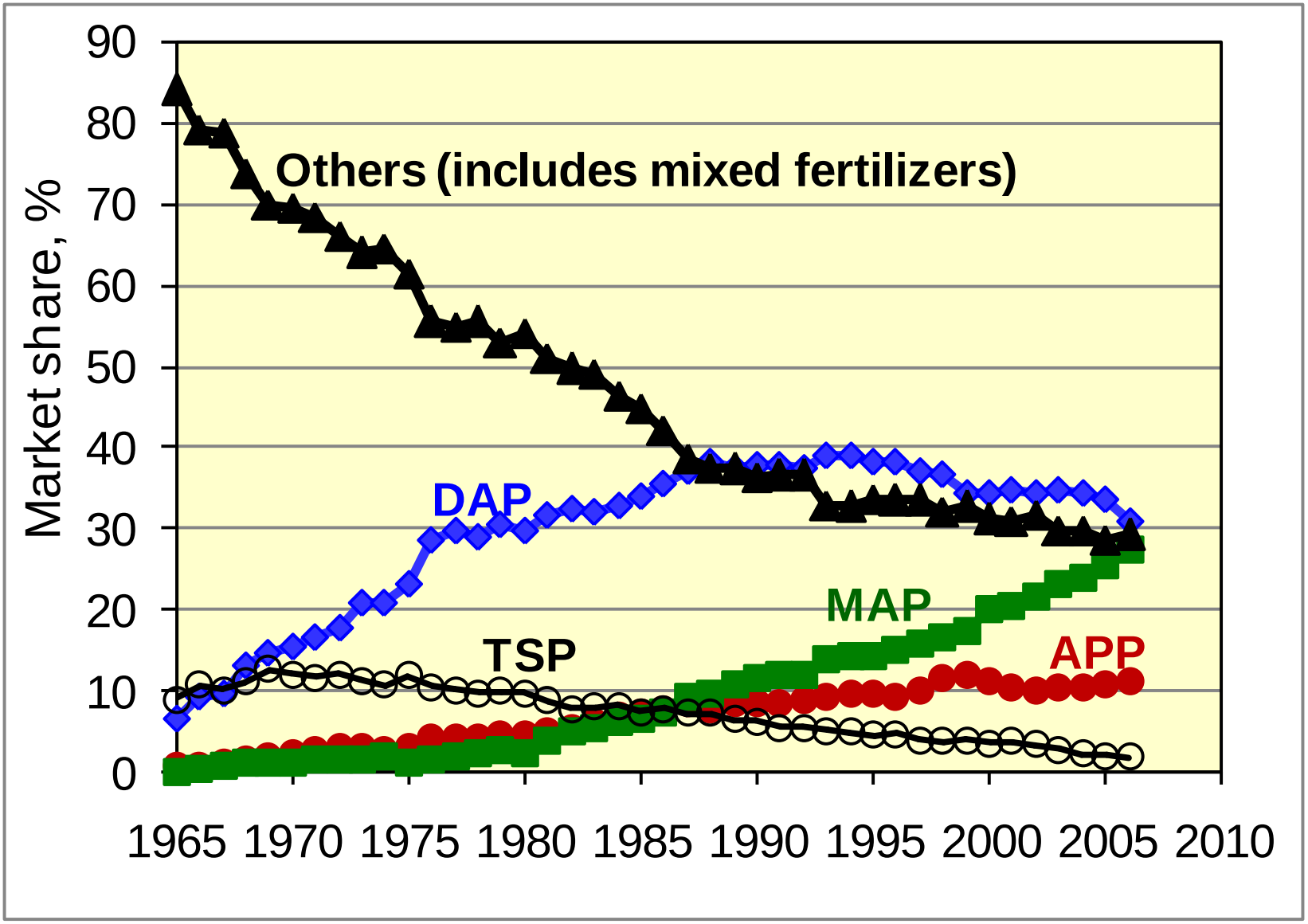


USA N fertilizer consumption by product.



Data source: Commercial Fertilizers, AAPFCO & TFI

USA P fertilizer market share.



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.

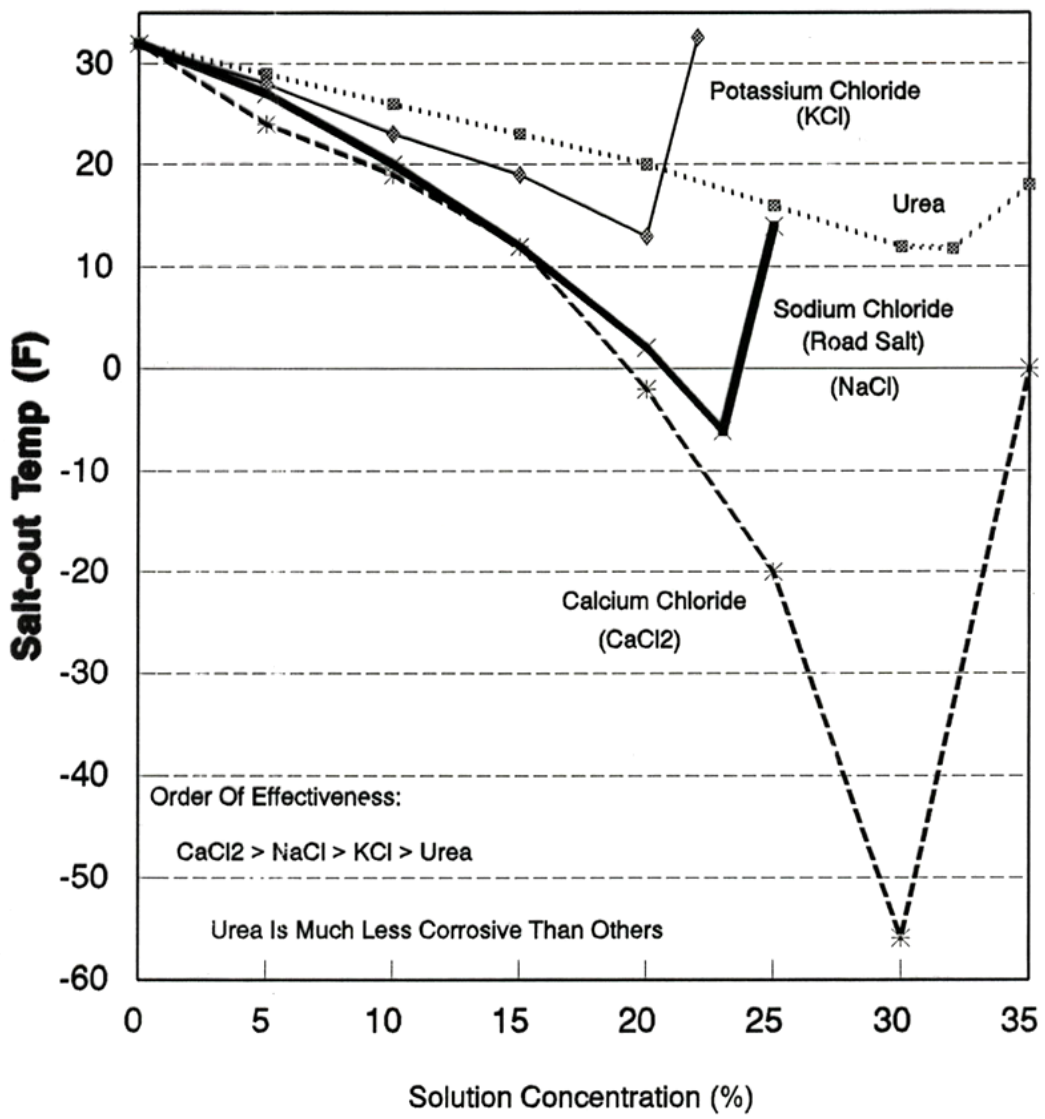
Muddy Water – Solutions with undissolved solids or suspensions containing too few undissolved salt crystals. Not a good range to try and operate in!!.

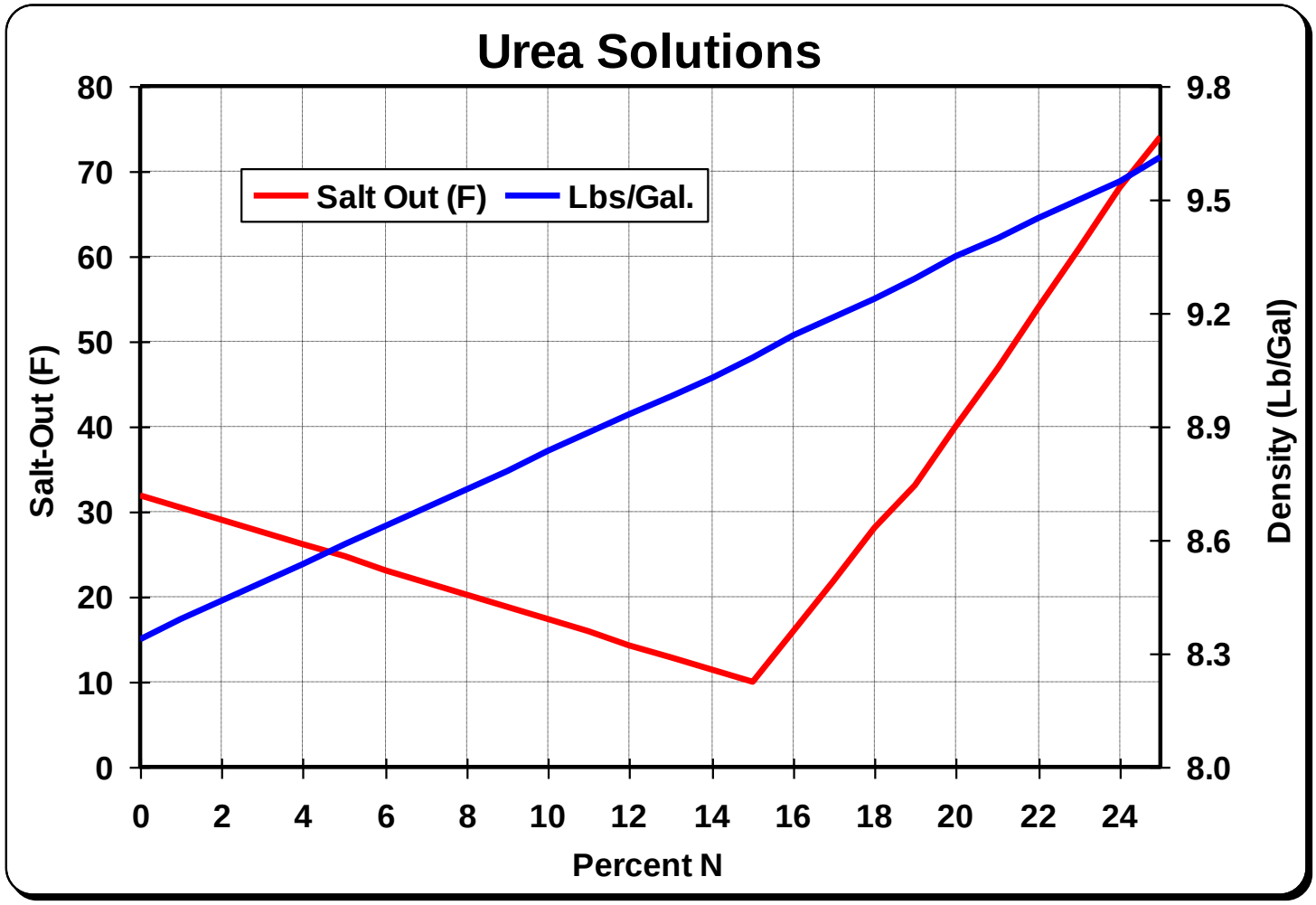
Falling Out Of Solution – No such thing.

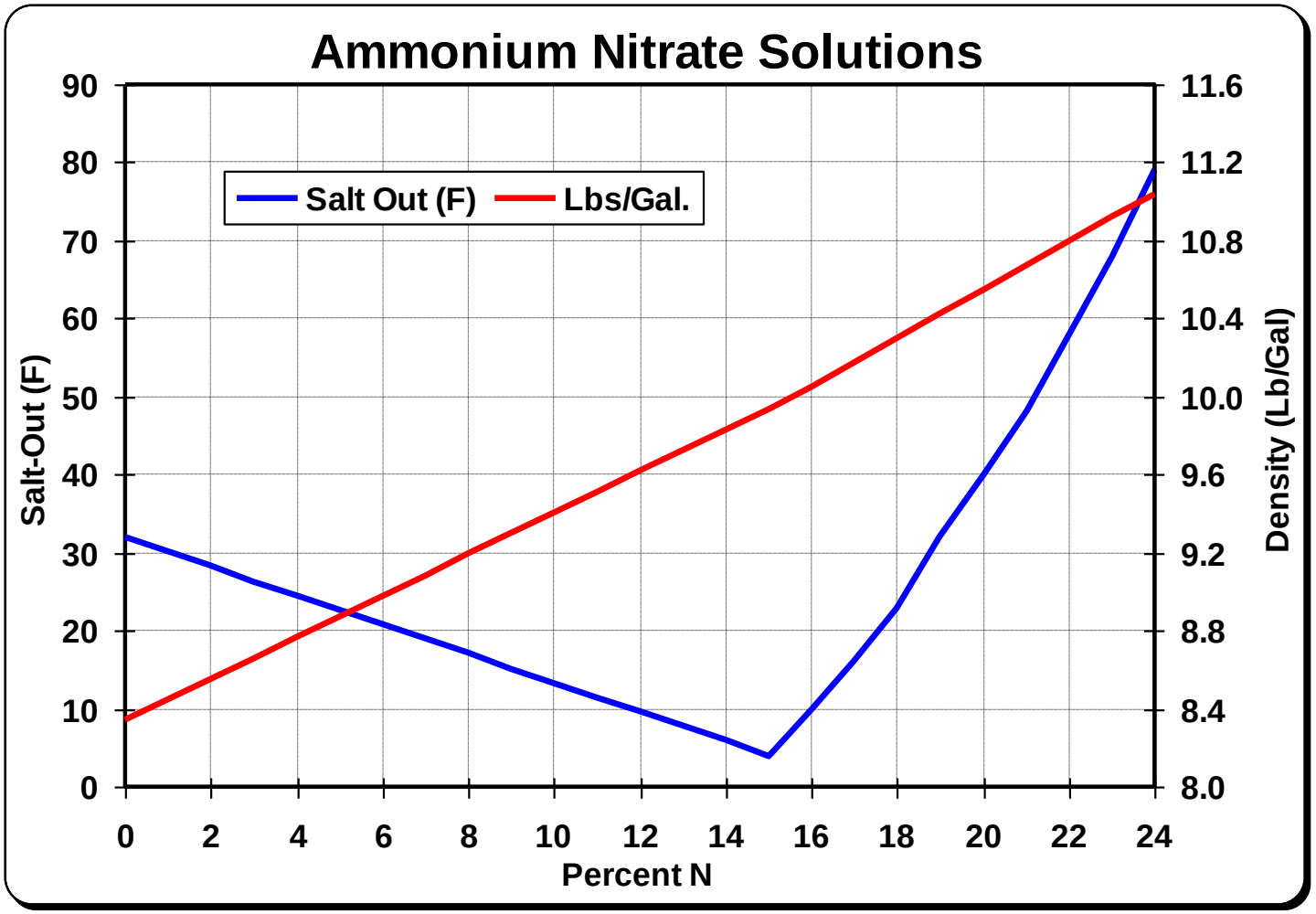
Salt-Out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

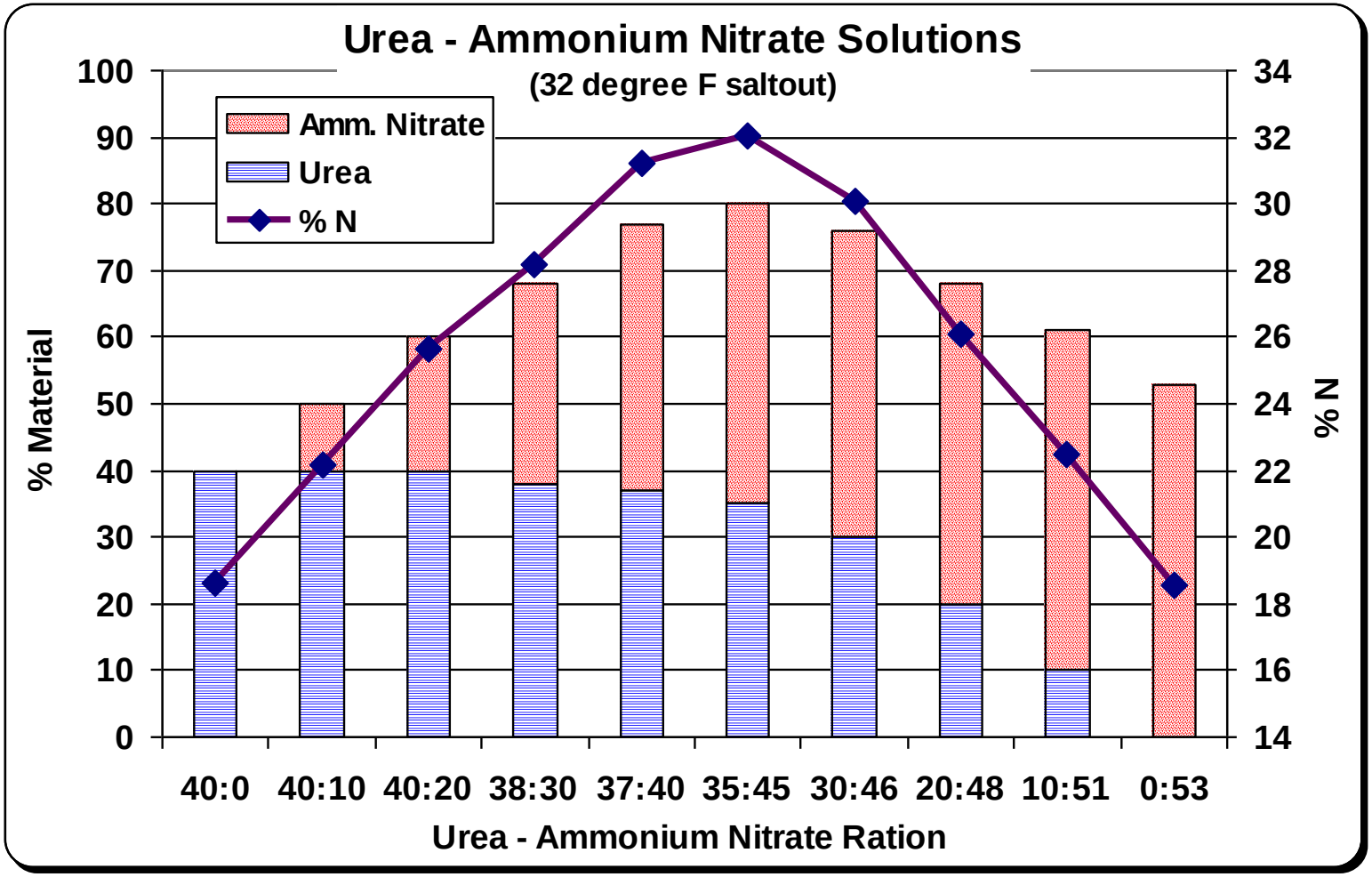
Precipitate Formation – Non-crystalline mass forms which has much lower solubility than original ingredients in solution. Example; Improperly stored fluid phosphates

EFFECT OF SALTS ON FREEZING POINT




Urea Solutions
Salt Out (F)
Lbs/Gal.
Salt-Out (F)
Density (Lb/Gal)
Percent N
80
70
60
50
40
30
20
10
0
9.8
9.5
9.2
8.9
8.6
8.3
8.0
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
90
80
70
60
50
40
30
20
10
0
11.6
11.2
10.8
10.4
10.0
9.6
9.2
8.8
8.4
8.0
0
2
4
6
8
10
12
14
16
18
20
22
24

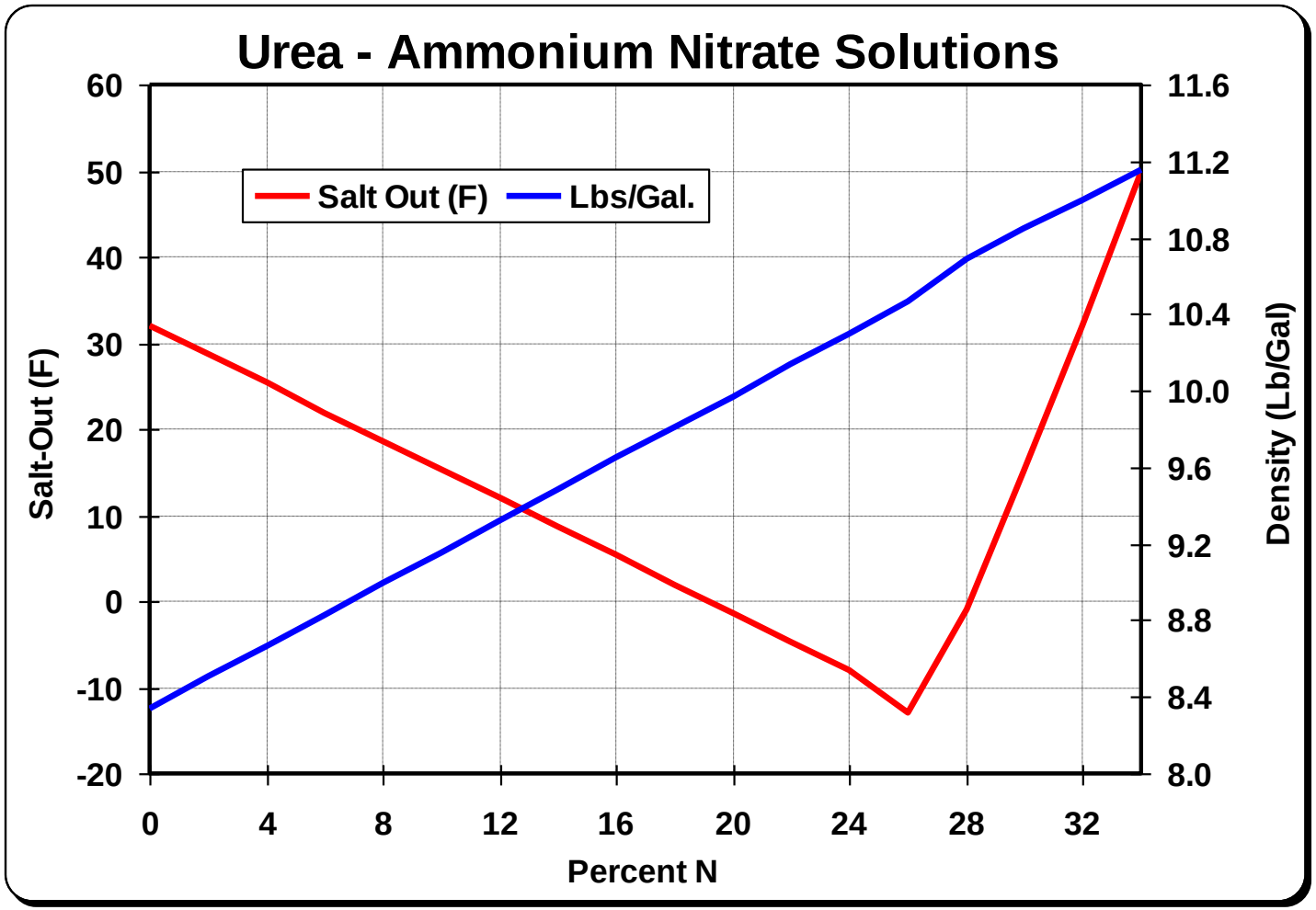


Eutectic Point – point of maximum solubility

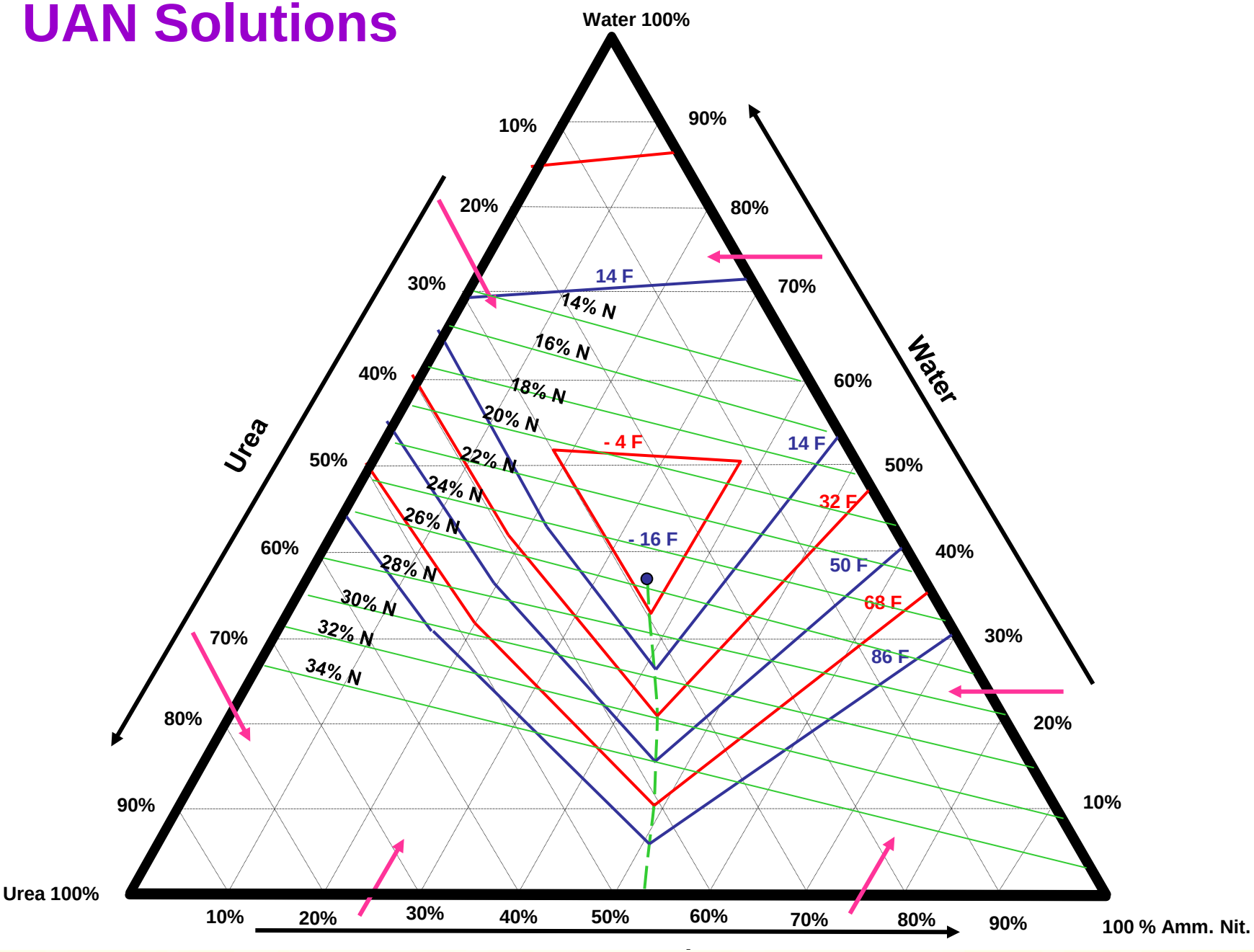
32% UAN contains:

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

28% UAN contains 30% water


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

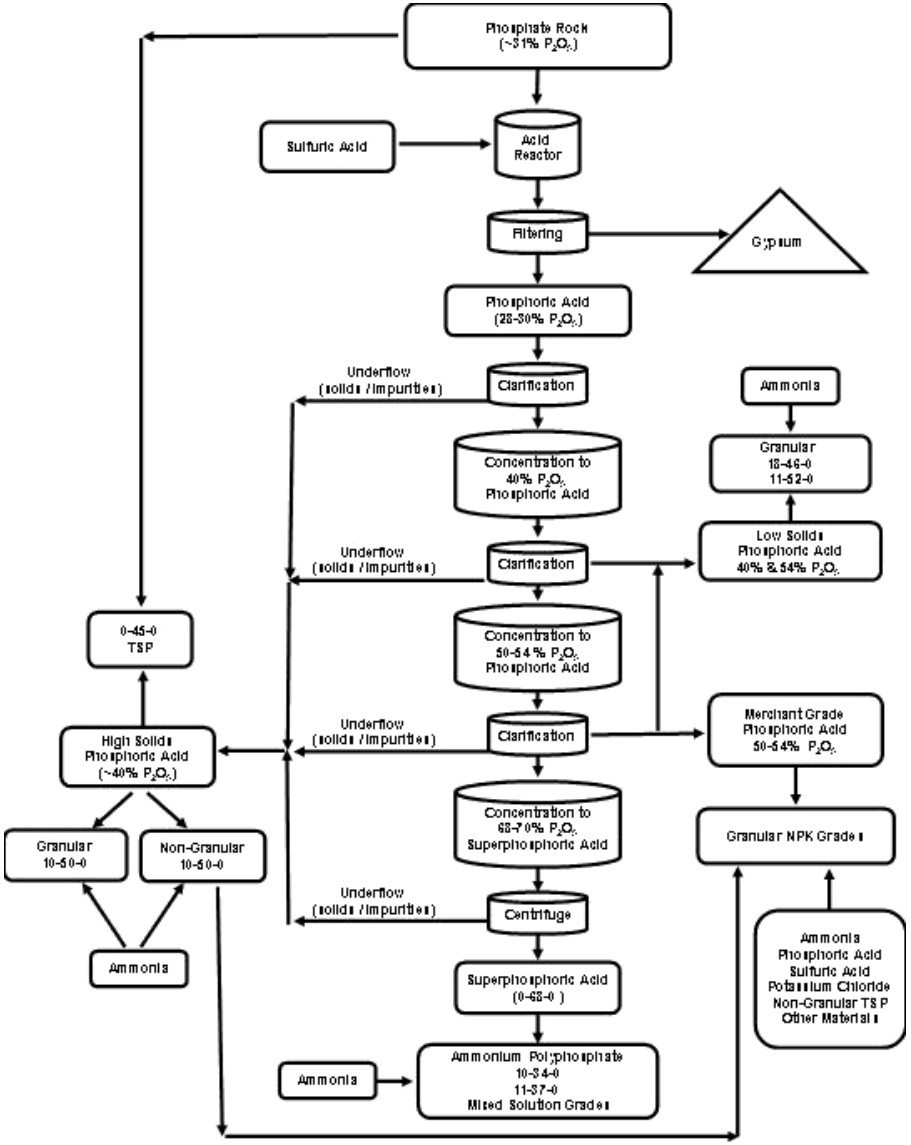
- Salt-out is an issue in many environments
  - ✓ There is very little water in UAN solution.
  - ✓ Warm water has ability to dissolve more salts than cold water
  - ✓ Salt-out occurs when salt content exceeds solubility at a given product temperature
  - ✓ Crystals form on tank walls as temperature 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

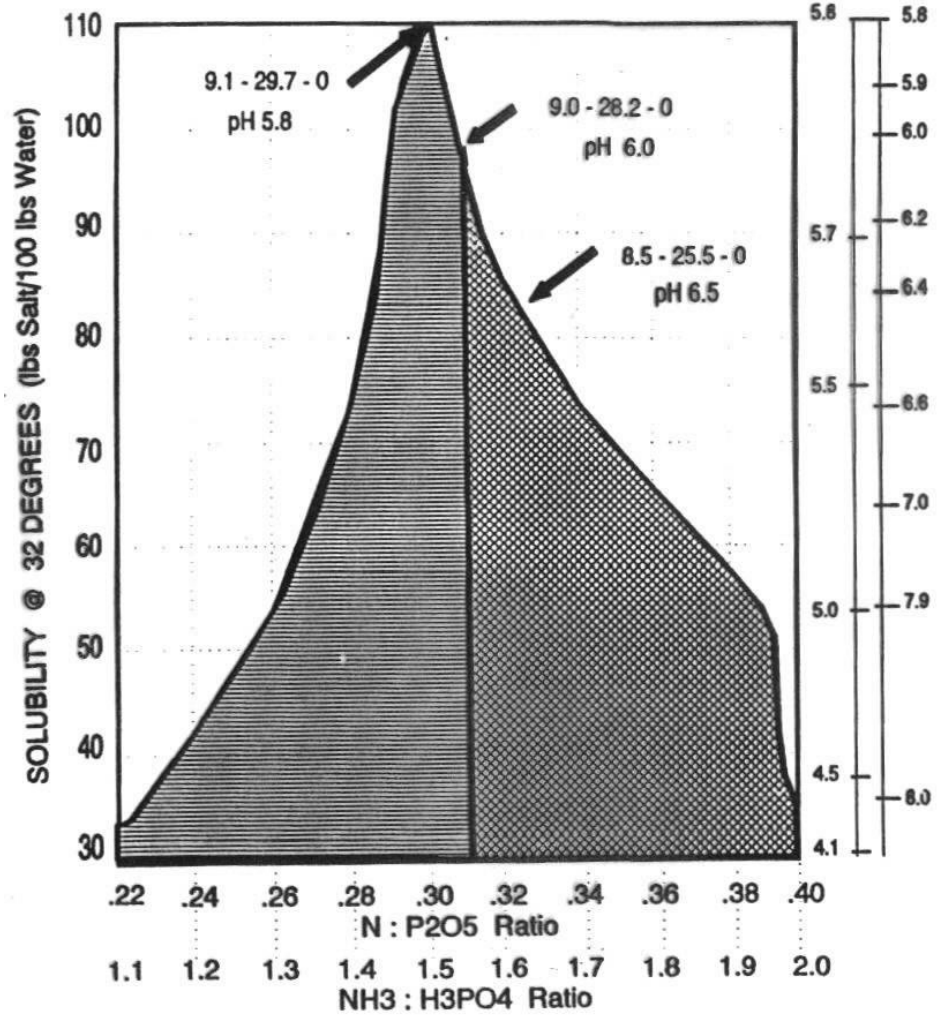
Liquid Phosphate Products

Fluid Phosphate Products and Characteristics

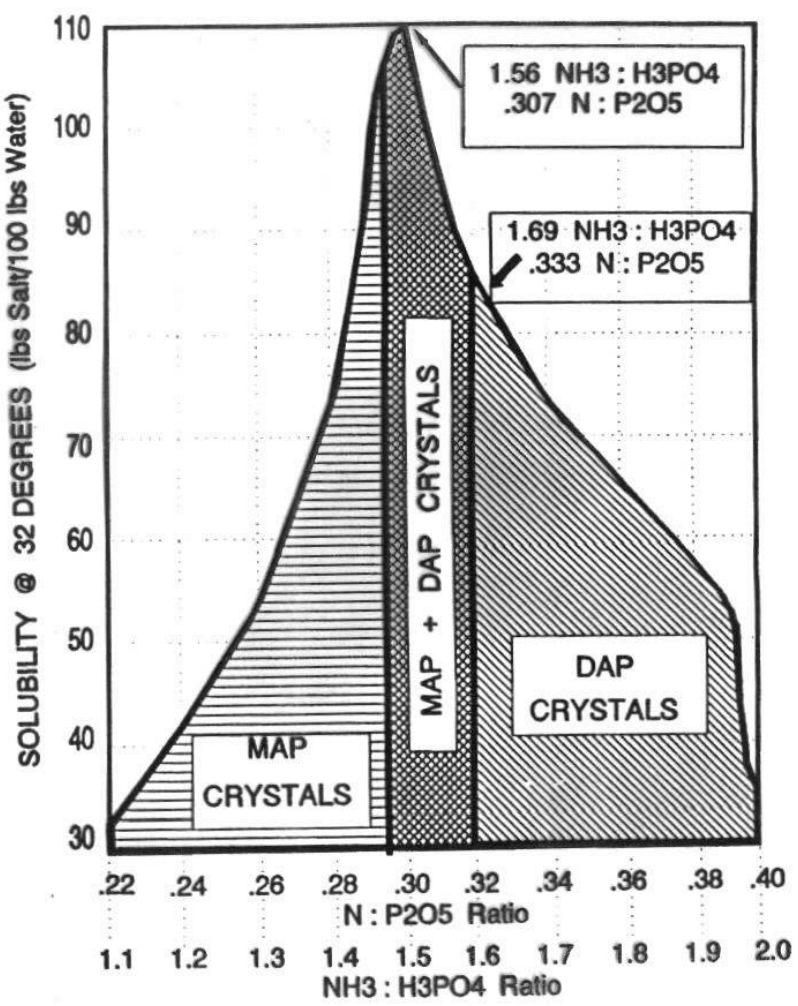


SOLUBILITY OF AMMONIUM PHOSPHATES

(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

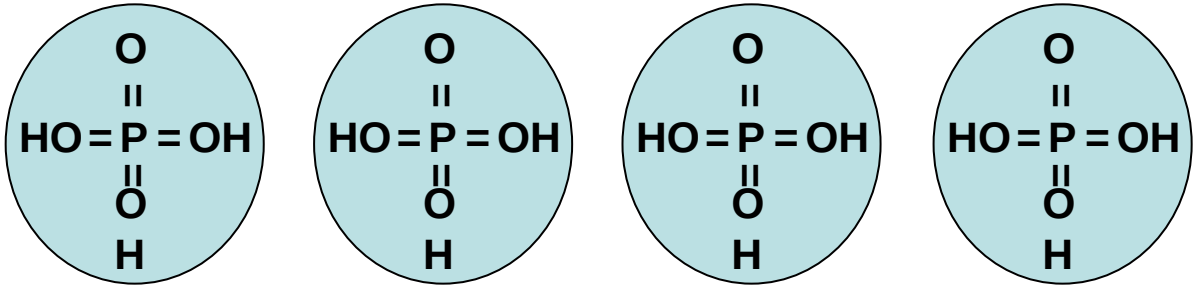
Orthophosphoric Acid Examples

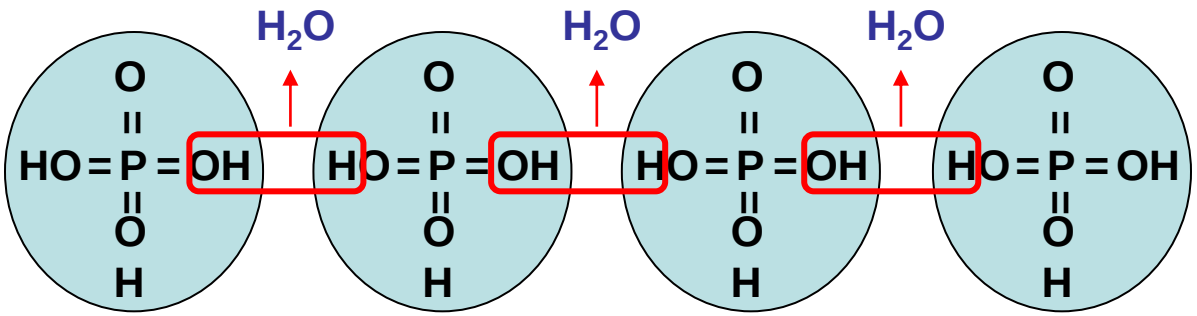
Source	Acid 1	Acid 2	Acid 3	Acid 4
P2O5	61	53.2	52.8	57
MgO	0.3	1.2	1.1	0.2
Fe2O3	0.35	0.5	1	0.32
Al2O3	0.18	0.4	0.5	0.16
F	0.3	0.4	2.1	0.1
Solids	0.5	0.1	0.1	Nil
Visc.@100F	40	90	100	27
P/F	89	58	46	248

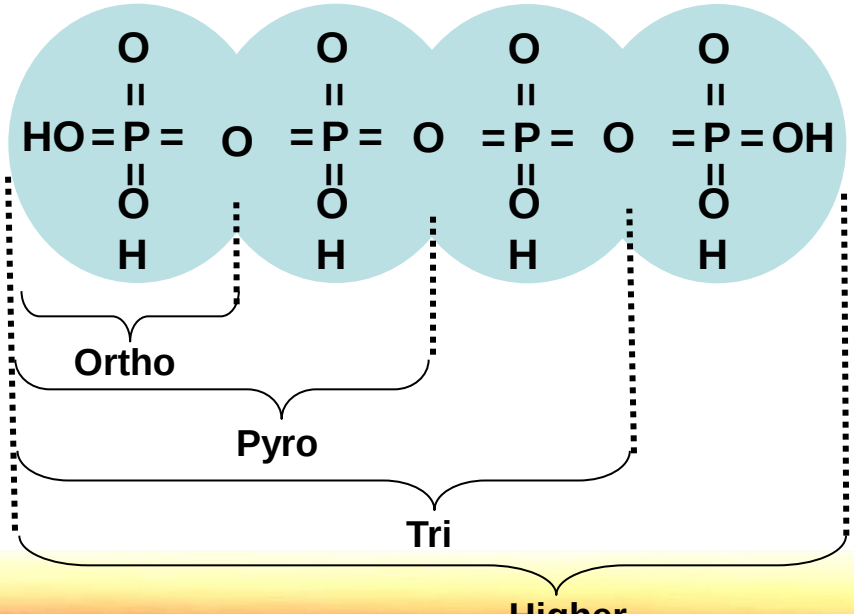
Source: Texas Gulf

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





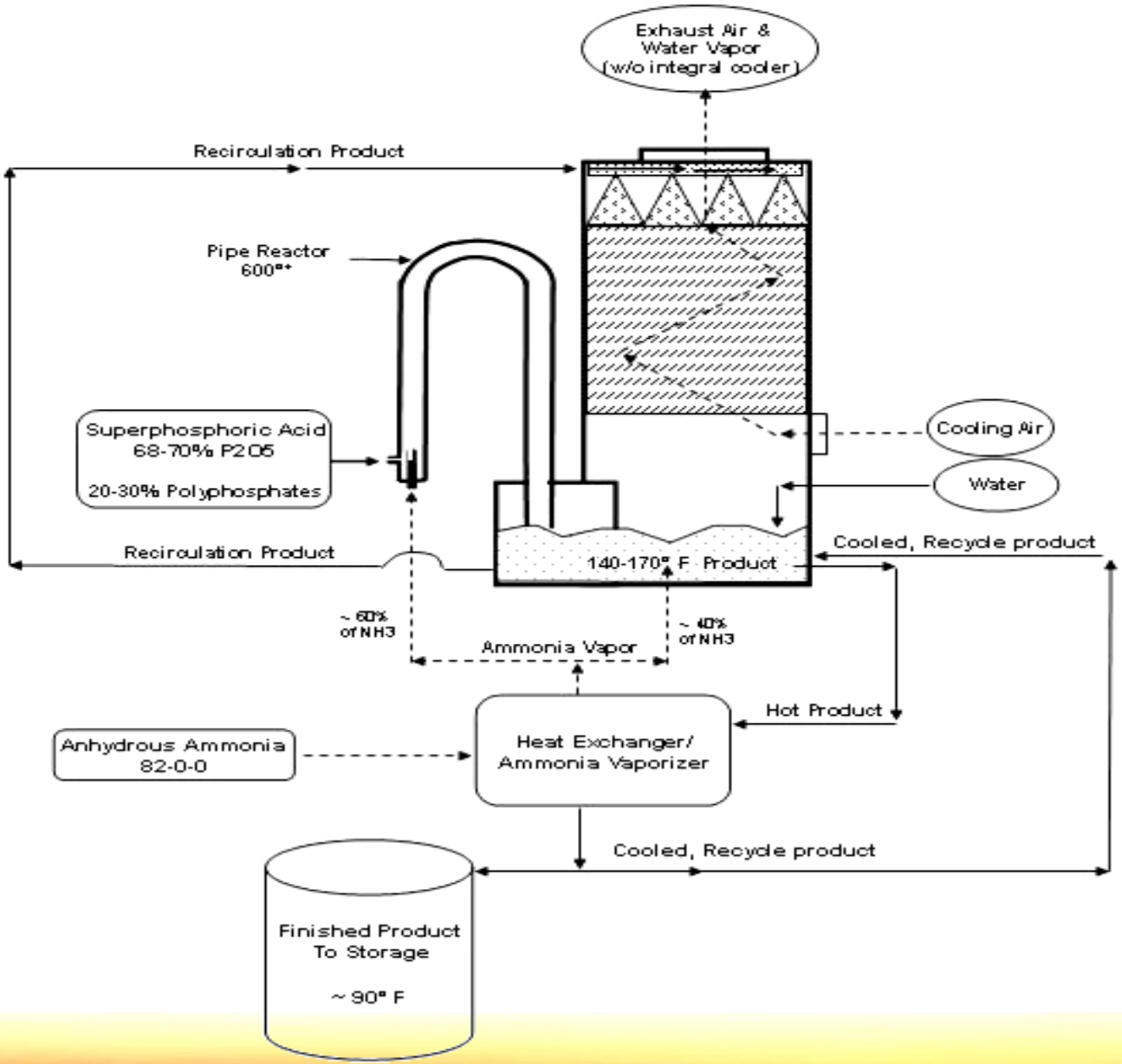


Heat links phosphates by removing chemically bound water

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)

Hydrolysis Of Polyphosphate To Orthophosphate

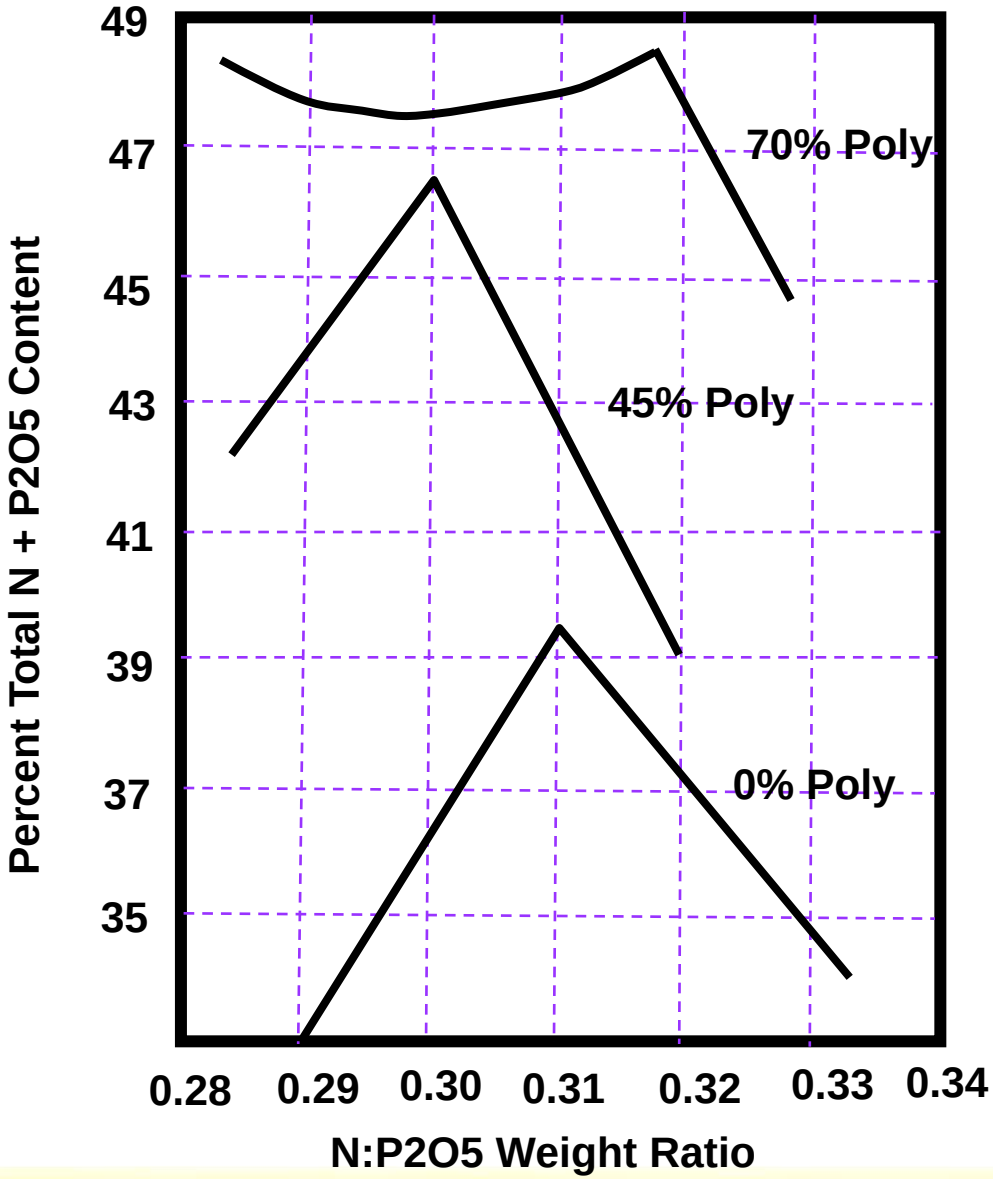
Soil Temperature	24 Hour Polyphosphate Hydrolysis (%)
41 F	30-40 %
68 F	50-60 %
95 F	80-90 %

Chang and Racz, 1977

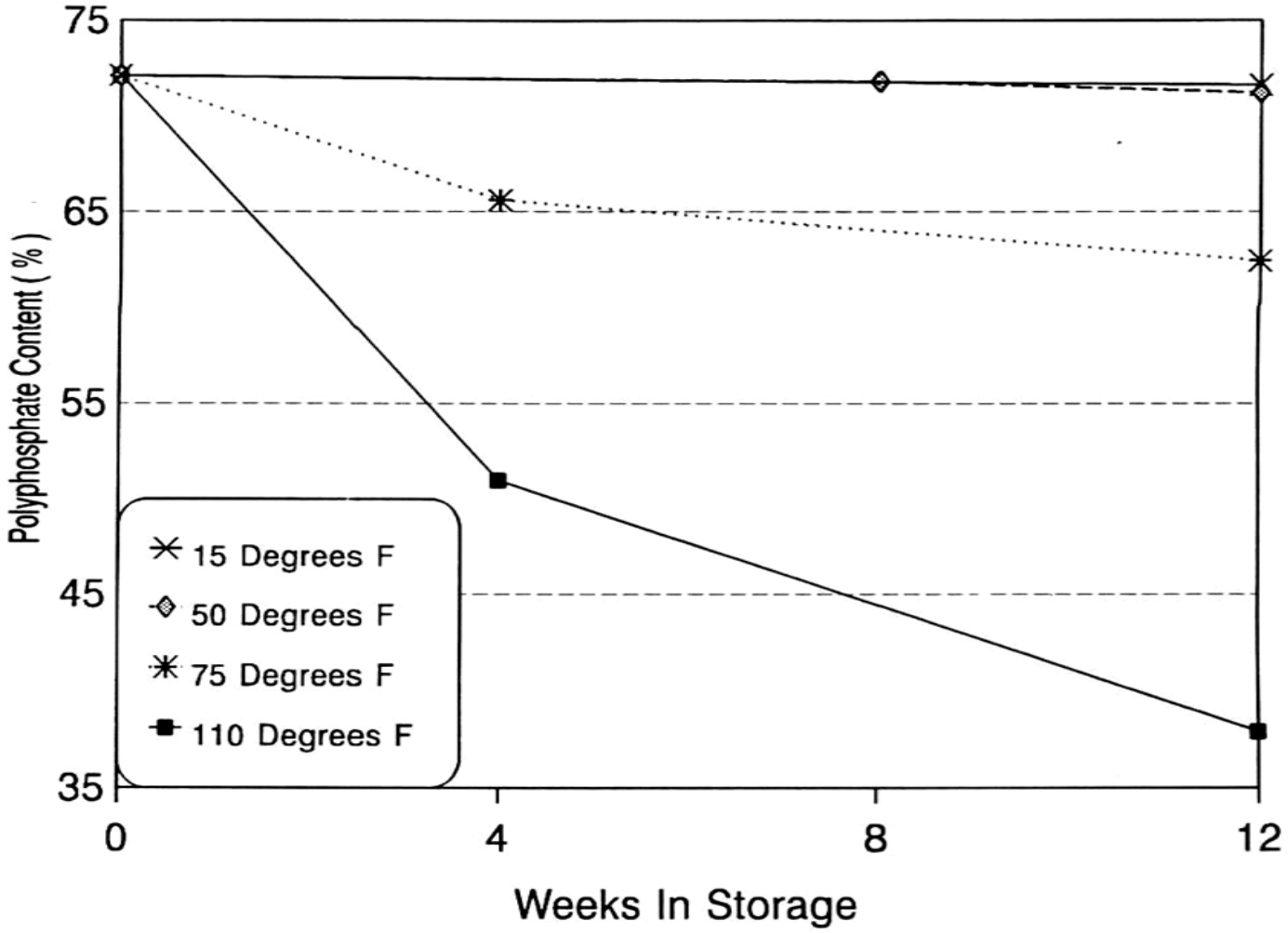
After application to soils, polyphosphate is quickly converted to orthophosphate by abundant soil enzymes

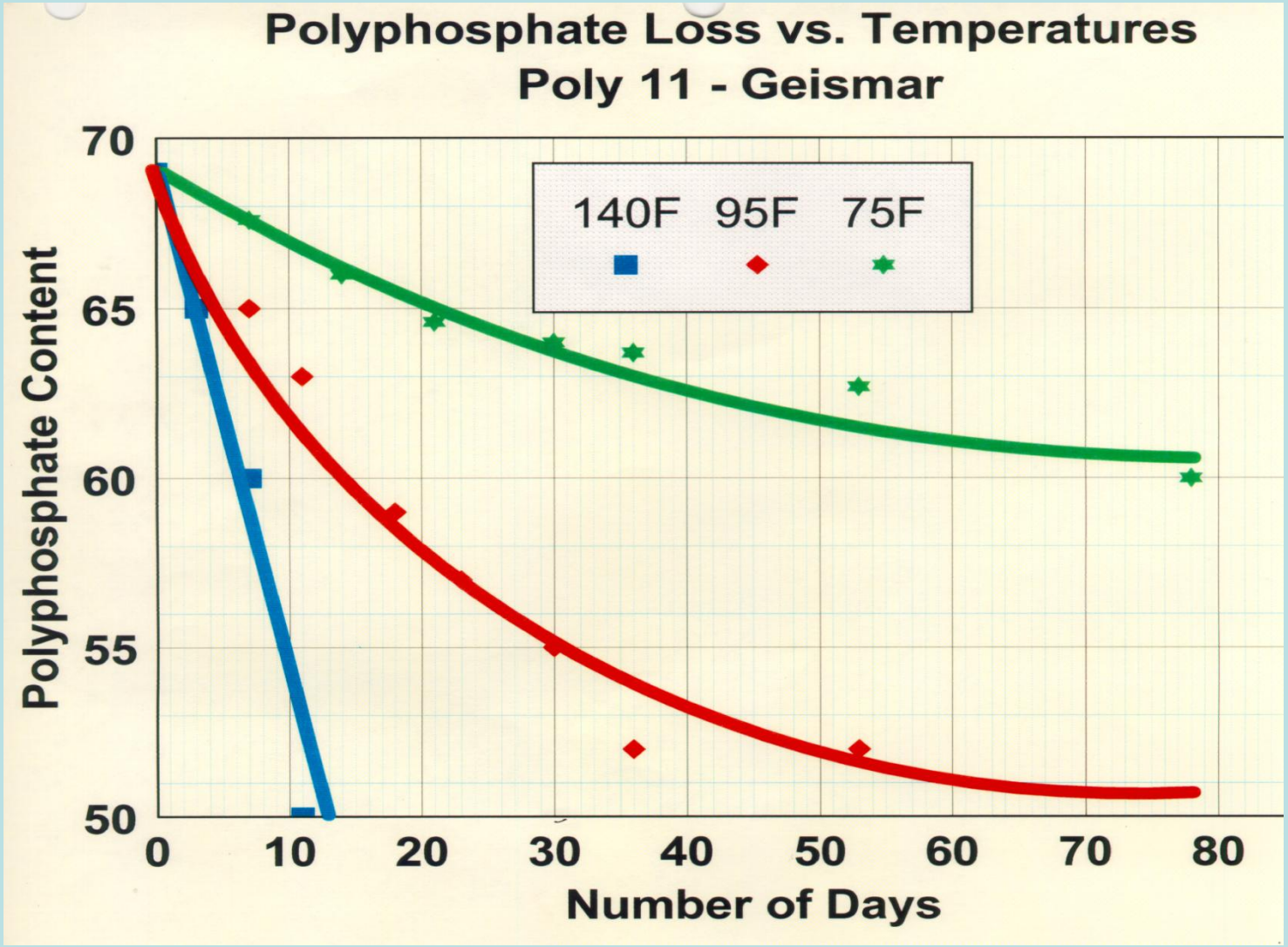
Plants utilize orthophosphates

Effect of Poly Content and N:P2O5 Ratio On Solubility



Temperature Effect On 10-34-0 Quality




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

Zinc Sequestering By 10-34-0

Zinc Sources

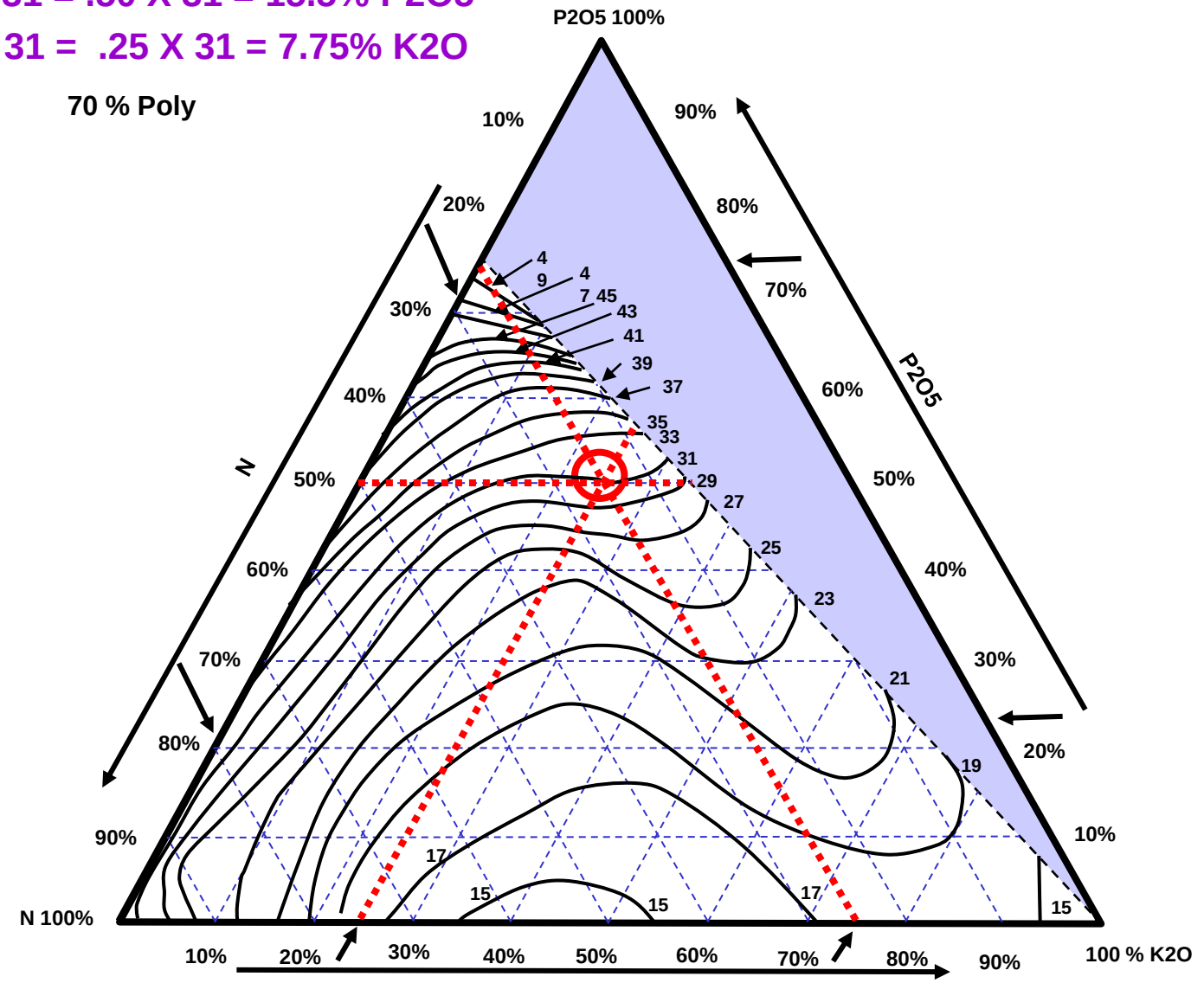
Original Zinc Source	% Zinc Remaining As Original Source	% Zinc Sequestered By Polyphosphate
Zn EDTA	100	0
Zn Sulfate	4	96
Zn-NH3 Complex	8	92
Zn Phenolic Acid	11	89
Zn Citrate	8	92
Zn Nitrate + UAN	15	85
Zn HEIDA	19	81

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

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



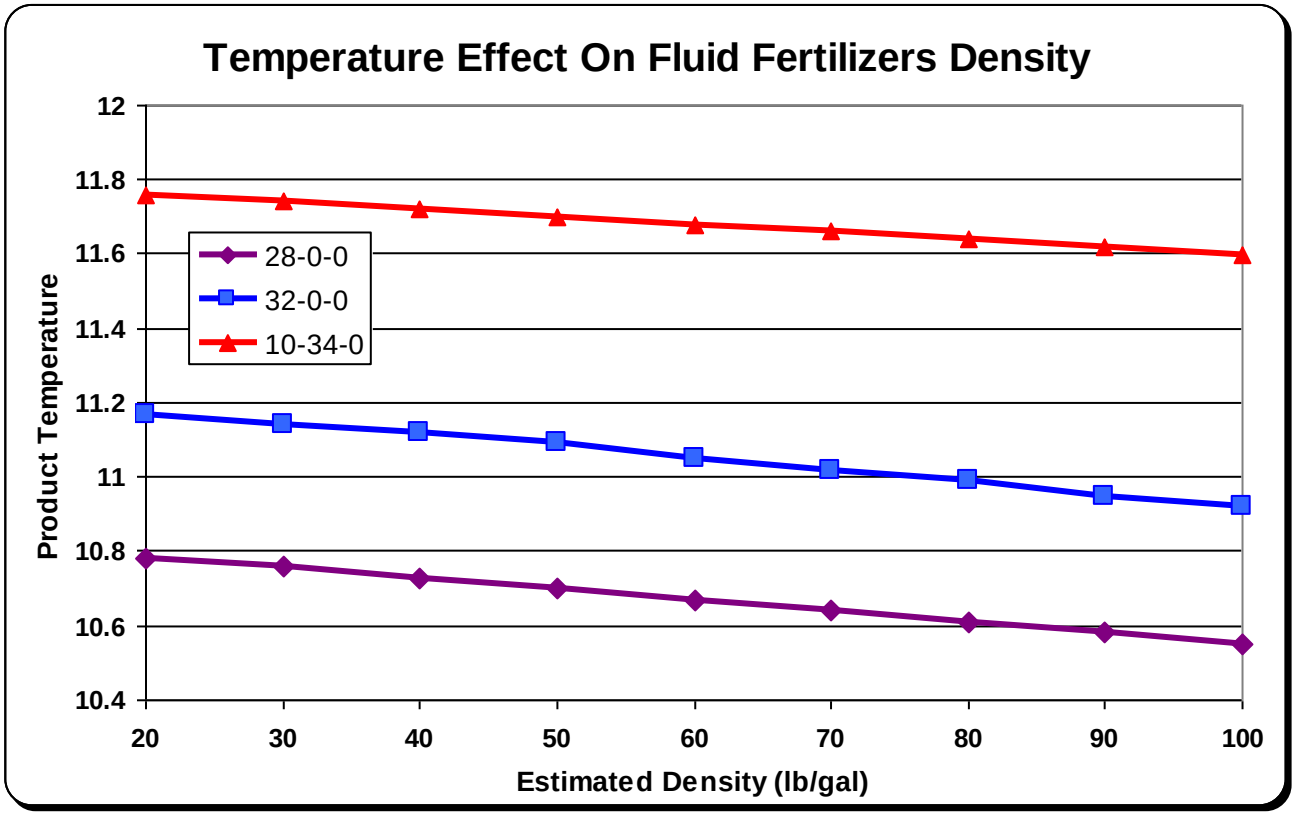
Solution Grades For UAN Solution (28-32% N), Potassium Chloride (0-0-62) and Ammonium Polyphosphate (10-34-0, 11-37-0) System

$N:P_2O_5:K_2O$ 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	^oF	
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

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)

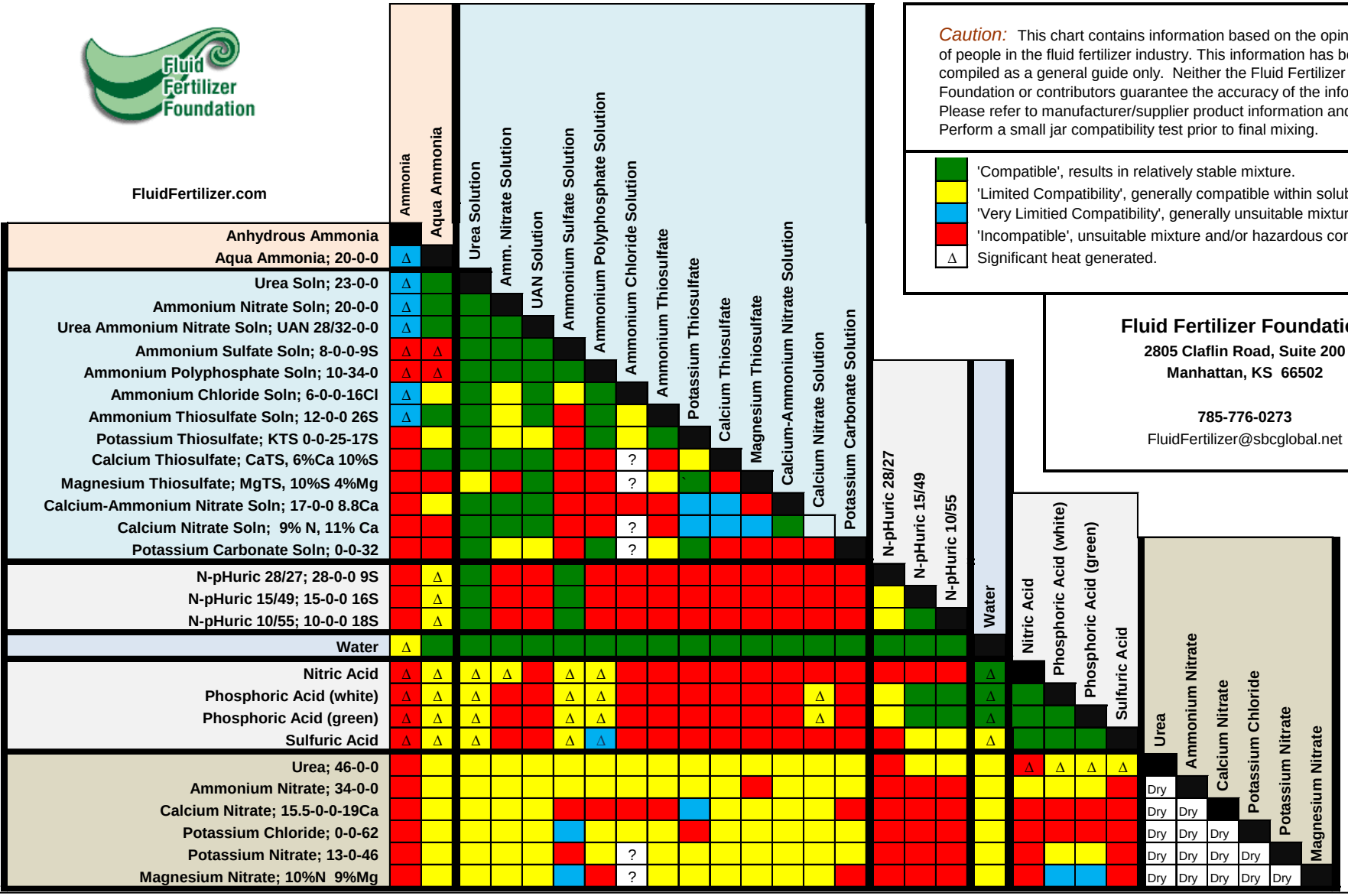
Fume generator – Generates fumes which can be safety hazard. Example; UAN solution + Potassium carbonate → ammonia fumes.

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

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

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

UAN in Irrigation Water ?


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

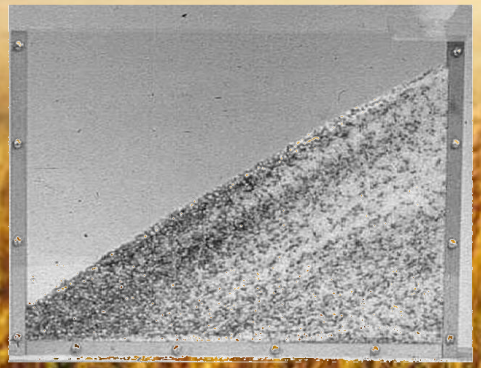
Thank You And Enjoy The Conference

Dale F. Leikam

Fluid Fertilizer Foundation
www.FluidFertilizer.com

The Fluid Advantage

Size Matters ……
Dry Fertilizer Segregation



The Fluid Advantage

FLEXIBILITY (Timing)
FLEXIBILITY (Method)
EFFICIENCY (Agronomic)
EFFICIENCY (Logistics)
ADAPTABILITY (Equipment)
ADAPTABILITY (Cropping System)

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