Fluid Starter Fertilizer Sources

RD Lohry

D Zabel

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Two Distinct Fluid Starter types

- Ammonium polyphosphates
- 100% orthophosphates

Two Distinct Fluid Starter Types

- With exception of nitrogen, the two types made from different sets of P & K raw materials
- Different marketing techniques

Plant Food Madness

- The market is becoming more diverse with blends
  - 30/70 ortho/poly—typical high polyphosphate
  - 50/50 ortho/poly
  - 60/40 ortho/poly
  - 70/30 ortho/poly
  - 80/20 ortho/poly
  - 100/0 ortho/poly
  - We’re no longer “purists”

Blends are the growth area. K source can be KCl or KOH.

High Ortho High Poly

- N from ammonia, urea
- P from very (clean) orthophosphoric acid
- K from KOH
- S from ATS
- Micros from EDTA chelated sources

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High Ortho

- N from ammonia, urea
- P from high grade orthophosphoric acid
- K from KOH
- S from ATS
- Micros from EDTA chelated sources

High Poly

- N from ammonia, UAN
- P from polyphosphate (converted from ortho)
- K from KCl
- S from ATS + other
- Micros from ammoniated complexes, sulfates, chlorides and chelates

Nitrogen Sources

- Nitrogen – N
  - Ammonia NH_3
  - Urea $CO(NH_2)_2$
  - UAN
  - Complexed N
    - Ammonium phosphate
    - Ammonium (thio) sulfates
    - Ammonium nitrates

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All N comes from Atmosphere

- Earth's atmosphere is 78% nitrogen.
- 1884—Development of the theoretical principles for combining hydrogen and atmospheric nitrogen to form ammonia.
- Hydrogen (natural gas) + air and under high pressure (2200 psi) and temperature (400-500 C) + catalyst = Ammonia.
- 33,000 cubic feet of natural gas is needed to supply hydrogen for 1 ton of ammonia.

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Ammonia NH_3 82-0-0

- Used to make all other forms of nitrogen fertilizer.
- Both of our starter types use ammonia (sometimes called ammonium hydroxide when dissolved in water) ammoniacal

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Urea $CO(NH_2)_2$ 46-0-0

- Ammonia is reacted with carbon dioxide in the presence of a catalyst.
- Less corrosive than some other N fertilizers
- Most likely to be included in the high ortho mixes to adjust pH

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Nitric Acid

- Not used directly as fertilizer, but is necessary to produce certain N fertilizers.
- Nitric acid (HNO_3) is produced by the oxidation of Ammonia with air in the presence of a catalyst, usually platinum.

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Ammonium Nitrate

- Nitric acid and ammonia are reacted to produce ammonium nitrate (NH_4NO_3).
- 34-0-0. (20-0-0 in solution)

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Ready to make 32% UAN

- We made urea from ammonia and CO2
  - In solution urea might be 20 – 23% N
- Made Ammonium nitrate from nitric acid and ammonia
  - In solution about 20% N
- Time to combine them

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UAN 32-0-0

- When ammonium nitrate and urea in more or less equal proportions are mixed with water, the solubility of the combination is greater than the solubility's of the individual components.
- 32%, 28% (urea ammonium nitrate) are stable solutions.
- What a happy outcome!

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Phosphates

Fluid Phosphate Source

- Tricalcium phosphate rock (fluoroapatite)
- "Rock phosphate" in the "old days"
- Needed Bray II P test to measure it in the soil after application
- Turn phosphate rock it into phosphoric acid

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Phosphoric Acid Sources

Wet, Thermal & Kiln Process Acid

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Wet Process (Ortho)

- Made by reacting finely ground tricalcium phosphate rock (fluoroapatite-a naturally occurring mineral) with sulfuric acid.
- (Green or black acid) Used directly for production of Ammonium polyphosphate such as 10-34-0, 8-24-0, 9-30-0 and 11-37-0
- Can be further purified by removing fluorine—Animal grade acid
- Solvent extraction and arsenic removal to make food grade acid

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Thermal or “Dry” Process

- Burn dry, rock phosphate in furnace: (furnace grade or “white” acid)
- Very pure—food grade—additional arsenic removal may be needed for critical industrial applications.
- Clear in color because all impurities that give color to P acid have been removed
- Ortho form

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Kiln Process Acid

- New process called “Improved Hard Process”
- Makes low grade phosphate rock reserves commercially viable
- Increase phosphate recovery from existing reserves
- May significantly extend commercial viability of phosphate reserves

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Phosphate Types

- Orthophosphates
  - Simplest form of liquid phosphate
- Polyphosphates
  - Complex phosphate chains (polymer)
  - Formed by removing water from ortho
- Monopotassium Phosphate
  - Phos acid reacted with potassium hydroxide
  - Can be ortho and/or poly

Polyphosphates

What are they?

How they are produced?

What do they do?

Precautions

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What is a polyphosphate?

- Polyphosphates are molecules containing more than one phosphorus atom
  - Prior to the advent of the TVA pipe reactor process they were very difficult to make
  - Only source lay in “high poly” superacids (which are very corrosive)
    - **Required high heat and high vacuum conditions**
    - **50% poly was about the most that could be achieved**

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Why develop Poly P?

- Industry wanted higher P grades
- Save on transportation—more P per load

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TVA PIPE REACTORS

How they work

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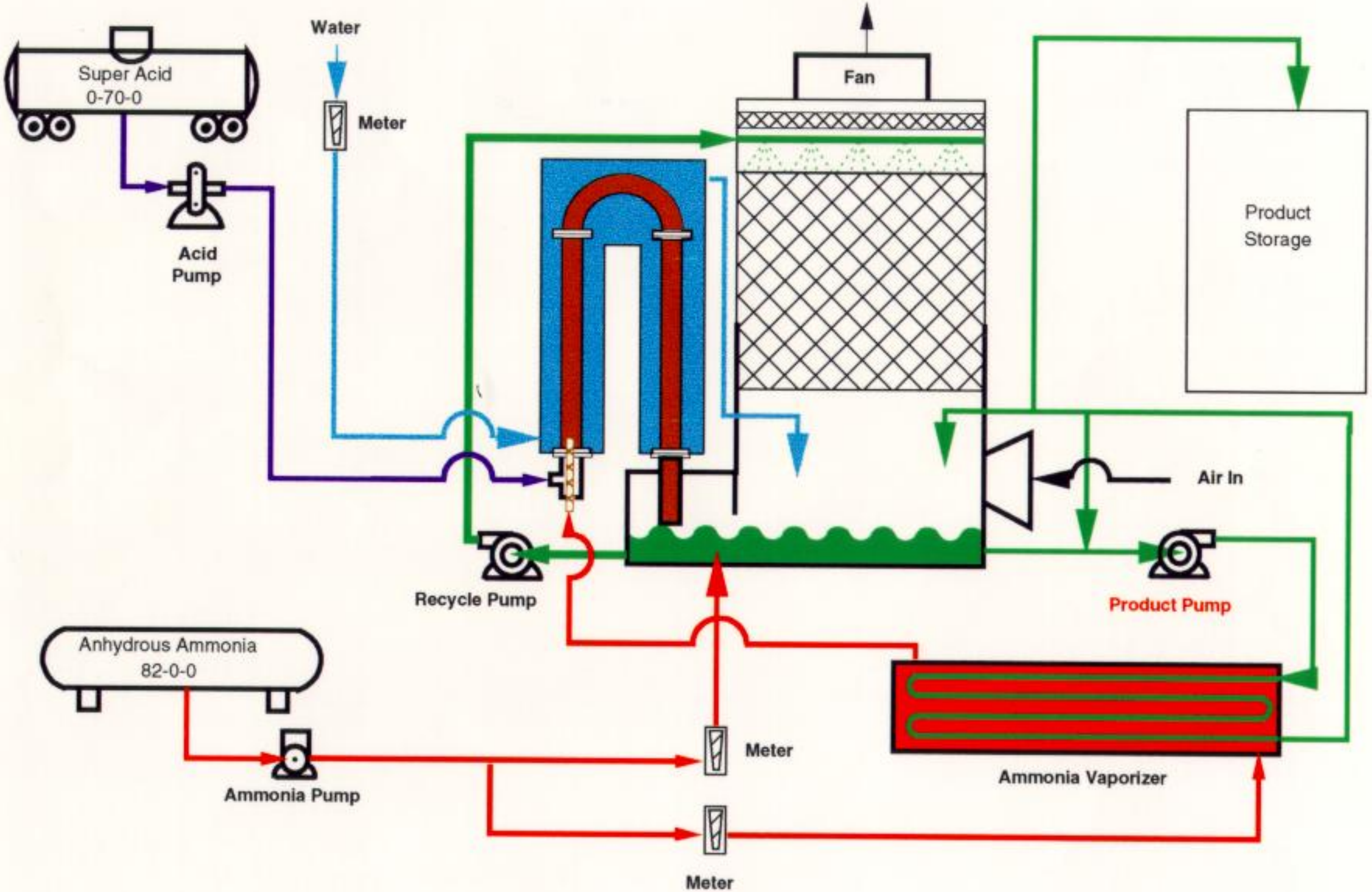

TVA PIPE REACTOR PROCESS SCHEMATIC

Benefits of the TVA pipe reactor process

(Developed in the mid-60's)

1. Allowed production of High poly ammonium phosphate solutions
2. Eliminated the need for high poly superacids
3. Higher grades of phosphates—saved on shipping P

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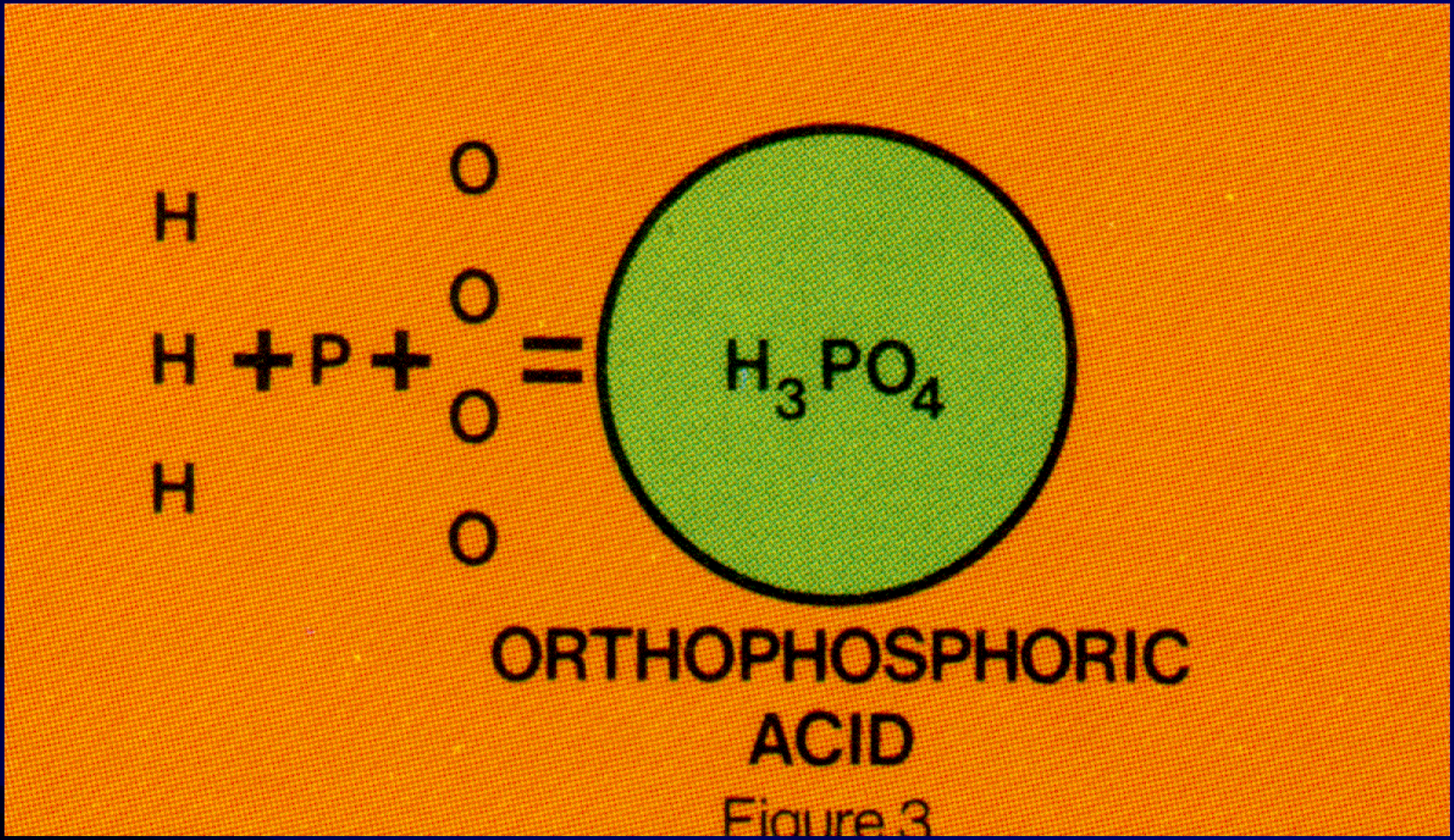
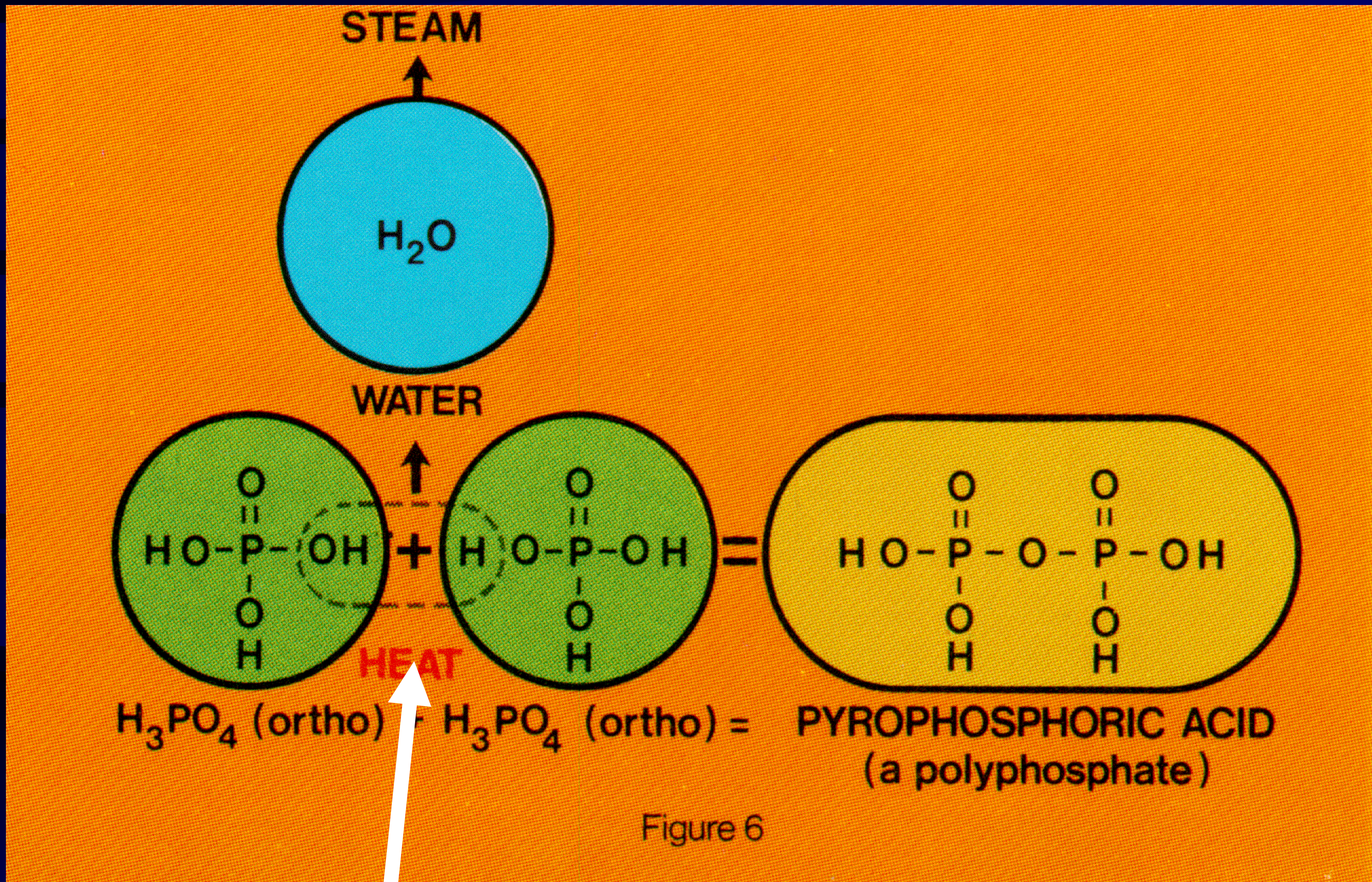
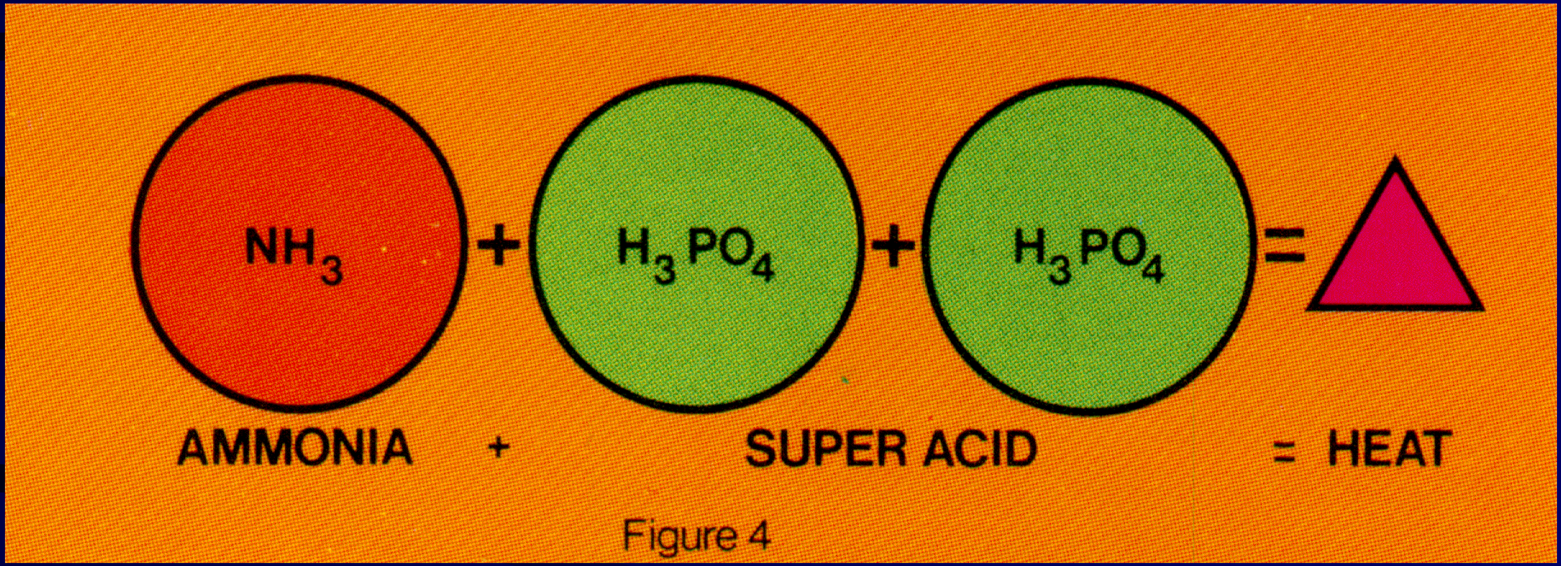


The basic building block for polyphosphates



Where does the heat come from?



Ah-ha! An Exothermic Reaction

600 to 700°F

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The overall process

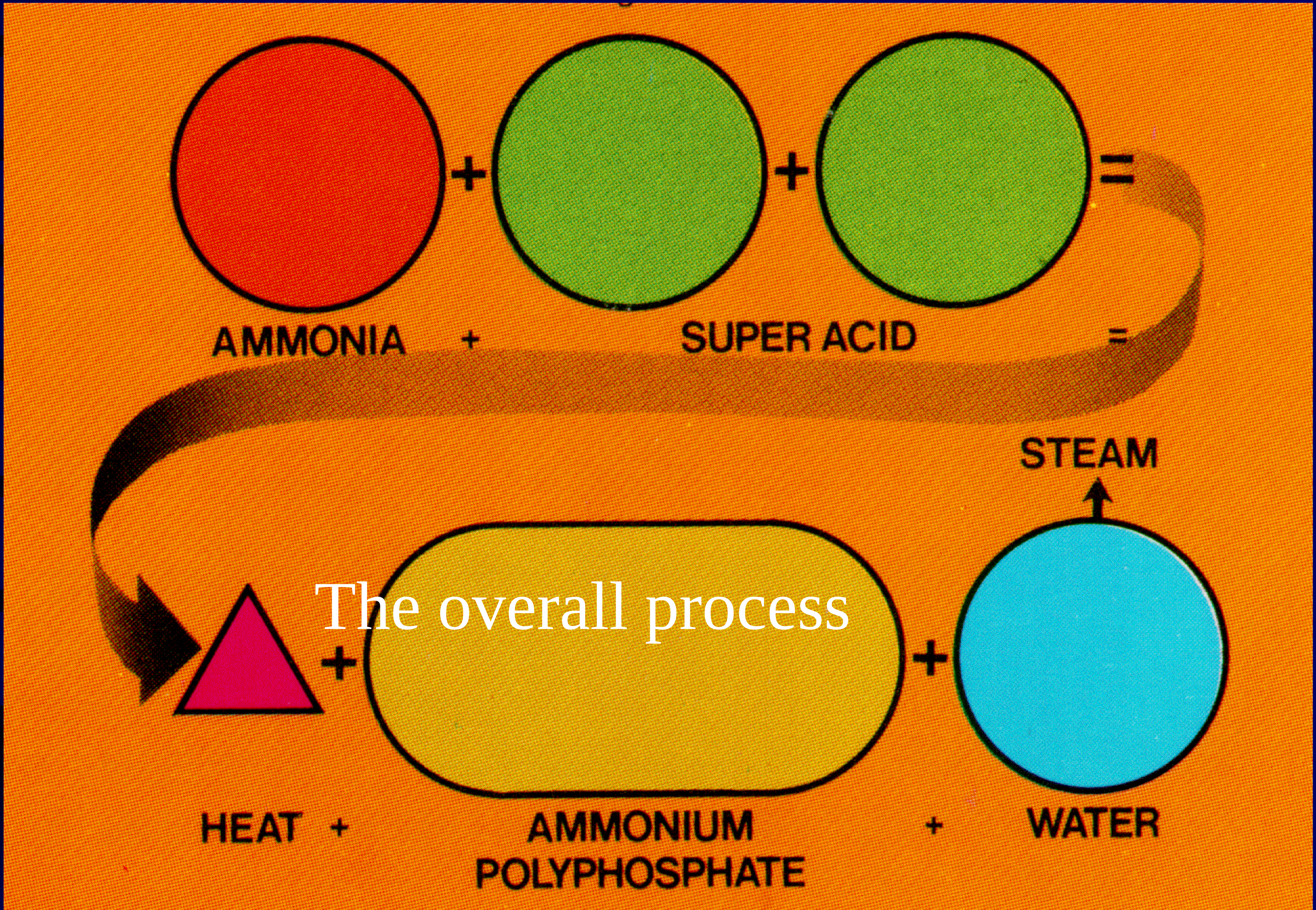
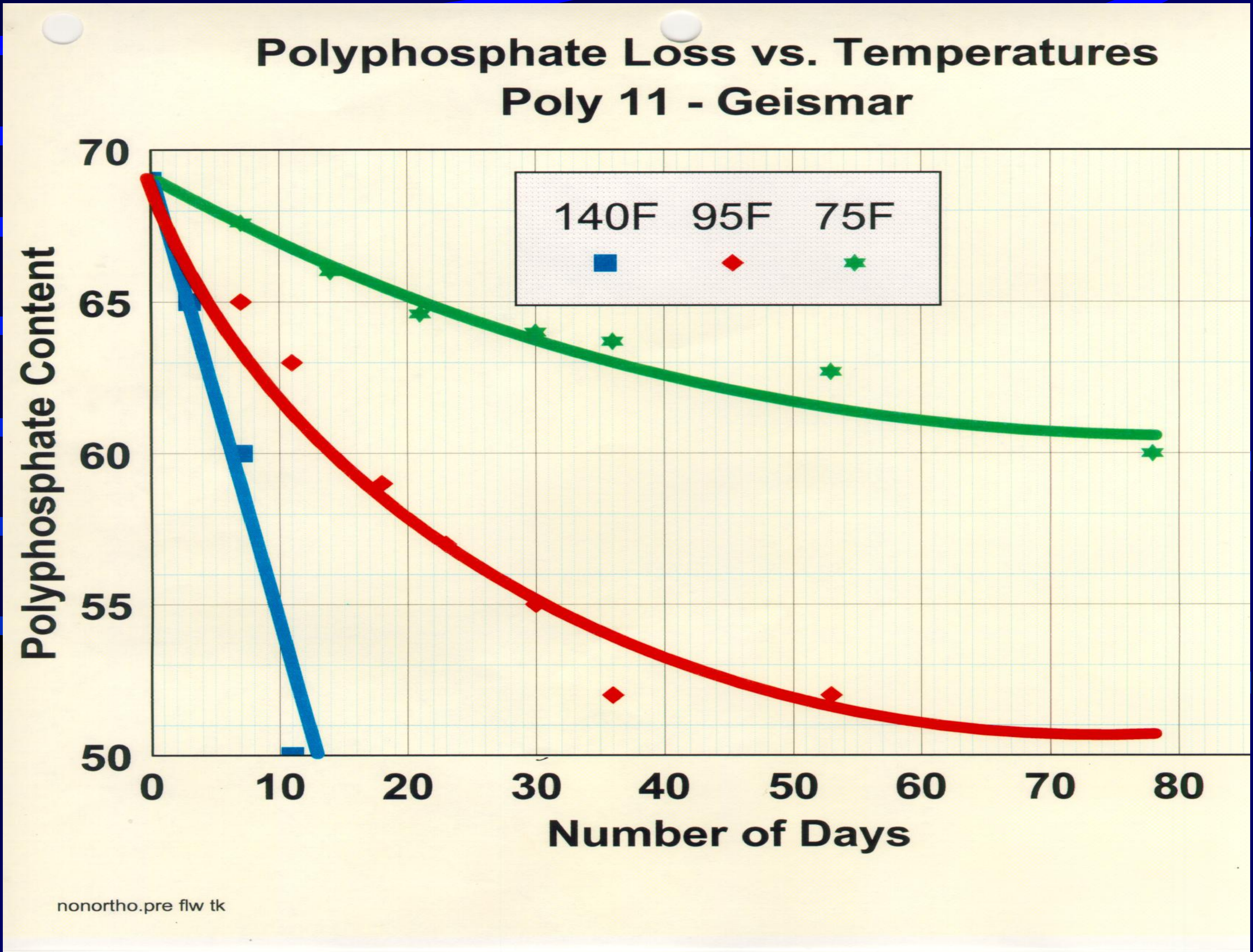


Figure 8



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
nonortho.pre flw tk

Potassium

- Widely distributed in earth's crust
- Mined, brines in saline lakes and seas
- Underground deposits
- 60% of world's reserves are in North America—most in Western Canada

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Monopotassium Phosphate
High OrthoP/KOH 'low salt'

- React KOH with Phos acid
- Exothermic reaction—heat released 220°F
- Minimizes escape of ammonia when reacted with urea and ammonium phosphates
- Ortho and/or poly P
- Used in production of low-salt starter and foliar fertilizers, fungicides (powdery mildew), buffering agents and food additives (Gatorade) and for greenhouse and hydroponics nutrient source

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Monopotassium Phosphate

- 6-24-6 high orthophosphate starter contains 3 kinds of potassium phosphate
  - Potassium orthophosphate monobasic (predominate form)
  - Potassium orthophosphate dibasic
  - Dipotassium pyrophosphate
- Very low corrosion on mild steel
- Can have K included and still have salt index less than APP 10-34-0—K source for seed placement

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Potash sources for fluids

• Potassium chloride	0-0-60 (62)
• Monopotassium phosphate	0-52-35
• Potassium carbonate	0-0-30 (32)
• Potassium thiosulfate	0-0-25-17
• Potassium sulfate	0-0-50-18
• Potassium nitrate	13-0-45

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Most Common K Sources
In our corner of the universe

- KCl - Blend with APP and UAN to make 7-21-7 and similar grades
- KOH – blend with ammonia, urea, ortho and poly phosphates, thiosulfates to make an array of low-salt affect grades of fertilizer (potassium phosphates)

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Fluid Sulfur Sources

• Ammonium thiosulfate	12-0-0-26
• Potassium thiosulfate	0-0-25-17
• Ammonium sulfate	21-0-0-24
• Potassium sulfate	0-0-52-18
• Urea-sulfuric acid	

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Micronutrient Sources

- EDTA chelated micros used for all fluids, --necessary for high ortho P products
- HEEDTA, NTA, DTPA and EDDHA
- Ammoniated zinc complexes—intended for products with high poly P content
- Sulfate, chloride or oxide forms
- Borates and Molybdates

Agronomic Considerations

- Or, does corn care? Yes, it just might!
- Handling, storage (sludge) and ease of use may be just as important to the grower as agronomic differences.
- Low salt index important for seed placement—lean to potassium hydroxide (monopotassium phosphate) for K source
- Low salt index important for maximum P uptake when K is added
- Growers and their dealers have choices

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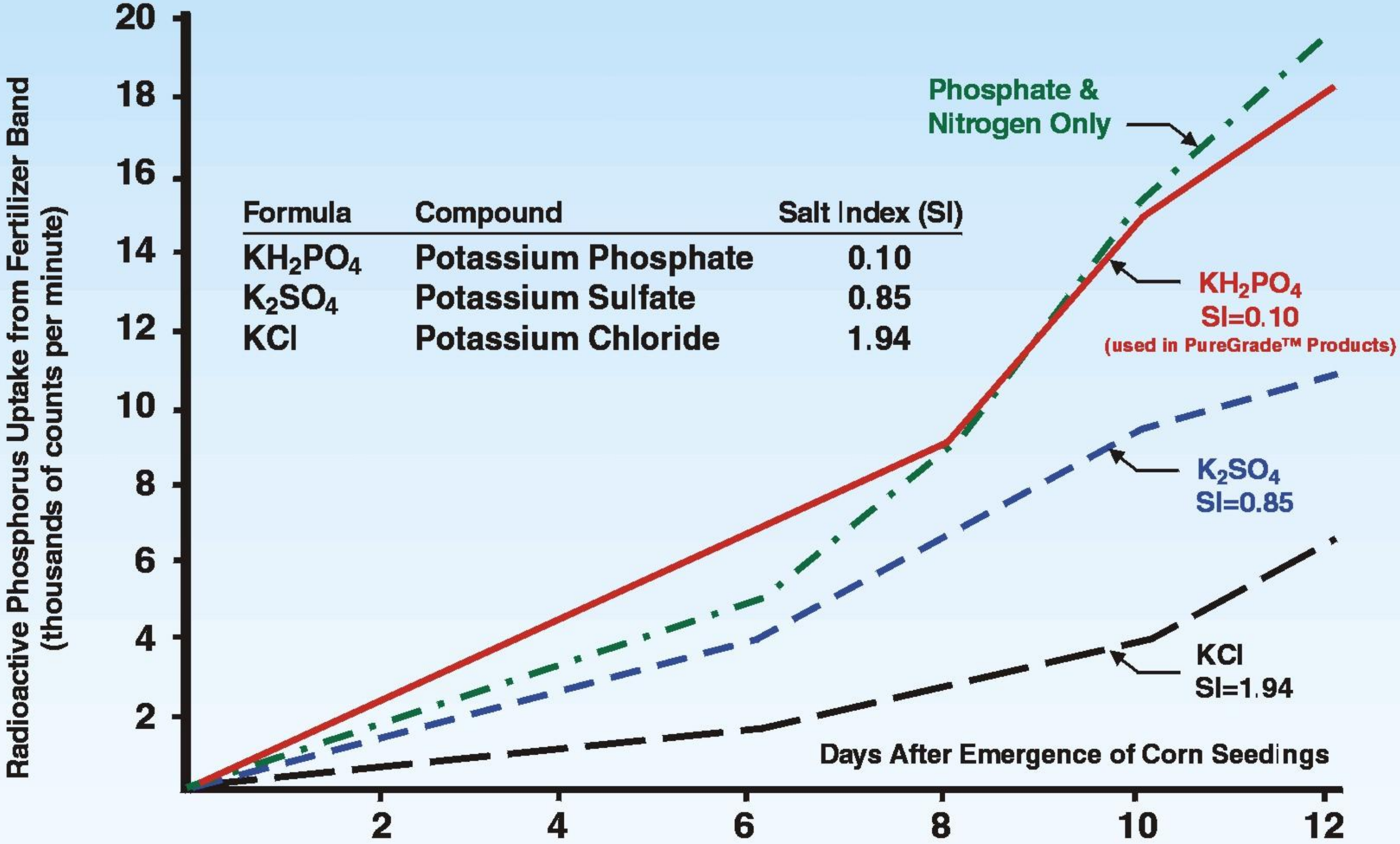
Phosphorus Uptake by Corn as Affected by the Potassium Salt Added to Phosphate-Nitrogen Mixture in Band



Formula	Compound	Salt Index (SI)
KH_2PO_4	Potassium Phosphate	0.10
K_2SO_4	Potassium Sulfate	0.85
KCl	Potassium Chloride	1.94

Source - How Roots Tap a Fertilizer Band by Prof .A.J. Ohlrogge
National Plant Food Institute, Washingtion, D.C.

Salt Index Values of Fertilizer Materials

Material and analysis	Salt Index: Per equal wts of materials	Salt Index: Per unit of nutrients*
NITROGEN/SULFUR		
Ammonia, 82% N	47.1	0.572
Ammonium nitrate, 34% N	104.0	3.059
Ammonium sulfate, 21% N, 24% S	68.3	3.252
Ammonium thiosulfate, 12% N, 26% S	90.4	7.533
Urea, 46% N	74.4	1.618
UAN, 28% N (39% a. nitrate, 31% urea)	63.0	2.250
32% N (44% a. nitrate, 35% urea)	71.1	2.221
PHOSPHORUS		
APP, 10% N, 34% P_2O_5	20.0	0.455
DAP, 18% N, 46% P_2O_5	29.2	0.456
MAP, 11% N, 52% P_2O_5	26.7	0.405
Phosphoric acid, 54% P_2O_5		1.613[a]
72% P_2O_5		1.754[a]
POTASSIUM		
Monopotassium phosphate, 52% P_2O_5, 35% K_2O	8.4	0.097
Potassium chloride, 62% K_2O	120.1	1.936
Potassium sulfate, 50% K_2O, 18% S	42.6	0.852
Potassium thiosulfate, 25% K_2O, 1 7% S	68.0	2.720

[a] Salt index per 100 lbs of H_3PO_4 *One unit equals 20 lb.

Mortvedt, "Calculating Salt Index"

Salt Index of Some Common Liquid Formulations

Formulation	Salt index	Salt index per unit of plant nutrient (20 lb)
2-20-20 [a]	7.2	0.17
3-18-18 [a]	8.5	0.22
6-24-6 [a]	11.5	0.32
6-30-10 [a]	13.8	0.30
9-18-9 [a]	16.7	0.48
10-34-0 [b]	20.0	0.45
7-21-7 [c]	27.8	0.79
4-10-10 [c]	27.5	1.18
28%UAN [c]	63.0	2.25

[a] These grades are formulated using potassium phosphate as the K source.
[b] Use in seed-row placement with caution.
[c] Not suggested for use in seed-row placement.

Mortvedt, "Calculating Salt Index"

Calculating Salt Index of 7-21-7

Material	% Nutrient	lbs/ton	Nutrient units N	Nutrient units P_2O_5	Nutrient units K_2O	Salt index per unit (20 lb)[a]	Salt index in formulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10-34-0	10% N, 34% P_2O_5	1,235	6.2	21.0	—	0.455	12.4
UAN	28% N	57	0.8	—	—	2.250	1.8
KCl	62% K_2O	226	—	—	7.0	1.936	13.6
Water		482	—	—	—	—	—
		2,000	7.0	21.0	7.0		27.8 [b]

[a] Salt index per unit (20 lb) of plant nutrients, listed Table 1, also called the partial salt index.
[b] 0.79 SI/unit plant nutrient

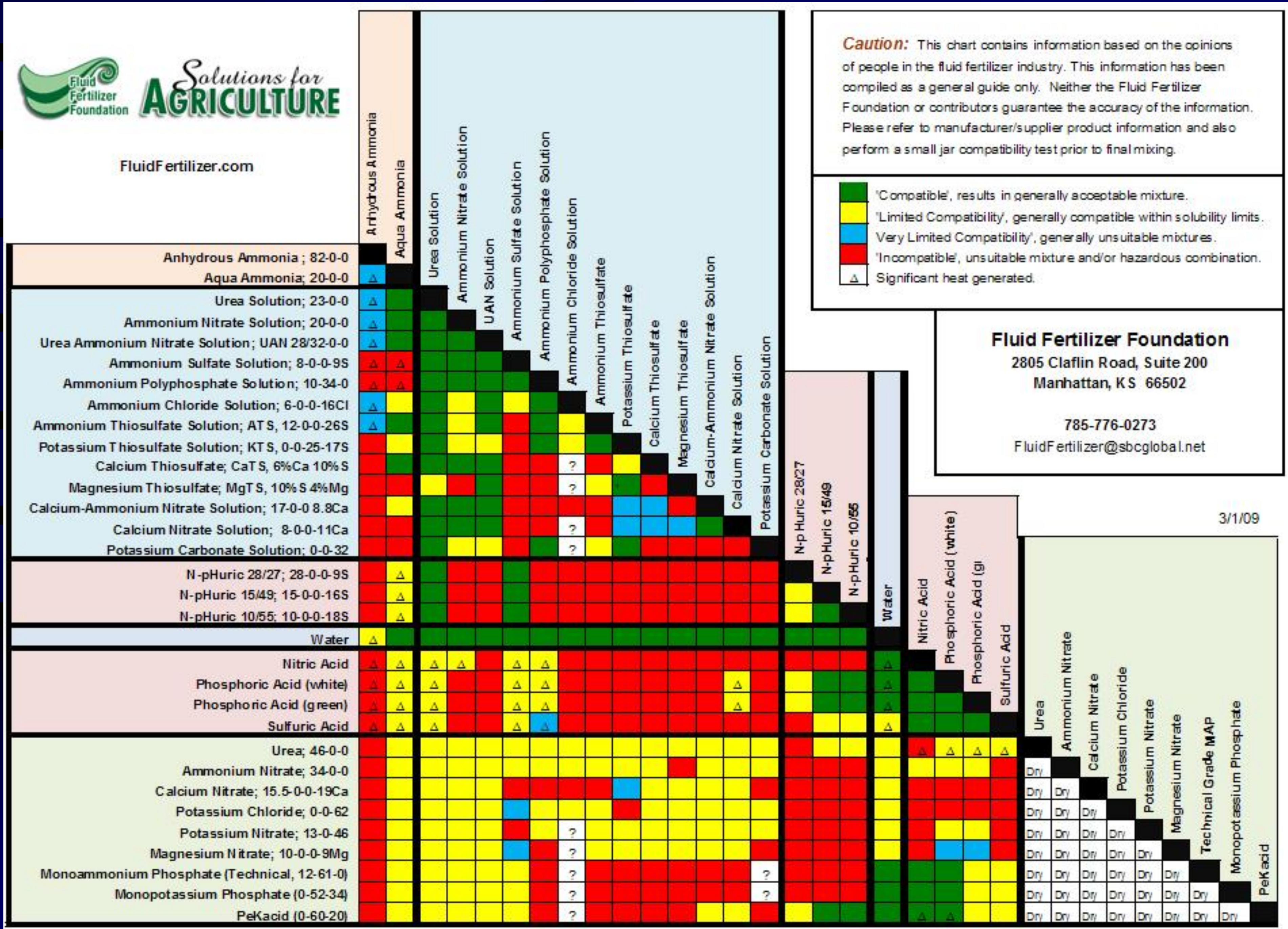
Mortvedt, “Calculating Salt Index”

Calculating Salt Index of 6-24-6

Material	% Nutrient	lbs/ton	Nutrient units N	Nutrient units P_2O_5	Nutrient units K_2O	Salt index per unit (20 lb)[a]	Salt index in formulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NH_3	82%N	146	6.0	—	—	—[b]	—
H_3PO_4	54% P_2O_5	666	—	18.0	—	1.613	10.7
Potassium	22% K_2O						
Phosphate	22% P_2O_5	546	—	6.0	6.0	0.097	1.2
Water		642	—	—	—	—	
		2,000	6.0	24.0	6.0		11.9[c]

[a] Salt index per unit (20 lb) of plant nutrients, listed in Table 1, also called the partial salt index.
[b] Ammoniation of phosphoric acid to a 1-3-0 ratio forms a mixture of MAP and DAP.
[c] 0.32 SI/unit plant nutrient.

Mortvedt, "Calculating Salt Index"


Fluid Fertilizer Foundation
Solutions for AGRICULTURE
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 generally acceptable mixture.
'Limited Compatibility', generally compatible within solubility limits.
'Very Limited Compatibility', generally unsuitable mixtures.
'Incompatible', unsuitable mixture and/or hazardous combination.
Δ Significant heat generated.
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3/1/09
Anhydrous Ammonia
Aqua Ammonia
Urea Solution
Ammonium 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 (gr
Sulfuric Acid
Urea
Ammonium Nitrate
Calcium Nitrate
Potassium Chloride
Potassium Nitrate
Magnesium Nitrate
Technical Grade MAP
Monopotassium Phosphate
PeKacid
Anhydrous Ammonia; 82-0-0
Aqua Ammonia; 20-0-0
Urea Solution; 23-0-0
Ammonium Nitrate Solution; 20-0-0
Urea Ammonium Nitrate Solution; UAN 28/32-0-0
Ammonium Sulfate Solution; 8-0-0-9S
Ammonium Polyphosphate Solution; 10-34-0
Ammonium Chloride Solution; 6-0-0-16Cl
Ammonium Thiosulfate Solution; ATS, 12-0-0-26S
Potassium Thiosulfate Solution; KTS, 0-0-25-17S
Calcium Thiosulfate; CaTS, 6%Ca 10%S
Magnesium Thiosulfate; MgTS, 10%S 4%Mg
Calcium-Ammonium Nitrate Solution; 17-0-0 8.8Ca
Calcium Nitrate Solution; 8-0-0-11Ca
Potassium Carbonate Solution; 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; 10-0-0-9Mg
Monoammonium Phosphate (Technical, 12-61-0)
Monopotassium Phosphate (0-52-34)
PeKacid (0-60-20)

The End

NutraFlo®