FLUID PHOSPHATES:
ORTHO VS. POLY
SALT INDEX
STORAGE

Fluid Technology Roundup

December 5, 2017

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1M Solutions, LLC

EVERYTHING YOU NEED TO KNOW

- https://fluidfertilizer.org/
- F09-a4 .pdf
- 33P8-11.pdf
- 35P17-19 .pdf

TWO DISTINCT FLUID STARTER TYPES

- Ammonium polyphosphates
- 100% orthophosphates

TWO DISTINCT FLUID STARTER TYPES

- Ammonium polyphosphates
- 100% orthophosphates
- With exception of nitrogen, the two types made from different sets of P & K raw materials
- Different marketing techniques

POLYPHOSPHATES

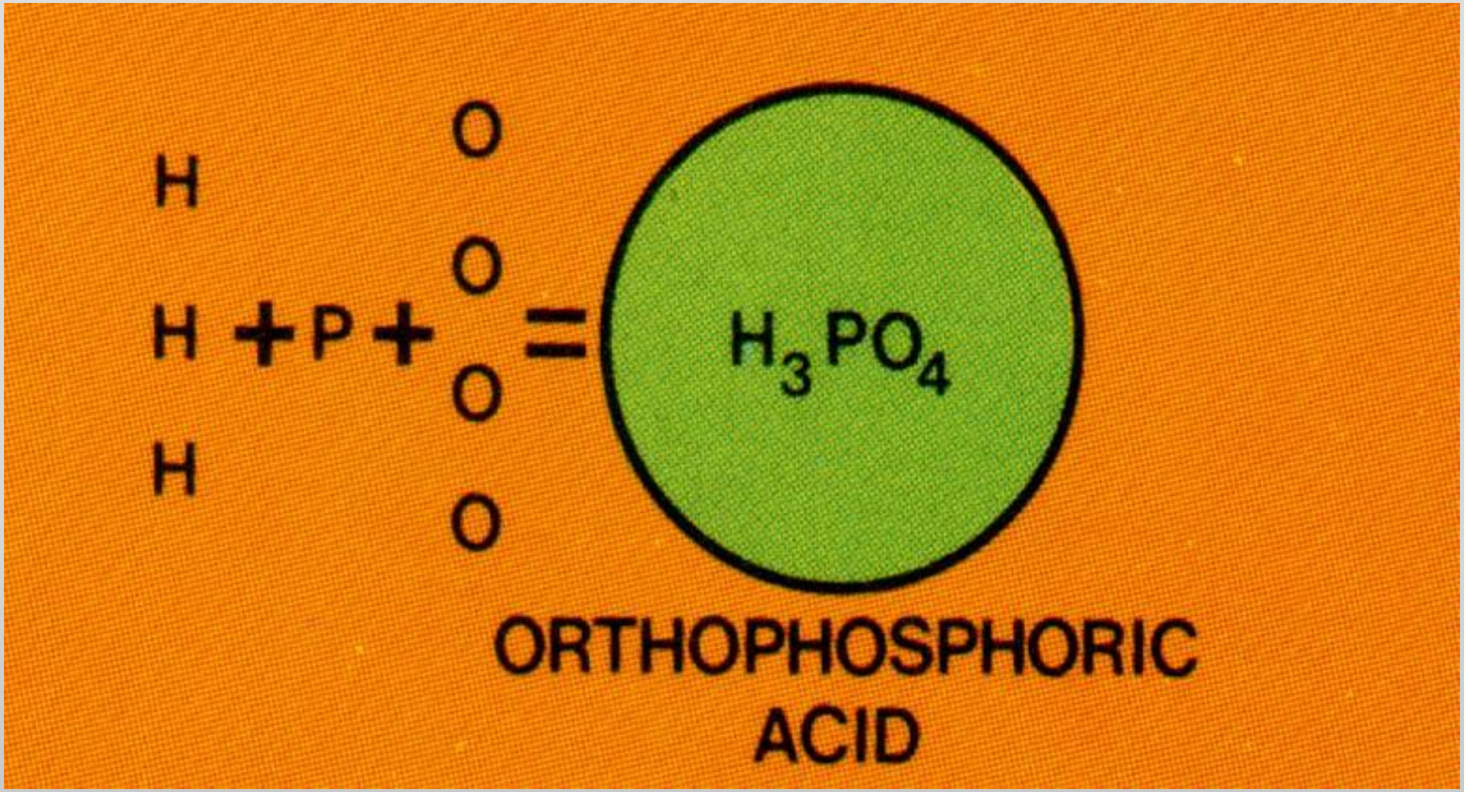
- What are they?
- How they are produced?
- What they do and advantages to having "polys"?
- Precautions

PHOSPHORIC ACID SOURCES

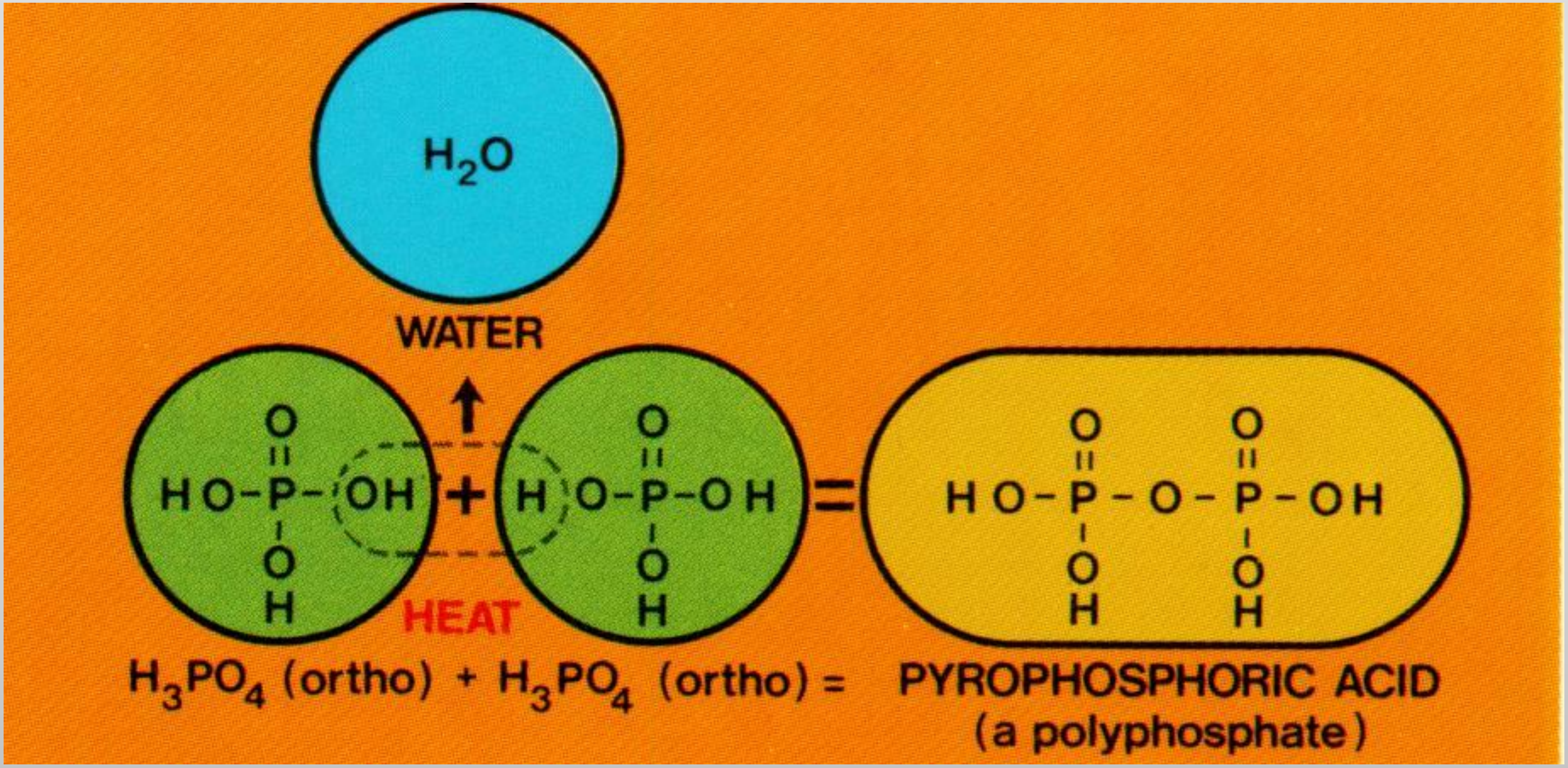
- Wet
- PPA
- Thermal
- Kiln Process Acid

WHAT IS A POLYPHOSPHATE?

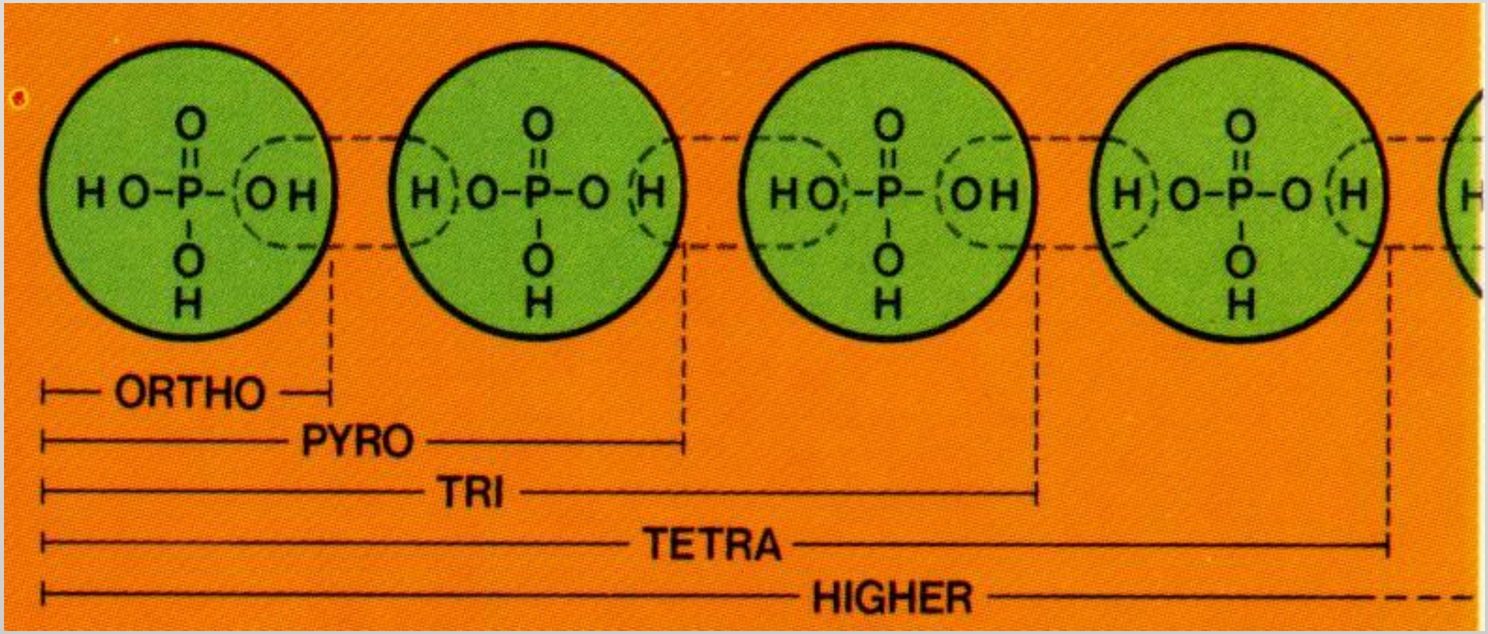
- Polyphosphates are molecules containing more than one phosphorus atom
  - Prior to the advent of the TVA pipe reactor process they were very difficult to make
  - Only source lay in “high poly” superacids (which are very corrosive)
    - Required high heat and high vacuum conditions
    - 50% poly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



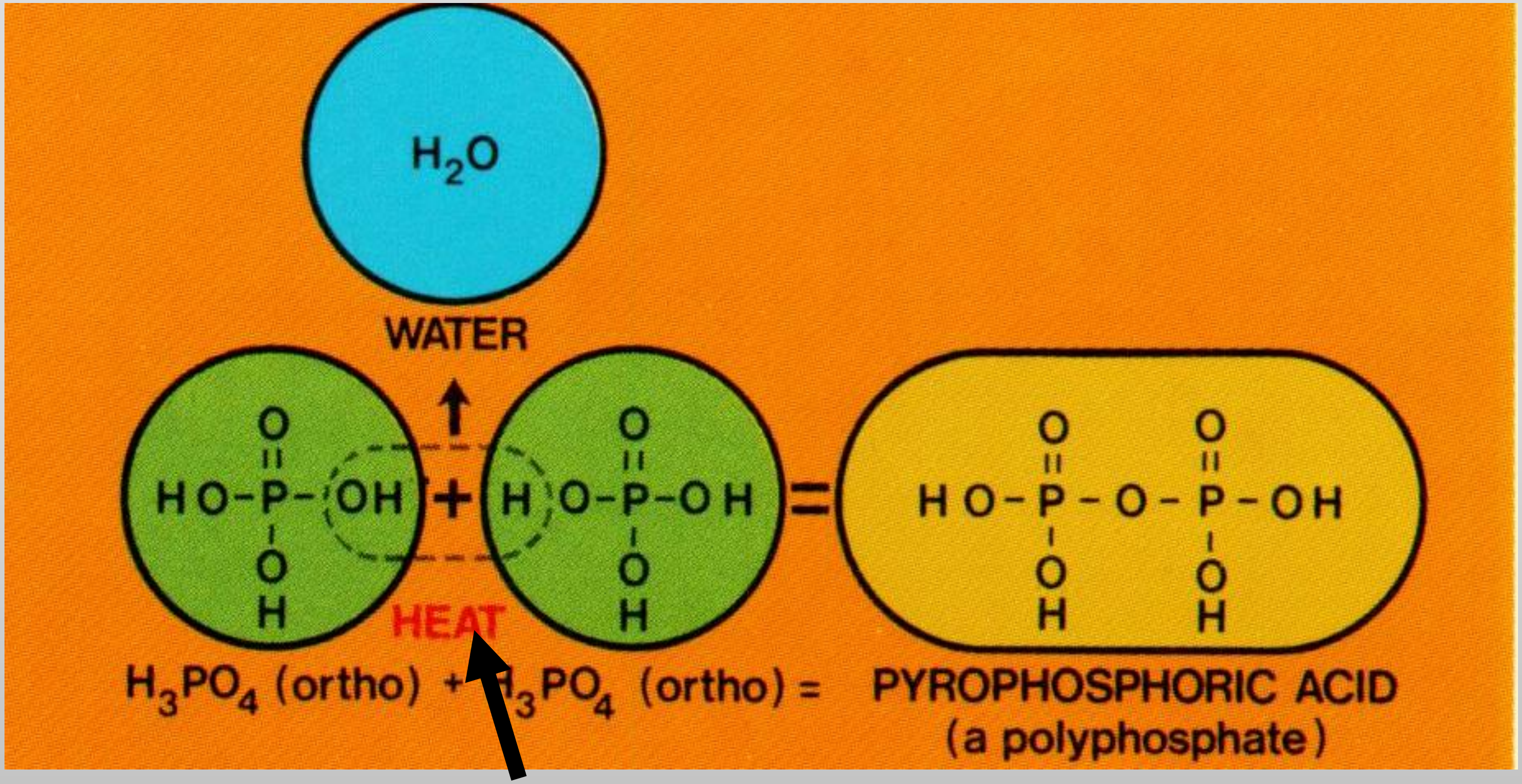
The basic building block for polyphosphates



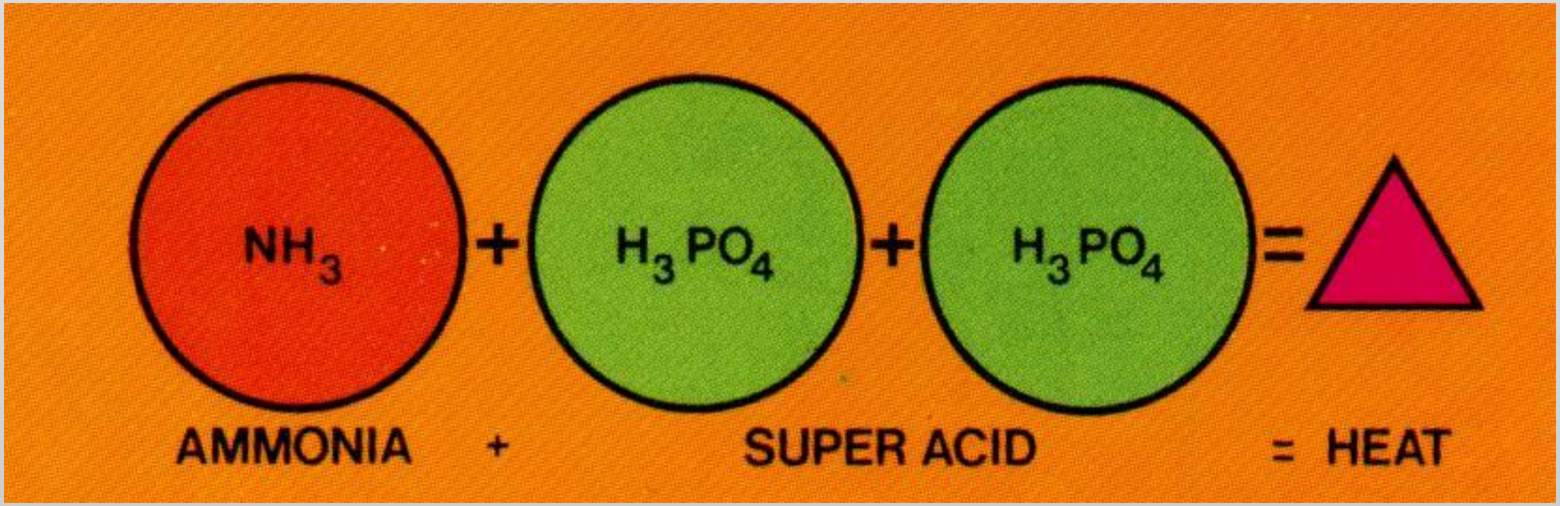
Using heat to drive out chemically bound water and link the phosphate molecules



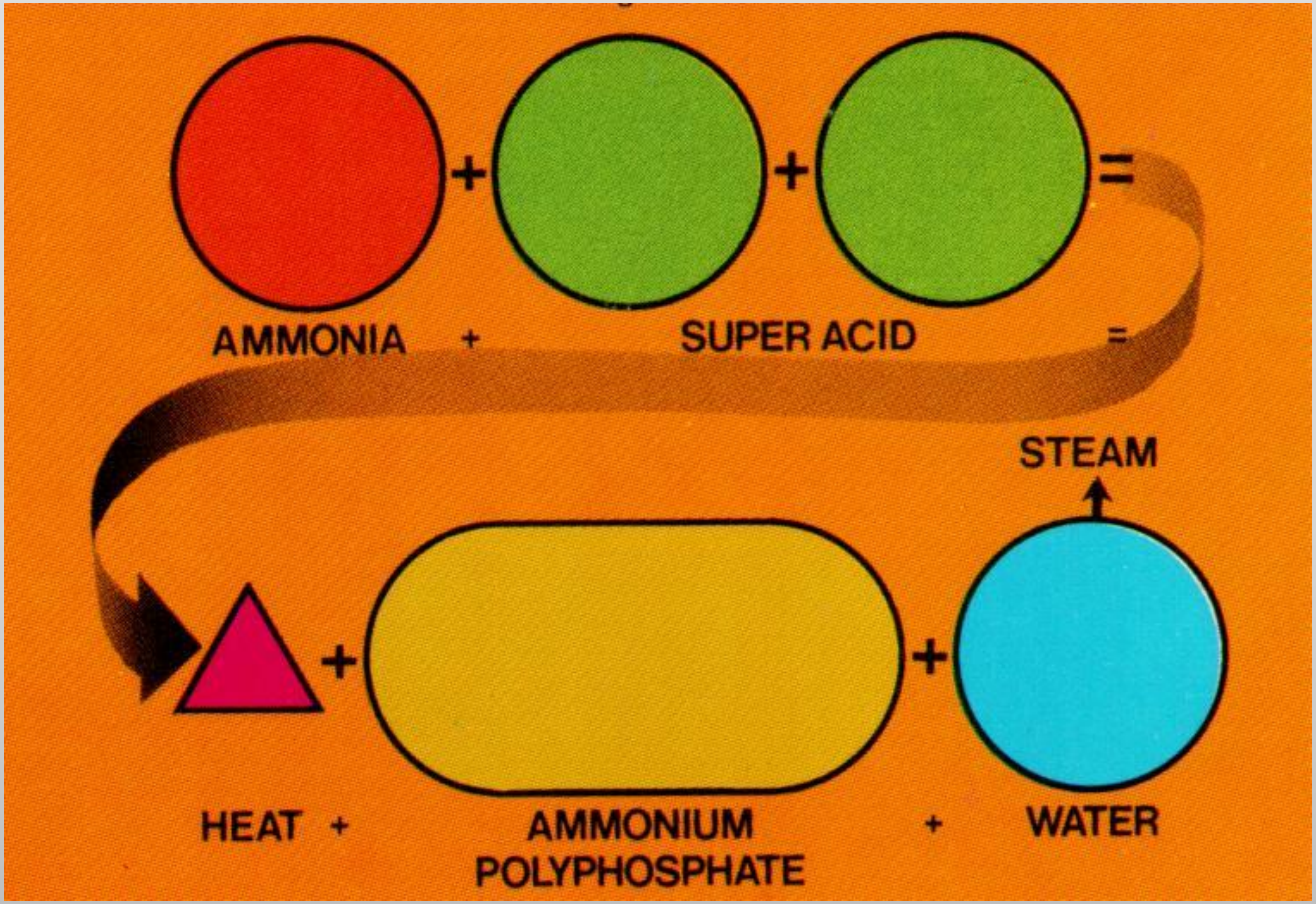
With more heat additional links can be made each time removing another molecule of chemically bound water



Where does the heat come from?

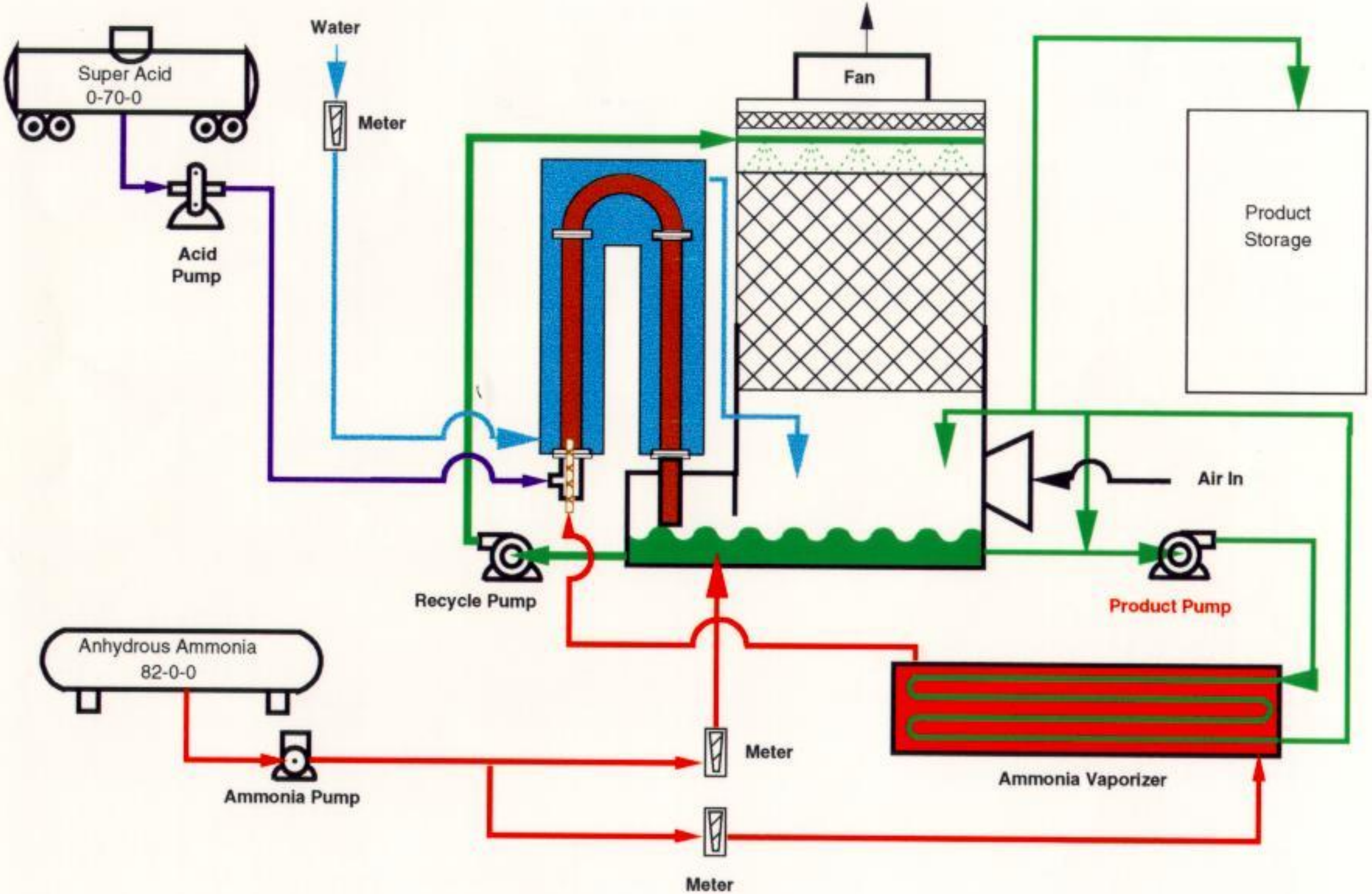


Ah-ha!



The overall process

THE TVA REACTOR



TVA PIPE REACTOR PROCESS SCHEMATIC

HIGH ORTHO

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

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 super acid)
- K from KCl
- S from ATS + other
- Micros from ammoniated complexes, sulfates, chlorides and chelates

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, KTS.

ORTHO BENEFITS

- Plants use only ortho phosphate
- Immediately available phosphorus
- Higher ortho = lower viscosity for uniform flow rates over a wide range of temperatures
- Fewer contaminants to settle out
- 100% ortho—virtually no contaminants
- Excellent storability

ORTHO CONS

- Does not sequester micronutrients
- Must use completely chelated micros
- Usually more expensive per unit of phosphate

POLY BENEFITS

- Concentrated P
- Sequesters micros (important for zinc)
- Cheaper acid raw material source
- So called “Contaminants” include micronutrients at no extra charge

POLY CONS

- Often not recommended for in-furrow placement depending on K source
- Polyphosphate chains need to break down (hydrolyze) for bio availability
- Higher Viscosity (due to concentration)
- Storability problems if Poly converts in the tank before use

SEED SAFETY

- High orthos tend to be built with monopotassium phosphate as raw material. (ortho acid + KOH) = low salt index
- Safer on the seed
- High poly fertilizers are usually built with potassium chloride for the K source. Lowest cost, but higher salt index. Avoid seed placement. Economical for other placements

CORROSIVENESS

- Important for equipment, especially planters
- Spend a quarter million dollars on a planter and what becomes the main concern if used for fertilizer application? Rust and corrosion!
- Foliar application gets fertilizer on equipment
- Generally, low salt index fertilizers made with monopotassium phosphate are also least corrosive to mild steel

SALT INDEX BASICS

- The salt index (SI) is a ***relative*** measure of a fertilizer to draw moisture and compete with roots and plants for water
- The higher the fertilizer SI the greater the risk of injury to the plant.
- Germinating seeds are especially sensitive to fertilizer mixtures with a high SI
- SI values are based on sodium nitrate = 100

SI BASICS (CONT'D)

- Each component of a mixture has its own SI
- The SI of fluid mixtures can be calculated from the SI values of its components
- The SI permits the comparison of fluid formulations using different components
- SI tables are available from a number of sources (Farm Chemicals Handbook; Professional Dealers Manual – ARA; Publications of the FFF)

SI BASICS (CONT'D)

- Again, the SI of a mixture is the sum of the SI values contributed by each of its components
- The SI for a "high analysis" NPK mixture may be greater than for a "low analysis" one --- however, the SI ***per unit of plant nutrient*** may be lower for the higher analysis product!
- Thus must compare mixtures on the basis of per unit of plant nutrient

CALCULATING SALT INDEX VALUES

- Step 1. Determine the SI ***per unit of plant nutrient*** of each raw material
- Step 2. Calculate the total units contributed to the final mixture by each raw material
- Step 3. Multiply the above value (total units contributed) by the value found in Step 1
- Step 4. Repeat Steps 1,2 and 3 for each raw material
- Step 5. Sum the contributions from each of the raw materials to find the SI of the total blend

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”

Calculating Salt Index of 6-24-6

Material	% Nutrient	lbs/ton	N	Nutrient units P_2O_5	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”

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”

SALT INDEX OF SOME COMMON LIQUID FORMULATIONS

Formulation	Salt Index	Salt Index per Unit of Plant Nutrient (20 lb)
2-20-20	7.2	0.17
3-18-18	8.5	0.22
6-24-6	11.5	0.32
9-18-9	16.7	0.48
10-34-0	20.0	0.45
7-21-7	27.8	0.79
4-10-10	27.5	1.18
28% UAN	63.0	2.25

USING ORTHO AND POLY IN THE FIELD

- Rader said that salt index determines placement
- Far from seed—no concern about SI
- Strip-till: Poly P with high SI fertilizers applied preplant in subsurface band. Planter applied low SI 6-24-6 for safety in seed furrow
- Ammonia and 10-34-0 applied together in “dual band.” Plus planter applied low SI starter fertilizer in seed furrow
- Liquid or dry surface broadcast + row placed liquid, low SI ortho at planting

WHY SI IS IMPORTANT TODAY

- Seed Row placement easier with large planters
- Need more seed safety
- Fertilizer openers on large planters have disadvantages
  - Expensive
  - Take extra horsepower
  - Obstruct trash flow in high residue conditions
  - Disturb seedbed in no-till
  - Seed depth variable because moist soil kicked out by fertilizer opener sticks to seed depth control wheels

ORTHO VS POLY: SUMMARY

- Original liquid fertilizers were all ortho
- Plants use only ortho form
- High ortho products are typically more dilute
  - Flow better in cold temperatures
  - Lack sequestration power
- Polys naturally break down to form ortho P
- TVA pipe reactor process used concentrated acid and ammonia under high temperature to form high poly
- Most fertility programs include both.

SALT INDEX: SUMMARY

- For seed row placement (and foliar) or very close to the seed use low salt index products to protect expensive seed and leaf tissue
- Don't want corrosion on equipment? Use low salt index fertilizer made from monopotassium phosphate. No chloride or nitrate
- Broadcasting or banding several inches from seed furrow--look for economical alternatives
- Successful fertilizer programs include both low SI products and "conventional" fertilizers

SALT INDEX MADE PRACTICAL

- Salt index is a relative concept
- Labs report the test value but won't render judgement
- Not necessarily predictive of behavior
- N on Rice recommendation
  - 23 agronomists asked to comment on in-furrow N rate for rice
    - Grower wanted to put 100L/ha of 11-37-0 on 20 inch rows
  - Not one calculated a salt index

Fertilizer Compatibility

NPK'S & MICROS

- Concentration – Chemistry Constraints
  - Can't put 6 gallons in a 5 gallon bucket!
  - Certain elements need help to stay in solution
    - Sequestration
    - Chelation
- Compatibility – Choose Wisely
- Cross contamination is a wily foe
  - High ortho, high poly
  - Sequestered, chelated micros
  - Tank type

NITROGEN – COMMON FORMS

- Ammonia
- UAN
- Urea
- Controlled release
  - Urea-formaldehyde
  - Isobutylidene diurea
  - Urea Triazone

PHOSPHORUS – COMMON FORMS

- Ammonium phosphate
- Potassium phosphate

POTASSIUM – COMMON FORMS

- Potassium chloride, KCl
- Potassium hydroxide
- Potassium thiosulfate, KTS®
- K-Row 23® 0-0-23-8S.
- Less Common
  - Carbonates
  - Acetates

SULFUR: COMMON FLUID SOURCES

- ATS 12-0-0+26S (ammonium thiosulfate)
- KTS 0-0-25+17S (potassium thiosulfate)
- K-Row 23® 0-0-23-8S. Supplies K and S. A new product designed for blending with ammonium polyphosphate for seed safe application with pop-up fertilizers.

MICRONUTRIENTS: COMMON FLUID SOURCES

- Zinc: Chelates, ammoniated zinc complexes, sulfate, nitrate, chloride
- Manganese: Chelates, sulfate,
- Copper: Chelates, sulfate, chloride
- Iron: Chelates, sulfate
- Boron: Boric acid, MEA, Solubor®

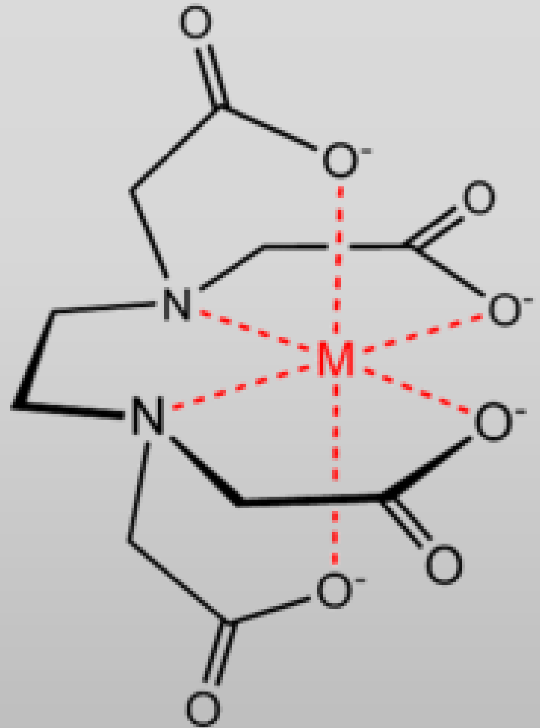
CHELATES AND MICRONUTRIENTS

Chelating Agent	Micronutrients			
	Copper	Iron	Manganese	Zinc
EDTA	X	X	X	X
HEEDTA	X	X	X	X
NTA		X		X
DTPA		X		
EDDHA		X		
Glucoheptonate		X		X

STORAGE & TRANSPORTATION ISSUES

- Transports may need to be thoroughly cleaned before loading (chart follows)
- Chelates - plastic, lined, or fiberglass tanks
  - EDTA has an order of chelation (see slide)
  - Chelated Cu displaced by Fe, Cu metal plates on mild steel surface

AFFINITY CHART FOR EDTA



- Iron (Ferric)
- Mercury
- Copper
- Aluminum
- Nickel
- Lead
- Cobalt
- Iron (Ferrous)
- Zinc
- Cadmium
- Manganese
- Magnesium
- Calcium

Last product in trailer

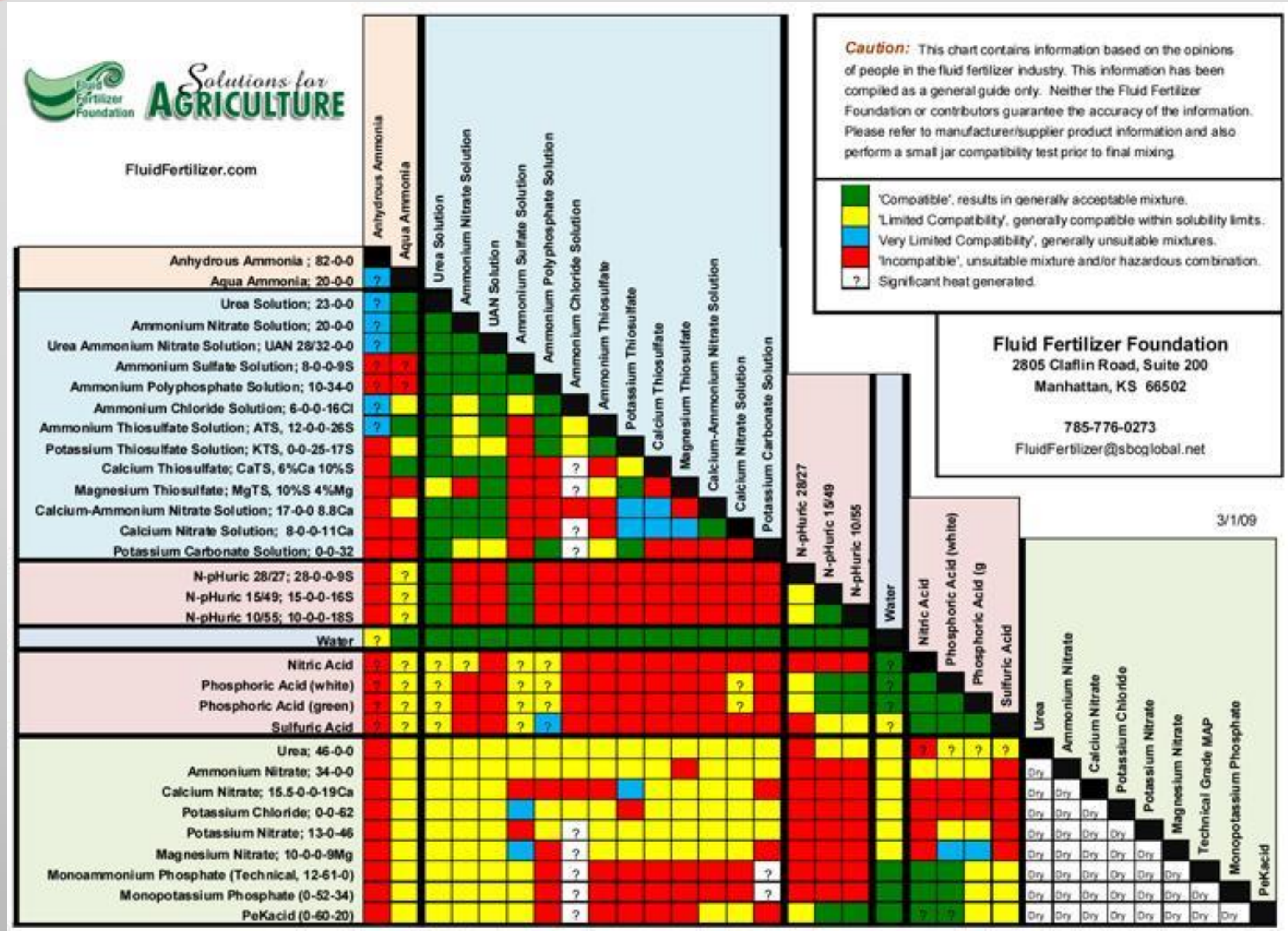
Product to be loaded	> 50% Polys	20% - 50% Polys	100% Ortho	X-0-X	Aqua Ammonia	Urea Solution	UAN/AN	Ammonium Sulfate	ATS/KTS	K Carbonate	Urea Triazone	Water	Ammoniated Zinc Complex	Citrate, EDTA 10% Zn (10XL)	Chelate 9 Zn	Chelate Mn 6	10% B MEA	4.5 % Fe EDTA	7.5% Cu EDTA
Greater than 50% Polys																		Color	Color
20% - 50% Polys																		Color	Color
100% Ortho																		Color	Color
X-0-X zero Phosphates																			
Aqua Ammonia														Color				Color	Color
Urea Solution																		Color	Color
UAN/AN														Color				Color	Color
Ammonium Sulfate solution																		Color	Color
ATS/KTS																		Color	Color
K Carbonate																		Color	Color
Urea Triazone																		Color	Color
Water														Color					
Ammoniated Zinc Complex														Color		Color		Color	Color
Citrate, EDTA 10% Zn																Color		Color	Color
Chelate 9 Zn														Color		Color		Color	Color
Chelate Mn 6																		Color	Color
10% B MEA																			
4.5 % Fe EDTA																			Color
7.5% Cu EDTA																		Color	

Compatible
Limited Compatibility
Incompatible
Color Might change final color

	> 50% Polys	20% - 50% Polys	100% Ortho	X-0-X	Aqua Ammonia	Urea Solution	UAN/AN	Ammonium Sulfate	ATS/KTS	K Carbonate	K Chloride	Urea Triazone	Water	Ammoniated Zinc Complex	Citrate, EDTA 10% Zn (10XL)	Chelate 9 Zn	Chelate Mn 6	10% B MEA	4.5 % Fe EDTA	7.5% Cu EDTA
Greater than 50% Polys																			Color	Color
20% - 50% Polys																			Color	Color
100% Ortho																			Color	Color
X-0-X zero Phosphate																			Color	Color
Aqua Ammonia															Color				Color	Color
Urea Solution															Color				Color	Color
UAN/AN															Color				Color	Color
Ammonium Sulfate solution															Color				Color	Color
ATS/KTS																			Color	Color
K Carbonate																			Color	Color
K Chloride																			Color	Color
Urea Triazone																			Color	Color
Water															Color		Color		Color	Color
Ammoniated Zinc Complex															Color		Color		Color	Color
Citrate, EDTA 10% Zn					Color	Color	Color	Color					Color	Color		Color	Color		Color	Color
Chelate 9 Zn															Color		Color		Color	Color
Chelate Mn 6													Color		Color	Color			Color	Color
10% B MEA																			Color	Color
4.5 % Fe EDTA	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color		Color
7.5% Cu EDTA	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	Color	

BLEND PHYSICAL PROPERTIES

- Boron - Store above 50°
- Boron & Mn don't play well together
- Ammoniated zinc, Zn citrates & acetates don't mix well with low polyphosphates.
- Potassium precipitates nitrates & sulfates (within ranges)


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.
? Significant heat generated.
Fluid Fertilizer Foundation
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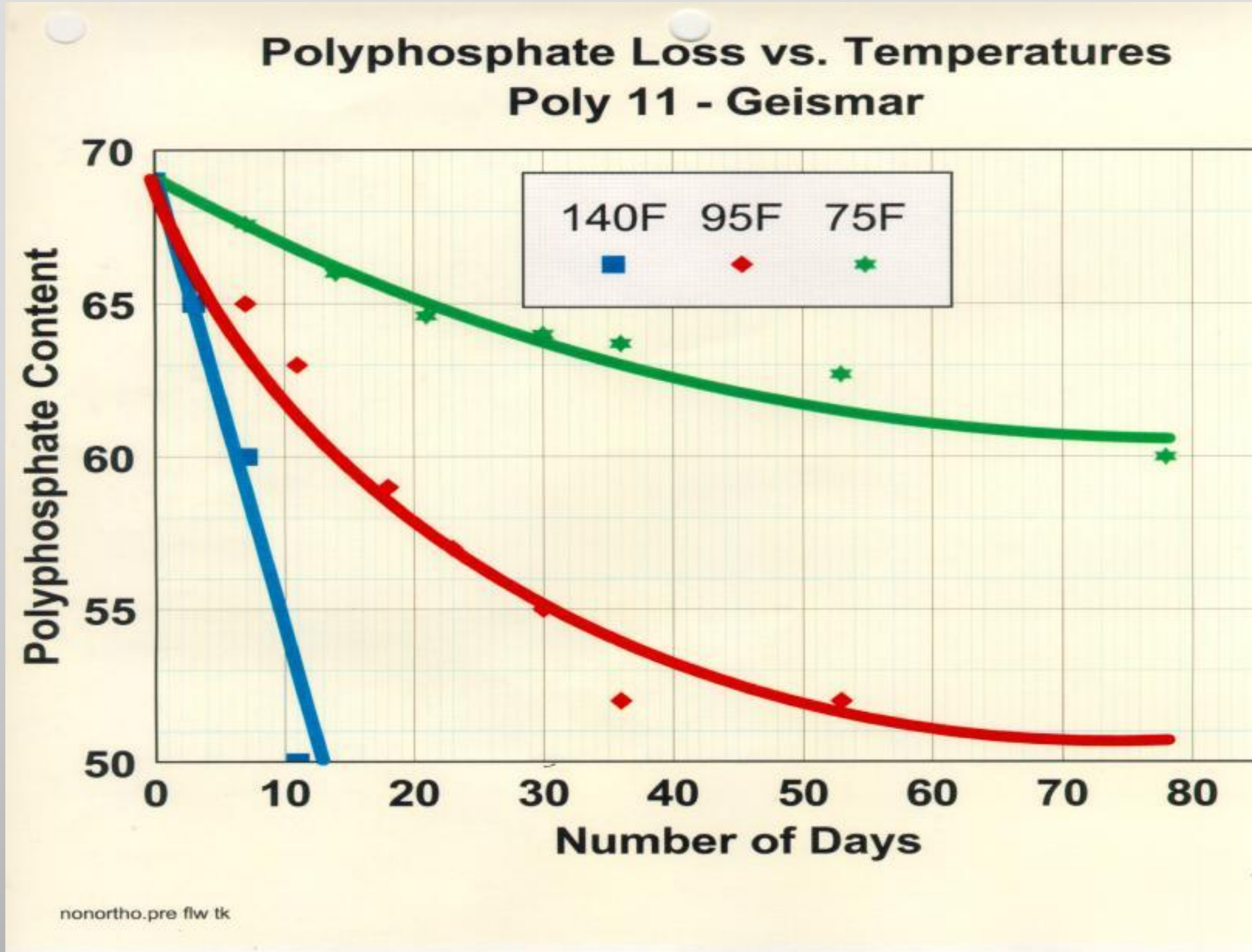
3/1/09
Anhydrous Ammonia ; 82-0-0
Aqua Ammonia; 20-0-0
Urea Solution; 23-0-0
Ammonium Nitrate Solution; 20-0-0
Urea Ammonium Nitrate Solution; UAN 28/32-0-0
Ammonium Sulfate Solution; 8-0-0-9S
Ammonium Polyphosphate Solution; 10-34-0
Ammonium Chloride Solution; 6-0-0-16Cl
Ammonium Thiosulfate Solution; 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)
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 (g
Sulfuric Acid
Urea
Ammonium Nitrate
Calcium Nitrate
Potassium Chloride
Potassium Nitrate
Magnesium Nitrate
Technical Grade MAP
Monopotassium Phosphate
PeKacid

STORAGE

Weather & Adulteration

BASIC WEATHER ISSUES

- Too hot
- Too cold
- Best when average temp between 32 and 75


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

AVOIDING ORTHO-POLY PROBLEMS

- 10-34-0 can degrade over summer
- 6-24-6 may be a problem in small tanks
- Build inventory in late summer & early fall
- Winter transport may be a problem
- Clean tanks
- Dedicated lines
- In-line filters
  - Screens – Thompson strainer
  - Sock filters

AVOIDING ORTHO-POLY PROBLEMS

- Flush lines
- Process is important
  - Keep up to date
  - Paperwork has to match tank farm
  - Visual cues
  - Valves and tanks labelled
- 100% ortho & 0 phosphate products are less forgiving
  - Color can hide a multitude of sins

Thank You

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