

FLUID PHOSPHATES: ORTHO VS. POLY SALT INDEX STORAGE

Fluid Technology Roundup
December 5, 2017
Raun Lohry
1M Solutions, LLC



EVERYTHING YOU NEED TO KNOW

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



Let's Be Careful When Defining Salt Index Original data and definition of salt-index predate many current fertilizers.

Summary: The original data and definition of salt index come from a time before many of the current fertilizer products, especially fluids after the 1940s, were developed. In recent years, some have adopted a method that measures electrical conductivity (EC) and not the original osmotic pressure approach. A few products may have widely different salt index values, depending on methodology used. Salt index, by itself, does not tell us how much of a given product is safe when applied with the seed. It only provides relative differences among products. Many other factors such as soil temperature, soil moisture, and potential free ammonia formation may all impact germination and/or seedling root development.

In the 1940s, dry fertilizer materials available at that time were evaluated for changes that occurred in the soil solution osmotic pressure upon application. In 1943, Rader et al. reported salt index values for 45 dry fertilizer materials based on the osmotic pressure of the soil solution when applied to Norfolk sand. This method involved mixing fertilizer materials with air-dried soil and then spraying with water to bring the moisture content to 75 percent of its moisture equivalent. After five days, the soil solution was removed and evaluated for conductivity and freezing point. The resulting freezing point values were then converted to osmotic pressure by tables developed for vegetable asps. A salt index value was then expressed relative to the increase in

os the so nlt we be (U fro me Jai a li co prc Ho res inc me thi coi ap as (AF

Fluid fertilizers containing potassium phosphate as the source of K have lower SI values than those containing KCl. When applied near the seed, fertilizers with lower SI values generally cause fewer problems in seed germination or seedling injury. SI of any fluid formulation can be calculated using the SI values of the most common fertilizer sources. Dealers or growers then can select those formulations with lower SI values that best fit their needs.

Banding of nutrients has received much attention over the years. Usually, the fertilizer is placed at a depth greater than that of the seed to allow root interception of the fertilizer band as roots grow outward and downward in the soil.

Band vs broadcast
Regions showing the greatest improvement in efficiency from banding over broadcasting lie in the northern U.S. and Canada, where colder soil conditions are experienced during spring seeding of row crops and small grains. Higher P rates are generally recommended if grown broadcast instead of band these fertilizers.

by Dr. Raun Lohry

Ortho Vs. Poly

Author takes a look at the history and behavior of ortho and polyphosphates.

Summary: Reports covering nearly 40 years of research present strong

temperature related. Many know fast hand the problem of hydrolysis that

barley. Gilliam and Sample (1968) studied hydrolysis rates in soils with different chemical properties to assess the relative importance of chemical and biological influences. They found a significant chemical contribution to hydrolysis rate. All the observed changes could not be attributed solely to biological factors. Coarse-textured soils appeared to hydrolyze PP faster than fine. Hunt et al. (1966) also found texture to significantly interact with other factors to influence rate. Significant interactions expressed were: texture x organic matter content, texture x pH, texture x time, organic matter x time, pH x soil moisture, pH x time, and temperature x time.

Dick and Tabatabaie (1966) demonstrated hydrolysis rate differences in four soils at three temperature regimes (Figure 1). Rates were lower at 50° than at 68° or 86° F. The amount of P hydrolyzed in the three acid soils (Clairton, Webster, Muscatine) decreased with increasing chain length although there were no significant differences between pyro-P₃ and tri-polyphosphate (P₃).

Chang and Racz (1977) quantified temperature effects on sodium pyrophosphate hydrolysis (Figure 2). Rates increased linearly and increased about two- to three-fold from 68° to 95° F. Tri-polyphosphate hydrolysis was greater than pyrophosphate and both rates were higher in the non-calcareous soil. About 40-70% of the phosphate hydrolyzed in 120 hours at 68° F whereas about 80-95% hydrolyzed in 120 hours at 95° F.

Minerals may also affect hydrolysis rate. Dick and Tabatabaie (1967) showed Ca²⁺, pH, and non-buffered phosphate activity to be positively correlated with hydrolysis rate while percentage of clay, extractable Al³⁺, and water soluble Mg²⁺ were negatively correlated.

APP
The most commonly applied polyphosphate is ammonium

Dr. John J. Mortved

Calculating Salt Index

Salt content is one of the most critical characteristics of fertilizers that should be considered when fertilizers are applied, especially with seed-row or "in furrow" placement.

Summary: Salt index (SI) of a fertilizer is a measure of the salt concentration that fertilizer induces in the soil solution. SI does not predict the exact amount of a fertilizer material or formulation that could produce crop injury on a particular soil, but it does allow comparisons of fluid formulations regarding their potential salt effects. As we all know, placement of some formulations in or near the seed may decrease seed germination or result in seedling injury.

Fluid fertilizers containing potassium phosphate as the source of K have lower SI values than those containing KCl. When applied near the seed, fertilizers with lower SI values generally cause fewer problems in seed germination or seedling injury. SI of any fluid formulation can be calculated using the SI values of the most common fertilizer sources. Dealers or growers then can select those formulations with lower SI values that best fit their needs.

Banding of nutrients has received much attention over the years. Usually, the fertilizer is placed at a depth greater than that of the seed to allow root interception of the fertilizer band as roots grow outward and downward in the soil.

Band vs broadcast
Regions showing the greatest improvement in efficiency from banding over broadcasting lie in the northern U.S. and Canada, where colder soil conditions are experienced during spring seeding of row crops and small grains. Higher P rates are generally recommended if grown broadcast instead of band these fertilizers.

Banded P tends to be more efficient on very acid soils, highly calcareous soils, and those soils with very low levels of available soil P. Band applications also are usually more efficient when low P application rates are used.

Early planting dates, large amounts of crop residues on the soil surface, and soil compaction may subject plants to more stress. Banded nutrients are usually more effective for crops under these stress conditions. Vegetables respond well to banded fertilizers because they require a relatively large percentage of their total nutrients early in their growth period, and their rooting volume in the soil usually is restricted.

An extra equipment has been installed on planters over the years, it has become more difficult to have enough room to include the coulters required to open the soil for fertilizer placement below and to the side of the seed row. Some growers have quit applying starters because of this limitation and also because of the weight of operators for very large planters. Others have applied starters directly to the seed furrow, which does not require extra operators.

Seed-row application
This method refers to placement of relatively lower rates of nutrients in direct seed contact, usually for row crops. It also has been called "pop-up" or "in-furrow" application, but "seed-row" is more descriptive. Seed-row placement increases the possibility of early root interception by nutrients.

Problems: Major concern of this practice is decreased seed germination or seedling injury caused by high salt concentrations in the soil solutions around germinating seeds.

the A/N + K₂O in direct seed contact with corn and sorghum. These applied to formulations using KCl as the K source and would not be accurate if potassium phosphate was used as the source of K instead of KCl. This is because of the lower SI value of potassium phosphate compared with KCl (Table 1).

Crop tolerance to increased osmotic pressures (salt content) of the soil solution in the vicinity of the seed varies considerably. For example, wheat is more tolerant of high salt conditions than is grain sorghum, while corn is intermediate. Tolerance of most oil-seed crops (soybeans and cotton) to seed-row application of nutrients is very low, and seed-row application of fertilizers for these crops should be viewed with caution.

Fluid fertilizers may produce a lower osmotic pressure in the soil solution than granular products of a similar grade. Fewer problems generally are encountered using fluids as seed-row fertilizers when compared to granular, since less soil water is required and salts are usually dissolved in fluid formulations.

Seed-row application
This method refers to placement of relatively lower rates of nutrients in direct seed contact, usually for row crops. It also has been called "pop-up" or "in-furrow" application, but "seed-row" is more descriptive. Seed-row placement increases the possibility of early root interception by nutrients.

Problems: Major concern of this practice is decreased seed germination or seedling injury caused by high salt concentrations in the soil solutions around germinating seeds.

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

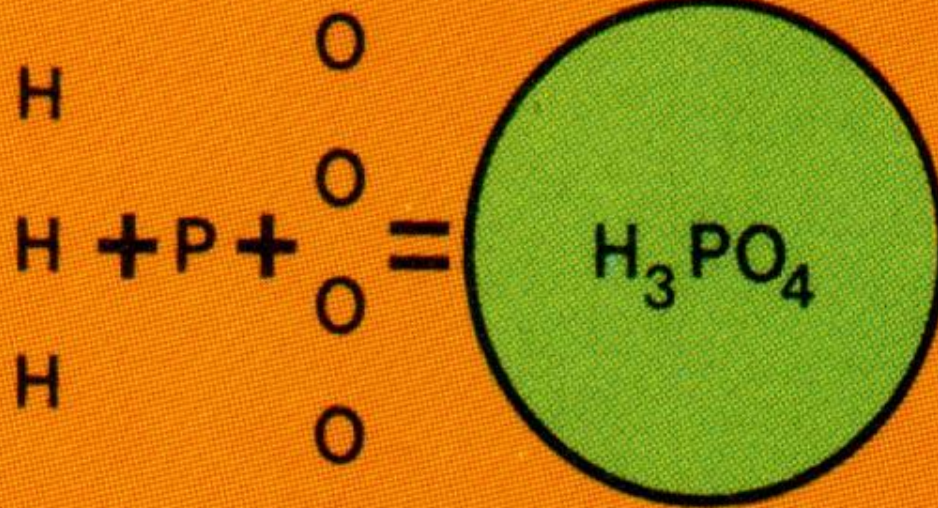
- What are they?
- How they are produced?
- What they do and advantages to having “polys”?
- Precautions

PHOSPHORIC ACID SOURCES

- Wet
- PPA
- Thermal
- Kiln Process Acid

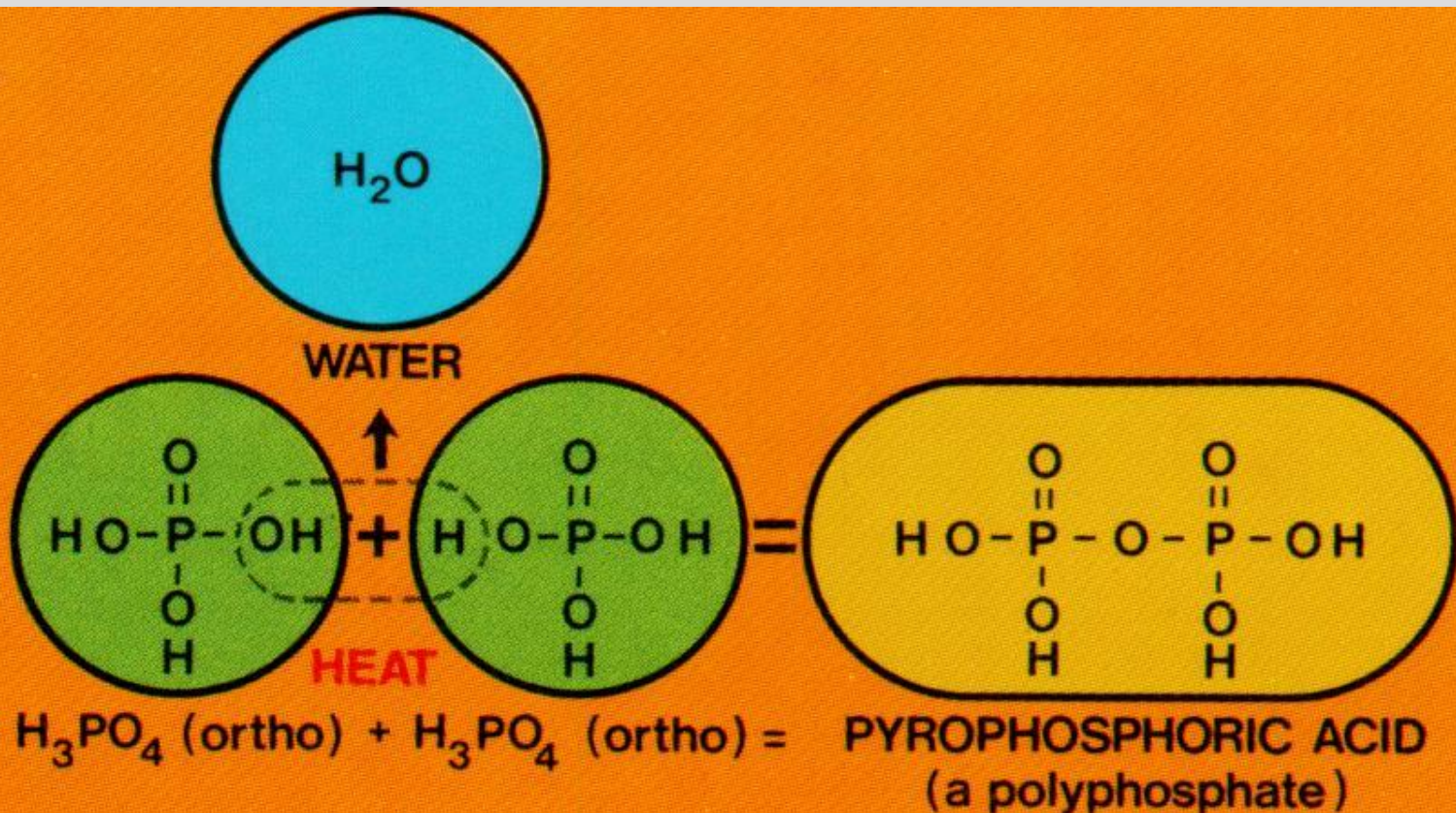
WHAT IS A POLYPHOSPHATE?

- 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

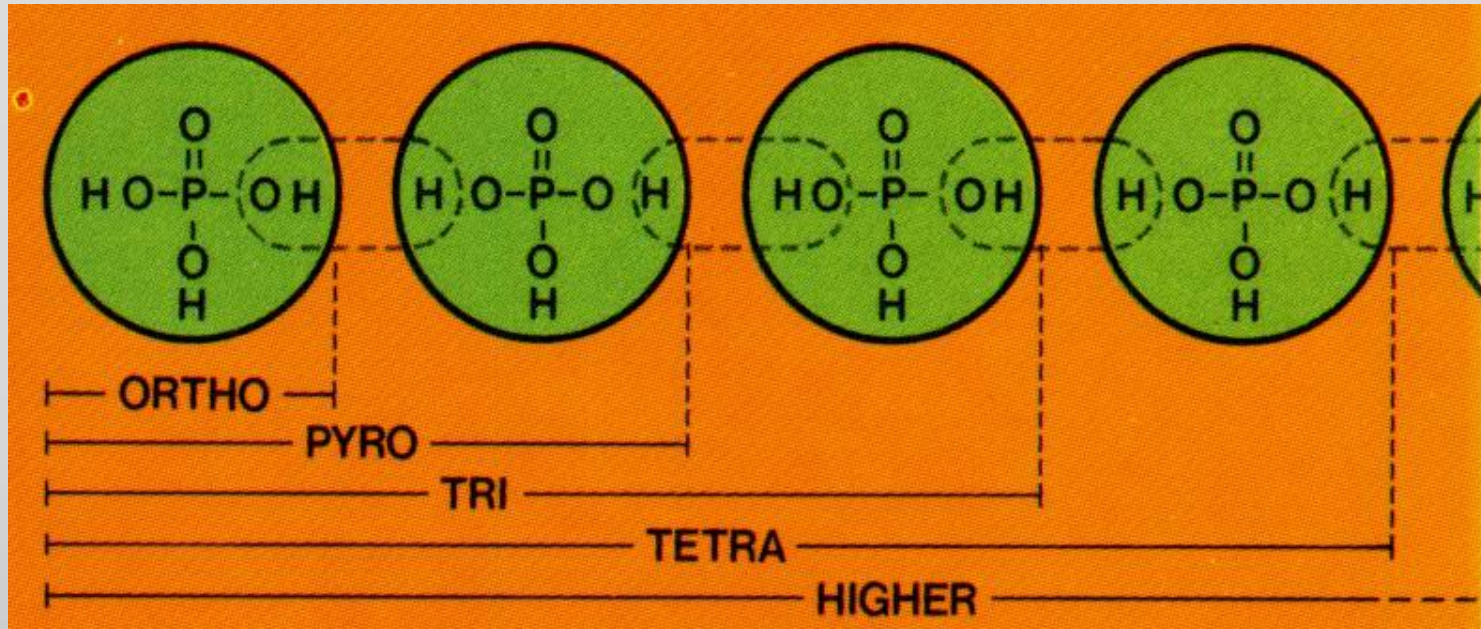


ORTHOPHOSPHORIC
ACID

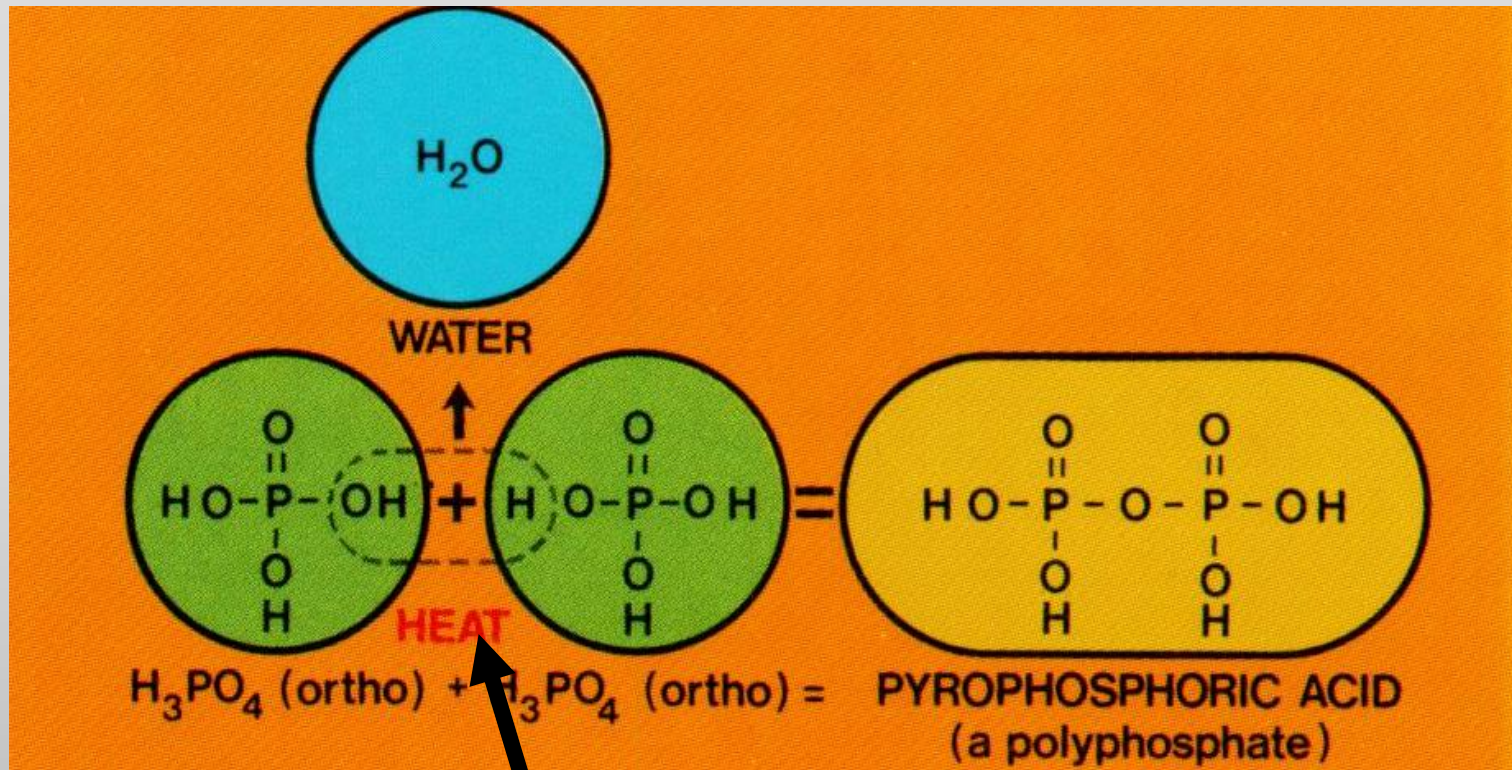
The basic building block for polyphosphates



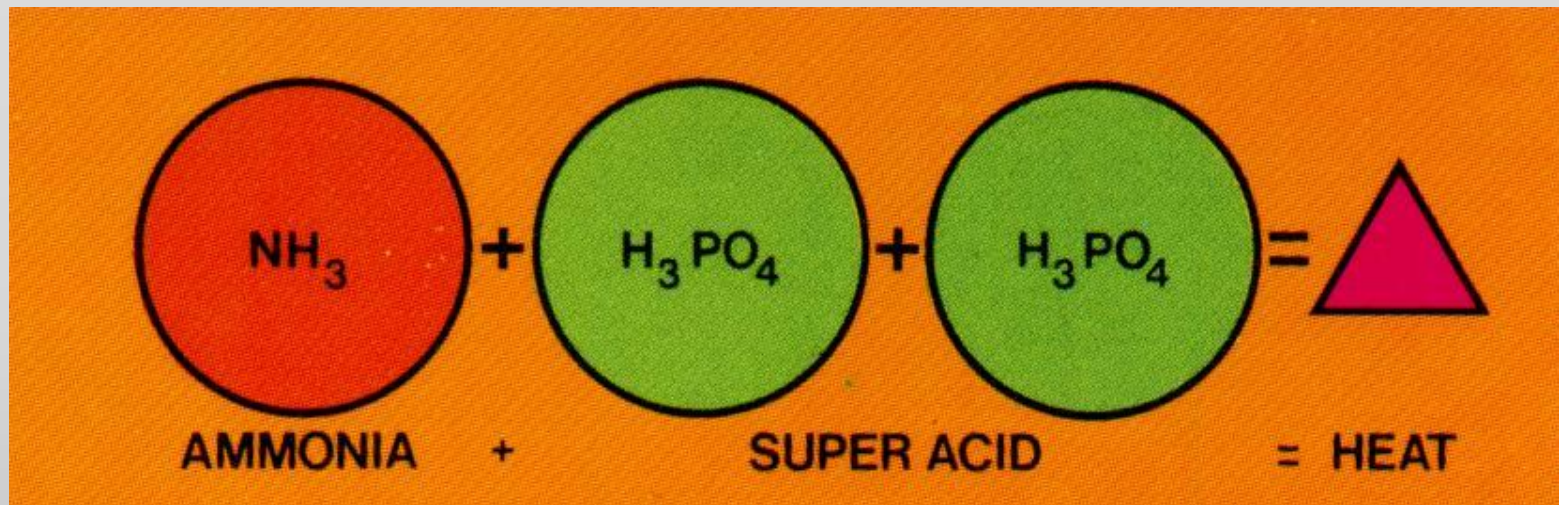
Using heat to drive out chemically bound water and link the phosphate molecules



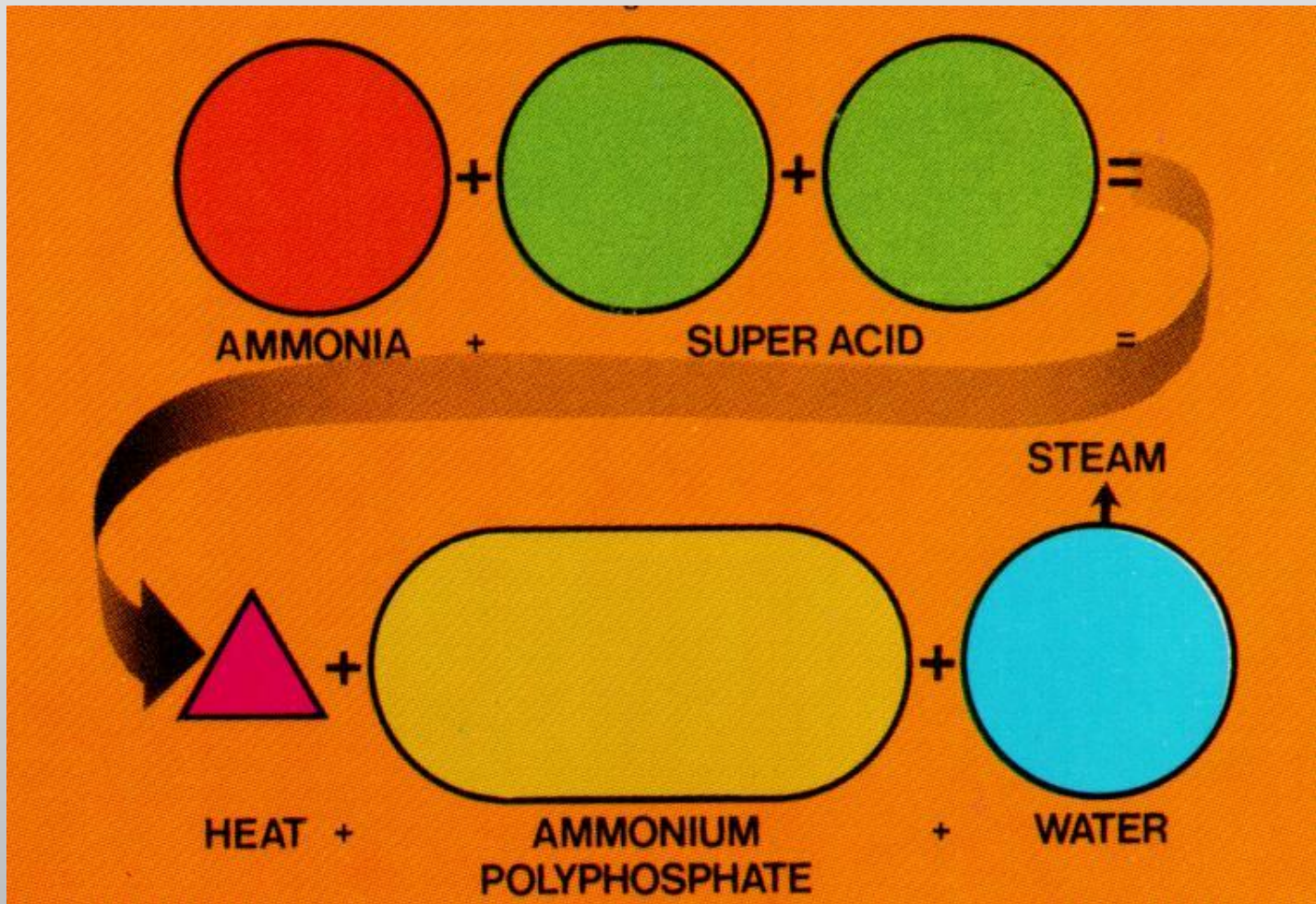
With more heat additional links can be made each time removing another molecule of chemically bound water



Where does the heat come from?

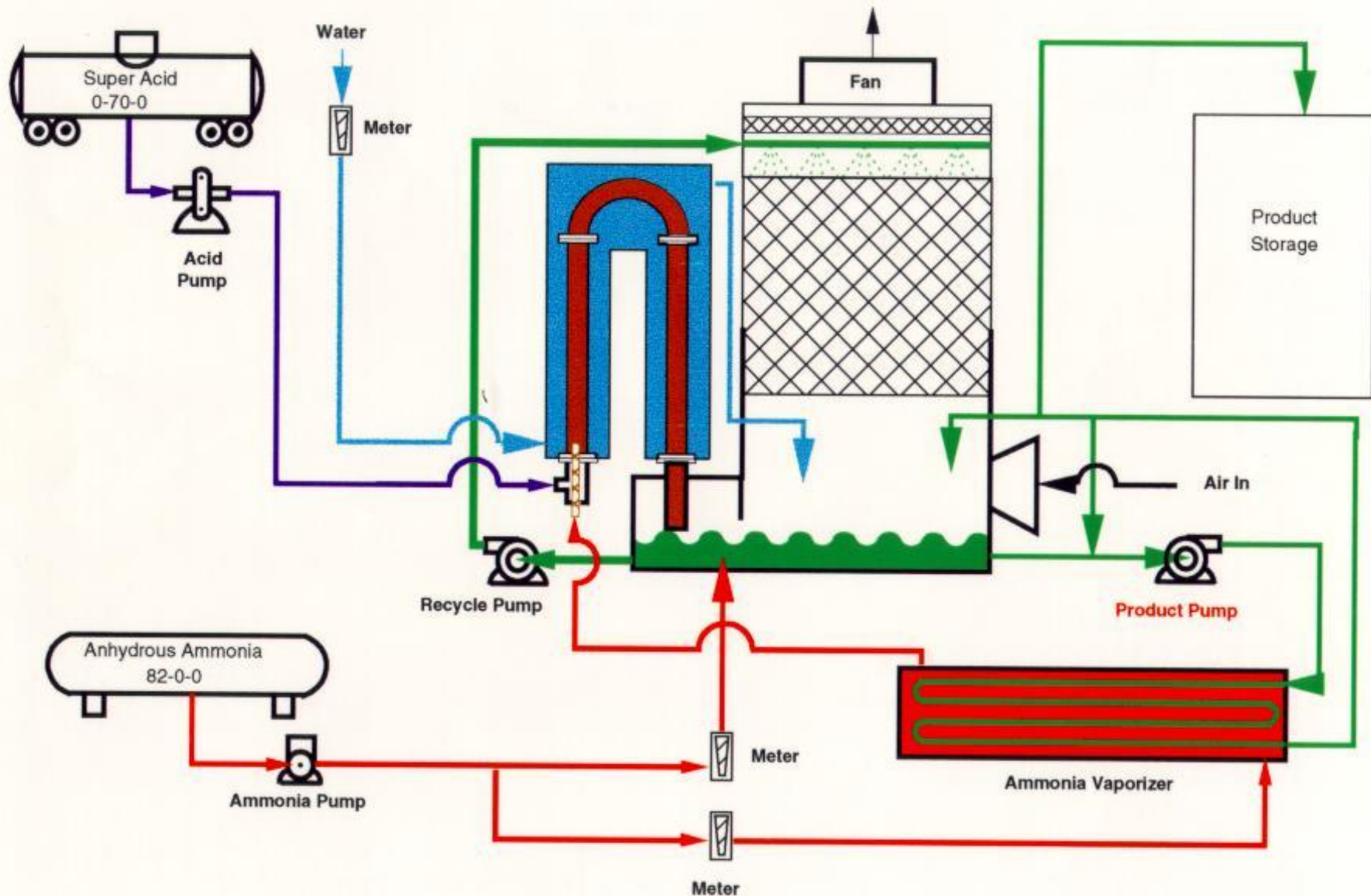


Ah-ha!



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	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 , 17% S.....	68.0	2.720

^a Salt index per 100 lbs of H_3PO_4 , *One unit equals 20 lb.

Calculating Salt Index of 6-24-6

Material	% Nutrient	lbs/ton	N	Nutrient units		Salt index	
				P ₂ O ₅	K ₂ O	per unit (20 lb) ^a	in formulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NH ₃	82%N	146	6.0	—	—	— ^b	—
H ₃ PO ₄	54% P ₂ O ₅	666	—	18.0	—	1.613	10.7
Potassium	22% K ₂ O						
Phosphate	22% P ₂ O 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.

Calculating Salt Index of 7-21-7

Material	% Nutrient	lbs/ton	N	Nutrient units		Salt index	
				P ₂ O ₅	K ₂ O	per unit (20 lb) ^a	in formulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10-34-0	10% N, 34% P ₂ O ₅	1,235	6.2	21.0	—	0.455	12.4
UAN	28% N	57	0.8	—	—	2.250	1.8
KCl	62% K ₂ O	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[®]

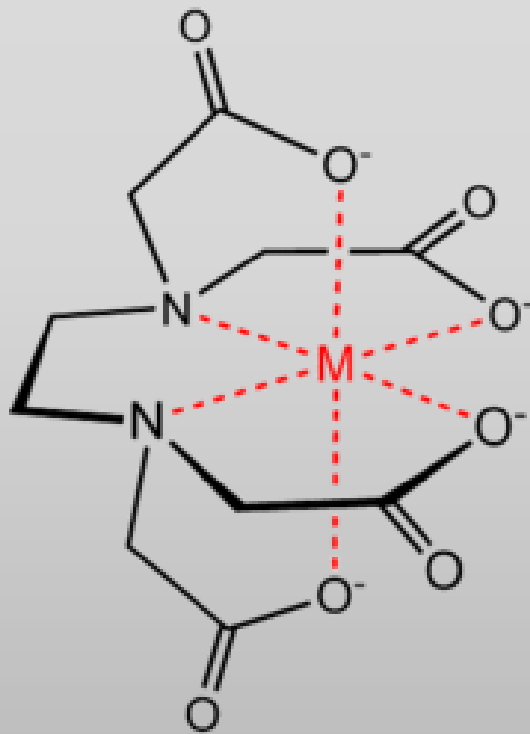
CHELATES AND MICRONUTRIENTS

Chelating Agent	Micronutrients			
	Copper	Iron	Manganese	Zinc
EDTA	X	X	X	X
HEEDTA	X	X	X	X
NTA		X		X
DTPA		X		
EDDHA		X		
Glucosheptonate		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	Color
K Carbonate															Color				Color	Color
K Chloride															Color				Color	Color
Urea Triazone															Color				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	Color
Chelate 9 Zn															Color		Color		Color	Color
Chelate Mn 6													Color		Color	Color			Color	Color
10% B MEA															Color				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)



Solutions for
AGRICULTURE

FluidFertilizer.com

	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 (green)	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)																																

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

2805 Claflin Road, Suite 200
Manhattan, KS 66502

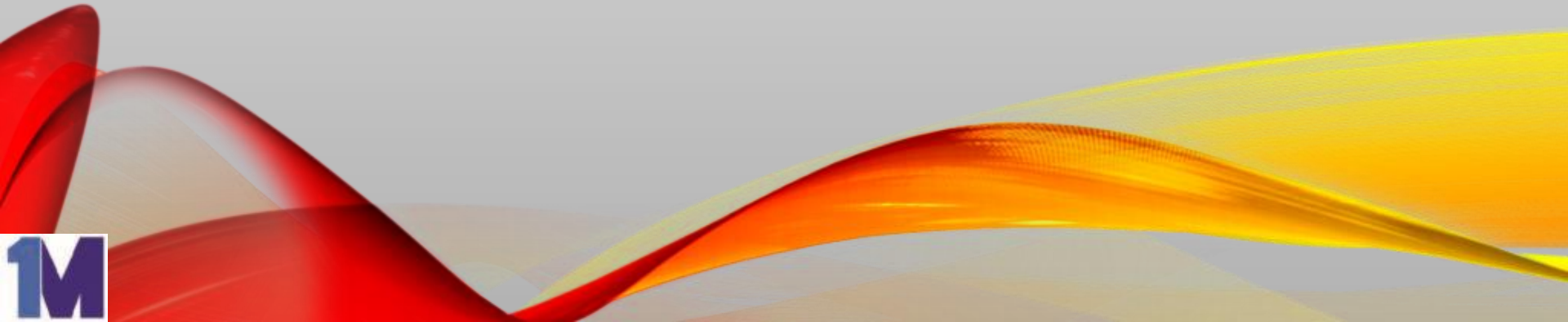
785-776-0273

FluidFertilizer@sbcglobal.net

3/1/09

STORAGE

Weather & Adulteration

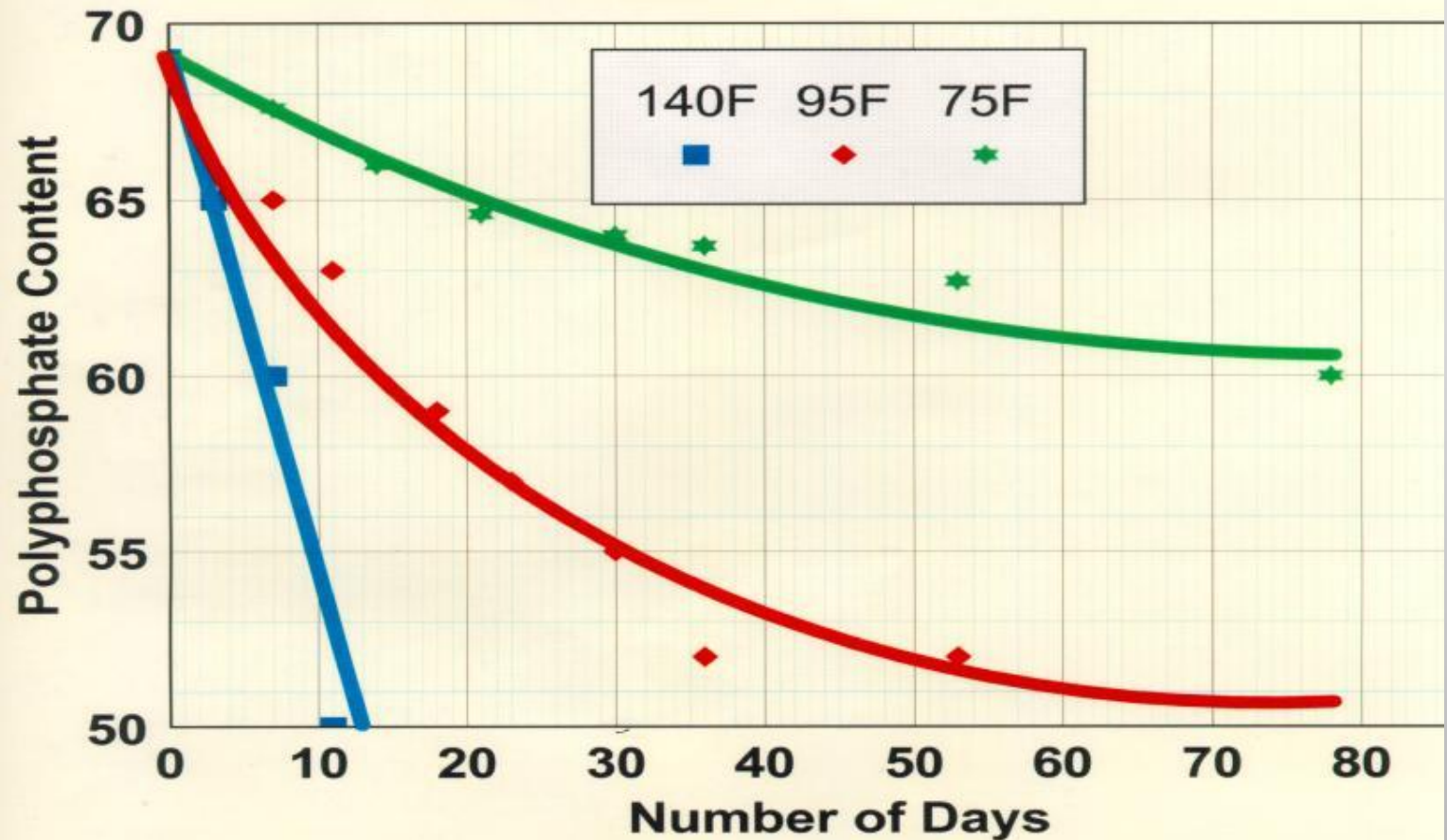




BASIC WEATHER ISSUES

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

Polyphosphate Loss vs. Temperatures Poly 11 - Geismar



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

Raun Lohry, Ph. D.
rdlohry@gmail.com

