MICHAEL ORR

"THE BROTHER FROM ANOTHER MOTHER"

MONTANA GROW

SPECIALTY PROCESS CONSULTING

FLUID FERTILIZER FOUNDATION TECHNOLOGY ROUNDUP COUNCIL BLUFFS, IOWA

DECEMBER 6-7, 2016

Agricultural Outlook

Global Population Growth:

- Gerald Nelson, University of Illinois:
  - The world's population will continue growing through
    at least 2050, barring a major war or the widespread outbreak of a serious disease
- Chairman & CEO, ADM:
  - Population is projected to grow by 33% in the next 20 years, from 6 to 8 billion people, while food demand increases 50% due to higher living standards and more demand for protein.

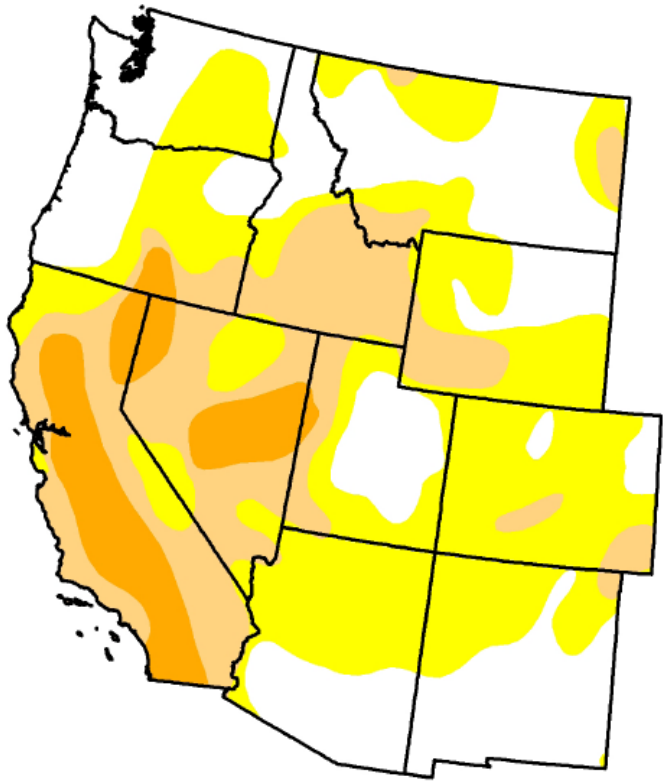
U.S. Drought Monitor

December 2, 2008
Valid 7 a.m. EST

West

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	32.8	67.2	29.6	8.6	0.0	0.0
Last Week (11/25/2008 map)	36.0	64.0	29.3	8.6	0.0	0.0
3 Months Ago (09/09/2008 map)	34.3	65.7	30.1	10.2	0.1	0.0
Start of Calendar Year (01/01/2008 map)	26.3	73.7	54.7	33.1	2.7	0.0
Start of Water Year (10/07/2008 map)	41.3	58.7	28.6	10.4	0.1	0.0
One Year Ago (12/04/2007 map)	26.1	73.9	54.8	32.8	2.7	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

USDA National Drought Mitigation Center

Released Thursday, December 4, 2008

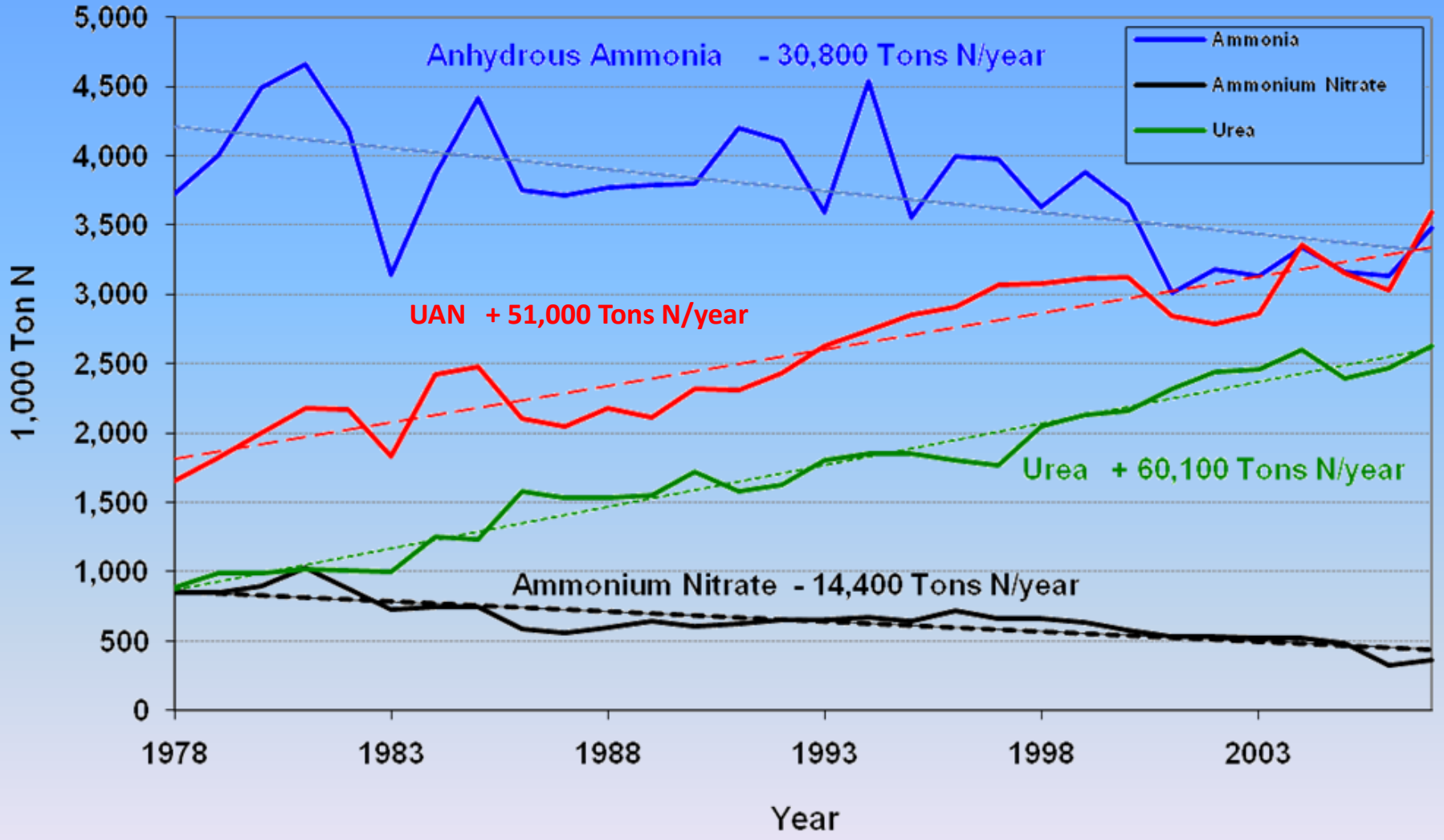
http://www.drought.unl.edu/dm/monitor.html

FORECAST DATE

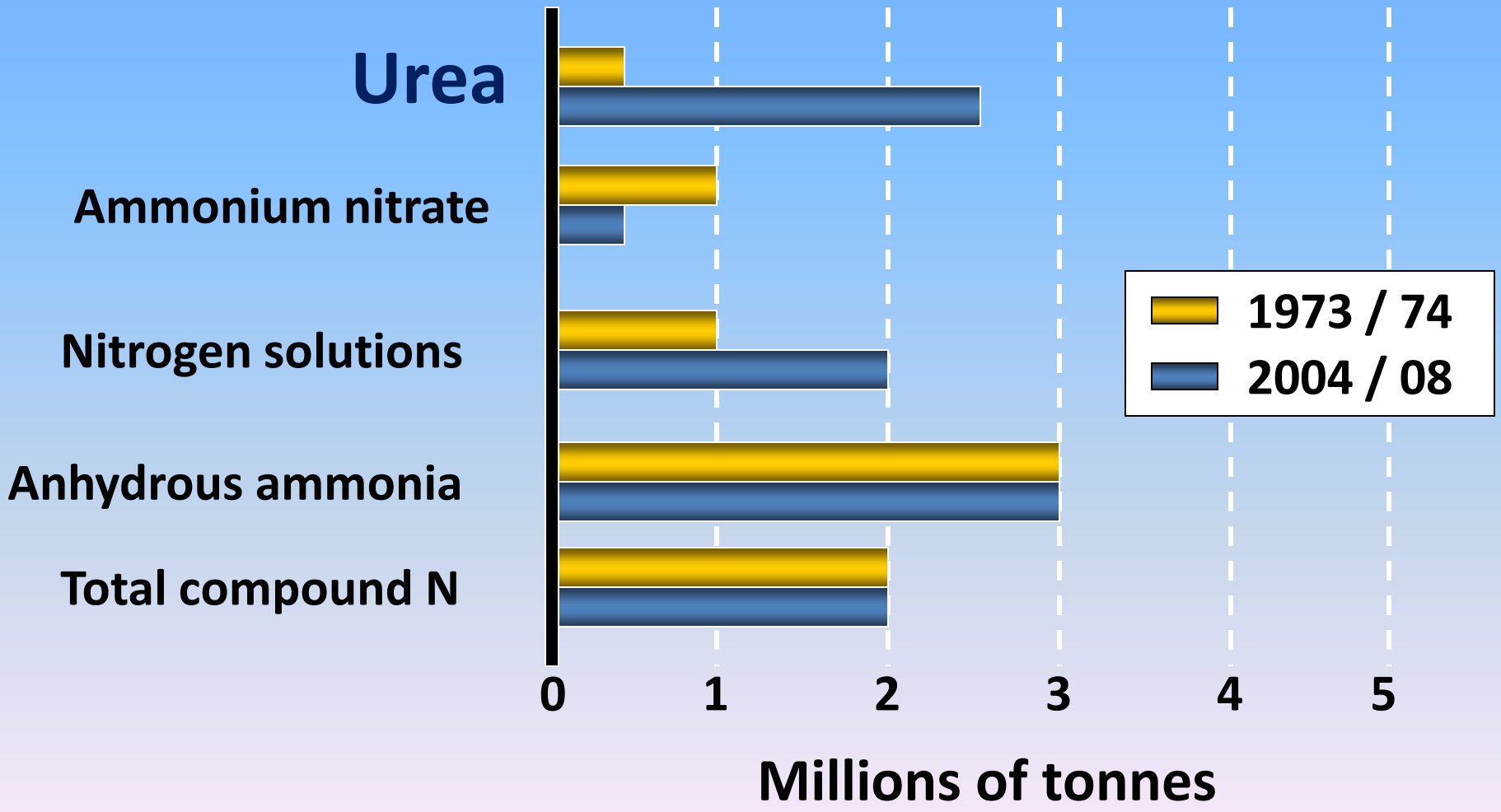
- Improving crop nutrient demand drivers and outlook
  - Upturn in the global economic outlook
  - Constructive agricultural fundamentals
- Tighter phosphate fundamentals begins to take hold
  - Low stocks from producer warehouses to farm field
  - Demand recovery underway
- Potash shipments remain slow
  - Waiting for a China settlement and price discovery
  - Strong demand recovery expected in 2018
  - Demand recovery at what price?
- Unpredictable factors to watch
  - Agricultural commodity prices and farm economics
  - Macroeconomic conditions
  - Government policies

U.S. Nitrogen Fertilizer Consumption

Tons N/year



USA Evolution of N Fertilizer Consumption



Nutrient Demand of a 225 bu/a Corn Crop and Nutrient Supply from the Soil

	Estimates on Amounts (lb/a) Supplied by Barney			
Nutrient	Demand (lb/a)	Interception	Mass Flow	Diffusion
Potassium	**250**	**6**	**34**	**210**
Nitrogen	**254**	**3**	**206**	**45**
Phosphorus	**60**	**2**	**3**	**55**
Sulfur	**30**	**2**	**28**	**0**

As a rule, elements as you move upper left are more soluble with elements as you move upper right

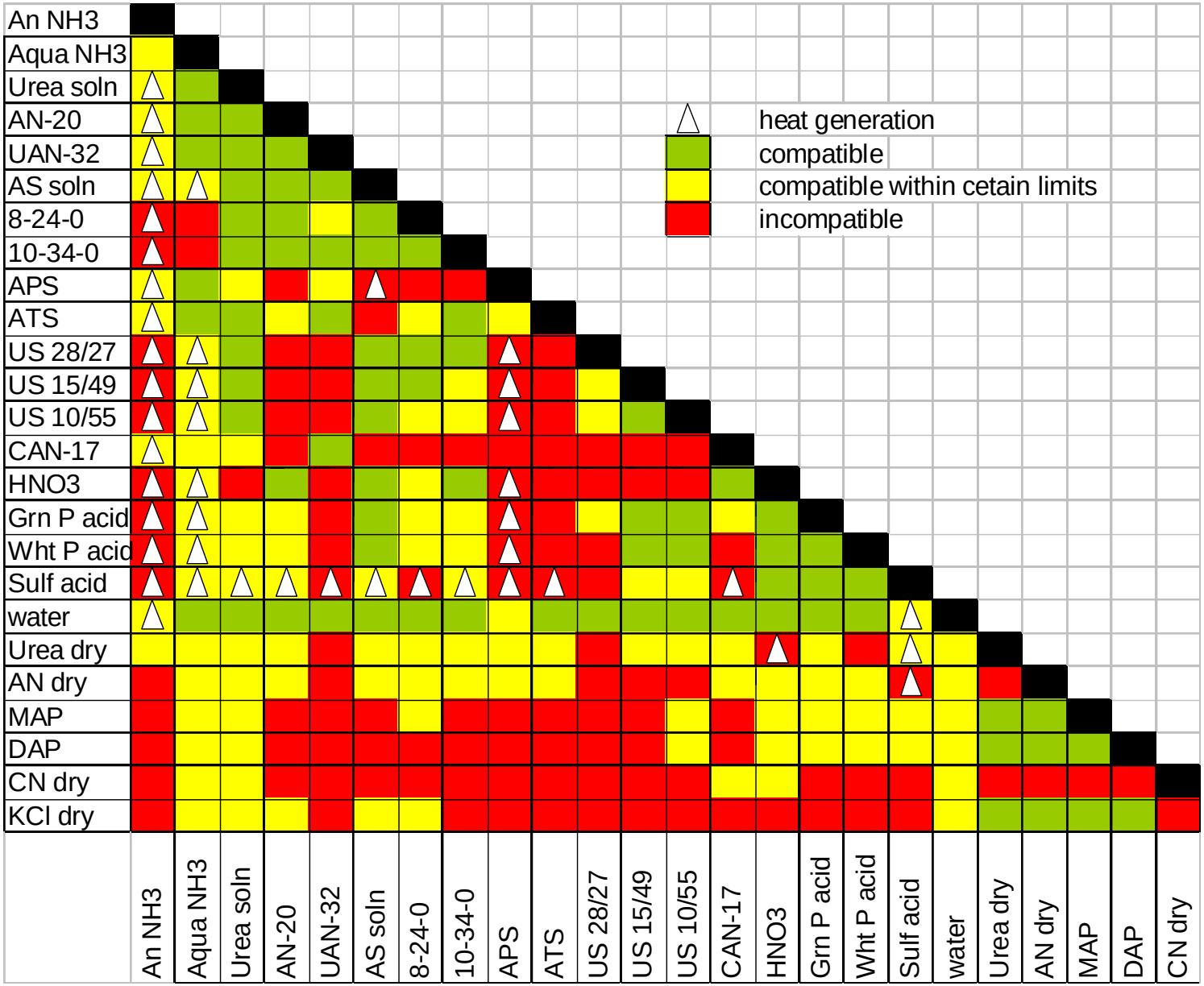
hydrogen																	helium
H																	**He**
1.00794	IIA											IIIA	IVA	VA	VIA	VIIA	4.002602*
3	**4**											**5**	**6**	**7**	**8**	**9**	**10**
lithium	beryllium											boron	carbon	nitrogen	oxygen	fluorine	neon
Li	**Be**											**B**	**C**	**N**	**O**	**F**	**Ne**
6.941*	9.01218											10.811	12.011	14.0067	15.9994	18.9984	20.179
11	**12**											**13**	**14**	**15**	**16**	**17**	**18**
sodium	magnesium											aluminum	silicon	phosphorus	sulfur	chlorine	argon
Na	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
22.9898	24.305	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	26.9815	28.0855	30.9738	32.066	35.453	39.948
19	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
potassium	calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
K	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
39.0983	40.078	44.9559	47.88--	50.9415	51.9961	54.938	55.847	58.9332	58.69	63.546	65.39*	69.723	72.59	74.9216	78.96	79.904	83.8
37	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**
rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon
Rb	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
85.4678*	87.62	88.9059	91.224*	92.9064	95.94	(98)	101.07	102.906	106.42	107.868	112.41	114.82	118.71	121.75	127.6	126.905	131.29
55	**56**	**57**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**
cesium	barium	lanthanum	hafnium	tatalum	tungsten	rheunium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon
Cs	**Ba**	**La****	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
132.905	137.33	138.906	178.49	180.948	183.85	186.207	190.2	192.22	195.08	196.967	200.59	204.383	207.2	208.98	(209)	(210)	(222)
87	**88**	**89**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**		**114**				
francium	radium	actinium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	unununium	ununbium		ununqadium				
Fr	**Ra**	**Ac****	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Ds**	**Uuu**	**Uub**		**Uuq**				
(223)	226.025	227.028	(261)	(262.11)	(266.12)	(264.12)	(269.13)	(268.14)	(271)	(272.15)	(285)		(289)				

** Lanthanides																	
				58	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**
				cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium
				Ce	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
				140.12	140.908	144.24	(145)	150.36	151.96	157.25	158.9254	162.50	164.9304	167.26	168.9342	173.04	174.967
**Actinides																	
				90	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**
				thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium
				Th	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**
				232.0381	231.0359	238.0289	237.0482	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(260)

KEY

atomic number
Element name
Symbol
atomic weight

Unocal Compatibility Chart




125 NITRATE OF SODA, 16 %
300 SULPHATE OF AMMONIA, 20 %
160 MURIATE OF POTASH, 50 %
360 SUPERPHOSPHATE, 43 %
1035 GROUND LIMESTONE
COMPLETE FERTILIZER
(4-8-4)
READY FOR APPLICATION
TO THE LAND

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
2805 Claflin Road, Suite 200
Manhattan, KS 66502

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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		Δ																											
Aqua Ammonia; 20-0-0	Δ																												
Urea Soln; 23-0-0	Δ																												
Ammonium Nitrate Soln; 20-0-0	Δ																												
Urea Ammonium Nitrate Soln; UAN 28/32-0-0	Δ																												
Ammonium Sulfate Soln; 8-0-0-9S	Δ	Δ																											
Ammonium Polyphosphate Soln; 10-34-0	Δ	Δ																											
Ammonium Chloride Soln; 6-0-0-16Cl	Δ																												
Ammonium Thiosulfate Soln; 12-0-0 26S	Δ																												
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		Δ																											
N-pHuric 15/49; 15-0-0 16S		Δ																											
N-pHuric 10/55; 10-0-0 18S		Δ																											
Water	Δ																												
Nitric Acid	Δ	Δ	Δ	Δ		Δ	Δ												Δ										
Phosphoric Acid (white)	Δ	Δ	Δ			Δ	Δ							Δ					Δ										
Phosphoric Acid (green)	Δ	Δ	Δ			Δ	Δ							Δ					Δ										
Sulfuric Acid	Δ	Δ	Δ			Δ	Δ												Δ										
Urea; 46-0-0																				Δ	Δ	Δ	Δ						
Ammonium Nitrate; 34-0-0																								Dry					
Calcium Nitrate; 15.5-0-0-19Ca																								Dry	Dry				
Potassium Chloride; 0-0-62																								Dry	Dry	Dry			
Potassium Nitrate; 13-0-46								?																Dry	Dry	Dry	Dry		
Magnesium Nitrate; 10%N 9%Mg								?																Dry	Dry	Dry	Dry	Dry	

Fluid Fertilizer Foundation

Solutions for AGRICULTURE

FluidFertilizer.com

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	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
Anhydrous Ammonia ; 82-0-0																																
Aqua Ammonia; 20-0-0	Δ																															
Urea Solution; 23-0-0	Δ																															
Ammonium Nitrate Solution; 20-0-0	Δ																															
Urea Ammonium Nitrate Solution; UAN 28/32-0-0	Δ																															
Ammonium Sulfate Solution; 8-0-0-9S	Δ	Δ																														
Ammonium Polyphosphate Solution; 10-34-0	Δ	Δ																														
Ammonium Chloride Solution; 6-0-0-16Cl	Δ																															
Ammonium Thiosulfate Solution; ATS, 12-0-0-26S	Δ																															
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		Δ																														
N-pHuric 15/49; 15-0-0-16S		Δ																														
N-pHuric 10/55; 10-0-0-18S		Δ																														
Water	Δ																															
Nitric Acid	Δ	Δ	Δ	Δ		Δ	Δ												Δ					Δ	Δ	Δ	Δ					
Phosphoric Acid (white)	Δ	Δ	Δ			Δ	Δ							Δ					Δ													
Phosphoric Acid (green)	Δ	Δ	Δ			Δ	Δ							Δ					Δ													
Sulfuric Acid	Δ	Δ	Δ			Δ	Δ												Δ													
Urea; 46-0-0																				Δ	Δ	Δ	Δ									
Ammonium Nitrate; 34-0-0																								Dry								
Calcium Nitrate; 15.5-0-0-19Ca																								Dry	Dry							
Potassium Chloride; 0-0-62																								Dry	Dry	Dry						
Potassium Nitrate; 13-0-46								?																Dry	Dry	Dry	Dry					
Magnesium Nitrate; 10-0-0-9Mg								?																Dry	Dry	Dry	Dry	Dry				
Monoammonium Phosphate (Technical, 12-61-0)								?	?	?	?	?			?	?	?	?						Dry	Dry	Dry	Dry	Dry	Dry			
Monopotassium Phosphate (0-52-34)								?	?	?	?	?			?	?	?	?						Dry	Dry	Dry	Dry	Dry	Dry	Dry		
PeKacid (0-60-20)								?												Δ	Δ			Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	

“Any chemical reaction that proceeds smoothly under normal conditions can proceed violently in the presence of an idiot!”

This usually is preceded by the words:
“Hey Bubba watch this!”

CHEMICAL COMPATIBILITY FOR LIQUIDS FERTILIZERS

Table Key:

A- Acceptable if compatible with container or appurtenances
N- Not acceptable because of chemical compatibility
1- Acceptable if product is treated with corrosion inhibitor
2- Acceptable if warranted by equipment manufacturer for the intended use
3- Acceptable if cleaned after seasonal use and is used to store materials less than three months (cumulative) annually

Product	Urea Ammonia Nitrate	Ammonium Thiosulfate	Ammonium Poly-phosphate	Potassium Phosphate	Potassium Hydroxide	Potash Solutions	Mixed Fertilizers, Starters
Container Material							
Stainless Steel	A	A	A	A	A	A	A
Mild Steel	1	1	A	N	N	3	3
Mild Steel with Liner	2	2	A	2	2	2	2
Aluminum	A	A	N	N	N	N	N
Fiberglass	A	A	A	A	2	A	A
Poly or Plastic	A	A	A	A	2	A	A
Brass or Copper Alloys	N	N	N	N	N	N	N
Plugs, Valves, Tank Inserts							
Stainless Steel	A	A	A	A	A	A	A
Nickel Stainless Insert	A	A	A	A	2	A	A
Fully Lined Metal Stainless Insert	A	A	A	A	N	A	A
Nylon Ball Valve	A	A	A	A	A	A	A
Forged Steel	A	A	A	2	N	A	A
Cast Iron/Mild Steel	N	N	A	N	N	N	N
Poly or Plastic	A	A	A	A	2	A	A
Brass or Copper Alloys	N	N	N	N	N	N	N
Plumbing							
Stainless Steel	A	A	A	A	A	A	A
Forged Steel	A	A	A	2	N	A	A
Cast Iron/Mild Steel	1	1	A	N	N	3	3
Galvanized	N	N	A	N	N	N	3
PVC/Other Synthetics	2	2	2	A	2	2	2

Source: Wisconsin Department of Agriculture, Trade and Consumer Protection

What is a BTU?

- A BTU, short for British Thermal Unit, is a basic measure of thermal (heat) energy. One BTU is the amount of energy needed to heat one pound of water one degree Fahrenheit, measured at its heaviest point. In other words, if you placed 16 ounces of water at 59°F into a stovetop pan and turned on the gas burner, it would take one BTU to raise the temperature of the water to 60°F.

UAN PRODUCTION

- AN Liquor + Urea Liquor
- Nitric acid + Ammonia + Urea Liquor
- Melt
- Adjust concentration

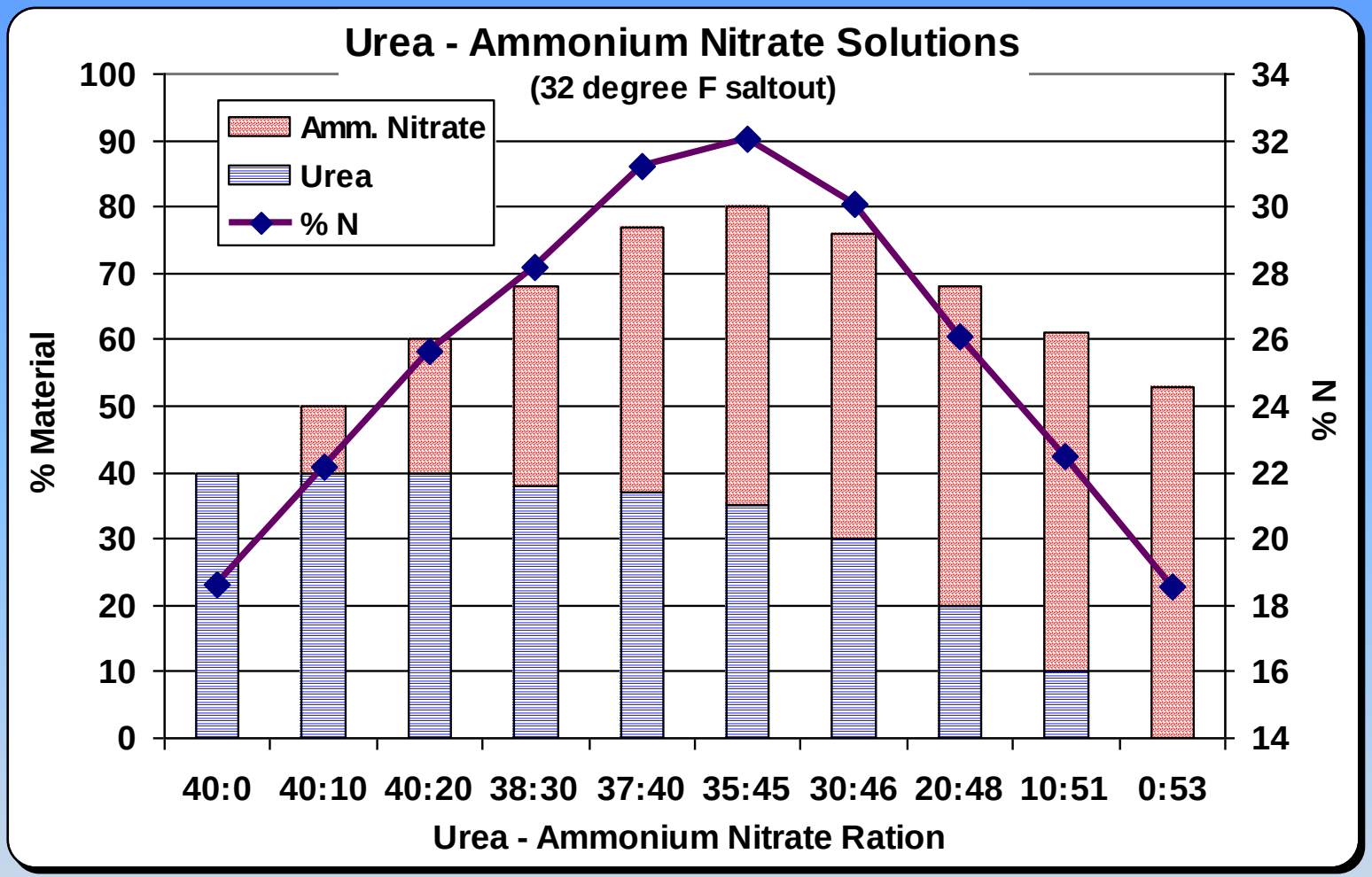
Composition of UAN 28% N

- 14 % N from Ammonium Nitrate
  - 7% ammonium N
  - 7% nitrate N
- 14% N from Urea
- 30% water
- + small amounts of inhibitors to inhibit corrosion of mild steel

ADJUST UAN

- Addition of Urea-summer, winter blend
- Addition of Ammonia to adjust pH
- Addition of one or the other also impacts salt out temperature
- Addition of water to cut concentration impacts salt out
- Inhibitor addition impacts salt out temperature

pH	% Free NH_3
0 - 6.30	0.00
6.31 - 6.85	0.01
6.86 - 7.10	0.02
7.11 - 7.25	0.03
7.26 - 7.35	0.04
7.36 - 7.45	0.05
7.46 - 7.52	0.06
7.53 - 7.57	0.07
7.58 - 7.61	0.08
7.62 - 7.67	0.09
7.68 - 7.72	0.10
7.73 - 7.75	0.11
7.76 - 7.80	0.12
7.81 - 7.83	0.13
7.84 - 7.86	0.14
7.87 - 7.88	0.15
OVER 7.88	TITRATE



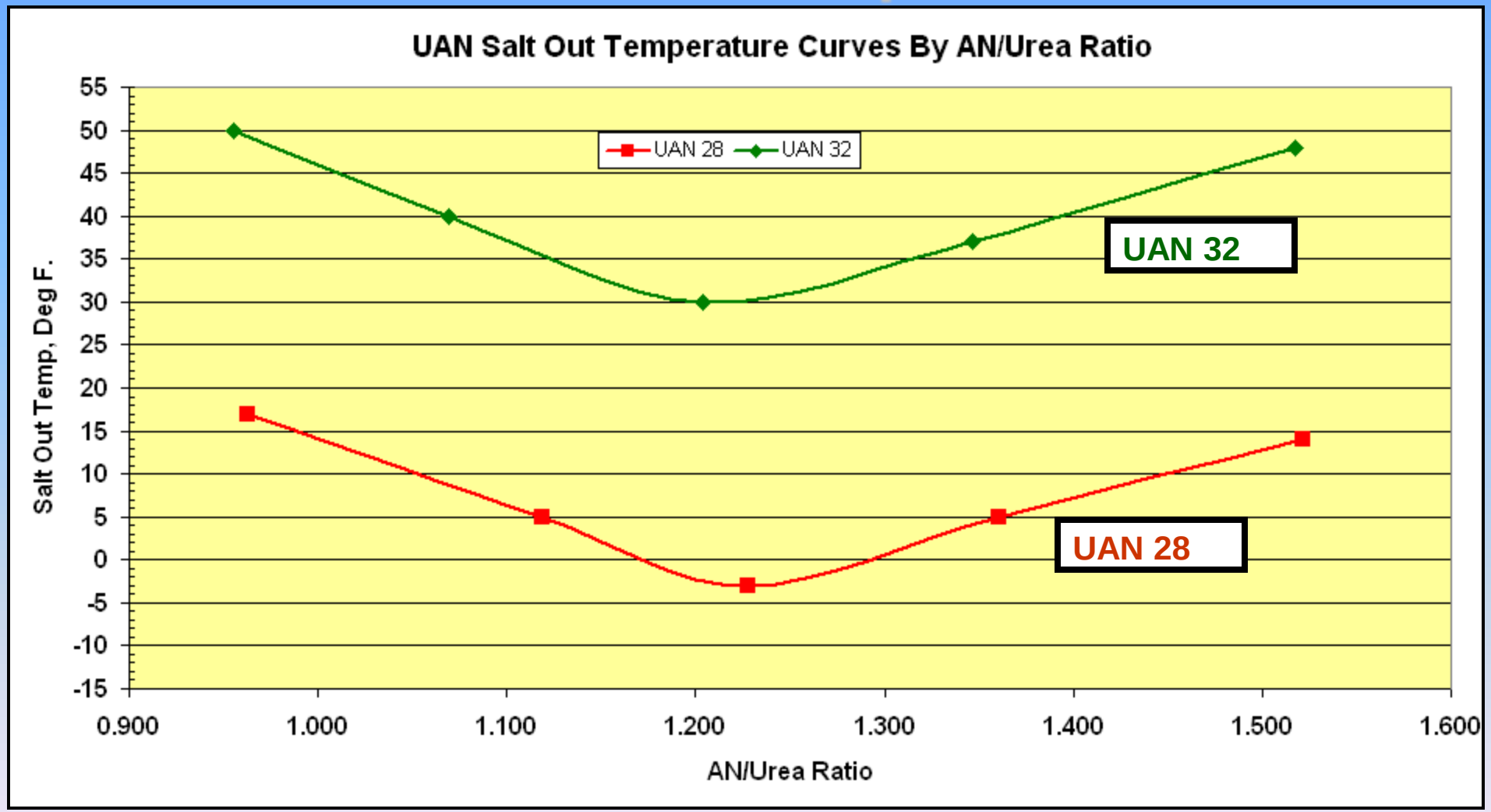
Eutectic Point – point of maximum solubility

32% UAN contains:

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

28% UAN contains 30% water

The Ratio of AN to Urea in UAN Determines the Salt Out Temperature



The ideal ratio range is 1.1 to 1.4

Lowering Water Freezing Temperature With UAN Solution

% N	Freezing Temperature ° F	28-0-0	32-0-0
		gal per 100 gal water	
0	32	0	0
2	29	6.1	5.2
4	25	13.1	11.2
6	22	21.5	18.2
8	19	31.5	26.2
10	15	43.7	35.6
12	12	59.0	47.2
14	9	78.7	61.2

Appearance Value –Cross Contamination

- A Product Is Only As Good As The Skill It Was Made
- Contamination Can Be Disastrous To A Blend
- Dries That Go Into Blends Must Be Segregated
- Alley Ways Must Not Be Allowed To Co-Mingle

UAN Solution

- Salt-out is an issue in many environments
  - 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
  - There is very little water in UAN solution.

Do you Circulate Continuous?

Receiving and Unloading Materials Into the Plant

- HAVE ALL PERTINENT SHIPPING INFORMATION, BOLs, DOT requirement, etc.
- REVIEW AND UNDER STAND SDS AND RMP/PSM REQUIREMENTS
- HAZARDOUS MATERIALS RECEIVING

Filling Liquid Storage Tanks

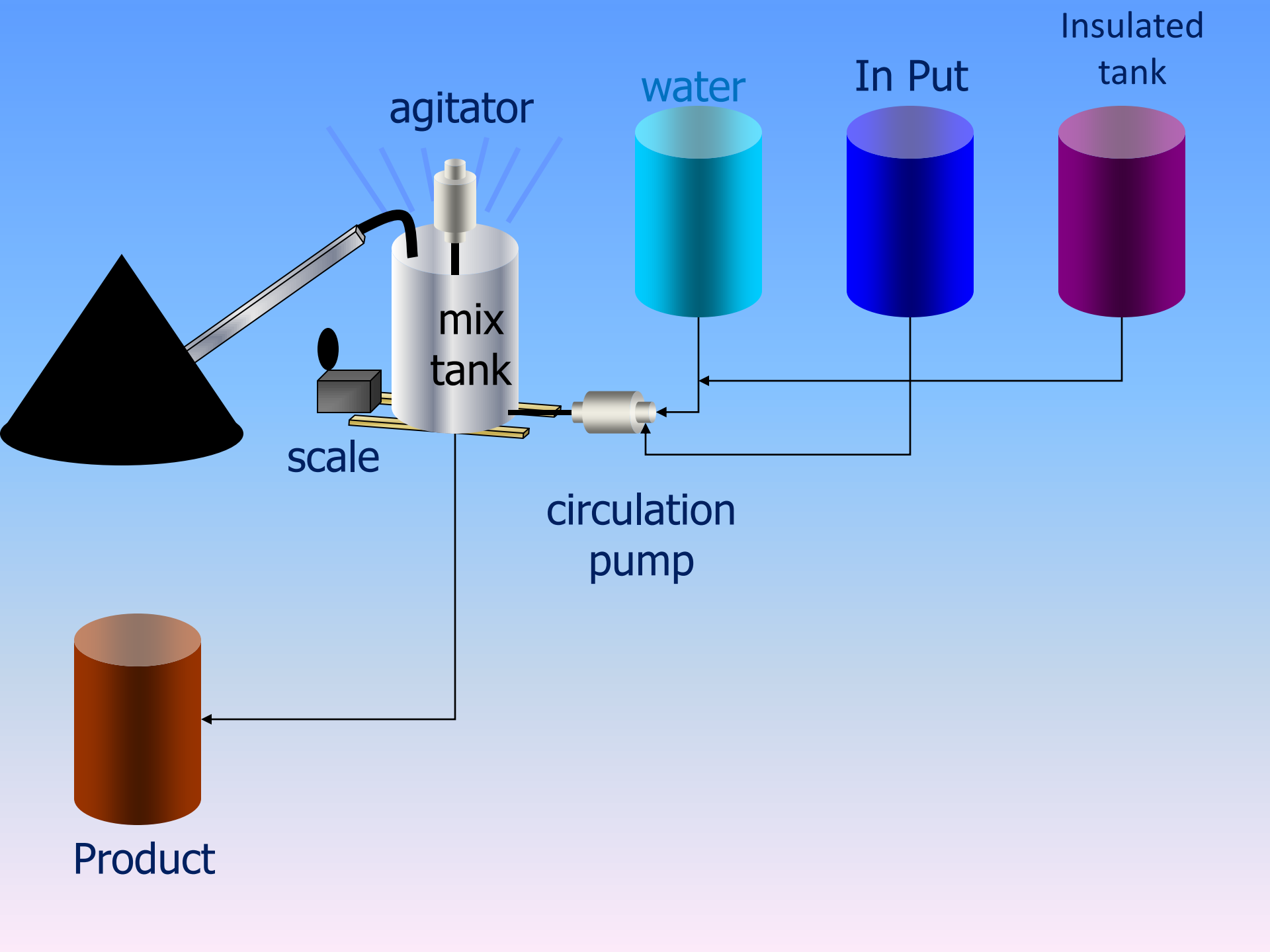
- Make Sure Inbound Transport Is Connected to the Correct Storage Tank
- Open All Appropriate Valves and Close Others
- Contain All Leaks
- Check Tank Inventory Prior To Transfer
- Wear Proper PPE
- Close All Appropriate Valves Upon Completion Of Transfer
- Complete All Documentation and Record Ending Inventory

BLENDING LIQUID FERTILIZERS

- Solubility
- Order of Addition
- Stability

CHANGING NITROGEN SUPPLY

- Ammonium nitrate
- Increased importation of UAN
- pH variation in UAN
- AN/Urea ratio
- Supply
- Discoloration


Insulated tank
In Put
water
agitator
mix tank
scale
circulation pump
Product

Source and Quality of Water

- Major concern is Water Quality
- pH and Bicarbonates (HCO_3^-)
- Treat water with acid bring to pH 6.5
- Electrical Conductivity (EC)
- Snow melt and rain fed lake water
- Need gypsum if EC is < 0.3 dS/m
- Or EC is < 0.3 mmhos/cm


WATER

Order of Addition

- Water (Hot / Cold)
- Chelating /Complexing Agent
- Nitrogen
- Phosphates
- pH adjustment (initial)
- Micronutrients for Chelating/Complexing
- Potash
- Additional Micronutrients
- Calcium Nitrate / Chloride
- ATS / Pot Carbonate / SRN’s
- Final pH Adjustment

Order of Addition

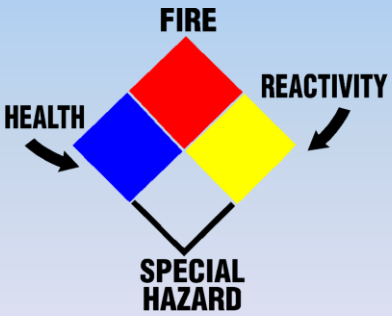
- Suspend Solids While Mixing
- Chelating / Complexing
- pH
- Temperature
- Reaction / Compatibilities
- Foaming / Air Entrapment

Many exceptions to Rules of Addition

LABELING

- Use Placards, NFPA, and Caution Labels & Symbols
- Label All Containers Properly

  Avoid trade symbols: KOH, MOP, APP

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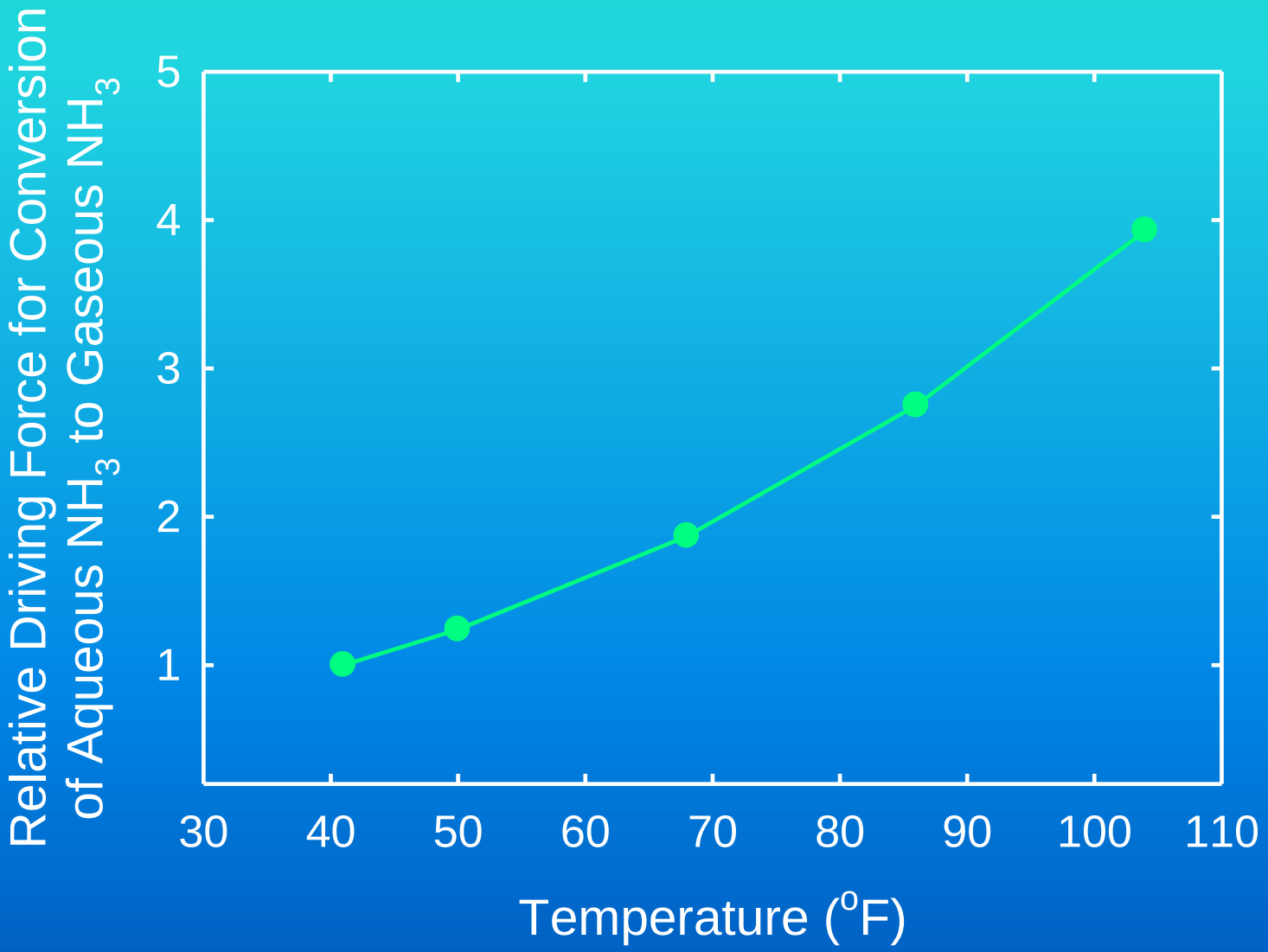
Summary of ammonia loss from UAN???

- Urea in UAN does not hydrolyze in the fertilizer tank.
- The NH_4^+ from the ammonium nitrate portion of the UAN cannot be lost as NH_3.
- The amount of NH_3 added to some UAN to inhibit corrosion is very small, around 10 lb per ton. A small portion of this NH_3 may be lost during application.

Effect of Temperature on Conversion of Aqueous NH_3 to Gaseous NH_3

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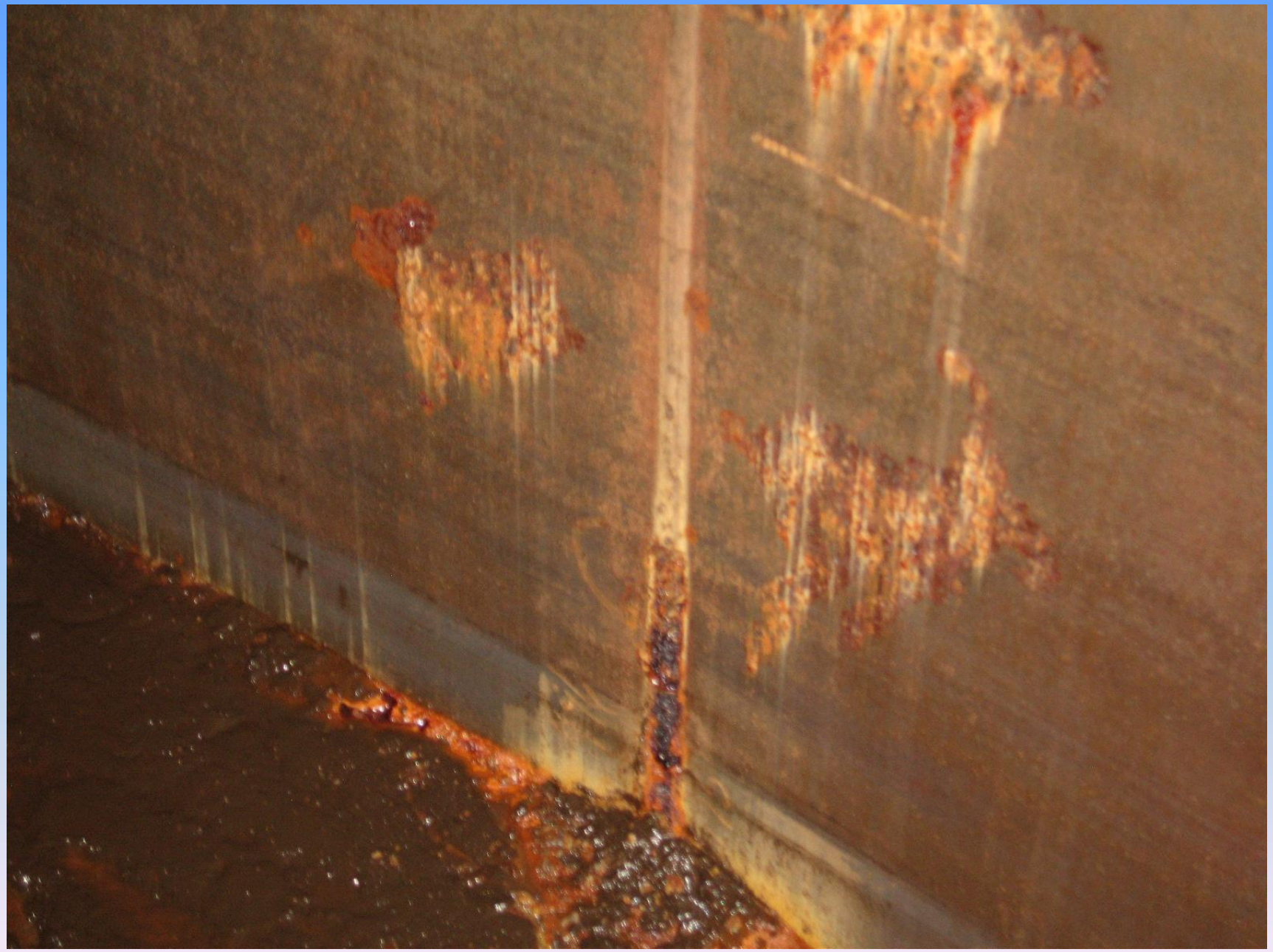
STOP
WRONG WAY
DO NOT ENTER


18:11

So Why Do Tanks Fail?

- Improper Construction
- Corrosion
- Specific Gravity of fluid incompatible with tank wall
- Internal/External forces or events (fire, flood, impact, etc.)
- Age/UV related issues – Poly & Fiberglass
- Seismic zone design not compatible with area



UAN Corrosion Management Should Be Taken Seriously by Every UAN Tank Owner

- All UAN producers strive to make quality material, that is clean, bright and only minimally corrosive
- However, you should not depend solely on the UAN producer to manage your corrosion concerns.
- Some producers have gone to lined tanks, or use epoxy coatings extensively. Their piping is all stainless.
- UAN corrosiveness can vary:
  - producer to producer,
  - plant to plant,
  - and even day to day in the same plant

If a UAN tank located on your property leaks, you may be liable for contamination in ground and surface water…

You may lose significant amounts of product and property

The EPA and OHSA might become your new business partners

Your business reputation may be put at risk


weld erosion at tub ring
vert
repair weld on chine

Key UAN Corrosion Mechanisms

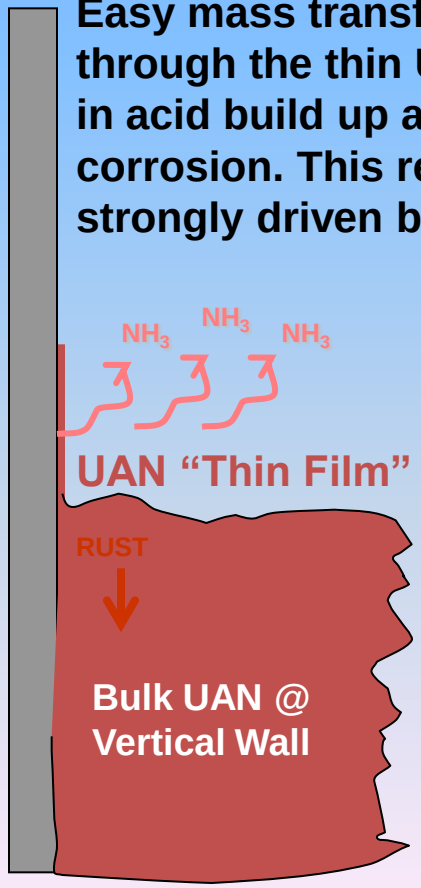
Surface Corrosion in UAN

$NH_4NO_3 \rightarrow NH4^+ + NO_3^-$

$NH_4^+ \leftrightarrow NH_3 + H^+$

$H^+ + NO_3^- \rightarrow HNO_3$

Easy mass transfer of ammonia through the thin UAN film results in acid build up and surface corrosion. This reaction is strongly driven by temperature



Pitting Corrosion in UAN

Crevice or Under-Deposit Corrosion

$Fe^{+2} \rightarrow Fe^{+3}$

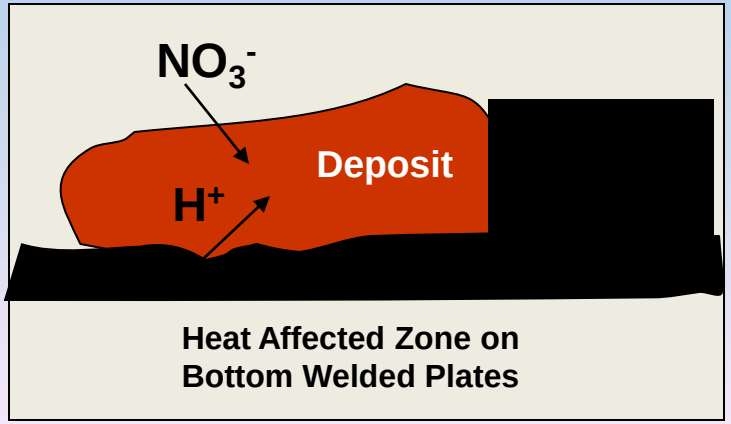
$Fe^{+3} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$

Solution

$NH_4NO_3 \rightarrow NH4^+ + NO3^-$

$NO_3^- + H^+ \rightarrow HNO_3$

The H^+ can't diffuse out of the crevice fast enough. To remain electrically neutral, NO_3^- ions come in and in effect make Nitric Acid resulting in low pH inside the crevice, resulting in accelerated (pitting) corrosion.



Tank Failure Background & History

- Storage tank failure is not a new phenomenon in fact…

  On January 15, 1919 a United States Industrial Alcohol Company's distilling tank which recently had received a shipment of molasses in from Puerto Rico, exploded. At about 12:40 p.m. the giant tank ruptured, emptying its entire contents of about 2.5 million gallons of molasses, into Commercial Street in the space of a few seconds. The tank, a 90'-0 diameter x 50-foot high cast iron tank was filled to the top with molasses. Upon failure, a 15-foot high wave of dark molasses moving about 35 miles per hour swallowed the streets of Boston's North End. Almost 150 people lie injured in the streets with the final death toll being 21. A Massachusetts court determined that insufficient safety inspections had played a part in the accident. In time, after 3,000 witnesses testify during 300 days of hearings, the courts found the company liable, concluding shoddy construction and overfilling of the tank was to blame, along with the apparent sudden expansion of the molasses -- the temperature had only been 2 degrees above zero the previous day. The company paid almost $1 million to settle the claims.

Tank Failure Background & History (Cont.)

- 3/1997 – Washington, a 500k gallon storage tank of Potassium Thiosulfate has a weld rupture resulting in loss of 100k gallons of material.
- 3/1997 – Iowa, a 1M gallon ammonium phosphate tank ruptures and in turn damages two other liquid fertilizer tanks
- 7/1999 – Michigan, a 1M gallon APP ruptures and damages 3 adjacent tanks
- 1/2000 – Ohio, a 1M gallon fertilizer tank ruptures and damages 4 adjacent tanks and 5 tractor trailer rigs. More than 800k gallons spills into the Ohio River.
- 3/2000 – Ohio, a 1.5M gallon ammonium phosphate tank ruptures and damages 2 adjacent tanks. Some of the released liquid flows into nearby creeks.
- 10/2000 – Montana, a 2M gallon nitrogen fertilizer intermediate tank has a massive roof failure, no loss of product, but tank is damaged significantly.

UAN Corrosion Management Should Be Taken Seriously by Every UAN Tank Owner

- Purchasing UAN from multiple sites, may result in mixed inhibitors
  - These different inhibitors, (now diluted), may not be as effective together as they are by themselves when at full strength
- Purchasing quality UAN, from a trusted source, may be worth a little extra in price
  - You should monitor what you receive
  - Look closely at the quality of the UAN you are buying and the assets that will be exposed to that UAN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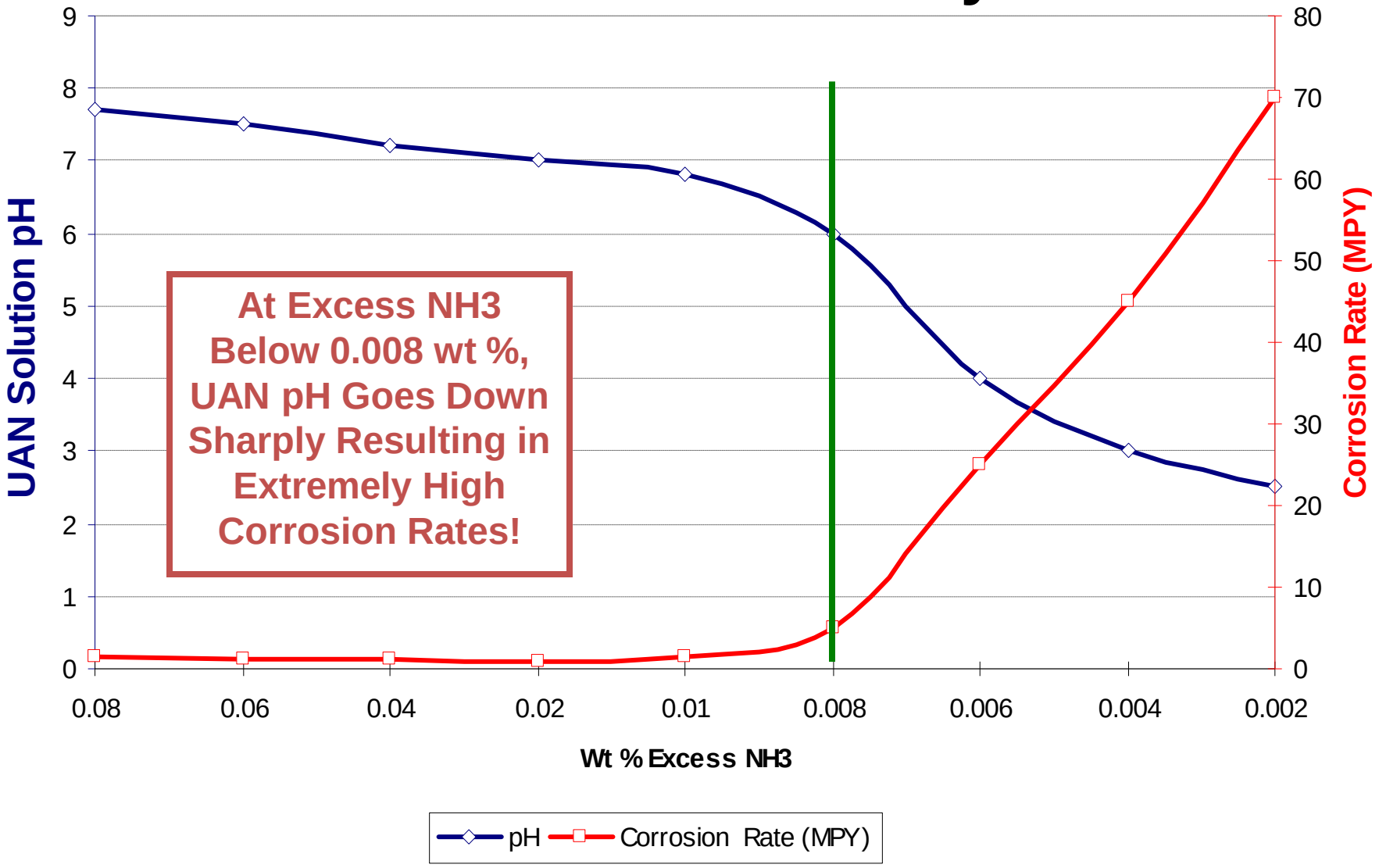
Excess NH3 Controls the pH and also the Corrosivity



Considerations

- **Systematic approach**
- **Compatible components**
- **Short term vs. long term**
- **Plan ahead for future expansion**

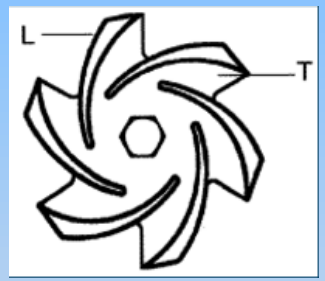
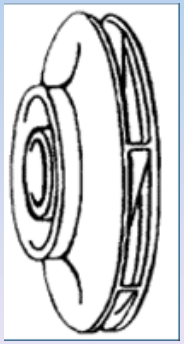
Floor Failure Prevention

- Concrete Foundations
- Internal Coatings
- Full draining of liquids/thorough circulation of liquids
- Routine solids removal
- Cathodic protection

HOUSEKEEPING

- Keep the Place Clean
- Plumbing
- Pumps
- Gaskets
- Etc.

Open vs. closed impeller design pumps

Open 	The fluid enters the eye of the impeller where the turning vanes add energy to the fluid and direct it to the discharge nozzle. A close clearance between the vanes and the pump volute, or back plate in a few designs, prevents most of the fluid from recirculating back to the eye of the impeller. (L) shows the leading edge or higher-pressure side of the impeller. (T) describes the trailing edge of the impeller
Closed 	The fluid enters the eye of the impeller where the vanes add energy to the fluid and direct it to the discharge nozzle. There is no impeller to volute or back plate clearance to set. Wear rings restrict the amount of discharge fluid that recirculates back to the suction side of the impeller. When this wear ring clearance becomes excessive the wear rings must be replaced.

FRICTION LOSS OF WATER IN FEET PER 100 FEET LENGTH OF PIPE—BASED ON WILLIAMS & HAZEN FORMULA USING CONSTANT 100. SIZES OF STANDARD PIPE IN INCHES

U.S. Gals. per min.	½" Pipe		¾" Pipe		1" Pipe		1¼" Pipe		1½" Pipe		2" Pipe		2½" Pipe		3" Pipe		4" Pipe		5" Pipe		6" Pi	
	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	Loss in Feet	Vel. ft. per Sec.	
2	2.10	7.4	1.20	1.9																		
4	4.21	27.0	2.41	7.0	1.49	2.14	.86	.57	.63	.26												
6	6.31	57.0	3.61	14.7	2.23	4.55	1.29	1.20	.94	.56	.61	.20										
8	8.42	98.0	4.81	25.0	2.98	7.8	1.72	2.03	1.26	.95	.82	.33	.52	.11								
10	10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	.50	.65	.17	.45	.07						
12			7.22	53.0	4.46	16.4	2.57	4.3	1.89	2.01	1.23	.79	.78	.23	.54	.10						
15			9.02	80.0	5.60	25.0	3.21	6.5	2.36	3.00	1.53	1.08	.98	.36	.68	.15						
18			10.84	108.2	6.69	35.0	3.86	9.1	2.83	4.24	1.84	1.49	1.18	.50	.82	.21						
20			12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.20	2.04	1.82	1.31	.61	.91	.25	.51	.06				
25					9.30	64.0	5.36	16.6	3.80	7.30	2.55	2.73	1.63	.92	1.13	.38	.64	.09				
30					11.15	89.0	6.43	23.0	4.72	11.0	3.06	3.84	1.96	1.29	1.36	.54	.77	.13	.49	.04		
35					13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.10	2.29	1.72	1.59	.71	.89	.17	.57	.06		
40					14.88	152.0	8.58	40.0	6.30	18.8	4.08	6.6	2.61	2.20	1.82	.91	1.02	.22	.65	.08		
45							9.65	50.0	7.08	23.2	4.60	8.2	2.94	2.80	2.04	1.15	1.15	.28	.73	.09		
50							10.72	60.0	7.87	28.4	5.11	9.9	3.27	3.32	2.27	1.38	1.28	.34	.82	.11	.57	
55							11.78	72.0	8.66	34.0	5.62	11.8	3.59	4.01	2.45	1.58	1.41	.41	.90	.14	.62	
60							12.87	85.0	9.44	39.6	6.13	13.9	3.92	4.65	2.72	1.92	1.53	.47	.98	.16	.68	
65							13.92	99.7	10.23	45.9	6.64	16.1	4.24	5.4	2.89	2.16	1.66	.53	1.06	.19	.74	
70							15.01	113.0	11.02	53.0	7.15	18.4	4.58	6.2	3.18	2.57	1.79	.63	1.14	.21	.79	
75							16.06	129.0	11.80	60.0	7.66	20.9	4.91	7.1	3.33	3.00	1.91	.73	1.22	.24	.85	
80							17.16	145.0	12.59	68.0	8.17	23.7	5.23	7.9	3.63	3.28	2.04	.81	1.31	.27	.91	
85							18.21	163.8	13.38	75.0	8.68	26.5	5.56	8.1	3.78	3.54	2.17	.91	1.39	.31	.96	
90							19.30	180.0	14.71	84.0	9.19	29.4	5.88	9.8	4.09	4.08	2.30	1.00	1.47	.34	1.02	
95									14.95	93.0	9.70	32.6	6.21	10.8	4.22	4.33	2.42	1.12	1.55	.38	1.08	
100									15.74	102.0	10.21	35.8	6.54	12.0	4.54	4.96	2.55	1.22	1.63	.41	1.13	
110									17.31	122.0	11.23	42.9	7.18	14.5	5.00	6.0	2.81	1.46	1.79	.49	1.25	
120									18.89	143.0	12.25	50.0	7.84	16.8	5.45	7.0	3.06	1.17	1.96	.58	1.36	
130									20.46	166.0	13.28	58.0	8.48	18.7	5.91	8.1	3.31	1.97	2.12	.67	1.47	
140									22.04	190.0	14.30	67.0	9.15	22.3	6.35	9.2	3.57	2.28	2.29	.76	1.59	
150											15.32	76.0	9.81	25.5	6.82	10.5	3.82	2.62	2.45	.88	1.70	
160											16.34	86.0	10.46	29.0	7.26	11.8	4.08	2.91	2.61	.98	1.82	
170											17.36	96.0	11.11	34.1	7.71	13.3	4.33	3.26	2.77	1.08	1.92	
180											18.38	107.0	11.76	35.7	8.17	14.0	4.60	3.61	2.94	1.22	2.04	
190											19.40	118.0	12.42	39.6	8.63	15.5	4.84	4.01	3.10	1.35	2.16	
200											20.42	129.0	13.07	43.1	9.08	17.8	5.11	4.4	3.27	1.48	2.27	
220											22.47	154.0	14.38	52.0	9.99	21.3	5.62	5.2	3.59	1.77	2.50	
240											24.51	182.0	15.69	61.0	10.89	25.1	6.13	6.2	3.92	2.08	2.72	
260											26.55	211.0	16.99	70.0	11.80	29.1	6.64	7.2	4.25	2.41	2.95	
280													18.30	81.0	12.71	33.4	7.15	8.2	4.58	2.77	3.18	
300													19.61	92.0	13.62	38.0	7.66	9.3	4.90	3.14	3.40	
320													20.92	103.0	14.52	42.8	8.17	10.5	5.23	3.54	3.64	
340													22.22	116.0	15.43	47.9	8.68	11.7	5.54	3.97	3.84	
360													23.53	128.0	16.34	53.0	9.19	13.1	5.87	4.41	4.08	
380													24.84	142.0	17.25	59.0	9.69	14.0	6.19	4.86	4.31	
400													26.14	156.0	18.16	65.0	10.21	16.0	6.54	5.4	4.55	
450															20.40	78.0	11.49	19.8	7.35	6.7	5.11	
500															22.70	98.0	12.77	24.0	8.17	8.1	5.68	
550															24.96	117.0	14.04	28.7	8.99	9.6	6.25	
600															27.23	137.0	15.32	33.7	9.80	11.3	6.81	
650																	16.59	39.0	10.62	13.2	7.38	
700																	17.87	44.9	11.44	15.1	7.95	
750																	19.15	51.0	12.26	17.2	8.50	
800																	20.42	57.0	13.07	19.4	9.08	
850																	21.70	64.0	13.89	21.7	9.65	
900																	22.98	71.0	14.71	24.0	10.20	

- Doubling the diameter of a pipe increases its capacity four times

SAFETY

Special Situations

- Respirators
- Confined Space Entry
- Forklifts/Loaders/Shuttle Trucks
- Elevated Work / Maintenance
  - Harnesses
  - Safety Cages
  - Rest Platforms
  - Ladders & Man Lifts/Boom Trucks

SAFETY

- Our Most Important Priority
- Every Employee Goes Home Safe
  - Training – Documented
  - PPE when you can't eliminate hazards
  - Regular Tailgate & Huddles Meetings
  - Policies, Procedures, Work Directions
  - Develop Culture of Safety in
  - Environmental Safety
  - Facility / Equipment Safety

Training

- Haz-ops Trained. What Level?
- PPE
- Safety Meetings/Documentation
- Understanding Of the Process
- Response To Releases, etc.
- Understanding Of Chemistry

PERSONNEL RESPONSIBILITIES

- Safety And Quality Are Everyone's Business
- Be Properly Trained
- Understand All Products
- Chemistry (basic understanding)

SECURITY

- Site & Transportation Security
  - Homeland Security Compliance
    - Hazmat Railcar Training
    - Security Fencing
    - Restricted Entry

Supervision

- If You Are Not Committed To Training
- If You Are Not Committed To Proper Equipment
- If You Are Not Committed To Safety
- Don’t Make These Products And Have Someone Toll Them For You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Key Take Aways…

- Training and Safety is Paramount
- Take Pride in Your Operation
- Quality Inputs make Quality Products
- Stored Liquid Can be Corrosive
- But **YOU** can manage this risk:
  - Manage Risk
  - Control Your UAN chemistry
  - Proper Tank Design and Maintenance Practices

Questions?