Fluid Fertilizers: Properties and Characteristics

Dale F. Leikam

Fluid Fertilizer Foundation
www.FluidFertilizer.com

Dale.Leikam@sbcglobal.net
785-776-0273
785-770-0009
Tuesday, December 8, 2009

12:30  12:45  Welcome and Announcements (B. Easterwood)
12:45  1:15  Fluid Fertilizer Solutions and Opportunities (A. Campos)
1:15  2:00  Southeast/Global Fertilizer Outlook and Trends; 2010 and Beyond
2:00  2:15  Break

Session A
2:15  3:15  Local Plant Operation/Maintenance (T. Scoble)
3:15  4:00  Florida Nutrient Criteria Issues: A Precedent For the Rest of the Nation? (J. Brown)
4:00  5:00  Storage Tank Failures & Maintenance (C. Meyers)
6:00  7:30  Social Hour / Reception

Session B
2:15  3:15  Advanced Production Systems For Citrus (A. Schumann)
3:15  4:00  Production, Characteristics, Salt-out, Precipitate Formation, etc. For Common Fluid Fertilizers (D. Leikam)
4:00  5:00  Compatibilities, Formulation With ATS, CaNO3, K2CO3, KNO3, etc. (M. Orr)

Wednesday, December 9, 2009

Session A
8:00  9:00  Urea Volatilization: Mechanisms, Magnitude and Management (D. Klese)
9:10  10:10  Fertilization/Maintenance of Fertilization Systems (B. Hobbs)
10:10  10:30  Break
10:30  11:30  Production Issues For Fluid Products (D. Plank)
11:30  12:15  Specialty Fertilizer Law/Issues (M. Hartney)
12:15  12:30  Wrap-Up, Thank You, Enjoy The Mosaic Tour, Have a Safe Trip Home!!
1:00  7:00  Tour of Mosaic Phosphate Mine (Mosaic Company)
FLUID FERTILIZER MANUFACTURERS

Actagro, LLC
Agricem
AgriEnergy Resources
Agrium
Agro-Culture Liquid Fertilizers
Agro-K Corporation
Brandt Consolidated Inc.
Chemical Dynamics, Inc.
CSI Chemical Corp.
CSR Distilleries Operations Pty. Ltd.
Floractive Biosciences, Inc.
Frit Industries
Georgia-Pacific Corporation
Great Salt Lake Minerals Corporation
Incitec Pivot
Intrepid Potash
Itronics Metallurgical, Inc.
J. R. Simplot Company
Koch Mineral Services, LLC
Martin Resources
Mineral Research and Development
Mosiac Company
NaChurs Alpine Solutions
PhosCan Chemical Corp.
Poole Chemical Co., Inc.
PotashCorp
Rotem BKG LLC
Terra Industries
Tesserendero Kerley, Inc.
TETRA Micronutrients
Westfarms CSBP Limited
Yara North America, Inc.

FLUID FERTILIZER DISTRIBUTORS

Active Minerals International
Agrico Canada Ltd.
Evans Enterprises, LLC
Gavilon Fertilizers, LLC
Helena Chemical Co.
International Raw Materials, Ltd.
MFA Incorporated
Nipro Products
Nutra-Flo Company
Sustainable Liquid Technology Pty Ltd
The Andersons
United Suppliers, Inc.
Wilbur-Ellis

LABORATORIES

A & L Canada Laboratories Inc.
A & L Great Lakes Laboratories
AgSource Be mould Labs
Ag Source Harris Laboratories
Agywise Laboratories
Brookside Laboratories, Inc.
Olson's Agricultural Laboratory, Inc.
Smi-Tech Inc.
Ward Laboratories, Inc.
Waters Agricultural Laboratories, Inc.
Western Laboratories, Inc.

INDUSTRY SUPPORT

Agricultural Retailers Association
Foundation for Agronomic Research
  Keith Erny
  Leikam AgroMax
  Lohry, Dars & Bill
  Murphy Agro
  Seck Farms
  Southwest Fertilizer Conference
    Specialty Process Consulting, LLC

INDUSTRY SUPPLIERS

Acadian Seaplants Ltd.
AGCO
Agrotain International, LLC
BASF
Bio Huma Netics, Inc.
Enviropac, Inc.
Exactrix Global Systems
John Deere
Junge Control, Inc.
Kahler Automation Corporation
Mears Fertilizer Inc.
Mid-State Tank Co., Inc.
Murray Equipment Inc.
Nalco
Pattison Liquid Systems Inc.
Precision Tank & Equipment
Specialty Fertilizer Products
  The Reactor, Inc.
NPKS Starters Improve Profitability On High-Testing Soils

Studies conducted at Southern Research and Outreach Center in Waseca, Minnesota.

Historically, starter fertilizers have not been commonly recommended for corn production on high or very high P-testing soils due to poor yield response even though early growth responses may be seen. However, we’ve seen renewed interest in starter (band-placed) fertilizers as 1) corn yields continue to increase, 2) tillage intensity tends to decrease, and 3) corn planting comes earlier. With this renewed interest, questions have been raised regarding the inclusion of K and S in the fluid starter, as well as about optimum placement (in-row with seed vs. bands 2 inches from the seed or bands dribbled on the soil surface). Objectives of the research in this report were:

- Provide to corn producers, crop advisors, and the fertilizer industry management guidelines on fluid starter fertilizer rates and placements for corn grown on high P- and K-testing soils with reduced tillage.

**Concentration**

Concentrations of N, P, K, and S in the whole small plant at the V6 stage were inconsistently affected by NPES treatments (Table 1). This was particularly true for N and P where statistically significant differences were found but there was no clear effect of rate or placement and no interaction between rate and placement. Whole-plant K concentrations were not affected by starter P and K treatments. Whole-plant S concentration was increased by the 2 x 2 and 2 x 0 treatments that received S. Concentrations of NPES were similar between 2 x 0 and 2 x 2 placement.

**Dry matter**

Dry matter accumulation at V6 was affected by the starter P
Fluid Fertilizers

- Increasing in popularity in U.S. and elsewhere

- Advantages include
  - Flexibility and versatility in application
  - Efficiency and adaptability
  - Potential benefits of continuous bands
  - Ease of handling
  - Does not segregate
  - Etc.

- Limitations
  - Generally higher purchase cost than solid fertilizers
  - Salt-out and precipitate formation potential with certain products and blends
Fluid Fertilizers

- Increasing in popularity in U.S. and elsewhere

- Advantages include
  - Flexibility and versatility in application
  - Efficiency and adaptability
  - Benefits of continuous bands
  - Ease of handling
  - Does not segregate
  - Flexibility

- Limitations
  - Often higher purchase price than solid fertilizers
  - Salt-out and precipitate formation potential with certain products and blends
Fluid Fertilizers

Terminology, Solubility, Density and N Solutions

**Solution** – All salts totally dissolved in water. No solids allowed!

**Slurry** – Fluid product containing water, dissolved salts and undissolved salts. Settles out quickly. Not Common.

**Suspension** – Fluid product containing water, dissolved salts, fine undissolved salt crystals and a suspending agent – normally attapulgite clay.

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

**Falling Out Of Solution** – No such thing.
Salt-Out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

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

- Percent N
- Density (Lb/Gal)

- Salt-Out (F)
- Lbs/Gal.

Graph showing the relationship between Percent N and Density (Lb/Gal) for different Salt-Out (F) values.
To Make 32-0-0 UAN Solution - How Much Water Is Needed?
**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**
To Make 32-0-0 UAN Solution - How Much Water Is Needed?
UAN Solutions

Water 100%

Water

Urea 100%

Urea

10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

10% 20% 30% 40% 50% 60% 70% 80% 90%
Salt-out is an issue in many environments

- There is very little water in UAN solution.
- Warm water has ability to dissolve more salts than cold water.
- Salt-out occurs when salt content exceeds solubility at a given product temperature.
- Crystals form on tank walls as temperature cools.
- Eventually salts accumulate at tank bottom.
- Salts will re-dissolve with sufficient heat and recirculation.
## Lowering Water Freezing Temperature With UAN Solution

<table>
<thead>
<tr>
<th>% N</th>
<th>Freezing Temperature - F</th>
<th>28-0-0 (gal per 100 gal water)</th>
<th>32-0-0 (gal per 100 gal water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>6.1</td>
<td>5.2</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>13.1</td>
<td>11.2</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>21.5</td>
<td>18.2</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>31.5</td>
<td>26.2</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>43.7</td>
<td>35.6</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>59.0</td>
<td>47.2</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>78.7</td>
<td>61.2</td>
</tr>
</tbody>
</table>
SOLUBILITY OF AMMONIUM PHOSPHATES

(ORTHO- SOLUTIONS)

(ORTHO- SUSPENSIONS)

SOLUBILITY @ 32 DEGREES (lbs Salt/100 lbs Water)

N : P2O5 Ratio

NH3 : H3PO4 Ratio

1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0

1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0

1.56 NH3 : H3PO4
.307 N : P2O5

1.69 NH3 : H3PO4
.333 N : P2O5

MAP CRYSTALS

DAP CRYSTALS
Phosphoric Acid

Wet-Process Acid
- Black, brown, green (calcined)
- Contains many rock impurities
- Used in fertilizer industry

Furnace, food-grade acid
- Clear
- No impurities
- Food and industrial processes
# Orthophosphoric Acid Examples

<table>
<thead>
<tr>
<th>Source</th>
<th>Acid 1</th>
<th>Acid 2</th>
<th>Acid 3</th>
<th>Acid 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2O5</td>
<td>61</td>
<td>53.2</td>
<td>52.8</td>
<td>57</td>
</tr>
<tr>
<td>MgO</td>
<td>0.3</td>
<td>1.2</td>
<td>1.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>0.35</td>
<td>0.5</td>
<td>1.0</td>
<td>0.32</td>
</tr>
<tr>
<td>Al2O3</td>
<td>0.18</td>
<td>0.4</td>
<td>0.5</td>
<td>0.16</td>
</tr>
<tr>
<td>F</td>
<td>0.3</td>
<td>0.4</td>
<td>2.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Solids</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td>Nil</td>
</tr>
<tr>
<td>Visc.@100F</td>
<td>40</td>
<td>90</td>
<td>100</td>
<td>27</td>
</tr>
<tr>
<td>P/F</td>
<td>89</td>
<td>58</td>
<td>46</td>
<td>248</td>
</tr>
</tbody>
</table>

Source: Texas Gulf
Ammonium Polyphosphate

- Primary P source for much of fluid industry
- Most NPKS products made from APP
- Produced from ammonia, superphosphoric acid and water
- Generally equal agronomic performance as compared to solid fertilizers
  - If applied at equal P rates in similar manner
  - Potentially superior to solids if discontinuous bands result from with solid fertilizer band applications
- Contains most P as polyphosphate
  - Polyphosphates and orthophosphates are considered agronomically equal
Heat links phosphates by removing chemically bound water.

Heat comes from chemical reaction of reacting phosphoric acid with ammonia.
Flow Diagram For Ammonium Polyphosphate Production
10-34-0 & 11-37-0
Why Do We Want Polyphosphates?

- Not necessarily for agronomic reasons
- Manage sludge problems in fluid P products
  - Polyphosphates sequester metal cation impurities in the product (especially Mg) to form relatively insoluble precipitates
  - Provides superior storage qualities
- Increased analysis compared to orthophosphate
- Provides ability to include higher amounts of micronutrients in product (not Ca or Mg)
Hydrolysis Of Polyphosphate To Orthophosphate

<table>
<thead>
<tr>
<th>Soil Temperature</th>
<th>24 Hour Polyphosphate Hydrolysis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>41 F</td>
<td>30-40 %</td>
</tr>
<tr>
<td>68 F</td>
<td>50-60 %</td>
</tr>
<tr>
<td>95 F</td>
<td>80-90 %</td>
</tr>
</tbody>
</table>

Chang and Racz, 1977

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

Plants utilize orthophosphates.
Effect of Poly Content and N:P2O5 Ratio On Solubility

- 70% Poly
- 45% Poly
- 0% Poly

Percent Total N + P2O5 Content

N:P2O5 Weight Ratio
Why Do We Want Polyphosphates?

- Not necessarily for agronomic reasons
- Manage sludge problems in fluid P products
  - Polyphosphates sequester metal cation impurities in the product (especially Mg) to form relatively insoluble precipitates
  - Provides superior storage qualities
- Increased analysis compared to orthophosphate
- Provides ability to include higher amounts of micronutrients in product (not Ca$^{++}$ or Mg$^{++}$)
# Zinc Sequestering By 10-34-0

## Zinc Sources

<table>
<thead>
<tr>
<th>Original Zinc Source</th>
<th>% Zinc Remaining As Original Source</th>
<th>% Zinc Sequestered By Polyphosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn EDTA</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Zn Sulfate</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>Zn-NH3 Complex</td>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>Zn Phenolic Acid</td>
<td>11</td>
<td>89</td>
</tr>
<tr>
<td>Zn Citrate</td>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>Zn Nitrate + UAN</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>Zn HEIDA</td>
<td>19</td>
<td>81</td>
</tr>
</tbody>
</table>

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

- Primary P source for much of fluid industry
- Most NPKS products made from APP
- Produced from ammonia, superphosphoric acid and water

- Generally equal agronomic performance as compared to solid fertilizers
  - If applied at equal P rates in similar manner
  - Potentially superior to solids since discontinuous bands result with solid fertilizer band applications

- Contains most P as polyphosphate
  - Polyphosphates and orthophosphates are considered agronomically equal
Temperature Effect On 10-34-0 Quality

Source: Farmland Industries
Polyphosphate Loss vs. Temperatures
Poly 11 - Geismar

Polyphosphate Content

Number of Days

140F  95F  75F

- 50  55  60  65  70

- 0  10  20  30  40  50  60  70  80
Factors Impacting Precipitate Formation In Storage

- Amount of polyphosphate initially present
- Amount of impurities in super-acid
- Other ‘impurities’ added to product
  - Zinc
  - Previous product sludge
- Temperature of stored product
- Length of time product stored
APP Storage and Housekeeping Suggestions

- Do not store longer than necessary
- Avoid storage in summer months
- Completely empty and clean tanks regularly
- Know the quality of remaining product before adding additional product to tanks
- Do not contaminate with products/impurities that may affect storage properties
- Never mingle any calcium or magnesium with product or mix plant
- Make sure that farmers and dealers lines, tanks and equipment are completely cleaned after use
• Final maximum grade May Contain 31 Total Plant Food Units.
  - N = 25% of 31 = .25 X 31 = 7.75% N
  - P$_2$O$_5$ = 50% of 31 = .50 X 31 = 15.5% P$_2$O$_5$
  - K$_2$O = 25% of 31 = .25 X 31 = 7.75% K$_2$O
<table>
<thead>
<tr>
<th>N:P$_2$O$_5$:K$_2$O Ratio</th>
<th>Solution Analysis (32 °F Saltout)</th>
<th>N:P$_2$O$_5$:K$_2$O Ratio</th>
<th>Solution Analysis (32 °F Saltout)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-0-1</td>
<td>7-0-7</td>
<td>3-0-1</td>
<td>13.5-0-4.5</td>
</tr>
<tr>
<td>1-0-2</td>
<td>5.5-0-11</td>
<td>3-0-2</td>
<td>8.4-0-5.6</td>
</tr>
<tr>
<td>1-0-3</td>
<td>4.3-0-12.9</td>
<td>3-0-4</td>
<td>6.6-0-8.8</td>
</tr>
<tr>
<td>1-1-0</td>
<td>19.5-19.5-0</td>
<td>3-1-0</td>
<td>24.6-8.2-0</td>
</tr>
<tr>
<td>1-1-1</td>
<td>7.3-7.3-7.3</td>
<td>3-1-1</td>
<td>12.6-4.2-4.2</td>
</tr>
<tr>
<td>1-1-2</td>
<td>5.3-5.3-10.6</td>
<td>3-1-2</td>
<td>8.7-2.9-5.8</td>
</tr>
<tr>
<td>1-1-3</td>
<td>4.2-4.2-12.6</td>
<td>3-1-3</td>
<td>6.9-2.3-6.9</td>
</tr>
<tr>
<td>1-1-4</td>
<td>3.5-3.5-14</td>
<td>3-1-4</td>
<td>6-2-8</td>
</tr>
<tr>
<td>1-1-5</td>
<td>2.9-2.9-14.5</td>
<td>3-2-0</td>
<td>21.6-14.4-0</td>
</tr>
<tr>
<td>1-2-0</td>
<td>15.3-30.6-0</td>
<td>3-2-1</td>
<td>12-8-4</td>
</tr>
<tr>
<td>1-2-1</td>
<td>7.7-15.4-7.7</td>
<td>3-2-2</td>
<td>8.7-5.8-5.8</td>
</tr>
<tr>
<td>1-2-2</td>
<td>5.1-10.2-10.2</td>
<td>3-2-3</td>
<td>6.9-4.6-6.9</td>
</tr>
<tr>
<td>1-2-3</td>
<td>3.8-7.6-11.4</td>
<td>3-2-4</td>
<td>6.3-4.2-8.4</td>
</tr>
<tr>
<td>1-2-4</td>
<td>3.2-6.4-12.8</td>
<td>3-2-5</td>
<td>5.7-3.8-9.5</td>
</tr>
<tr>
<td>1-2-5</td>
<td>2.7-5.4-13.5</td>
<td>3-3-1</td>
<td>11.7-11.7-3.9</td>
</tr>
<tr>
<td>1-2-6</td>
<td>2.3-4.6-13.8</td>
<td>3-3-2</td>
<td>8.4-8.4-5.6</td>
</tr>
<tr>
<td>1-3-0</td>
<td>12.5-37.5-0</td>
<td>3-3-4</td>
<td>6.3-6.3-8.4</td>
</tr>
<tr>
<td>1-3-1</td>
<td>7.4-22.2-7.4</td>
<td>3-3-5</td>
<td>5.7-5.7-9.5</td>
</tr>
<tr>
<td>1-3-2</td>
<td>4.7-14.1-9.4</td>
<td>3-4-1</td>
<td>11.4-15.2-3.8</td>
</tr>
<tr>
<td>1-3-3</td>
<td>3.5-10.5-10.5</td>
<td>3-4-2</td>
<td>9-12-6</td>
</tr>
</tbody>
</table>
## Typical Characteristics Of Several Fluid Fertilizer Products

<table>
<thead>
<tr>
<th>Source</th>
<th>Analysis</th>
<th>Density</th>
<th>Salt-Out</th>
<th>General Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAN</td>
<td>28-0-0</td>
<td>10.67</td>
<td>0</td>
<td>~ 30% water</td>
</tr>
<tr>
<td>UAN</td>
<td>32-0-0</td>
<td>11.06</td>
<td>28 - 32</td>
<td>~ 20% water</td>
</tr>
<tr>
<td>ATS</td>
<td>12-0-0-26S</td>
<td>11.04</td>
<td>&lt;20</td>
<td>Fluid S Source of Choice</td>
</tr>
<tr>
<td>APP</td>
<td>10-34-0</td>
<td>11.65</td>
<td>&lt;10</td>
<td>11-37-0 grade also</td>
</tr>
</tbody>
</table>
Temperature Effect On Fluid Fertilizers Density

Estimated Density Of Fluid Products

<table>
<thead>
<tr>
<th>Product Temperature</th>
<th>28-0-0</th>
<th>32-0-0</th>
<th>10-34-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>-</td>
<td>11.17</td>
<td>11.76</td>
</tr>
<tr>
<td>30</td>
<td>10.78</td>
<td>11.14</td>
<td>11.74</td>
</tr>
<tr>
<td>40</td>
<td>10.76</td>
<td>11.12</td>
<td>11.72</td>
</tr>
<tr>
<td>50</td>
<td>10.73</td>
<td>11.09</td>
<td>11.7</td>
</tr>
<tr>
<td>60</td>
<td>10.7</td>
<td>11.05</td>
<td>11.68</td>
</tr>
<tr>
<td>70</td>
<td>10.67</td>
<td>11.02</td>
<td>11.66</td>
</tr>
<tr>
<td>80</td>
<td>10.64</td>
<td>10.99</td>
<td>11.64</td>
</tr>
<tr>
<td>90</td>
<td>10.61</td>
<td>10.95</td>
<td>11.62</td>
</tr>
<tr>
<td>100</td>
<td>10.55</td>
<td>10.92</td>
<td>11.6</td>
</tr>
</tbody>
</table>
Salt-out – Crystals form as solution cools; goes back in solution as product is warmed. Example; UAN Solution.

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

Heat generator – Generates chemical heat when producing solutions. Examples; ammonia + phosphoric acid; dilution of sulfuric acid)

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

\[
2\text{NH}_4\text{NO}_3 + \text{K}_2\text{CO}_3 \rightarrow 2\text{KNO}_3 + (\text{NH}_4)_2\text{CO}_3
\]

2NH\textsubscript{3} + H\textsubscript{2}CO\textsubscript{3} \rightarrow \text{H}_2\text{O} + \text{CO}_2

UAN in Irrigation Water?
UAN in Irrigation Water?

Urea N Volatilization?

\[ 2NH_4NO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + (NH_4)_2CO_3 \]

\[ \uparrow 2NH_3 + H_2CO_3 \]

\[ H_2O + CO_2 \]
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.

<table>
<thead>
<tr>
<th>Anhydrous Ammonia</th>
<th>Aqua Ammonia; 20-0-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea Soln; 23-0-0</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Nitrate Soln; 20-0-0</td>
<td>△</td>
</tr>
<tr>
<td>Urea Ammonium Nitrate Soln; UAN 28/32-0-0</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Sulfate Soln; 8-0-0-9S</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Polyphosphate Soln; 10-34-0</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Chloride Soln; 6-0-0-16Cl</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Thiosulfate Soln; 12-0-0-26S</td>
<td>△</td>
</tr>
<tr>
<td>Potassium Thiosulfate; KTS 0-0-25-17S</td>
<td>△</td>
</tr>
<tr>
<td>Calcium Thiosulfate; CaTS, 6% Ca 10% S</td>
<td>?</td>
</tr>
<tr>
<td>Magnesium Thiosulfate; MgTS, 10% S 4% Mg</td>
<td>?</td>
</tr>
<tr>
<td>Ammonium Potassium Phosphate; 10-34-0</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Sulfate Soln; 8-0-0-9S</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Chloride Soln; 6-0-0-16Cl</td>
<td>△</td>
</tr>
<tr>
<td>Ammonium Thiosulfate Soln; 12-0-0-26S</td>
<td>△</td>
</tr>
<tr>
<td>Potassium Thiosulfate; KTS 0-0-25-17S</td>
<td>△</td>
</tr>
<tr>
<td>Calcium Thiosulfate; CaTS, 6% Ca 10% S</td>
<td>?</td>
</tr>
<tr>
<td>Magnesium Thiosulfate; MgTS, 10% S 4% Mg</td>
<td>?</td>
</tr>
<tr>
<td>Potassium Thiosulfate</td>
<td>?</td>
</tr>
<tr>
<td>Calcium-Ammonium Nitrate Solution</td>
<td>17-0-0 8.8 Ca</td>
</tr>
<tr>
<td>Calcium Nitrate Solution</td>
<td>9% N, 11% Ca</td>
</tr>
<tr>
<td>Potassium Carbonate Solution</td>
<td>0-0-32</td>
</tr>
<tr>
<td>N-pHuric 28/27; 28-0-0 9S</td>
<td>△</td>
</tr>
<tr>
<td>N-pHuric 15/49; 15-0-0 16S</td>
<td></td>
</tr>
<tr>
<td>N-pHuric 10/55; 10-0-0 18S</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>△</td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>△ △ △ △ △ △</td>
</tr>
<tr>
<td>Phosphoric Acid (white)</td>
<td>△ △ △ △ △</td>
</tr>
<tr>
<td>Phosphoric Acid (green)</td>
<td>△ △ △ △</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>△ △ △ △</td>
</tr>
<tr>
<td>Urea; 46-0-0</td>
<td>△ △ △ △ △</td>
</tr>
<tr>
<td>Ammonium Nitrate; 34-0-0</td>
<td>△</td>
</tr>
<tr>
<td>Calcium Nitrate; 15.5-0-0-19Ca</td>
<td></td>
</tr>
<tr>
<td>Potassium Chloride; 0-0-62</td>
<td></td>
</tr>
<tr>
<td>Potassium Nitrate; 13-0-46</td>
<td></td>
</tr>
<tr>
<td>Magnesium Nitrate; 10% N 9% Mg</td>
<td>△ △ △ △ △</td>
</tr>
</tbody>
</table>
Thank You And Enjoy The Conference

Dale F. Leikam

Fluid Fertilizer Foundation
www.FluidFertilizer.com

Dale.Leikam@sbcglobal.net
785-776-0273
785-770-0009