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Storage Properties of Ammonium Polyphosphate
(11-37-0 / 10-34-0)
LOMAG - Feed to 11-37-0/10-34-0 Plant
LOMAG - Low Magnesium Superacid

- It is a Polyphosphoric Acid
LOMAG is Made by Evaporating Phosphoric Acid

Water

$\text{H}_2\text{O}$

$\text{H}_3\text{PO}_4$ Ortho

$\text{H}_3\text{PO}_4$ Ortho

Pyrophosphoric Acid ($\text{H}_4\text{P}_2\text{O}_7$) - A Polyphosphoric Acid

Conversion: The Amount of Orthophosphate Converted to Polyphosphate
LOMAG

LOMAG - Low Magnesium Superacid

- It is a Polyphosphoric Acid
- It is used to Produce Ammonium Polyphosphates (11-37-0 or 10-34-0)
Producing Liquid Fertilizer from LOMAG

TVA PIPE REACTOR PROCESS SCHEMATIC
Converting the LOMAG to 11-37-0/10-34-0 Increases the Phosphate Conversion Level

- The Pipe Reactor Temperature Exceeds 600 °F
- This Increases the Conversion Level
  20 - 28 Percent in Superacid to
  70 Percent or Higher in the 11-37-0 or 10-34-0
- The Majority of the Polyphosphates in the
  11-37-0/10-34-0 Range from $H_4P_2O_7$ to $H_{10}P_8O_{25}$
Polyphosphates found in 11-37-0/10-34-0

\[
\begin{align*}
H_4P_2O_7 \\
H_5P_3O_{10} \\
H_6P_4O_{13} \\
H_8P_6O_{19} \\
H_9P_7O_{22} \\
H_{10}P_8O_{25}
\end{align*}
\]
Benefits of High Conversion

- Extended Shelf life

- Ability to Sequester
  - Metals (Zinc or Boron)
  - Potassium
  - Make NPK’s
What Impacts Quality of 11-37-0/10-34-0?

- Conversion Level
- Storage Tank Cleaning
- Agitation in Storage Tank
What Impacts Conversion?

- Storage Temperature
Impact of Temperature on Conversion Level

11-37-0 Aging Test

Days of Aging: 0 - 340

Conversion: 0 - 72.00

Temperature Conditions:
- 150 F Oven
- 130 F Oven
- 105 F Oven
- 90 F Oven
- Counter 75 F
- Refrigerator 30 F
- Freezer 10 F

Minimum Conversion and Solid Precipitation markers are also included.
# Impact of Temperature on Conversion Level

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Days of Aging to Drop Conversion Level to 65%</th>
<th>Days of Aging to Drop Conversion Level to 55%</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 F</td>
<td>Less Than 1 Day</td>
<td>2</td>
</tr>
<tr>
<td>130 F</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>105 F</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>90 F</td>
<td>14</td>
<td>77</td>
</tr>
<tr>
<td>75 F</td>
<td>84</td>
<td>Plus 336</td>
</tr>
</tbody>
</table>

Starting Conversion 70.4 percent
# Maximizing Shelf Life of 11-37-0

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp (F) Average</th>
<th>Case 1 11-37-0 Tons</th>
<th>11-37-0 Conversion (%)</th>
<th>Case 2 11-37-0 Tons</th>
<th>11-37-0 Conversion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 1</td>
<td>90</td>
<td>300</td>
<td>72.00</td>
<td>100</td>
<td>72.00</td>
</tr>
<tr>
<td>Sep 1</td>
<td>75</td>
<td></td>
<td>64.50</td>
<td></td>
<td>64.50</td>
</tr>
<tr>
<td>Oct 1</td>
<td>50</td>
<td></td>
<td>62.60</td>
<td></td>
<td>62.60</td>
</tr>
<tr>
<td>Nov 1</td>
<td>40</td>
<td></td>
<td>62.30</td>
<td>100</td>
<td>67.15</td>
</tr>
<tr>
<td>Dec 1</td>
<td>30</td>
<td></td>
<td>62.20</td>
<td></td>
<td>67.05</td>
</tr>
<tr>
<td>Jan 1</td>
<td>&lt;30</td>
<td></td>
<td>62.20</td>
<td></td>
<td>67.05</td>
</tr>
<tr>
<td>Feb 1</td>
<td>40</td>
<td></td>
<td>62.20</td>
<td>100</td>
<td>68.70</td>
</tr>
<tr>
<td>Mar 1</td>
<td>50</td>
<td></td>
<td>62.10</td>
<td></td>
<td>68.60</td>
</tr>
<tr>
<td>Apr 1</td>
<td></td>
<td></td>
<td>61.80</td>
<td></td>
<td>68.30</td>
</tr>
</tbody>
</table>

Change in Conversion | 10.20 | 3.70
Conversion Level

➢ As the Conversion Drops
  ➢ Reduces Ability of the 11-37-0/10-34-0 to Sequester
  ➢ Solids Begin to Precipitate when the Conversion Drops Below 55 Percent

➢ TVA Identified Several Solids That Can Precipitate
  ➢ MgAl(NH$_4$)$_5$(P$_2$O$_7$)$_2$F$_2$*6H$_2$O
  ➢ Mg(NH$_4$)$_2$P$_2$O$_7$*4H$_2$O
  ➢ (NH$_4$)$_2$HPO$_4$ - DAP
  ➢ NH$_4$H$_2$PO$_4$ - MAP
Tank Cleaning

- Annual Cleaning Reduces Solids Precipitation

- Uses for Liquid Fertilizer Tank Solids/Sludge
  - Make Suspensions
  - Make Solid Fertilizers
  - Applied to a Field by Farmer Using Manure Spreader
Agitation

- 10-34-0 and 11-37-0 are often stored in mild steel tanks. The products react with iron in the steel to form an iron phosphate coating, which serves as a barrier to further corrosion.

- Tank design must take into consideration the need to preserve this phosphate coating. It is critically important to avoid product turbulence and high velocities.

- If the iron phosphate is repeatedly removed by turbulence, a solids layer can form in the storage tank.
Tank With Hydrogen Grooving

Area of shell susceptible to hydrogen grooving below a roof inlet nozzle.
Aurora’s Procedures to Maintain 11-37-0 Quality

- Annually Clean 11-37-0 Storage Tank
- Air Blow 11-37-0 Loading Lines
- Only Sell 11-37-0 with No Less Than a Conversion Level of 65 Percent
- Mild Steel Storage Tank is Lined with Devchem 253
- Minimize the Agitation and Recirculation
Salt-Out

➢ Ammonium Polyphosphates Do Have Limits

➢ Conversion Level
➢ Temperature
➢ NPK Blend

References:
Fluid Fertilizer Manual 1994 Volume 2 Chapter 3
WWW.FLUIDFERTILIZER.COM
PCS Sales – Liquid Fertilizer Formulation Book

Diagram: Solubility at 32 °F

<table>
<thead>
<tr>
<th>Polyphosphate level</th>
<th>% of total P₂O₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>45</td>
</tr>
<tr>
<td>III</td>
<td>70</td>
</tr>
</tbody>
</table>

Crystallizing phase:
(1) (NH₄)₂HPO₄
(2) (NH₄)₂H₂PO₄
(3) (NH₄)₃HP₃O₁₀·H₂O
(4) (NH₄)₃P₂O₁₀·2H₂O
(5) (NH₄)₂HPO₄·2H₂O
(6) (NH₄)₄P₂O₇·H₂O

Graph: Solubility of Polyphosphates at 32 °F
Recommendations and Conclusions

- Annually Clean and Inspect the 11-37-0/10-34-0 Storage Tank
- Inspect Mild Steel 11-37-0/10-34-0 Storage Tank as Per API 653
- Maintain Minimum 11-37-0/10-34-0 Conversion Level of 60 Percent
- Shelf Life of 11-37-0/10-34-0 is Approximately 9 Months at 75 °F
- Minimize Agitation in Mild Steel Tanks by
  - Introducing the Liquid Away from Walls to Minimize Wall Erosion
  - Extending the Pump Suctions Into the Tank far Enough to Minimize Wall Erosion
  - Minimizing the Recirculation and Agitation
- Minimize Storage Temperature by
  - Operating Coolers to Minimize Temperature of 10-34-0 to Storage
  - Painting the Storage Tank White or Other Light Color
Thank you.

Questions ?