UAN Fertilizer Corrosion Management

Fluid Technology Roundup

Dec 10th, 2013

Phil Bureman
Nalco Company
Sr. Industry Technical Consultant-Chemicals & Biofuels
pebureman@nalco.com
913-708-4969
Agenda

• Who Is Nalco?
• UAN corrosion mechanisms
• UAN corrosion….. what you can do
  – Cause & Prevention Strategy
• Nalco’s efforts to help producers reduce UAN corrosivity & improve UAN quality
Who Is Nalco?
Nalco joined with Ecolab in 2011

• Global leader in water, hygiene and energy technologies and services
  – Foodservice, food processing, hospitality and healthcare
  – Petroleum & Gas Production and Refining
  – Paper Manufacturing & Finishing
  – Mining

• 44,000+ Employees

• $12 Billion Sales in 2012
  – UAN Corrosion Management Leader since 1994
    • Primarily with UAN producers
Our Experience in the UAN Industry

- Nalco has had a long, on-going commitment to the fertilizer industry to improve UAN corrosion management
  - 1994: introduced molybdate-based passivation technology
  - 2003: started extensive UAN CI research program
    • Developed the Nalco UAN Corrosion Simulator
  - 2004: introduced two new technology UAN corrosion inhibitors
    • NITROSolve 220 filmer technology that works
    • NITROSolve 330 passivation technology that works and is affordable
  - 2006: introduced products for post-inspection and pre-treatments programs for new rail cars and storage tanks
  - 2012: 3D Trasar® for UAN
  - 2013: 3D Trasar® for % Nitrogen

- Many long-term relationships in the fertilizer industry
  - Nalco provides inhibitor for about half of the UAN producer sites in North & South America and for about 35% of Global UAN production!

Okay, enough about Nalco, let’s talk about your business…..
You may have heard about the explosion in West, Texas in May 2013.

From the May 27th issue of Chemical & Engineering News:
The catastrophic explosion at a fertilizer depot in Texas last month is raising new questions about the effectiveness of the federal government’s program to ensure the security of plants that handle large amounts of extremely dangerous industrial chemicals. Some Democratic lawmakers are suggesting that the disaster has exposed major flaws in the Department of Homeland Security’s (DHS) Chemical Facilities Anti-Terrorism Standards (CFATS) program. The nearly six-year old initiative is designed to safeguard facilities that produce, store, or use hazardous chemicals that could be exploited by terrorists to inflict mass casualties in the U.S.

I’m sure I don’t have to tell you that your “fertilizer” business is under increased scrutiny by local and state officials.

What about risk associated with UAN and other liquid fertilizers?
Leaks from UAN and Other Liquid Fertilizer Assets Present A Real Business Risk

• For those attendees that have attended past Technology Roundup Conferences you may have heard John Boyd’s presentation

In March 2000 in Ohio, USA a tank leak...

Quickly resulted in complete tank collapse...

And a “river of fertilizer flowed through Main Street”

• You could lose significant amounts of product and property
• Your business reputation may be put at risk
• The EPA and OHSA might become your new business partners
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 from day to day in the same plant

Let me share some examples of the severe corrosion that has occurred in producer storage tanks
UAN Corrosion Can Be Quite Serious!

Heat affected zone

Sludge in low spots

Sludge in tanks

Sludge in railcars

Severe Pitting

Heat affected zone

Please allow me to tell you more about why UAN is so corrosive
A corrosion coupon with an existing corrosion spot, was placed in a sealed jar, ~ 20 mls of UAN was added – just enough to partially cover the surface.

The Jar was sealed and placed in the KS July sun for 7 days.

No new corrosion occurred while the jar was sealed.

This photo was taken just prior opening the jar for ~ 3 hours:

- Allows for release of the ammonia that is dissolved in UAN
- The jar was then resealed and allowed to bake in the sun for ~24 hours.
Initial Investigation

- Photo taken after being resealed and 24 sun hour bake
- Note the similarity with rail car UAN heel discoloration & texture
• The pH and amount of excess ammonia in UAN is important

• “Thin UAN films” in tanks, pipelines and rail cars allow for rapid “surface corrosion” and produces lots of rust sludge!

How might this be applicable to your business?
In a full rail car: The air in the car is saturated with NH3 vapor.

In an empty rail car: The fresh air pulled into the car when emptied must re-establish equilibrium vapor pressure using NH3 available from the thin film on the tank wall.

What about storage tanks?
“Thin UAN Film” Sludge Generation and Pitting Corrosion in UAN Tanks

UAN corrodes carbon steel by two different mechanisms:

- **“Thin Film” or “Surface” Corrosion** occurs on the vertical tank walls and generates iron sludge that falls to the tank bottom.

- **Under Deposit Corrosion** develops when iron sludge falls to the tank bottom and collects in low spots.

This is why corrosion is usually minor on the vertical tank walls and is most severe on the tank bottom.
## What Makes UAN Corrosive?

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &amp; excess NH₃ are too low</td>
<td>Minimum pH: 7.0</td>
</tr>
<tr>
<td></td>
<td>Minimum NH₃: 0.05 % (500 ppm)</td>
</tr>
<tr>
<td>Temperatures that are too high or too low</td>
<td>Keep tank between 40-100°F if possible</td>
</tr>
</tbody>
</table>
Example From Actual Conditions In A Real UAN Storage Tank

8 Days In UAN32 With % Excess NH3 @ 0.003 And Tank Temperature @ 150 Deg. F.

The conditions here would “burn through” 2 inches of steel in one year!

Let me show you more how temperature can affect pH & corrosivity
UAN pH Is A Function of Temperature

Non-Inhibited UAN 32 (actual pH will also vary as a function of excess NH3 content)

<table>
<thead>
<tr>
<th>UAN Temp (F)</th>
<th>Med pH 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>7.00</td>
</tr>
<tr>
<td>77</td>
<td>6.84</td>
</tr>
<tr>
<td>86</td>
<td>6.69</td>
</tr>
<tr>
<td>104</td>
<td>6.40</td>
</tr>
<tr>
<td>122</td>
<td>6.13</td>
</tr>
<tr>
<td>140</td>
<td>5.88</td>
</tr>
<tr>
<td>158</td>
<td>5.64</td>
</tr>
<tr>
<td>138</td>
<td>5.82</td>
</tr>
<tr>
<td>120</td>
<td>6.30</td>
</tr>
<tr>
<td>100</td>
<td>6.50</td>
</tr>
<tr>
<td>82</td>
<td>6.80</td>
</tr>
<tr>
<td>73</td>
<td>6.90</td>
</tr>
<tr>
<td>70</td>
<td>6.95</td>
</tr>
</tbody>
</table>

- Note that the pH **drops** as Temperature increases
- However, the pH **increases** again as the UAN cools
- Why does this happen?

**Because the ammonium nitrate “dissociates” to a strong acid and a weak base:**

\[
\text{NH}_4\text{NO}_3 \rightleftharpoons \text{NH}_4^+ + \text{NO}_3^- \\
\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+ \\
\text{H}^+ + \text{NO}_3^- \rightleftharpoons \text{HNO}_3 \text{ (Nitric Acid)}
\]

So why is this important to liquid fertilizer dealers?
Effect of Temperature on UAN Corrosivity

**Actual pH** *(will vary slightly as a function of the amount of excess NH3 and heating rate)*

<table>
<thead>
<tr>
<th>UAN Temp (F)</th>
<th>Low pH 6.7</th>
<th>Med pH 7.0</th>
<th>Hi pH 7.5</th>
<th>Very High pH 8.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>6.70</td>
<td>7.00</td>
<td>7.50</td>
<td>8.00</td>
</tr>
<tr>
<td>77</td>
<td>6.54</td>
<td>6.84</td>
<td>7.34</td>
<td>7.84</td>
</tr>
<tr>
<td>86</td>
<td>6.39</td>
<td>6.69</td>
<td>7.19</td>
<td>7.69</td>
</tr>
<tr>
<td>104</td>
<td>6.10</td>
<td>6.40</td>
<td>6.90</td>
<td>7.40</td>
</tr>
<tr>
<td>122</td>
<td>5.83</td>
<td>6.13</td>
<td>6.63</td>
<td>7.13</td>
</tr>
<tr>
<td>140</td>
<td>5.58</td>
<td>5.88</td>
<td>6.38</td>
<td>6.88</td>
</tr>
<tr>
<td>158</td>
<td>5.34</td>
<td>5.64</td>
<td>6.14</td>
<td>6.64</td>
</tr>
</tbody>
</table>

**Severe Corrosion Activation pH**

<table>
<thead>
<tr>
<th>Metal Type</th>
<th>UAN 32</th>
<th>UAN 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>A36 Welds</td>
<td>6.60</td>
<td>6.95</td>
</tr>
<tr>
<td>A36 Plate</td>
<td>5.75</td>
<td>6.10</td>
</tr>
</tbody>
</table>

**Storage Type**

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Typical Storage Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Tank</td>
<td>40-122 ºF</td>
</tr>
<tr>
<td>Rail Car</td>
<td>Cold to 140 ºF</td>
</tr>
</tbody>
</table>

**What Can You Do?**

- Consider the pH & Excess ammonia sales specification of your supplier
  - How good is their QC program?
  - How often do they test and what do they test?
  - Test incoming product yourself
- We recommend light colored storage tanks
- Prevent ammonia loss through proper tank venting

*What else is important for managing UAN corrosion?*
# What Makes UAN Corrosive?

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &amp; excess NH₃ are too low</td>
<td>Minimum pH: 7.0</td>
</tr>
<tr>
<td></td>
<td>Minimum NH₃: 0.05 % (500 ppm)</td>
</tr>
<tr>
<td>Temperatures that are too high or too low</td>
<td>Keep tank between 40-100°F if possible</td>
</tr>
<tr>
<td>UAN 28 and dilute UAN solutions</td>
<td>Where ever possible, avoid long term storage of UAN 28</td>
</tr>
</tbody>
</table>
16% Nitrogen UAN is MUCH more corrosive than 32% Nitrogen UAN.

This is because the increased water content of UAN16 allows for increased ion formation:

\[
\begin{align*}
\text{NH}_4\text{NO}_3 & \leftrightarrow \text{NH}_4^+ + \text{NO}_3^- \\
\text{NH}_4^+ & \leftrightarrow \text{NH}_3 + \text{H}^+ \\
\text{H}^+ + \text{NO}_3^- & \leftrightarrow \text{HNO}_3 \text{ (Nitric Acid)}
\end{align*}
\]

Non Inhibited UAN 16

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Temp (°F)</th>
<th>UAN 16 Corr. Rate* (MPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.7</td>
<td>62.06</td>
<td>0.1</td>
</tr>
<tr>
<td>17.4</td>
<td>63.32</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>0.1</td>
</tr>
<tr>
<td>50.7</td>
<td>123.26</td>
<td>48.1</td>
</tr>
<tr>
<td>72.4</td>
<td>162.32</td>
<td>59.2</td>
</tr>
<tr>
<td>74.3</td>
<td>165.74</td>
<td>79.2</td>
</tr>
<tr>
<td>78.7</td>
<td>173.66</td>
<td>99.9</td>
</tr>
<tr>
<td>91.6</td>
<td>196.88</td>
<td>99.9</td>
</tr>
<tr>
<td>102.3</td>
<td>216.14</td>
<td>99.9</td>
</tr>
<tr>
<td>100.6</td>
<td>213.08</td>
<td>99.9</td>
</tr>
<tr>
<td>81.4</td>
<td>178.52</td>
<td>99.9</td>
</tr>
<tr>
<td>69.3</td>
<td>156.74</td>
<td>99.9</td>
</tr>
<tr>
<td>63</td>
<td>145.4</td>
<td>58.3</td>
</tr>
<tr>
<td>59.1</td>
<td>138.38</td>
<td>58.3</td>
</tr>
<tr>
<td>54</td>
<td>129.2</td>
<td>58.3</td>
</tr>
<tr>
<td>51</td>
<td>123.8</td>
<td>58.3</td>
</tr>
<tr>
<td>47.9</td>
<td>118.22</td>
<td>39.2</td>
</tr>
<tr>
<td>44.9</td>
<td>112.82</td>
<td>39.2</td>
</tr>
<tr>
<td>41.5</td>
<td>106.7</td>
<td>39.2</td>
</tr>
<tr>
<td>40</td>
<td>104</td>
<td>44.3</td>
</tr>
<tr>
<td>31</td>
<td>87.8</td>
<td>23.0</td>
</tr>
</tbody>
</table>

Note that at roughly the same temperature of 124 °F (51 °C) the corrosivity of UAN 16 is approx. 35-40 times more corrosive than UAN 32!

What Can You Do?

- Avoid storing dilute UAN solutions
- Be careful about leaving rinse water in tanks

What about UAN 28?
UAN 28 is about 20% more corrosive than UAN 32

This is because the increased water content of UAN 28 allows for increased ion formation:

\[
\text{NH}_4\text{NO}_3 \iff \text{NH}_4^+ + \text{NO}_3^- \\
\text{NH}_4^+ \iff \text{NH}_3 + \text{H}^+ \\
\text{H}^+ + \text{NO}_3^- \iff \text{HNO}_3 \text{ (Nitric Acid)}
\]

<table>
<thead>
<tr>
<th>Non Inhibited UAN 32</th>
<th>Non Inhibited UAN 28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>32% Temp (°C)</strong></td>
<td><strong>32% Temp (°F)</strong></td>
</tr>
<tr>
<td>23.1</td>
<td>73.6</td>
</tr>
<tr>
<td>23.5</td>
<td>74.3</td>
</tr>
<tr>
<td>57.8</td>
<td>136.0</td>
</tr>
<tr>
<td>73.5</td>
<td>164.3</td>
</tr>
<tr>
<td>93.8</td>
<td>200.8</td>
</tr>
<tr>
<td>102.8</td>
<td>217.0</td>
</tr>
<tr>
<td>90</td>
<td>194.0</td>
</tr>
<tr>
<td>68.8</td>
<td>155.8</td>
</tr>
<tr>
<td><strong>50.7</strong></td>
<td><strong>123.3</strong></td>
</tr>
<tr>
<td>46.4</td>
<td>115.5</td>
</tr>
<tr>
<td>39.5</td>
<td>103.1</td>
</tr>
</tbody>
</table>

*As measured per the Nalco Corrosion Monitor Probe

Note that at roughly the same temperature of 124 °F (51 °C) the corrosivity of UAN 28 is approx. 20% more corrosive than UAN 32!

**What Can You Do?**

- Where possible, avoid storage of UAN 28 and other dilute UAN solutions
## What Makes UAN Corrosive?

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &amp; excess NH₃ are too low</td>
<td>Minimum pH: 7.0&lt;br&gt;Minimum NH₃: 0.05 % (500 ppm)</td>
</tr>
<tr>
<td>Temperatures that are too high or two low</td>
<td>Keep tank between 40-100°F if possible</td>
</tr>
<tr>
<td>UAN 28 and dilute UAN solutions</td>
<td>Where ever possible, avoid long term storage of UAN 28</td>
</tr>
<tr>
<td>Corrosion sludge</td>
<td>Clean tanks annually if possible</td>
</tr>
</tbody>
</table>
Corrosion Sludge Is What Leads To Serious Pitting Damage

Clean Your Storage Tanks Annually

Sludge comes in via railcars

Sludge & Oil in tanks

Sludge forms in tanks

Severe pitting

Pitting occurs under sludge

Rail car sludge and urea salt

Tramp Oil

Pitting is worse in “HAZ”
Electro-chemical Description of Pitting Corrosion in UAN

At Heat Affected Zone

$\text{Fe}^{+2} \rightarrow \text{Fe}^{+3}$ (occurs in crevices)

$\text{Fe}^{+3} + 3\text{H}_2\text{O} \rightarrow \text{Fe(OH)}_3 + 3\text{H}^+$

In Solution

$\text{NH}_4\text{NO}_3 \rightarrow \text{NH}_4^+ + \text{NO}_3^-$

$\text{NO}_3^- + \text{H}^+ \rightarrow \text{HNO}_3$

The $\text{H}^+$ can’t diffuse out of the crevice fast enough. To remain electrically neutral, $\text{NO}_3^-$ ions come in and in effect make Nitric Acid resulting in low pH inside the crevice, resulting in a pit.

There is plenty of $\text{NO}_3^-$ in the wetted sludge layer.
## What Makes UAN Corrosive?

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &amp; excess NH3 are too low</td>
<td>Minimum pH: 7.0</td>
</tr>
<tr>
<td></td>
<td>Minimum NH$_3$: 0.05 % (500 ppm)</td>
</tr>
<tr>
<td>Temperatures that are too high or too low</td>
<td>Keep tank between 40-100°F if possible</td>
</tr>
<tr>
<td>UAN 28 and dilute UAN solutions</td>
<td>Where ever possible, avoid long term storage of UAN 28</td>
</tr>
<tr>
<td>Corrosion sludge</td>
<td>Clean tanks annually if possible</td>
</tr>
<tr>
<td>Empty spaces with UAN heels or residuals</td>
<td>Never leave a tank or pipe with a small heel of UAN especially in summer</td>
</tr>
</tbody>
</table>
Dilute, Low Ammonia UAN Solutions Are Very Corrosive

- *Don’t leave “a few inches” of UAN in tanks*
  - Especially in winter
- Never leave small puddles of UAN
  - Empty & water wash the floor thoroughly
- *Avoid “air blow” of carbon steel UAN pipeline*
  - Water flush pipes well then air blow
- Pre-treat idle or newly repaired tank bottoms with an appropriate passivator
Nalco UAN Pre-Treatments for storage tanks, barges and rail cars helps prevent corrosion under severe conditions and maintain color and clarity.

This photo was taken at 45 days.
Nalco UAN Pre-Treatments
for storage tanks, barges and rail cars helps prevent corrosion
under severe conditions and maintain color and clarity

UAN heel in rail car NOT pre-treated

UAN heel in railcar pre-treated with a Nalco Pre-Treatment product

What about coatings?
A Word About Tank Coatings

- Various coatings have been applied to UAN tanks and even UAN rail cars for years
  - They can help minimize the impact of some major pH, temperature or poor corrosion inhibition events
  - They may also give a false sense of security
- Must be applied to clean surface floor & wetted side wall
- Coatings *almost always have “life” issues*
  - Any coating failure focuses the corrosivity of the entire tank on a small area

After sandblasting failed coatings often reveal **severe** corrosion

What about added chemical corrosion inhibitors?
Purchasing UAN from multiple sites, may result in mixed inhibitors

- The 3 dominant UAN corrosion inhibitor manufacturers in North & South America use very different chemistries
- If mixed, these different inhibitors, (now each diluted), are not as effective together as they are by themselves when at full strength

Purchasing quality UAN from one trusted source may be worth a little extra in price

- Price is important but look closely at the quality of the UAN you are buying
- Consider the value of the assets that will be exposed to that product
## What Makes UAN Corrosive?

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &amp; excess NH₃ are too low</td>
<td>Minimum pH: 7.0</td>
</tr>
<tr>
<td></td>
<td>Minimum NH₃: 0.05 % (500 ppm)</td>
</tr>
<tr>
<td>Temperatures that are too high or</td>
<td>Keep tank between 40-100°F if possible</td>
</tr>
<tr>
<td>too low</td>
<td></td>
</tr>
<tr>
<td>UAN 28 and dilute UAN solutions</td>
<td>Where ever possible, avoid long term storage of UAN 28</td>
</tr>
<tr>
<td>Corrosion sludge</td>
<td>Clean tanks annually if possible</td>
</tr>
<tr>
<td>Empty spaces with UAN heels or</td>
<td>Never leave a tank or pipe with a small heel of UAN especially in summer</td>
</tr>
<tr>
<td>residuals</td>
<td></td>
</tr>
<tr>
<td>Lack of a quality chemical</td>
<td>- Buy from trusted supplier(s)</td>
</tr>
<tr>
<td>inhibitor @ the proper dose</td>
<td>- Ask about inhibitor program</td>
</tr>
<tr>
<td></td>
<td>▪ <em>If you don’t ask, they won’t care</em></td>
</tr>
</tbody>
</table>
• UAN corrosion Inhibitors are relatively inexpensive and most are easy to handle and safe to work with
• Depending on your source of UAN and inhibitor package, treat costs will vary from $0.20 to $0.60 per ton of UAN treated
• Do not add petroleum oil to any UAN tank, car, truck, or pipe
• **UAN corrosion inhibitor choice matters**
  – If a producer has coated tanks and rail cars and stainless steel piping, corrosion inhibitor quality may not be a high priority
Test Conditions: 5.3 pH, 50 C, @ 7 Days, UAN 32

Untreated

Competitive Inhibitor

Competitive Inhibitor

Nalco NITROsolve 220 @ 108 ppm
Test Conditions: 5.3 pH, 50 C, @ 7 Days, UAN 32

But added corrosion inhibitors **cannot** stop all UAN corrosion, **manufacturer** quality counts!
UAN manufacturing involves many complicated, problematic and continuous processes and UAN is the last step.

Methane $\rightarrow$ $H_2 + CO_2$

$H_2 + N_2 \rightarrow NH_3$

$NH_3 \rightarrow NOx \rightarrow \text{Nitric Acid} + NH_3 \rightarrow AN$

$CO_2 + NH_3 \rightarrow \text{Urea}$

$AN + \text{Urea} + NH_3 \rightarrow UAN$

Issues w/ the NH3 Plant?

Is enough urea available?

How much excess NH3?

Is on-line pH control accurate?

Is lab sample testing sufficient?

Trimming pH w/ excess nitric acid?

How much NH3 recycle is coming back from the AN plant?

How much excess NH3?

How much AN vs. Urea?

Temperature and pH?

Circulation?

Sludge buildup?

Shut downs & start ups
Grab Samples Vs On-line Monitoring

- Most UAN Producers sample newly produced UAN via grab samples taken every few hours
- Those samples are often taken only from the large final storage tanks
- Short term upsets can go undetected

- So we introduced a new way to monitor and manage UAN quality using On-line Technology

- Nalco adapted our core 3DTRASAR Technology for use with manufacture of UAN
  - TRASAR technology has been used in cooling water applications for more than 20 years
3D Trasar for UAN

- Controls or Monitors
  - Corrosion Inhibitor Dosage
- Monitors:
  - pH
  - Temperature
  - Corrosivity
- Logs, Alarms and Reports all data wirelessly to the producer
- Helps the plant identify root causes of operational problems so they don’t get to you
Continuous monitoring offers a step change over periodic laboratory spot checks or mass balance calculations in maintaining target inhibitor treatment dosage and good pH control.

**Before**
- Erratic treatment control
- pH fluctuations

**After**
- Consistent inhibitor dosage
- Fewer, less severe acidic events

But these swings “equal out” in the storage tank...
Highs & Lows DON’T always “even out” in the storage tank

In addition, we have also introduced on-line nitrogen content measurement
This same technology may be applied to the addition of water to UAN 32 to create UAN 28
UAN Corrosion Management Summary

- UAN Corrosion creates **real risk** to your company, your employees and your community
- Liquid fertilizer dealers must **manage** this risk
- Don’t assume that all the liability will be your supplier’s problem
- You can take **effective** steps to minimize this risk!

**Thank You For Your Time!**

Phil Bureman
Nalco Sr. Industry Technical Consultant
Olathe, KS
Cell: 913-708-4969
E-mail: pebureman@nalco.com