Production Chemistry and the challenges in foam applications

Gert de Vries, Production Chemist
NAM
NAM, who, what, where

40 nationalities and a large number of areas of expertise

+/- 1800 staff
Where is the gas produced?

- The Netherlands have one of the largest gas fields of Europe: the Groningen field.
- Some 175 small gas fields in production.
- Over 50% of all natural gas reserves of the European Union is produced from Dutch territory.
Total gas production in 2006
The Netherlands: 67 bcm (2300 bscf)

- NAM: 80%
  - Groningen field: 47%
  - NAM offshore: 14%
  - Competitors: 24%
  - Rest NAM onshore: 15%

The “small fields” are producing half of the national gas production.
Total oil production in the Netherlands in 2006: 10 mln barrels

1 barrel = 0.159 m³ = 159.2 liter

Source: MinEZ/NAM
Foam application is very successful

Yearly Gains from Batch & Continuous Foam

- Batch Foam
- Continuous Foam
- Cumulative Gains

2003 2004 2005 2006 2007 2008 EST

Billion scf Gas

<table>
<thead>
<tr>
<th>Year</th>
<th>Batch Foam</th>
<th>Continuous Foam</th>
<th>Cumulative Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>2004</td>
<td>0.32</td>
<td>0.46</td>
<td>0.78</td>
</tr>
<tr>
<td>2005</td>
<td>1.27</td>
<td>1.62</td>
<td>2.29</td>
</tr>
<tr>
<td>2006</td>
<td>1.20</td>
<td>2.22</td>
<td>3.51</td>
</tr>
<tr>
<td>2007</td>
<td>4.03</td>
<td>4.56</td>
<td>8.57</td>
</tr>
<tr>
<td>2008 EST</td>
<td>7.06</td>
<td>3.53</td>
<td>10.59</td>
</tr>
</tbody>
</table>
Production Chemistry in NAM’s foam team

Responsible for:

• Product specifications
• Test procedures
• Selection of products
• Monitoring well fluid composition
• Technology improvement
Product specifications

Product specifications are made to ensure that foam products meet NAM’s HSE, legal, technical and performance criteria.

Pie charts indicate the number of applied products and changes due to the product specifications.
Product specifications

List of technical specifications (beside economics)

- Stability between –20 and 40°C (-4 – 104 F)
- Compatible with produced fluids
- Thermal stable for whole application
- Non-corrosive
- Good foam performance for all wells
  (salinity and hydrocarbon tolerance)
- Additional spec’s for offshore application
- Availability of a good anti-foam
- other spec’s
Stability (1)

Stability between –20 and 40°C:

solids drop out during storage

Top view in storage container
Stability (2)

Stability between –20 and 40°C

phase separation after cooling down to -18°C
Stability (3)

Stability between –20 and 40°C

phase separation after storage
Compatibility (1)

Compatible with produced fluids (no solids generation)

Solids create problems in facilities and may block our water disposal well
Compatibility (2)

Compatible with produced fluids (no emulsions)

Emulsion create problems in our treatment and water disposal facility
Compatibility (3)

Compatibility problems between foam products (change-out of products)

solids drop-out create problems on performance and blockage in a continuous application
Thermal stability at down hole conditions

Thermal stable up to 130°C (266 F)

Instability may give performance and corrosion problems
Corrosion towards materials in the continuous foam application

No corrosion towards 9Cr-1Mo steel

9Cr-1Mo is part of the subsurface assembly in the continuous foam application, which cannot be replaced
Performance test

Foam test performed at 90 °C (194 F)

Foam build-up time

Foam half-life time
### Test results interpretation

#### Foam build-up time

<table>
<thead>
<tr>
<th>Foam build-up time (s)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 80 s</td>
<td>good</td>
</tr>
<tr>
<td>80 &lt; x &lt; 120</td>
<td>moderate</td>
</tr>
<tr>
<td>&gt; 120</td>
<td>poor</td>
</tr>
</tbody>
</table>

#### Foam half-life time

<table>
<thead>
<tr>
<th>Foam half-life time (s)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 180</td>
<td>good</td>
</tr>
<tr>
<td>60 &lt; x &lt; 180</td>
<td>moderate</td>
</tr>
<tr>
<td>&lt; 60 s</td>
<td>poor</td>
</tr>
</tbody>
</table>
Good foam performance in low to high salinity water

<table>
<thead>
<tr>
<th>Chlorides (mg/l)</th>
<th>low salinity</th>
<th>medium salinity</th>
<th>high salinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5000</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>5000 - 100,000</td>
<td>moderate</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>&gt; 100,000</td>
<td>poor</td>
<td>moderate - poor</td>
<td>moderate - poor</td>
</tr>
</tbody>
</table>

- Product A: good, good, good
- Product B: moderate, poor, poor
- Product C: good, moderate, poor
- Product D: poor, poor, good
- Product E: good, moderate - poor, moderate - poor
## Good foam performance in presence of condensates

<table>
<thead>
<tr>
<th>Vol% condensate</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product A</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Product B</td>
<td>good</td>
<td>moderate-poor</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>Product C</td>
<td>good</td>
<td>moderate-poor</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>Product D</td>
<td>good</td>
<td>moderate</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>Product E</td>
<td>good</td>
<td>moderate</td>
<td>moderate</td>
<td>poor</td>
</tr>
</tbody>
</table>
Performance foam products

Lab tests vs. field trials

- Match: 65%
- Close: 14%
- No match: 21%
Challenge for offshore applications

Meeting legal requirements (North Sea):

- Permits for chemical foam products
- WOB discharge limit of 30 mg/l mineral oil

Oil in water increases after batch foam trial in North Sea area

- Legal limit for Oil in WOB
Challenge for offshore applications

Additional Lab tests show as well an increase in oil in water.

Other products (water clarifiers) may help solving this problem.

Affect on Oil in Water
different foam products and dose rates

- baseline: 2500 ppm
- 2500 ppm product x
- 5000 ppm product x
- 5000 ppm product z

OIW (mg/l)

- oil in water
- legal limit for Oil in WOB

Performance anti foam products

Without a good anti-foam, foam products cannot be applied

no re-foaming
Where do we work on (our wish list):

- More foam products that meets the specifications
- Foam products that not affect the oil in water (or a package of products to achieve the OIW limits)
- Foam/corrosion-inhibitor combo products (additional spec’s)
- Anti-foam products that meet the specifications
Summary

• Specifications for foam and anti-foam products are key in avoiding operational problems and ensuring good performance. Performance specifications can be supplied on request.

• Performance tests
  – Lab tests are representative in screening products for field trials
  – Test foam products on produced fluids from candidate well to ensure maximum success in field trials (salinity, hydrocarbon tolerance)

• The Foam product has shown to affect the oil in water content

• Ensure your anti-foam is working in combination with the applied foam product

• Steer to the chemical service industry for NAM:
  – More products which meet the specifications
  – Products (or package of products) which do not influence the oil in water quality and meet the legal requirements for Offshore.
Many thanks to:

NAM’s foam team

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