Implementation of foam in the North Sea

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Colorado is 6.5 times bigger than NL

In NL 3.6 times more citizens
• NAM operates most of the Gas fields in the Netherlands

• Yearly (2009) production of approx 70 BCM (2.5 TCF)

• Over 50% of all natural gas reserves of the European Union
NAM wells

• +/- 400 wells onshore
• +/- 300 wells offshore
• Typical tubing sizes 3 ½ ″, some 5″ or even 7″
• Liner sizes are between 4 ½ ″, 7″ and 9 5/8″
• All wells have SSSV’s (on and offshore)
• All wells have packers
• Typical reservoir depth is approx 10000 ft
• Mainly sand stone and some carbonate reservoirs

• Most small fields are mature and suffer from LL
Gains achieved with foam

Yearly gains from Batch & Continuous FOAM

- Offshore Continuous foam
- Offshore Batch foam
- Onshore Continuous Foam
- Onshore Batch Foam

Million Nm³ Gas

BCF Gas

2003 2004 2005 2006 2007 2008 2009 2010 2011

3.5
7
10.5

More than 30% of total 300 gas wells are currently liquid loading. GWD can increase ultimate recovery by 1-10%.

Southern North Sea (NL and UK)

ONEgas West (UK)

ONEgas East (NL)
Challenges applying foam Offshore

- **Normal product requirements as onshore**
  - performance, stability, corrosiveness, antifoam

- **Additional requirements**
  - Minimum impact on oil in water
  - Minimum impact on water in natural gas condensate

- **Permits/product registration**
  - CEFAS/MSDS/Toxicity
  - Location permit
Initial Batch treatments Offshore

Foam treatments 2008/2009

- Approx 20 wells batch treated
- Looking at production increase, foam was applied successfully

![Bar chart showing gas flowrate gain before and after foam treatment for Well A (batch), Well B (batch), and Well Continuous.](image-url)
Side effect Batch Foam treatments

Offshore location UK: 2009 av. Oil in Water (OIW)

- **Av. OIW (mg/L)**
- **Legal limit (30 mg/L)**
- **Water discharged (m³/day)**

Time (days):
- 4-Apr-09
- 5-Apr-09
- 6-Apr-09
- 7-Apr-09
- 8-Apr-09
- 9-Apr-09
- 10-Apr-09
- 11-Apr-09
- 12-Apr-09
- 13-Apr-09
- 14-Apr-09
- 15-Apr-09
- 16-Apr-09
- 17-Apr-09
- 18-Apr-09
- 19-Apr-09
- 20-Apr-09
- 21-Apr-09
- 22-Apr-09
- 23-Apr-09
- 24-Apr-09
- 25-Apr-09
- 26-Apr-09
- 27-Apr-09
- 28-Apr-09
- 29-Apr-09
- 30-Apr-09

Oil in Water (OIW) (mg/L):
- Trail begins
- Trial ends

Legal limit (30 mg/L)

Water discharged (m³/day)

Legal limit (30 mg/L)
Mitigation strategy for OIW

Water clarifier selected to overcome OIW issues

- Tests using fluid from the field
- Screened chemical → selected best fit
- Field trial → chemical tested on location by dedicated field engineer
Is there a differentiator between foamers

Surface injection trial (2010)

- Main location with water disposal well
- 4 different foam products
- Water production and Oil in water was monitored
Effect on OIW vs foam product

Surface injection trial (2010)

- Each Foam product was injected at 2 rates
- All affected the oil in water, there is a minor difference
- Effect on OIW is dependent on concentration of foam

![Oil in water over board during foam trial](chart.png)

Oil in water over board during foam trial
(samples taken after trial with foam product @ 25 and 50 l/d)

- Product a
- Product b
- Product c
- Product d
- Historic average
Effect of foam on centrifuge performance

Surface injection trial (2010)

- Centrifuge baseline efficiency approx 95%
- All foamers reduced centrifuge efficiency

![Bar chart showing centrifuge efficiency at approx 125 ppm foam](chart.png)
Approx 30% of total 300 gas wells are liquid loaded

Screening of wells identified best deliq solution

- Velocity string selected for approx 50%
- Continuous foam for the other 50%
  - OIW is affected by foam
  - Water disposal wells identified as most reliable option
  - Further investigation (lab) on effect different foam products
Deliquification project Offshore

Wells where continuous foam identified as best deliquification technique
Deliquification project Offshore

- Offshore:
  - Isolated foam flow path
  - No corrosion risk
  - Less restriction on foam product selection
  - One injection valve
  - Higher equipment cost

- Land:
  - Uses existing SSSV control line
  - Two injection valves
Deliquification project Offshore

Standardized Foam injection system

Size of system is approx 4 x 4 x 4 ft
Deliquification project  Offshore

First well running with new developed foam delivery system

- Successful foam application
- Water production increased (future handling under discussion)
- Water disposal well became unavailable
- Limited foam injection rate reduced production

![Graph showing FTHP (bar), FTHT (°C), Foam injection (l/h)]

Deliquification project  Offshore

Extra OIW data due to unavailable disposal well
SUMMARY

• Foam can be applied extremely successfully Offshore
• Foam (anti-foam) impact on oil in water
• A continuous foam injection allows better control of the oil in water
• Application is limited to locations with produced water re-injection wells (further study will done)
• Standardisation of hardware reduce costs
• Deliquification may create problem with water handling capacity
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