Southern North Sea De-Liquification Experience

Daniel Diaz  Nadim Kassan
Adam Beck    Renee Omsberg
Jennifer Herrera  Alan Bruce
Agenda

- SNS in brief
- Introduction
- SNS Experience with Deliquification Technology
  - Well cycling program
  - Velocity strings
  - Water Shut-off
  - Foam injection
  - Reducing THP
- The Importance of Data Acquisition
- Update 2007
- Knowledge Sharing
- Looking at the future
25 fields
40 platforms (29 NUI)
3 major pipelines
139 wells ~ 100 active
Gas - declining Qg ~ 1 BCF/d (gross)

- THP (95%)
- BHP (12%)
- Test Facilities (67%)
SNS Challenges & Opportunities

CHALLENGES
- Blending need
- Facility / location constraints
- Measuring issues
- Screened wells
- Mixed high / low Pr
- Water loading
- Cyclic production
- Sanding problems
- Tight sands
- Salt plugging
- Ageing infrastructure
- Others: Hydrates formation

OPPORTUNITIES
- 3rd party transport
- Good reservoirs
- Infill drilling
- De-watering
- Slow decline
- Stimulation
- New fields

*
<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>NAM (x Groningen)</th>
<th>CoP SNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas wells</td>
<td>200000</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td>Liquid loading, %</td>
<td>90</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Qg typical, Mcf/d</td>
<td>53-529</td>
<td>353-3530</td>
<td>800-12000</td>
</tr>
<tr>
<td>% Production</td>
<td>40</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Location</td>
<td>Onshore</td>
<td>Offshore</td>
<td>Offshore</td>
</tr>
<tr>
<td>Technology status</td>
<td>Mature</td>
<td>Evaluation</td>
<td>Evaluation</td>
</tr>
</tbody>
</table>

Sources: Veeken et al., Shell (SPE 16-17 Jun 2003)/ COP 2006
North Sea Challenges & Motivators

CHALLENGES
- Unmanned platforms
- Measuring issues
- Limited weight/space
- Completion type/size
- Environmental concerns
- Facilities capability
- Harsh weather
- Sand/salt production
- ROCE

MOTIVATORS
- "Appetite" for Gas
- Many in same situation
- Sustainable Production

Major Hurdles:
- Liquid/Gas Measurement
- DHSV

Major Motivator:
- $, £, €, No Kr
- Problem will worsen with time
Conventional Options

- Foam/Soap treatments
- Velocity strings
- Well cycling
- Water shut-off
- Gas lift
- Plunger lift
- Jet pump: bottom or surface
- Downhole pumping
- Downhole separation & disposal
- Downhole compression
- THP reduction/Compressor re-wheeling
- Other...

CRITERIA:
Applicability
Timeframe
Cost effective
The majority of our unavailable wells are due to an inability to lift fluid to surface – and the following have been used to enhance production to date:

- Well Cycling Program
- Velocity Strings
- Water Shut Off
- Foam Injection – in progress
Well Cycling Program

Static Cycling
• Wells on for X days then off for Y Days
• Required manual monitoring by CROs
• Little ability to optimise

Automated Off-cycling – 2005/06
• Recently added automation to shut in based on minimum WHT constraints
• Offtime still fixed number of days
• Allowed CROs to concentrate on other duties

Next Improvements 2008
• Shut in controlled by delta T rather than fixed minimum T (using VO/daily monitoring) ??
• Reposition gauges to allow for P based reopening condition

VO: Virtual Operator
Velocity Strings

Velocity String Campaign 2003

• 3 low rate wells and tubing sizes of 4.5”-5.5” were installed with 2 3/8” velocity strings.
  – Deployment using CT Injector head proved to be a success
  – Velocity strings were hung below the DHSV
  – Well was killed using fluid which was then displaced with Nitrogen into the formation
Velocity Strings

Velocity String Campaign 2003

- Wells did not initially return to production
  - Fluid pushed into the formation
- One well had the flowline removed before any production was observed so velocity string performance unknown
- One well showed no real improvement from pre velocity string performance
- One well had successful velocity string (even though it was only installed from the SSSV down!)
Velocity Strings - Future 2008

- Logistical challenges make velocity strings a very expensive and difficult operation → must identify good candidates
  - Good Gp/GIIP
  - High Peak rate, Qg
  - Still stable producer/good on rate
- Method of installing should be improved over 2003 velocity strings
  - No kill fluid & Velocity string to surface
  - Method to kick off if liquid loaded? Foaming??
Water Shut-off Attempts

- Inflatable Bridge Plugs & Cement (still in use)
  - Limited applicability - only aquifer drive
  - Temporary solution only

- Relative Permeability Modifier Trial (2003)
  - For reservoirs with commingled water/condensate/gas producing perforations
  - No significant success
  - Needs significant research, and somewhat risky
Batch Foamer Injection

Foamer Trial Oct 2006

• Candidate wells were known liquid loaders
  – results indicate significant water production increase
  – Marginal increases in gas rate
  – No discernable increase on time online

• Results of the trial were inconclusive
Batch Foamer Injection

Foamer Trial June 2007

- Candidate wells known/suspected liquid loaders
- Echometer used to determine liquid level
  - results indicate significant water production increase
  - Marginal increases in gas rate
  - No discernable increase on time online
- Echometer data slow to analyse
- Missed best candidate
Batch Foamer Injection

Foamer Trial June 2007

Results Summary

– Six wells foam treated. Best response in better candidate (higher above loading rate)
– Dead well flowed for some time, unloaded significant liquids
– The other four wells showed limited or no noticeable response
• Foam does help remove water from wells
• Candidate wells need to be identified with strict criteria
• Principal use should be for starting wells not for removing water from cycling wells
• May have longer term application using capillary string - continuous
Reducing THP

- **Surface Jet Pump** – *2004/05*
  - Installed Jet Pump that allows **substantial** 
P_suction reduction
  - Experience & “know how” acquired
  - Proved production results
  - Requires high pressure gas as driver
- **Compressor Re-Wheeling** - *2005*
  - Maximise compressor usage
  - Minimise suction pressure
- **Choke changes** – *2005/6*
  - Minimise/eliminate pressure drop across choke
Reducing THP

- **Wellhead Compression -2003/07.** Technology reviewed but nodal analysis showed that only downhole compression may add further production to Jet Pump results.
  
  Challenge: energy supply – eolic/ solar / wave/ Combination?

- **Downhole Compression 2007.** Current status of technology does not allow thru tubing implementation.
  
  Challenge: energy supply, wireline deployment.
  Technology holds promise for future

- **Onshore Compression. 2007** Viable when off/onshore distance is relatively short
Measuring Initiatives 2006 *

Liquid loading candidate selection greatly depends on individual well data availability

- Investigating Multiphase Metering:
  - Portable, light, easy to connect
- Wireless/Remote Pressure Gauge Sensors
  - Bottomhole & Wellhead
- Liquid Level Measurement
  - Echometer/ Sonolog
Improved data interpretation/acquisition
- **Low cost metering:**
  - Wireless gauges identified
  - Maintenance of existing measuring equipment
- **Reviewed multiphase metering options:**
  - Non intrusive clamp on: Ultrasonic- Dry gas only
  - Non intrusive Nucleonics: requires use of tracers (access)
  - Intrusive: Several alternatives, require careful maintenance, expensive, space consuming, rate limited
- Investigating innovative technologies potential
Measuring Initiatives 2007

- **Echometer:**
  - Echometers maintained and tuned up
  - Training course: offshore operators, production & reservoir engineers
  - Run some cases,
  - Developing experience, learning curve
  - Established cooperation with Echometer
Update 2007

- Breaking the DHSV barrier via R&D:
  - Co-sponsoring Torus SSSV – 2 7/8” API certified
  - Sponsoring Innovative Dewatering Pump
  - Interested in Composite Capillary Strings
- Got management support – awareness & capital

CHALLENGES:
Costs
Human Resources:
  - availability
  - high turnaround
  - project continuity
Knowledge Sharing / Cooperation

- **Internal:**
  - Corporate: Network of Excellence Intranet sites
  - Local: common folders

- **Partners & Other Peer Operators:**
  - BP: Gas Well Deliquification "Network"
  - Conferences like this

- **Service companies:**
  - COP SNS Technology Day
Looking at the Future

Great need for innovative technology development
- Improved data interpretation/acquisition
  - Low cost metering
  - More automation
- Breaking the DHSV barrier
  - Innovative Pumps
  - Offshore Plunger Lift
  - Capillary Strings
Special Recognition

Shell NAM: Stathis Kitsios & team
BP: Werner Schinagl & team
ConocoPhillips: SNS OU & Artificial Lift Network

SNS Reservoir Engineering Team
Daniel Diaz  Thierry Pujol
Adam Beck  Alan Bruce

SNS Production Optimisation Team
Nadim Kassan  Albert Isaj

Artificial Lift Network
Renee Omsberg  Tom Nations

Production/ Completions
Jennifer Herrera