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Lunskoye Big Bore Gas Wells - Maximising Gas, Minimising Sand

Mike Gunningham
Sakhalin Energy Investment Company
Presentation Overview

• Introduction Sakhalin II Project
• Lunskoye Field Overview
• Overview of Original Completion Design
• New Sandface Completion Selection
• New Completion Design
• Quantitative Risk Assessment and Sand Management Plan
• Conclusions
Where is Sakhalin?

You are here

Sakhalin
• Piltun B platform (70k BOPD)
• Astokh year round production (70k BOPD).
• Lunskoye A platform (1800 MMscf/d & 45k BCPD).
• Onshore processing facility.
• Oil and gas pipelines.
• LNG plant (9.6 MMTPA) & Oil Export Terminal.
A Mega-Project in a Frontier Environment

Every Aspect is HUGE! .. $22 billion

2 New Platforms

800km Oil & Gas Pipelines

1st LNG Plant in Russia

2 x 4.8 million tonnes p.a.

20,000+ People, 60x10^6 hrs p.a.

Environment

$100/second Spend
Lunskoye Gas Field

- Discovered in 1984 and appraised with 7 wells
- Excellent gas reservoir with thin oil rim
  - GIIP 18.6 Tcf,
  - STOIIP 931 MMbbl
- One platform (Lun-A) can sustain 20 years production plateau for two LNG trains.
Lunskoye Field – Formation Data

Aver Porosity = 25%,

\[ d_{50} = 55-357 \text{ (Av = 167\(\mu\)m) } \]

Perm = 150 – 1,200 mD,

Fines = 7-42 (23%)
Initial Gas Well Design, 2002

- 9-5/8” x 7” 13Cr tapered tubing, with Pre-Drilled Liner or Slotted Liner completion in open hole.

- Sand expected to be produced and managed, and retrofit sand control as required.

- Topsides designed for sand production (0.5 lbs/MMscf), with 1/2 tonne sand/day expected
Follow-Up Work in 2002-2004

- **Value Engineering of Topsides,**
  - Sand handling equipment removed
  - Reduced 14” flowlines to 12” (erosion critical)
  - No test separator

- **Acceleration of Gas Sales**
  - No float in drilling schedule to enable retrofit sand control.

- **In 2004:** High rate gas wells & sand expected, with:
  - No sand exclusion downhole,
  - Minimal surface sand handling capability.
2004, Openhole Sand Estimate

Sand Prone Plot, Lun-7

Current year: 2006, Geilikman and Van den Hoek model for open hole liner
What happens if a well produces sand?

If this happens on Lunskoye: A delay in the time to reach Plateau production would be 4-6 months minimum.
## Back to the Drawing Board: Sand Face Completion Selection

<table>
<thead>
<tr>
<th>Completion Type</th>
<th>Overall Score</th>
<th>Reliability</th>
<th>Installation / Do-ability</th>
<th>Capacity</th>
<th>Cost</th>
<th>HSE</th>
<th>Good Option</th>
<th>Possible Option</th>
<th>Worst Option</th>
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</thead>
<tbody>
<tr>
<td>Cased &amp; Perforated</td>
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<td>Open Hole Gravel Pack</td>
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<td>Expandable Sandscreen</td>
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<tr>
<td>Standalone Screen</td>
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<tr>
<td>Slotted Liner</td>
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<td>Internal Gravel pack</td>
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<td>Predrilled Liner</td>
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</table>

But C&P has no screen/filter to stop sand ... 
.... so how much sand will be produced? 
.... how much gas production?

**SPE 88493**
Openhole Vs Cased and Perforated: Sand Prediction

Openhole

Cased & Perforated

Sand Production is expected to be delayed (with smaller volumes) with cased and perforated completions compared to openhole completions.
2004 Prediction Calibrations: Cased & Perforated

- Drill Stem Tests from Lun-7 observed no sand
- Successfully predicted (Blind)
- Sand failure predictions also showed sand would not be expected in the DSTs performed on other wells – consistent with the observations.
Productivity Predictions: Lun-501

• Development well trajectories changed from vertical to inclined to increase reservoir exposure
• Completion sizes 8 ½” and 12 ¼” open hole considered

![Graph showing productivity predictions for different completion methods and sizes.](image-url)
## Downhole: Sandface Completion Comparison

<table>
<thead>
<tr>
<th>Sand face completion</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cased &amp; Perforated</td>
<td>Robust, Productive Water Shut Off capability</td>
<td>Sand production later in field life</td>
</tr>
<tr>
<td>Openhole Gravel Pack</td>
<td>Downhole sand control</td>
<td>Very difficult to achieve in winter</td>
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<tr>
<td></td>
<td></td>
<td>Lower Productivity</td>
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<tr>
<td></td>
<td></td>
<td>Costly &amp; Complex installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Water Shut Off capability</td>
</tr>
<tr>
<td>Expandable Sand Screen</td>
<td>Downhole sand control</td>
<td>Limited track record for high rate gas wells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Water Shut Off capability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 ½” hole only</td>
</tr>
</tbody>
</table>

**Conclusion of sand study - use C&P and make detailed contingency design for ESS/OHGP.**
Optimising Cased & Perforated Completion

- Development well geology estimated for 2m AHD intervals discretisation.
- 400 inflow intervals/well (~2 to 3m AHD).
- Sand Prediction gives failed intervals: these are not perforated.
Example of Petrel Discretisation of Daghinsky

2m Intervals
Impact on Initial Production with Selective Perforation

- Selective perforating based on sand free production until 2025
QRA: Quantitative Risk Analysis

Integrated Team reviewed LUN-A system

Facilities designed to manage sand production

QRA systematically evaluates the residual risks for different phases of the production

Recommendations made with minimal or no additional costs (procedural), to further reduce residual risk to facilities.

Phase 4 - Production

Xmas Tree

Production Separator

Flare KO Drum

Produced Water System

Solids Recovery System

Erosion Probe W1

Erosion Probe W2

Flare tip Lit by propane

CRI / Pits

Start-up header

4" HIPPS Valve

Other Flowline

K

Other

K

Flowline

SD

Erosion Probe P1

Erosion Probe P2

6" Well Clean Up Header

Other Wellbay

6" Gravel Flowline

Cyclone

Choke

Sand Detector

Production Separator

Produced Water System (De-gasser, Pumps, Manifold)

Production header

Condensate

MEG

Upper Completion

Sandface Completion

Near Wellbore

Other Wellbay

Wellbay

Grayloc Flowline

CRI / Pits

Flare KO Drum

Heaters

WCU Separator System

WCU Separator System

WCU Separator System

WCU Separator System
Mitigation Measures to Reduce Impact of Sand Production

Example
- 12” Flowline
- Erode until detected
- Remedial Options
  - Maximise use Well Clean Up Unit
  - Small bean Up steps
  - Use clamp on sand detector
  - Non destructive testing
**Remedial Completion Options**

- **Sand Above Limit**
  - **Yes** leads to **Sand back**
  - **No** leads to **Produce**

- **Production Adequate**
  - **Yes** leads to **Run Economics**
  - **No** leads to **Closely Monitor**

**Remedial Measures Selection Matrix**

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Bean-back</th>
<th>Sand Above Limit</th>
<th>Production Adequate</th>
<th>Run Economics</th>
<th>Remedial Measures</th>
<th>Closely Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through tubing</td>
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<td>Max Running OD = 1.5&quot;</td>
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<tr>
<td>ID restriction post deployment</td>
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<tr>
<td>Metallurgy CR A, 12Cr or higher</td>
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<tr>
<td>Deployment (W/L, CT, OP, W/O)</td>
<td>W/L &amp; CT</td>
<td>CT + SPT</td>
<td>W/L &amp; CT</td>
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<tr>
<td>Length Range</td>
<td>3m/treatment</td>
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<tr>
<td>Line deployment? (Y/N)</td>
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<tr>
<td>Valve assembly</td>
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<td>Mud return line</td>
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<tr>
<td>90° Inclined sand production</td>
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<tr>
<td>Bottom sand production</td>
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<tr>
<td>Sand location unknown</td>
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<tr>
<td>Whole section sanding</td>
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</tbody>
</table>

**Legend**: (Green = Yes, Red = No)
Sand Management Plan

• Lunskoye Sand Management Plan:
  – Completion Design
  – Quantitative Risk Assessment
  – Monitoring
  – Roles & Responsibilities
  – Contingency Planning

• Apply other operator’s experience
The $22 Billion Question?

Did it work?
LUN-A Start Up Configuration
Lunskoye Clean Up, Dec 2008
Bean Up Summary

- No incidents or accidents
- Each well delivers:
  - 350 MMscf/d or 10 Mln. m³/d gas
  - Practically no sand seen (half a cup)
- Lunskoye gas wells are:
  - Russia’s largest gas wells
  - Largest offshore gas wells in the world
Conclusions

• Pre-Drilled Liner produced too much sand
• New Sand Failure Prediction Tool predicts onset of sand & quantifies volumes
• Preferred new completion design is Cased and Selectively Perforated
  – Defer sand production to 2025+
  – Sand levels lower and more manageable
• Quantitative Risk Assessment to address risk
• Lunskoye Sand Management Plan to manage risk
Final Words

• Cased & Selectively Perforated Wells deliver World Class Performance
  – Maximise gas production
  – Minimise sand production
Acknowledgements

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Questions?
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• SPE 112099: Applying Sand Management Process on the Lunskoye High Gas-Rate Platform Using Quantitative Risk Assessment

• SPE 114805: The Integrated Use of New Technology in the Development of the Sakhalin II Project