Oman Central Gas
Velocity Strings in deep tight gas wells

Velocity Strings – Oman Central Gas

Agenda:
- Objectives
- Completions
- VS design and selection
- VS cases
- Conclusions
Velocity String Objectives

Objectives:

Velocity Strings in Central Oman Deep Gas are a trial to:

- **Achieve stable production at gas rates as low as ~50 km3/d.**
  Current LL rate is ~160-180 km3/d@ 90 bar FTHP.

- Install ~4500 m jointed pipe below a single retrievable packer system in a live well (>100,000 lbs). Is it technically and operationally possible?

- Run Cr13 P110 ‘hard material’ pipe in a live well.

- Calibrate inflow/outflow simulations VS installations.

- Understand liquid loading (identify the right mechanism!)

- Ultimately, increase Ultimate Recovery (+ 6%)
Central Oman Gas Completions

**LNG Phase-1**
- **Conventional Completions** (31 wells)
  - 13 3/8" 72#, L80, BTC
  - 5.5" TRSSSV
  - 5.5", 17#
  - 9 5/8", 53.4#, C95, NVAM
  - 5", 15#, P110
  - 7", 35#, C95, NVAM

**LNG Phase-2**
- **Monobore Cemented Completions** (51 wells)
  - 13 3/8" 72#, L80, BTC
  - 5.5", 23#, P110, VAMTOP
  - 9 5/8", 53.4#, C95, NVAM
  - 9 5/8", 53.4#, C95 or SM95S
  - 5", 15#, P110

**LNG Phase-3**
- **Tapered Cemented Completions** (+18 wells)
  - 4.5", 17#, P110
VS packer Design Criteria

- Deployment of VS in a live well
- Comply with barrier policy
- Capable of hanging in excess of 100,000 Lbs string weight
- Pass 4.313” restriction & set in 5-1/2” 17ppf
- 500 psi differential rating
- ID compatible for future Intervention
- Retrievable system
- Able to confirm pressure integrity
Velocity string Candidate Selection

Candidate selection:

- High CGR (~250), Low WGR (~15)
- Wells in the LL region ~ 160 – 180 km³/d@ 90 bar FTHP), BHP=~160-300 bar,
- Mainly 5.5” tubing,
- TVD ~4500 m,
- k~0.3 mD, Ø ~12%, T=~137 deg C, CGR=250, WG
- No further stimulation opportunities
Central Oman Deep - Velocity String Design

Velocity String Completions

- 13 3/8" 72#, L80, BTC
- 5.5" TRSSSV

1000 m

- 5.5", 17#

3000 m

- 2.7/8", 6.4#, P110, VTOP

4000 m

- 9 5/8", 53.4#, C95
- 5", 15#, P110

4800 m

- 7", 35#, C95, NVAM
- 2.3/8", 4.6#, P110, VTOP
- 3.5", 17#, P110

5080 m

- 5.5", 23#, P110

5200 m

- NO TRSSSV
Well-A is unstable at 90 bar FTHP!

Well start liquid loading ~160-180 km3/d @ 90 bar FTHP
Well-A Velocity String

Before: ~180 km3/d unstable. After: stable 173,000 m3/d@ 90 bar

After 2 7/8” velocity string installation, more stable well at lower rates!

Critical rate ~50,000 m3/d
Well-B - Before and After

Before: 0 m3/d – after: Stable @ 130 km3/d@90 bar with VS

Inflow (IPR) v Outflow (VLP) Curves

Minimum rate tested was 53,000 m3/d with 5.56 mm Choke

5.5” Tubing

After 2 7/8” Tubing installation

Gas Rate (1000Sm3/d)
- VS was installed fully Under-Balanced and no water/brine was used.
- VS string weight (~100,000 lbs) was set at single packer ~15 meter below TRSSSV.
- Running P110 pipe in “light mode” require Micro Grip technology to ensure safe practices
- Due to VS weight issues of shock loading, vibration and VS packer running issues solved
- Completed four VS string installations. Minimum stable rate tested 53,000 m3/d@ 90 bar FTHP. All wells produce stable after 3 months…
- Average installation time with Snubbing unit is 15 days per well.
Questions?
Back Up Slides
Generic Central Oman Gas Velocity String Design

- **5 ½" TRCSSSSV @ 67.25mbdf**
- **Red Spider 5 ⅛" X 2 7/8" VSP @ 87.25mbdf**
- **13 ⅜" Casing shoe @ 972.55mbdf/Cemented to**
- **9 5/8" Casing shoe @ 2989.07mbdf**
- **Tapered - Cemented Completion 5.5"X5"X**
- **Tapered - Velocity String 2 7/8" VT by 2 ⅜" VT**
- **2 7/8", 6.4#/ft VT CR**
- **SSD**
- **4.5" Liner 17#/VAM**
- **2 ⅜",4.6#/ft CR**
- **Dual pump open plug assay**

**Barik Reservoir**

**7" Liner 35#/NVAM**

**2 7/8" VT by 2 ⅜" VT**

**Semi Submersible Control Panel**
Well-A Well Test

**SUMMARY OF RESULT**

<table>
<thead>
<tr>
<th>Date &amp; End Time</th>
<th>Choke (/64')</th>
<th>Duration</th>
<th>Tubing Head</th>
<th>PhaseTester</th>
<th>Fluid Densities</th>
<th>Rates</th>
<th>Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Temp.</td>
<td>Temp.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>kPa</td>
<td>kPaa</td>
<td>kg/m³</td>
<td>kg/m³</td>
<td>(SG=1)</td>
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<tr>
<td>26-Dec-08 16:30</td>
<td>128</td>
<td>12:30</td>
<td>9,419</td>
<td>53.0</td>
<td>9,376</td>
<td>65.5</td>
<td>761.6</td>
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<tr>
<td>27-Dec-08 06:15</td>
<td>22</td>
<td>10:15</td>
<td>10,870</td>
<td>59.0</td>
<td>11,019</td>
<td>62.6</td>
<td>759.7</td>
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<tr>
<td>27-Dec-08 17:00</td>
<td>16</td>
<td>7:00</td>
<td>11,841</td>
<td>57.0</td>
<td>11,862</td>
<td>58.3</td>
<td>755.6</td>
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</table>

**Notes:**
- Flowing where PhaseTester-Vx at Upstream of Choke by using Schlumberger Adj. Choke on By Pass Manifold.
- Tubing Head Pressure (measured by MIDAS - MB), Oil density, Water density and Gas SG are taken as the last reading during wireline passes.
- The rest of results are the average value during wireline pass of each flow period.
# Well-D Well Test

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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cond.</td>
<td>Water</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>15-Jun-09 7:00</td>
<td>12A</td>
<td>10:00</td>
<td>9,119</td>
<td>56.5</td>
<td>9,147</td>
<td>56.0</td>
<td>754.0</td>
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<tr>
<td>15-Jun-09 18:15</td>
<td>21A</td>
<td>9:00</td>
<td>9,020</td>
<td>57.8</td>
<td>9,889</td>
<td>57.3</td>
<td>763.0</td>
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<td>16-Jun-09 2:45</td>
<td>14A</td>
<td>5:30</td>
<td>10,197</td>
<td>52.8</td>
<td>10,333</td>
<td>52.3</td>
<td>751.0</td>
</tr>
</tbody>
</table>

**Notes:**

* Flowing where PhaseTester-Vx at Upstream of Choke by using Schlumberger Adj. Choke on By Pass Manifold.
* Tubing Head Pressure (measured by DWT), Oil density, Water density and Gas SG are taken as the last reading during wireline passes.
* The rest of results are the average value during wireline pass of each flow period.
## Central Oman Gas: Learnings

<table>
<thead>
<tr>
<th>Action</th>
<th>Learning points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform 2 3/8” dummy run with 3.5” size drift and not 3.0” drift. VS hold up @ 4508 mtbf &amp; end-up setting VS more than 150 m shallower than planned.</td>
<td>Need to ensure 3.5” drift in 4.5”completion but and if tagging shallower then to run 3.5” scraper or bit to clear any obstruction.</td>
</tr>
<tr>
<td>Due to length of VS, W/F lack to pack-up for P110 slip dies &amp; end-up using mesh to help grapping pipes.</td>
<td>Before starting RIH with VS, need to ensure there are enough pack-ups for all running &amp; handling tools on site.</td>
</tr>
<tr>
<td>R/D HWO to below of work window to accommodate for S/L R/U preparing to run the special drift (4.28”) for VS packer.</td>
<td>Make sure that the special drift is to be run after R/U to above substructure.</td>
</tr>
<tr>
<td>Install equalizing line @ top of bottom stripper to allow well self equalizing.</td>
<td>Equalizing without pumping any fluid is achievable &amp; to be applied on coming VS wells.</td>
</tr>
</tbody>
</table>
Central Oman Gas: Learnings cont.

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<tr>
<th>Action</th>
<th>Learning points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install marker pups two joints above SSD &amp; two joints above L-80 pipes to avoid wrong slips/dies.</td>
<td>These to indicate the position of SSD &amp; change from P110 to L-80 pipes in case of the need of pulling out the string. The 2.3/8” to 2.7/8” X/Over is indicated by the SSD which is placed 2 joints above it.</td>
</tr>
<tr>
<td>VS packer was set with 3200 psi &amp; inflow tested by bleeding-off 200 psi via MB control pump.</td>
<td>For more sensitive pressure control it is advisable to use high pressure low volume pumps.</td>
</tr>
<tr>
<td>After VS packer inflow tested, string pressure was raised to original using N2 pumps. As well, POP was sheared using nitrogen.</td>
<td>It was critical not to exceed original pressure by more than 400 psi while raising the pressure (since max differential of VS packer is 500 psi) but N2 pump was a very controllable bleeding/pressurizing tool which end-up with a successful shearing of POP.</td>
</tr>
</tbody>
</table>
**Design Specification**

**Dual Pump-Out Plug**
- Size: 2-3/8”
- Pressure Rating: 6500psi WP
- ID: 1.680”
- Pump-out Pressure: 350-500psi

**Velocity String Packer**
- Size: 5-1/2”
- Weight Range: 17-26 Lb/ft
- OD: 4.280”
- ID: 2.300”
- Pressure Rating: 500psi
- Hanging capability: 120,000 Lbs
General Installation Procedure
1. Run Red Spider special drift
2. Make-up dual POP & inflow test
3. Snub 2-3/8” jointed string dry (torque-turn graphs)
4. Make-up SSD & inflow test
5. Snub 2-7/8” jointed string dry (torque-turn graph)
6. Make-up RST packer & setting tool, equalize & pump-out secondary plug
7. RIH, pass thru 4.313” s/v, pressure up 3,400psi to set packer, take over-pull confirm set
8. Bleed-off well pressure to 200psi diff & inflow test packer & POP
9. Equalise across packer with Nitrogen
10. Slack-off 4000 Lbs weight to disengage setting tool
11. Strip out with work-string & setting tool
12. Pressure up well with Nitrogen to pump-out primary plug
### VS Red Spider Packer Specs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.A.L. (Dim A)</td>
<td>103.0”</td>
</tr>
<tr>
<td>Max OD (Dim B)</td>
<td>4.280”</td>
</tr>
<tr>
<td>Min ID (Dim C)</td>
<td>2.300”</td>
</tr>
<tr>
<td>Packer Weight</td>
<td>85 kg</td>
</tr>
<tr>
<td>Material</td>
<td>420 St Stl / Inconel 718 (Main Mandrel)</td>
</tr>
<tr>
<td>Elastomers</td>
<td>Element - Nitrile</td>
</tr>
<tr>
<td>Pressure Rating</td>
<td>500 psi</td>
</tr>
<tr>
<td>Temperature Rating</td>
<td>100°C (212°F) maximum</td>
</tr>
<tr>
<td>Max Tensile Rating (hang weight)</td>
<td>138,190 lbs (Upper Cone)</td>
</tr>
<tr>
<td>Maximum allowable hang weight</td>
<td>120,000 lbs</td>
</tr>
<tr>
<td>Upper Connection</td>
<td>2.750” 6 TPI Left Hand Thread</td>
</tr>
<tr>
<td>Lower Connection</td>
<td>2-7/8” 6.4# VAM Top Pin</td>
</tr>
<tr>
<td>Setting Load</td>
<td>25,000 lbs</td>
</tr>
<tr>
<td>Setting Pressure</td>
<td>3,200 psi</td>
</tr>
<tr>
<td>Body Test</td>
<td>750 psi</td>
</tr>
<tr>
<td>Drift (2.250” OD)</td>
<td>003200-AL</td>
</tr>
</tbody>
</table>