Retrofit Deep Gas Lift
System Overview, Deployment History and Real Results

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Agenda

Presentation Outline

• Design Concept & Installation History
• Deep Gas Lift System & Equipment
• Deployment
• Lessons Learned
• Real Results
• Case Study
• Conclusions
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DGL Design Concept

- The WidePak™ Deep Gas Lift (DGL) system was originally designed to combat liquid loading in gas wells.
- As reservoir pressure declines, hydrostatic head from water influx can overcome the wells’ ability to naturally flow.
- Vast amounts of mobile gas can be stranded.
- This DGL concept was born from the pursuit of lifting water and allowing stranded mobile gas to produce.
DGL Design Concept

- DGL differs from conventional gas lift (G/L) in two obvious areas:

  1) Gas Lift Gas Wells

     - Typically G/L is applied to oil wells to lighten the density of the liquid phase

     - Gas lifting gas wells is less common since gas will generally flow naturally

  2) Gas Lift below the Production Packer

     - Typically G/L is achieved through side-pocket mandrels.

     - G/L can usually only be introduced no deeper than the production packer

         - This can be several thousand feet from the perforations.
DGL Design Concept

Liquid level balances reservoir pressure – gas well will not flow naturally

DGL system permits the introduction of gas lift below the production packer

Deep gas lift entry improves the hydraulic efficiency, enabling the lifting of water, and mobile gas production can commence
Installation History

- WidePak DGL system concept developed in 2009.
- 5-1/2” Pilot system deployed in Spring 2010.
- 8 more systems installed since.
  - North Sea
    - 4-1/2”, 7” and two additional 5-1/2” Systems
  - Alaska
    - Four 4-1/2” Systems
Two Trip Straddle Injection System using:
DGL Cross-flow Injection Sub
&
Weatherford WidePak™ Packer
All system components successfully tested & qualified (including anchor and all sealing elements) to ISO14310 V0
## DGL System Specifications

### SPECIFICATIONS

<table>
<thead>
<tr>
<th>TUBING SIZE (in.)</th>
<th>TUBING WEIGHT (lb/ft) (ID Range)</th>
<th>PACKER SIZE (in.)</th>
<th>MAXIMUM GAUGE RING OD (in./mm)</th>
<th>MAXIMUM PACKING ELEMENT OD (in./mm)</th>
<th>PACKER BODY ID (in./mm)</th>
<th>UPPER SEAL BORE (in./mm)</th>
<th>TEMPERATURE PRESSURE RATING (°F/°C)</th>
<th>RELEASE FORCE (lbf/N)</th>
<th>MINIMUM PRODUCTION FLOW AREA Sq. In.</th>
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DGL System BHA’s

- Lower Packer
- Slotted Joint
- PBR (Polished Bore Receptacle)
- Injection String (CT or Jointed Pipe as needed, additional unloading stations optional)
- DGL Injection Sub
- Upper Packer
- Spacer Pipe – as needed
- Cross-Flow Injection Sub (optional check valve)
- RS Anchor
- Injection Tube
- Stinger Seal Assembly
DGL Deployment

• Pre-Job Considerations
  • Test all well control equipment for integrity.
  • Perform integrity test on tubing and injection annulus.
  • Utilize caliper logs to identify any severe wall loss at setting depth.
  • Rig-up slickline and perform a series of drift runs to insure straddle assembly can make it to depth.
  • E-line run to punch tubing if required.
DGL Deployment - Lower BHA

- Set on HD Wireline, Coiled Tubing, or WO Rig
- Length, Weight and Type of Tailpipe (CT vs. JP)
  - Will determine conveyance method and type of setting tool.
  - Depending on available injection pressure, longer installations may require additional unloading stations to assist initial well kick-off
- Depth Correlation Critical
  - Set directly below existing GLM or tubing punch
  - E-line deployed - preferred if feasible
  - CT Deployed
    - Tag no-go or HUD, EOT /Nipple Locator
    - CT stretch calculations
DGL Deployment – Upper BHA

• Requires ability to stab two consecutive seal assemblies.

• Set Via HD Slickline/Braided Cable (Primary)
  – Ability to stab into the upper packer and then “tap” down using the mechanical (spang) jars to ensure that both seals are fully engaged and the anchor is latched.
  – Ability to take 1500# overpull to confirm that assembly is fully engaged.
  – Setting tool with slickline trigger.

• Coiled Tubing or Jointed Pipe (Secondary)
  – Brute force stab-in
  – Hydraulic setting tool
Well Candidate Assessment

- Punch Holes in Tubing @ 9200ft.
- Run 3.72” OD System and utilize 3.688” RPT Nipple as a No-go for depth control
Lessons Learned

• Cutting coil at the BOP
  – Use of a remote hydraulic cutter
  – Rigging for pipe straightening
• Rig-up
  – CT Work Windows extended
  – Cromar Quick test subs for pressure testing
• Stabbing upper assembly via braided line with mechanical spang jars.
  – CT attempted on 4-1/2” system with difficulty.
• Depth correlation of lower packer on coil is vital
• Punch tubing after setting the lower packer??
  – Use packer test tool and junk basket for debris management.
  – Potential to circulate annulus clean

Feb. 3 – 7, 2014

2014 Gas-Lift Workshop
Real Results

• Pilot 5-1/2” Installation in Q2-2010 took a well shut in for 2.5 years and came online producing in excess of 6 MMSCFD.
  – Initial Installation required 17 days, payout in 70 days.
• Second 5-1/2” Installation successfully completed in Q1-2011 and also producing in excess of 6 MMSCFD.
• Installation of Pilot 4½” system was in Q2-2011 – Brought online in May 2012 at over 5 MMSCFD.
• 4 Well installation completed in March 2013 - Alaska.
  – Average installation in 2-3 days.
  – Jointed Tailpipe vs. CT – Up to 3200ft.
    • Integral GLM’s used to assist unloading
    – Lower BHA deployed with HD E-line vs. CT
Real Results – Well A

Stabilized at over 2.5 MMSCF/day
Case Study – Velocity String vs. DGL

• Well B:
  – 4-1/2” Completion
  – SITP: 280 psi
  – FTHP: 60 psi
  – Production: 210 bopd, 92 bwpd,
  – GL gas: 1 MMSCFD, GL orifice: 3/8”
  – Velocity String: 1.75 CT, ID: 1.688”
  – ER Packer set @ 3,750 ft- MDKB
  – End of Velocity string: 5,248ft-MDKB

• Well C:
  – 4-1/2” Completion
  – SITP: 460 psi
  – FTHP: 60 psi
  – Production: 221 bopd, 30 bwpd
  – GL Gas: 1.1 MMSCFD, GL orifice: 3/8”
  – Velocity String: 1.75 CT, ID: 1.688”
  – ER Packer set @ 3,400 ft- MDKB
  – End of Velocity string: 5,400 ft-MDKB
# DGL Production Improvement - Well B

**G/L Velocity String**

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<tr>
<th>System</th>
<th>Operating Pressure (psia)</th>
<th>Liquid Rate (STB/d)</th>
<th>Oil Rate (STB/d)</th>
<th>Water Rate (STB/d)</th>
<th>Formation Gas Rate (MMSCF/d)</th>
<th>Injection Gas Rate (MMSCF/d)</th>
<th>Water Cut (Fraction)</th>
<th>Produced GOR (SCF/STB)</th>
<th>Injection MD (ft)</th>
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<td>G/L VS</td>
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<td>300</td>
<td>210</td>
<td>92</td>
<td>0.1</td>
<td>0.4</td>
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<td>DGL</td>
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<td>461.4</td>
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<td>0.4</td>
<td>0.3</td>
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**112 bopd Increase**
## DGL Production Improvement - Well C

### G/L Velocity String

<table>
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<th>System</th>
<th>Operating Pressure (psia)</th>
<th>Liquid Rate (STB/d)</th>
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<th>Water Rate (STB/d)</th>
<th>Formation Gas Rate (MMSCF/d)</th>
<th>Injection Gas Rate (MMSCF/d)</th>
<th>Water Cut (Fraction)</th>
<th>Produced GOR (SCF/STB)</th>
<th>Injection MD (ft)</th>
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**720 bopd Increase**
Looking Forward

• Production Case Study
  – Install system in “Well C” – DGL vs. Velocity String

• 6 Well Project in Indonesia – Q2 2014 Installation
  – 1.75” CT Injection string lengths up to 6000ft.

• 2-3 New installations in Alaska
  – Re-Install of existing system with integral unloading station, and 2 new wells.

• Additional candidates identified in Asia Pacific, West Africa, and North Sea operating regions. Currently in planning phase.
Conclusions

- Deep Gas Lift is a viable Thru-Tubing Intervention option that can be installed in most wells regardless of completion design.
- WidePak DGL is a suitable alternative to breath life into older oil & gas wells suffering from production decline or water influx.
Thanks & Questions