A Single Life-Cycle Completions Solution

Cost-effectively transition from natural flow to gas lift to plunger lift and on to rod pumping

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Agenda

- Challenges of horizontal well artificial lift
- Mitigating slug flow
- Slickline accessible artificial lift system
- Field trials
- Conclusion
Production and lifting strategies are characterized by transitions

**Predicament**
- Must address how to implement the lowest cost lifting system as soon as possible that maximizes drawdown reliably
- Top end of rod pumping is below bottom end of natural flow
- Rod pumping is the preferred choice for low per barrel costs

**Slug Mitigation Strategy**
1. Control flowback
2. Maximize natural flow period (lowest OPEX)
3. Eliminate or minimize intermediate artificial lift phases
4. Transition to rod pump as early as possible to minimize OPEX
5. Maximize pump reliability and drawdown
Severe slug flow conditions occur around bend / curve compounds slugging in Hz.
HEAL Advantages to Common Gas Lift Challenges in Horizontal Wells

Challenges:

- Liquid Loading in build section
  - Up to 2x gas requirements vs vertical
- Compressor shut downs due to production inconsistency.
- Inefficient lift method stand alone
- Large CAPEX investment to establish field wide infrastructure to make more efficient.

Solutions:

- HEAL lifts build section with no lift gas requirements:
  - Higher injection depth leads to lower gas requirements and lower injection pressures
  - Less lift gas required because in vertical
- Consistent fluid delivery to lowest lift mandrel
- Reduced CAPEX/OPEX due to lower gas requirements and compression horsepower
Downhole System for Slug Flow Mitigation

Conventional Artificial Lift

HEAL Vortex Separator

Sized Regulating String (SRS) - variable ID

Large solids sump

HEAL Seal

Separated gas

Separated oil + water + solids

Fluids turn corner to bottom of shroud
Slickline System: Extend Natural Flow, transition to Gas Lift, and on to Rod Pump

### Natural Flow
- HEAL Slickline Separator Flow Through configuration installed (HEAL Slickline Separator is bypassed)
- Extends natural flow period as SRS lifts fluids around bend and delays the onset of liquid loading
- Casing is closed

### Gas Lift
- Transition to gas lifting without pulling tubing
- Gas lift same as conventional; injecting gas down production annulus
- HEAL System SRS increases production drawdown over conventional gas lifting as fluids are efficiently lifted around bend section and slug flow is mitigated

### Rod Pump
- If required, can transition to rod pump without pulling tubing
- Install HEAL Separator Mandrel
- RIH with insert pump and rods into upper nipple profile
- Casing is open for separated gas
- HEAL System protects pump from gas and solids, as well as maximizes production drawdown.

*Formation Fluids (Oil, Water, Gas)*
*Separated Gas*
*Oil / Water*
*Separated Solids*
Slickline System: Extend Natural Flow, transition to Plunger Lift, and on to Rod Pump

**Natural Flow**
- HEAL Slickline Separator Flow Through configuration installed (HEAL Slickline Separator is bypassed)
- Extends natural flow period as SRS lifts fluids around bend and delays the onset of liquid loading
- Casing is closed

**Plunger Lift**
- Reconfigure to plunger lift configuration (install bumper spring, HEAL Separator Mandrel and standing valve)
- Plunger Lift similar to conventional
- Bumper spring landed shallower to improve efficiency; enables more cycles per day allows for lower GLR
- Casing is closed (unless gas assist required)
- SRS discharges to annulus at HEAL Slickline Separator and maintains continuous flow; liquid builds up in annulus, not in production tubing

**Rod Pump**
- If required, can transition to rod pump without pulling tubing
- Retrieve bumper spring, HEAL Separator Mandrel and standing valve
- Re-install HEAL Separator Mandrel
- RIH with insert pump and rods into upper nipple profile
- Casing is open for separated gas
- HEAL System protects pump from gas and solids, as well as maximizes production drawdown.

**HEAL Slickline Separator c/w Flow Through Configuration**
- HEAL Slickline Separator c/w Separator Mandrel
- Standing Valve

**Plunger Bumper Spring**
- HEAL Slickline Separator c/w Separator Mandrel

**Separated Solids**
- Formation Fluids (Oil, Water, Gas)
- Separated Gas
- Oil / Water
- Separated Solids

**HEAL Seal**
- SRS
- Insert Pump

**2017 Gas-Lift Workshop**

**Oct. 23 - 27, 2017**
Initial Field Trial:

- Straight gas lift
- Short Term function test with Continuous Flow Plungers
- Inject Gas below the system to calibrate gas lift modeling and the required gas-liquid ratio with the system versus the standard plunger lift design parameters

Plunger Lift Case Study

Second Field Trial Well Profiles:

- Permian Basin, Feb-Mar 2017
- 3 wells put on continuous plunger Lift with the HEAL Slickline system
- Irion County, TX
- Wolfcamp Formation

- TVD: 6,000 - 7,000 ft
- IP Rates: 1,000 – 4,000 BFPD
- Watercuts: 50%-75% range after initial post-fracturing clean-up
- Wells typically do not naturally flow, so Gas Lift used to achieve the higher IPs

Plunger Lift Case Study

Second Field Trial Results Well 1:

Plunger Lift Case Study

Second Field Trial Results Well 2:

Plunger Lift Case Study

Second Field Trial Results Well 3:

HEAL Slickline System can be installed as part of initial completion to significantly improve production economics by solving the underlying artificial lift challenge of slug flow behaviour.

Mitigating slug flow from the horizontal adds value

• Solids control
• Efficiency as all lift systems like smooth flow
• Drawdown reliably maximized

Used in conjunction with gas lift reduces lift gas rate and pressure requirements with no drawdown penalty

HEAL Slickline System offers additional value of reduced CAPEX and OPEX:

• Extension of natural flow period
• Simpler and lower cost transition to artificial lift
• Simpler and lower cost transitions between artificial lift systems
• Inter-wellbore communication or frac-hit risk mitigation
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