Eliminating slug flow from the horizontal wellbore increases production and reduces costs

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Eliminate slug flow: root cause

- **The Solution:** consistent, regulated flow
  - Flow conditioning prior to the separator and pump

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**BEFORE HEAL SYSTEM™ INSTALL**

![Graph showing inconsistent flow from horizontal](image1)

**AFTER HEAL SYSTEM™ INSTALL**

![Graph showing regulated consistent flow from horizontal](image2)

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Design to solve common problems with conventional approach

High Total Well Capital Expenditure
- Large artificial lift equipment due to production rate, depth and low efficiency
- Multiple lift systems required after natural flow period
- Complex directional profile to achieve production and geological objectives

High Operating Expenses
- Excessive workovers due to poor reliability and downhole equipment failures
- Expensive workovers due to pumps seized with solids
- Excessive energy consumption due to pump depth and low pump efficiency
- Excessive gas interference and poor runtimes

Production and Reserves Not Maximized
- Inadequate drawdown due to lift system limitations (gas lift, “pump limited”)
- Pump placement limiting ability maximize drawdown
- Persistent high annular fluid levels or pump inlet pressure
Full cycle artificial lift strategy defined by eliminating slugs flows

1. **Control flowback**
   - Reduced proppant flowback and fines generation
   - Lower risks and costs transitioning to artificial lift

2. **Maximize natural flow period (lowest OPEX)**
   - Bend section liquid loading dictates when a well ceases to naturally flow

3. **Transition to rod pump as quickly as possible to minimize OPEX**
   - Stabilize annular fluid level to allow balancing of pump jack and maximization of stroke rate
   - Maximize pump efficiency to extend top end of rod pump capacity (reduce or eliminate intermediate artificial lift)

4. **Maximize rod pump reliability and drawdown**
   - Minimize planned and unplanned workovers
   - Lowest BHP possible to maximize rate and reserves
Design to solve: Mechanical longevity as well declines

- **Significant install base (110+) → through learning curve on potential issues**
  - Anchors are notorious for coming unset leading to significant tubing movement each stroke
  - Sizing critical to ensure system flow conditioning over broad production range
  - Expect and therefore must manage solids

- **Cyclical loadings in pumping wells present a significant design challenge and many subtle failures using routine practice**
  - All components need “infinite fatigue life” (generally defined as over one million cycles)
  - If not infinite life, will fail very rapidly (at 7 SPM, 1 million strokes is ~100 days)
  - Elastomers cannot be subject to movement or pressure / temperature cycles or will rapidly fail
Design for low risk and reliable retrieval in solids-rich environment

- Minimize slug flow to suppress main solids transport mechanism resulting in less solids production
- Sump design to easily contain tons of sand / solids with no adverse effect on pumping or system retrieval
- Design features enable easy retrieval in environments with sand / solids
- Multiple retrievals of the system with no critical issues
  - 10+ systems retrieved
  - Up to 10 tons of sand / solids recovered HEAL System Sump after retrieval
  - Redundant design for the harshest environments
Case Study: Reliability

- Ran pump low to maximize drawdown → multiple pump failures
- Ran pump high → poor drawdown, rod breaks from gas interference
- Pre-HEAL: 9 pump changes in 2.25 years costing $600k
- Post-HEAL: Zero changes in 2+ years
Case Study: Reliability

- Improved pump life and rod life in multiple installs in several basins:
  - Wolfcamp, Permian Basin – longest running rod pump installing for client and ongoing
  - Niobrara, DJ Basin – rod failures every 6 months for prior two years, 12 months post install, no rod failures, ongoing.
  - Viking, central Alberta Canada – multiple solids related pump failures post flowback, since installs (20+) no failures
  - Belly River, central Alberta Canada – multiple solids related pump failures, since installs (10+) no failures
  - Glauconite, central Alberta Canada – multiple solids related pump failures, since installs no failures
Case Study: Gas Interference, NEBC Basin Canada

- Severe gas interference
- In the field, tried multiple downhole separator types (poor boy, packer style) with no improvement
- HEAL System has allowed same pump/rods/jack to more than double production
- Multiple wells in field with HEAL Systems with consistent production uplift
Case Study: Gas Interference, San Andres Permian Basin

- HEAL System solves the root cause of erratic pump fillage
- Regardless of the performance of the downhole separator, like a properly designed packer style gas separator, slug flow leads to gas interference
- Erratic pump fillage compromises rod and pump life
Slug flow is a major impediment to achieving a pumped off condition.

HEAL System positions pump in vertical section ~1200 feet above hz

– achieved lower producing BHP than a pump positioned at 80° inc

Pump placed at or above KOP to improve reliability and lower cost

– reduced size of pump / rods / jack (cost), while achieved reliable lower producing BHP
Case Study: Low bottomhole pressure versus gas lift, Montney Canada

- Gas lift has attractive reliability, but high OPEX and producing BHP
- HEAL System + rod pumping sustained attractive reliability of gas lift, but at significantly lower OPEX and producing BHP
Case Study: Low bottomhole pressure versus gas lift, Anadarko Basin

- Transition from ESP to gas lift resulted in undesirable production performance and higher OPEX
- HEAL System + rod pump maximized drawdown and the well production potential
Case Study: Production Enhancement, Montney Canada

- Montney suffers major rod pumping challenges: deep, high GOR, some areas have very high initial rates, high decline rates
- HEAL System installed in +18 wells with multiple operating companies
- Long term (>12 months) average result is +100% increase in production over previous trend
- Moving towards installing immediately after initial completion, full cycle
Case Study: Production Enhancement, Wolfcamp Permian Basin

• The Permian Basin Wolfcamp formation is challenged by depth, high total fluid rates, high watercuts and severe high GOR gas interference

• Installation in 7 Wolfcamp wells resulted in a sustained +40% increase in production
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