New Single Well Gas Lift Process Facilitates Fracture Treatment Flowback

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Introduction

- Current completion trend in shale resource plays is stimulation with 3-4 million gallons of water. (Palish, 2008; Gaudlip, 2008)

- Since energized fluids not used, wells often load up after less than 15% load recovery
  - Gas lift is common remedy: high flowrates with sand capability
  - When gas pipeline available, will utilize “buy-back” meter to purchase gas from pipeline, costing $30,000 plus gas used.
  - When pipeline not available, normal alternative is expensive nitrogen membrane generator or bulk liquid nitrogen
Problem Description

• When pipeline or buyback meter not available, once-through Nitrogen gas lift has several drawbacks
  – Cost
    • Membrane typically ~ $8,000 per day
    • Vaporizing liquid nitrogen ~ $12,000 per day
  – Poor measurement of formation gas contribution
    • Difficult due to blending with Nitrogen of uncertain volume
Recommended Solution: Recycle the lift gas

- Fill system with a suitable lift gas then recirculate it with a gas lift compressor in a closed loop system

- Set up compressor engine to operate on commercial propane supply, and start engine via air compressor

- Because of fluid slugging, utilize a low pressure gas receiver to maintain steady state flow to the compressor
Primary Challenges

- Cost effectively fill the system with lift nitrogen or natural gas
- Prevent loss of lift gas
  - Liquid dump valves may hang open
    - Two on separator, four on compressor
  - Compressor losses
    - Compressor rod packing leaks
    - Compressor blowdown losses
- Backup lift gas provision in the event of loss
Solutions to Filling System

• How much lift gas is needed to fill system (to 1000 psig)?
  – 2-3/8” x 4-1/2” annulus: 3.9 MSCF per 1000 feet
  – 2-3/8” x 5-1/2” annulus: 7.1 MSCF per 1000 feet
  – 2-7/8” x 5-1/2” annulus: 6.1 MSCF per 1000 feet

• Assuming first gas lift valve at 2000 feet, need between 8 and 15 MSCF to fill the annulus and surface lines
Capture Produced Gas During Initial Flowback

• *Discovery* of “Dissolved Gas” presence
  – Significant quantity of fine bubbles observed in flowback tank

• “Too small to measure” say well testers
  – Measured using low pressure receiver tanks/ Boyles law
Capture Produced Gas During Initial Flowback

• Methane is soluble in water?

**YES** – More so than most would believe

– Literature from 1951 reports on solubility of methane
  – “Phase Equilibria in Hydrocarbon-Water Systems”
  – Written by O.L. Culberson with Gulf Oil, and J.J. McKetta, Jr. with the University of Texas Chemical Engineering Dept.
  – Published in AIME Petroleum Transactions Vol 192, 1951
Volumetric Solubility of Methane in Water

- Literature predicts 12 ft$^3$ per barrel for EOG’s Barnett conditions

FIG. 5 — VOLUMETRIC SOLUBILITY OF METHANE IN WATER.
Capture Produced Gas During Initial Flowback

- Although literature depicts solubility of 12 ft\(^3\) per barrel, actual “captured” gas was half this amount once gas depressurized to surface conditions.

- Hypothesize that frac water not in contact with gas long enough to fully saturate, hence measurements of only 6 ft\(^3\) per barrel were repeatedly observed.
Capture Dissolved Gas During Initial Flowback

- **2000 barrels flowback water yields 12 MSCF**
  - This volume normally recovered in first 24 hours
  - Adequate to fill system with lift gas if collected

- **Utilize low pressure storage receivers while compressor runs in automatic bypass**
  - Automatic bypass closes when receiver pressure rises, and opens when receivers pulled down
  - Controlled by simple off-the-shelf electronic high-low safety system pilot
Pilot Test Low Pressure Gas Storage Receivers
Alternate Sources for Lift Gas

• **Fill With Nitrogen Bottles**
  - Available in 12 packs of 3.6 MCF each from welding supply house at low cost
  - Six twelve packs yields ample 21 MSCF

• **Drain into casing directly to fill, or into low pressure storage receivers**
Alternate Sources for Lift Gas

- **Fill With Nitrogen From Membrane Unit**
  - Arrange for hourly rate for nitrogen membrane unit instead of daily rate
  - Establish gas lift using nitrogen, and fill surface vessels
  - Once gas lift process operating smoothly, with nitrogen being recycled, release membrane unit
Solution to Loss of Lift Gas

- Operating practices can minimize the loss of lift gas
  - On compressor shutdown, shut-in well to prevent well from blowing down to flare
    - Gas strung up tubing collects below master valve
    - Available for re-injection on start up
Solution to Loss of Lift Gas

• Diligence
  – Make sure level controllers working correctly
  – Make sure trim in dump valves does not leak
  – Compressor rod packing in good condition
Solution to Loss of Lift Gas

• Despite good people and equipment, operating problems will occur, requiring a solution for recovering from lift gas loss
  – Produced gas or surplus nitrogen onsite storage needed to recharge closed loop system
  – Use high pressure receiver to store this produced gas
  – Fill this receiver with dissolved gas or nitrogen from bottle 12 packs or membrane unit
High Pressure Receiver Design Criteria

- Simplicity - No pressure or level controllers, just storage volume
- Must not collect condensate and water
- Easily moved and hooked up
- At least 1440 psig rating compatible with typical wellsite compression
High Pressure Receiver Version 1.0

- Eleven 8-5/8” x 25 foot long tubes arranged stairstepped
  - Capacity of 17.5 MSCF at 2200 psig
  - Capacity of 9.2 MSCF at 1350 psig
  - Gas enters top tube, leaves lowest tube

- Advantages:
  - Superior design for storing at high pressure

- Disadvantages:
  - Expensive
  - Holds 42% less gas than pair of 36” x 10’ separators at 1350 psig
Gas Capture Trailer Version 1.0

High Pressure Receiver – 8-5/8” tubes
Low Pressure Receiver – Two 1000 gallon tanks
Air Compressor receiver – 120 gallon tank
High Pressure Receiver Version 2.0

- Pair of 36” x 10’ horizontal 1440 psig vessels with bottom entry
  - Capacity of 15 MSCF at 1350 psig
  - Capacity of 11 MSCF at 1000 psig
  - Built of readily available separator materials
- Advantages:
  - Easy to mount on trailer
  - Less expensive due to standard material
- Disadvantages:
  - Unable to fill to 2200 psig for nitrogen storage
Gas Capture Trailer Version 2.0
Gas Capture Trailer Version 2.0

Features

• High Pressure Receiver – Two 36’ x 10’ Vessels

• Low Pressure Receiver – Two 1000 gallon tanks

• Air Compressor receiver – 120 gallon tank

• Control valves and process controllers
Conventional Gas Lift Flow Diagram

Pipeline provides:
- Lift gas
- Compressor fuel
- Removal of excess gas
Gas Recycle Flow Diagram

Pipeline replaced by:
- Low pressure receiver
- Pressure relief valve
- Flare stack
H. Youngblood #1H Fracture Flowback Data

- Flows without gas lift for 2 days
- Gas collected in 21 hours on day 2
- Gas lifted for 36 hours on day 3 and 4
H. Youngblood #1H
Fracture Flowback Data

- Pressure low during gas collection
- Once lifting, gas used for fuel / reserve
- Pressure steady once well turns to gas

![Separator Pressure and Injection Rate Vs. Time](image)

- Steady gas flare
- Continuous gas injection
- Gas collection with routine injection
- Gas collection with equipment purging
- No gas collection

Separator Pressure, psig

Inj. Rate MCFPD

Time, hrs

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H. Youngblood #1H Fracture Flowback Data

- During collection, gas displaces fluid, elevating pressure
- Steady once gas reaches first valve
- Other valves never used once well “turns to gas”
Gas Capture/ Recycle Project Summary

• Recommended Solution for stranded wells that need artificial lift:

Recycle the lift gas instead of buying once-through Nitrogen

  – Fill system with Dissolved Gas or Nitrogen, then recirculate the same gas using a conventional gas lift compressor

  – Provide low pressure receivers to:
    • Collect Dissolved gas
    • Act as surge tank due to varying rates that lift gas returns
Gas Capture/ Recycle Project Summary

- Provide high pressure receiver to store ample recharge gas in the event of:
  - Lift gas loss due to leak
  - Compressor shutdown

- Set up gas lift compressor to operate on propane, and start using air compressor
Gas Capture/ Recycle Project Summary
The recommended solution for stranded wells needing gas lift to unload fracture treatment fluids

• Potential Benefits
  – Allows extended well testing to help quantify the risk of laying an expensive pipeline (have tested three wells in excess of 30 days)
  – Facilitates expansion (outside the Barnett) of the completion practice of water fracs without expensive energized fluids (CO2 / Nitrogen)
  – Same concept can be used for single well gas lift installations, only using permanent equipment
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Gas Capture/ Recycle Project
Propane Fuel System

- Compressor fuel challenge
  - Normal usage of 20 MCFPD not possible with GLR of 6!
  - Plumb in pair of 500 gallon propane tanks to provide fuel source
  - When well starts making gas, can switch from propane
- Propane contractor moves tanks from job to job for EOG