A Review of Intermittent Gas Lift and Fallback Factor Modeling

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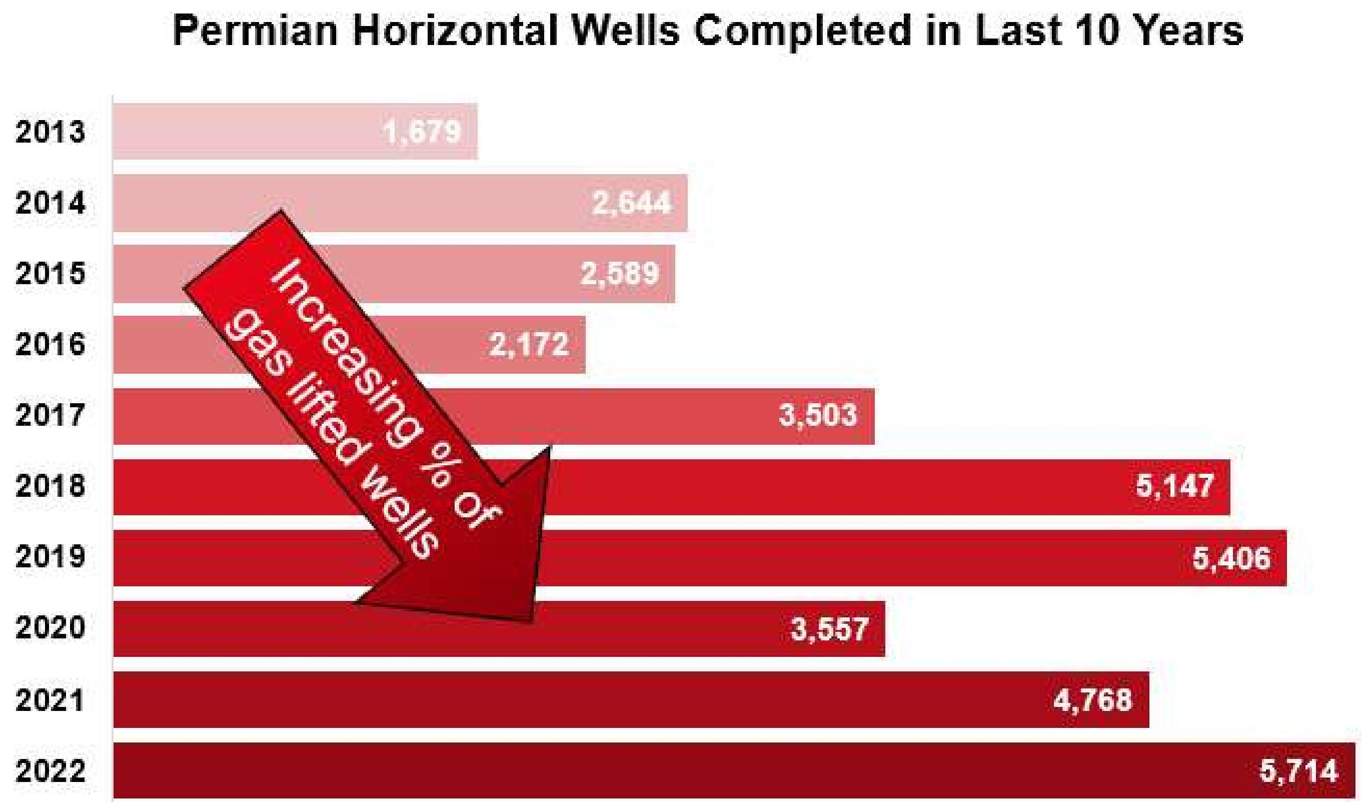
Presentation Main Points

1. A tidal wave is coming.
   Unconventional wells needing intermittent gas lift (IGL)
2. We need to master lifting liquid slugs with gas.
   IGL, GAPL, plunger lift, intermittent lift
3. We can learn a lot from the past.
   Literature review
4. We still have more to learn.
   Texas Tech Gas Lift Consortium

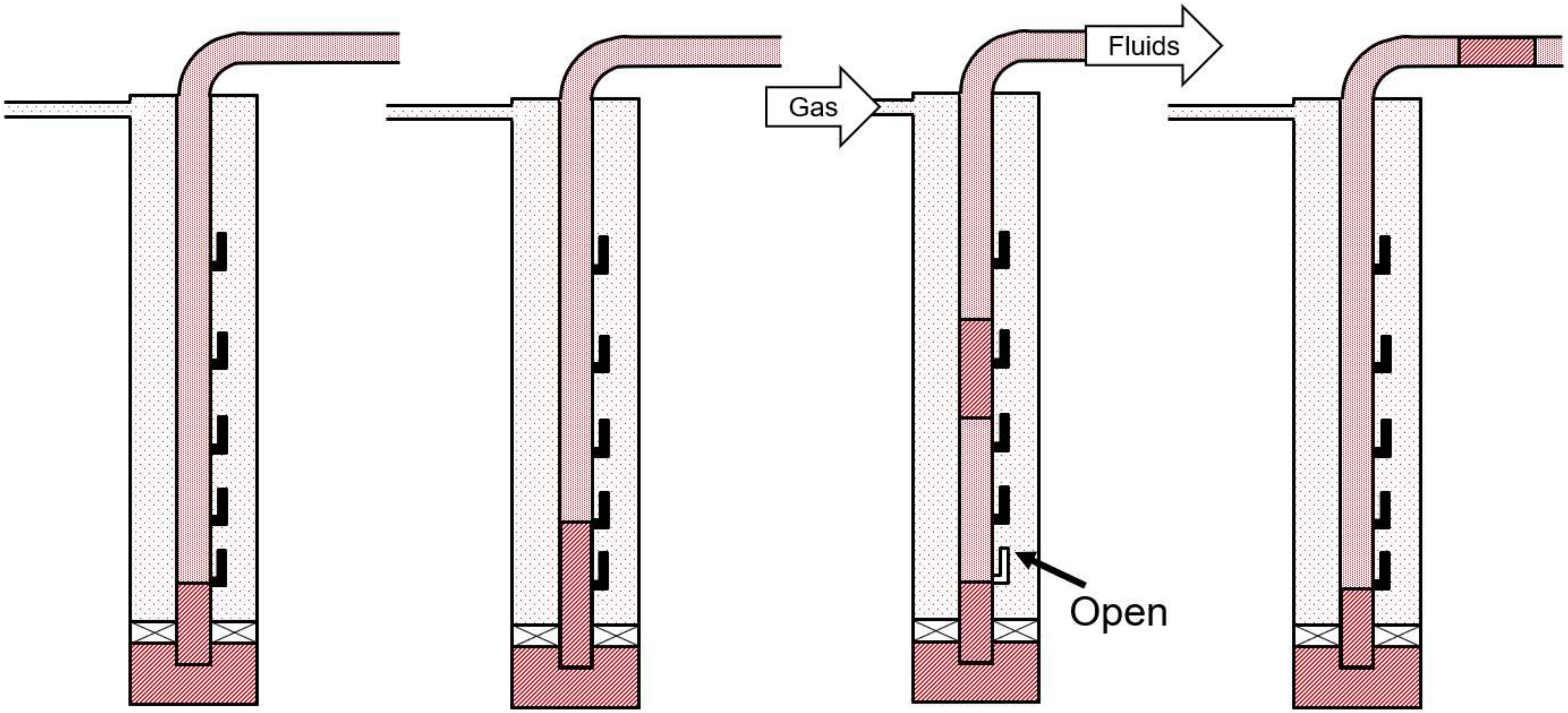
Tidal Wave


Permian Horizontal Wells Completed in Last 10 Years
2013
1,679
2014
2,644
2015
2,589
2016
2,172
2017
3,503
2018
5,147
2019
5,406
2020
3,557
2021
4,768
2022
5,714
Increasing % of gas lifted wells

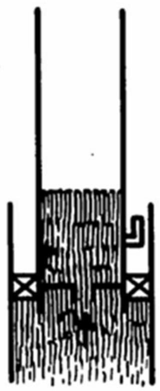
37,179 total

Lifting Liquid Slugs Using Gas

Intermittent Gas Lift



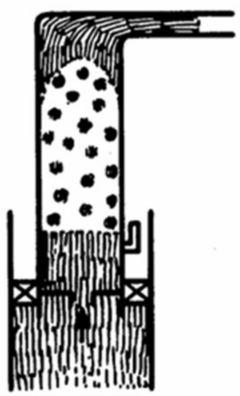
What is Fallback?



Initial slug

Fallback as droplets

Fallback as film



Slug produced with fallback receding

(Brill, 1966)

Multiple different definitions in the literature:

Definition	Units	Sources
Loss relative to initial amount	%	(Alahmed et al., 2017)
Percent normalized by depth	%/ft	(Winkler, 1959)
Volumetric flowrate	Gal/s	(Mower et al., 1985)
Average penetration velocity	ft/s	(Brill, 1966)

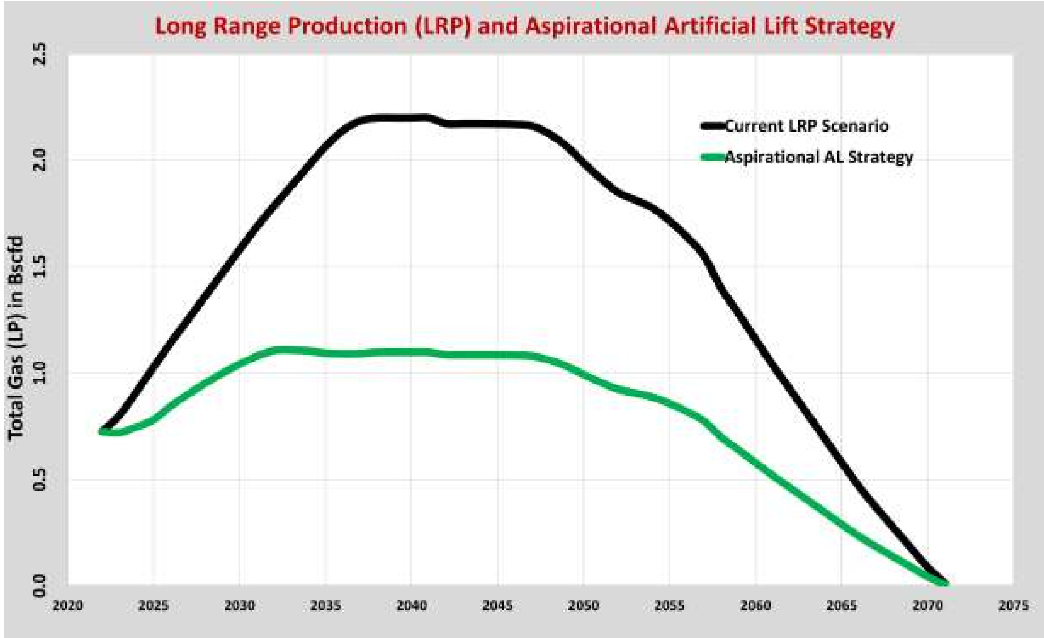
Lift Methods for Late-Life Wells Formerly on Continuous Gas Lift

Lift Type	Tubing	Notes
Gas-assisted plunger lift (GAPL)	Intermittently open	Intermitted on surface. Side-pocket mandrels present a challenge.
Intermittent gas lift (IGL)	Always open	Requires pilot valve and packer.
Chamber lift	Always open	Complex tubular configuration
Plunger lift	Intermittently open	No injection gas
Intermittent lift	Intermittently open	No injection gas

All methods involve intermittently lifting a liquid slug to surface using energy from expanding gasses below.

Benefits of Late-Lift Gas Lift Technologies

- Same or better production rates
- Less lift gas (~50% reduction)
  - Operating cost savings
  - Emission reductions
  - Redistribute lift gas to improve production on other wells
- Defer or eliminate conversions to sucker rod pump
  - Capital cost savings
  - Avoid high failure rates on high GLR wells



Bill Hearn, 2022 Gas Lift Workshop ALRDC

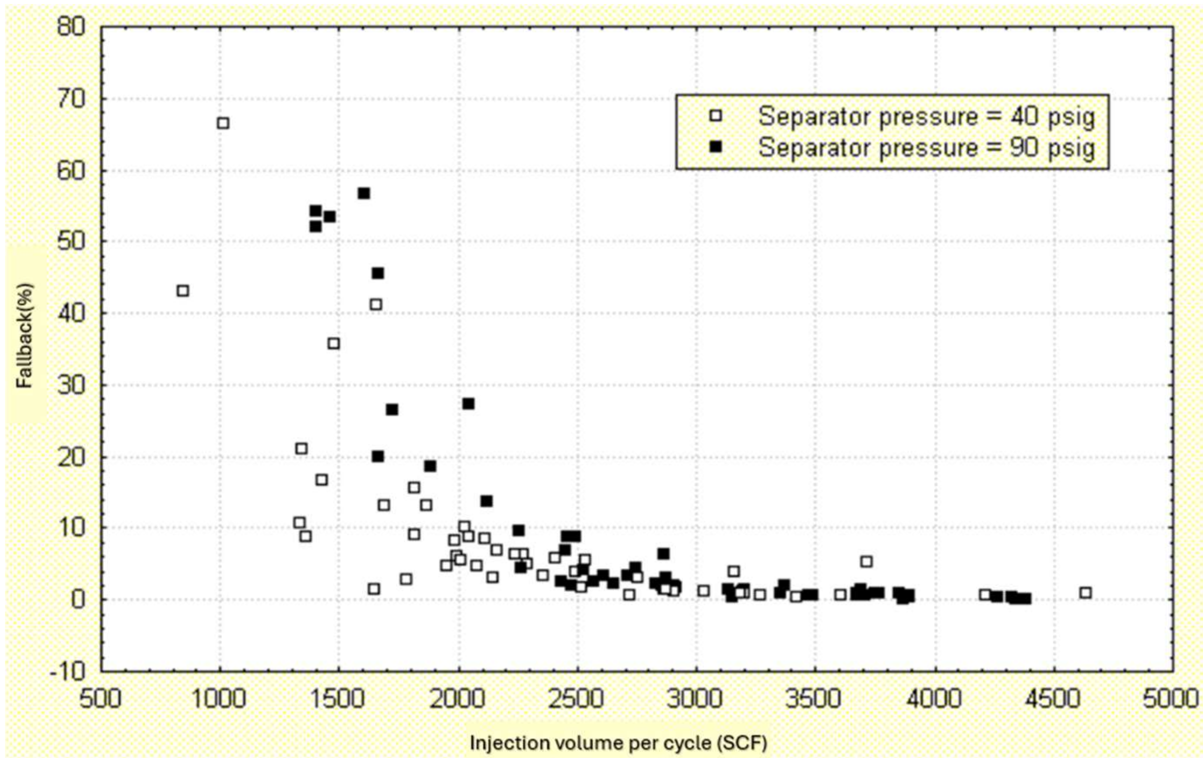
Remaining Challenges

- How do we design an IGL system?
- How do we minimize fallback?
- How do we optimize injection rate?
- How do we quantity an reduce P_{wf}?
- How do we reduce impacts on surface facilities?

Learn from the Past

Fallback Factor – Volume Expended per Cycle

Fallback



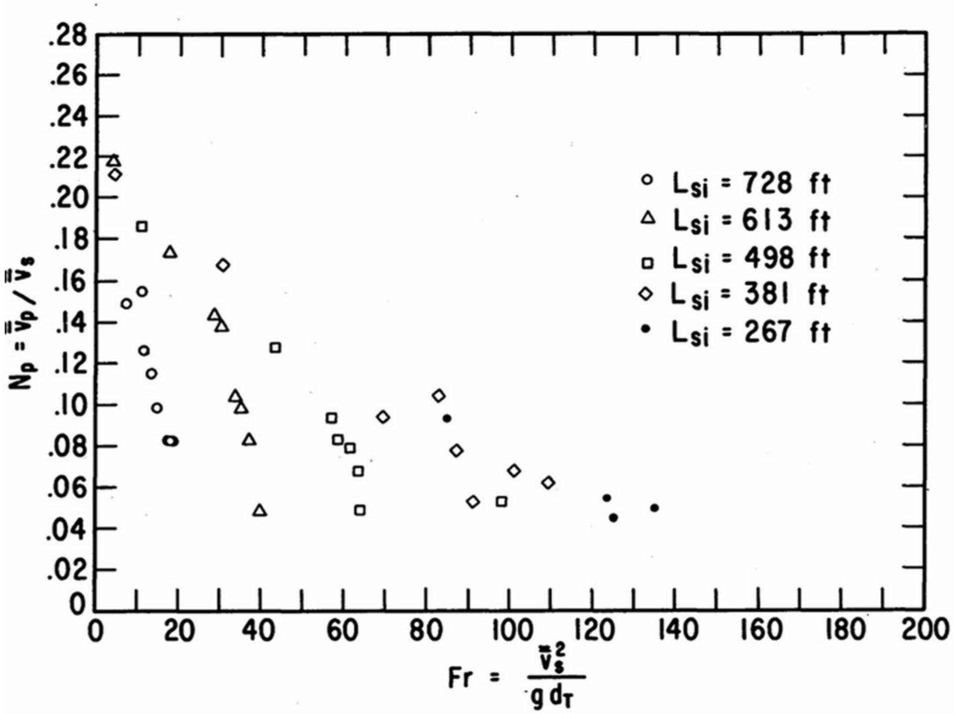
Injected gas volume

Hernandez, 1997

Fallback Factor – Volume Expended per Cycle

Water, 1.25" ID tubing

"Fallback"



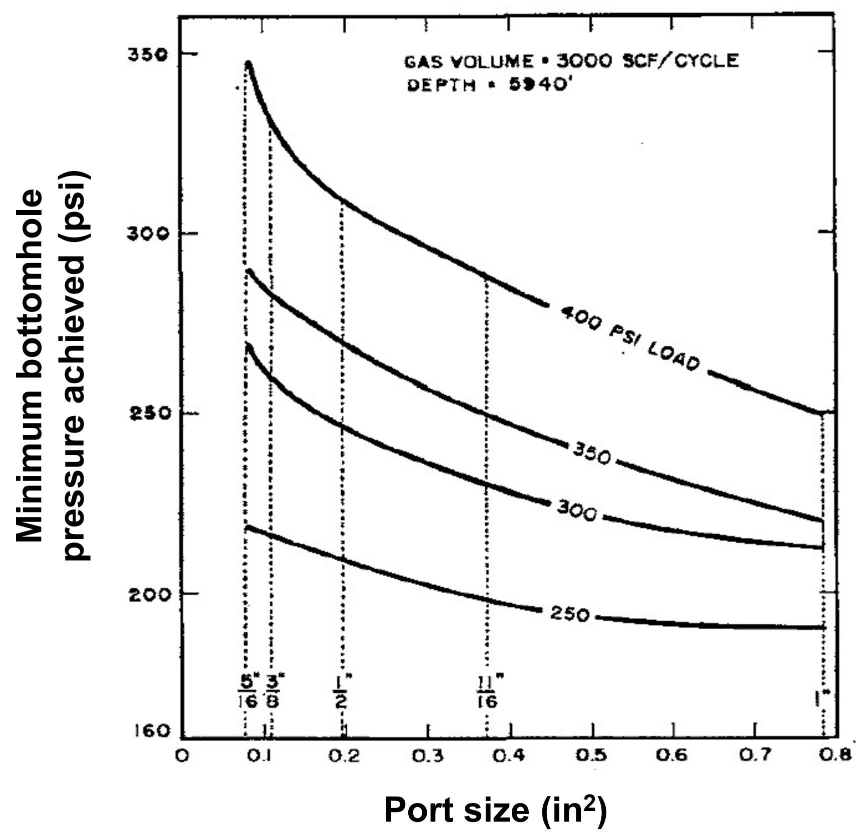
"Slug Velocity^2"

Yet, Ali Hernandez notes a limiting velocity at which fallback increases with velocity.

(Brill, 1966)

Fallback Factor – Pilot Valve Port Size, Slug Length

"Fallback"



"Slug velocity"

(Brown, Jessen, 1962)

Fallback Factor – Surface Restrictions

- Minimize 90° bends
- Yadav et al. saw an average 15% increase in production after applying a sweeping pipe bend on 3 wells
- If a choke needs to be installed, put it near the surface facility (Herald Winkler, 1970's class notes)

Yadav et al. 2021, SPE-207794-MS

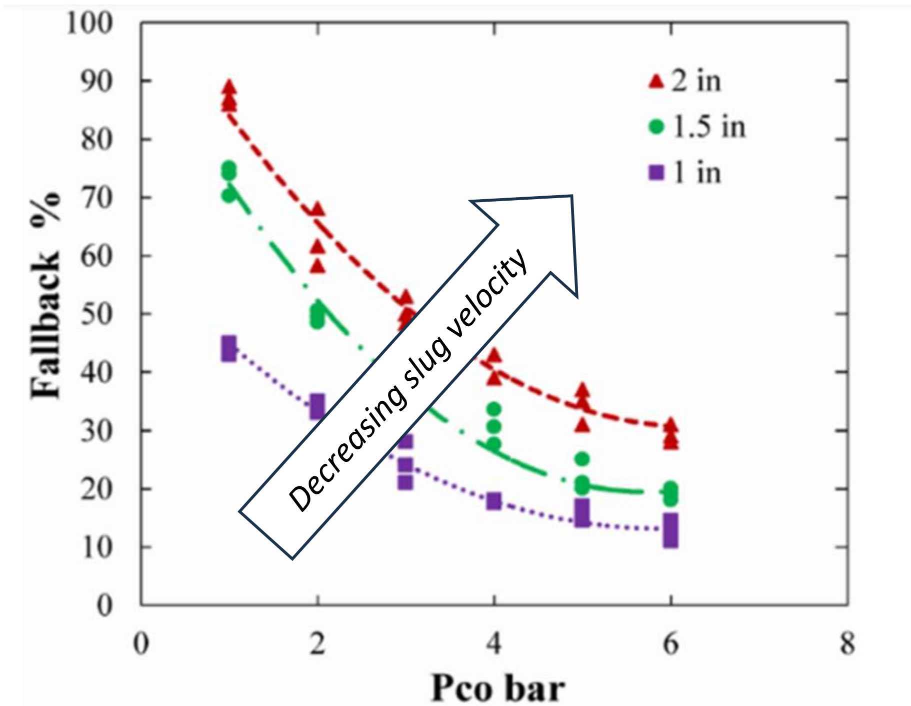
Fallback Factor – Viscosity

From Ali Hernandez Fundamentals of Gas Lift Engineering, 2016

At slug velocities of ~1,000 ft/min:

- For $\gamma_{o,API} > 23°$ viscosity negligible, fallback around 4-6%
- For $16° < \gamma_{o,API} < 23°$ fallback factor around 12-14%

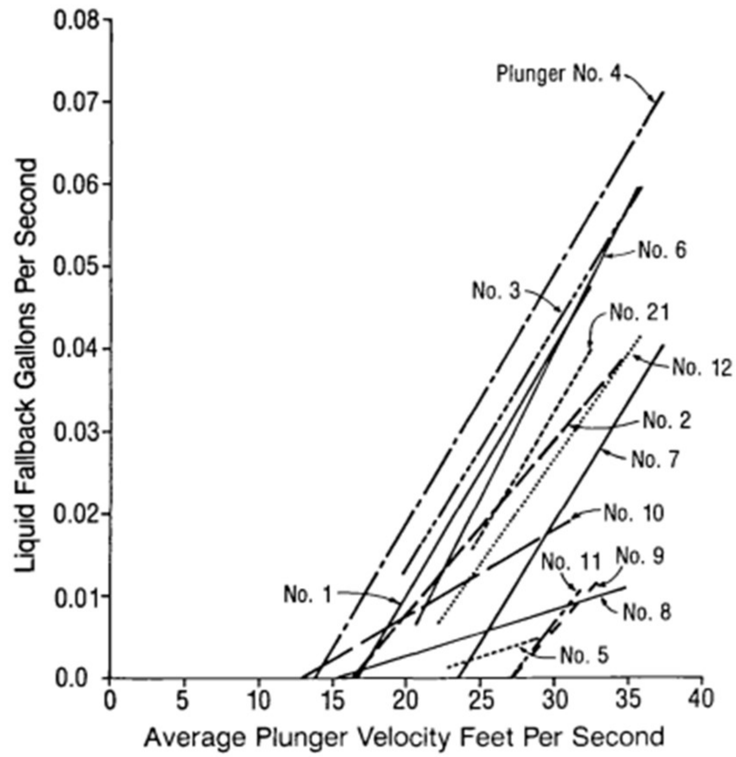
Fallback Factor – Pipe Diameter



Alahmed et al., 2017

Fallback Factor – Plunger

"Fallback"



"Plunger Velocity"

(Mower, Lea et al., 1985)

Intermittent Gas Lift Modeling

Empirical:

- Brown, Brill – 1960's

Analytical:

- White, 1963
- Neely, 1974
- Hernandez, 2016

Numerical:

- Liao, 1991 – Mechanistic model
- Pestana, T., Bordalo, S., et al. 2013 – Improved on Liao with gas lift valve throttling performance, two phase flow in the surface lines, etc...

Literature Review: Gaps and Opportunities

- No IGL results published for 2-7/8” tubing
- What is the most reliable way to characterize fallback?
  - Is “percent per 1000-ft” a reliable indicator?
  - Or is penetration velocity or volumetric loss flowrate more predictive?
- What is the limiting velocity at which fallback increases with velocity?
- There is an opportunity for improved fallback characterization for plungers

We Have More to Learn

TTU GL Consortium: Value Proposition

Address the research need for **late-life gas lift technologies** for horizontal unconventional wells to:

Reduce OPEX by reducing lift gas requirements.
Reduce CAPEX by deferring artificial lift conversions.
Increase production by minimizing bottomhole pressures.

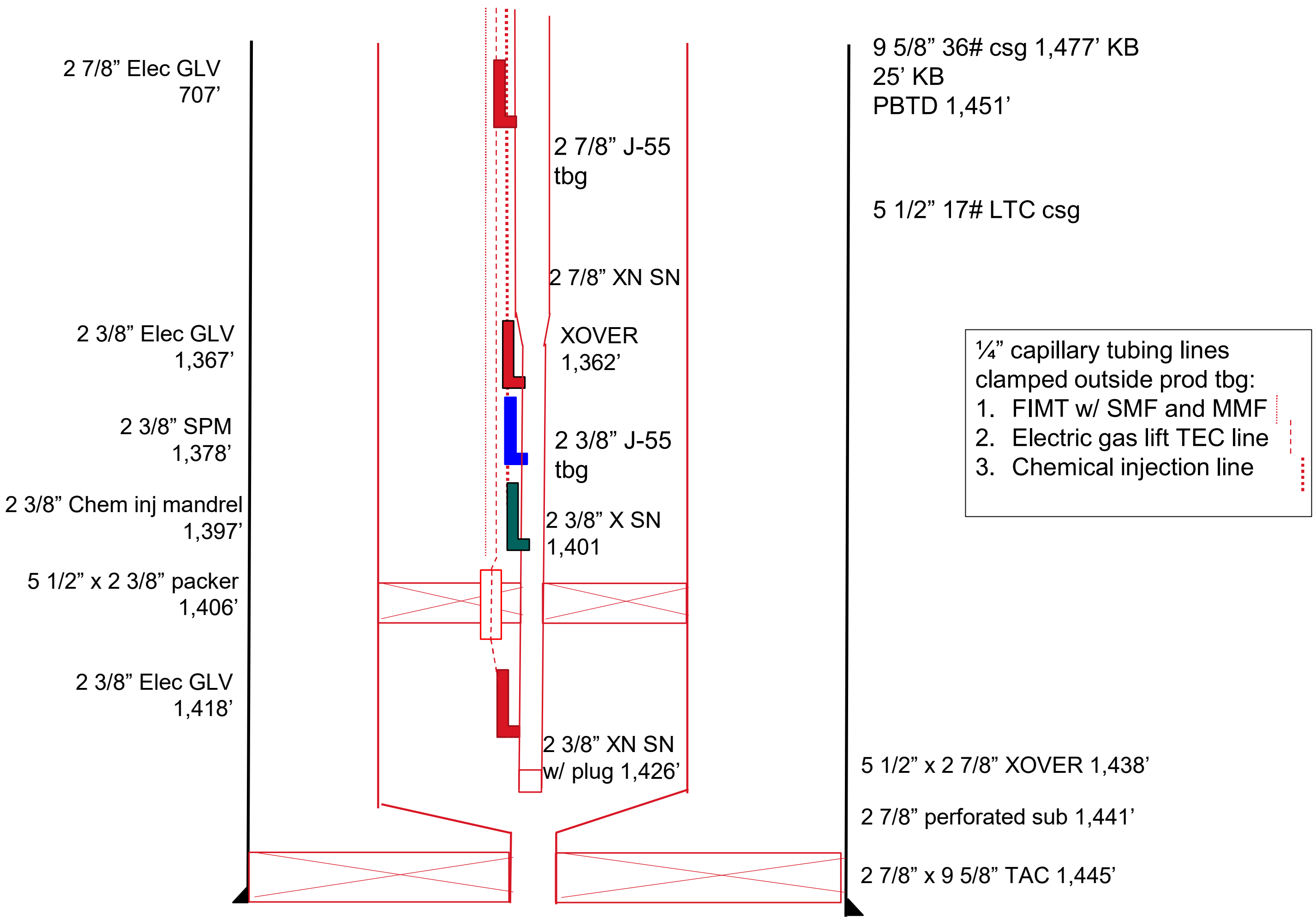
The Texas Tech University Gas Lift Consortium will support the development of:

1. A gas lift research and demonstration well
2. Simplified intermittent gas lift (IGL) design and application.
3. Fallback factor characterization and plunger recommendation.
4. IGL/GAPL smart, automated optimization.
5. Strategies for managing and mitigating surface facilities impacts.

Texas Tech Oilfield Technology Center (OTC)

Research
Education
Industry Training
Testing

Wellbore Schematic as Run



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Conclusions

Conclusions

1. Many unconventional wells are or will soon be candidates for a late-life gas lift method.
2. All late-life gas lift technologies involve lifting a liquid slug using energy from expanding gases below.
3. Fallback factor decreases with slug velocity (to a point), decreases with injected gas volume, and increases for highly viscous fluids.
4. Improved models for liquid fallback with a plunger are needed.
5. Robust, accessible models are needed for IGL design and application
6. The Texas Tech Gas Lift Consortium aims to address knowledge gaps in late-life gas lift technologies.

GAS LIFT WORKSHOP 2024

Question Time

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