Artificial Lift R&D Council

Electric Gas Lift Valve Flow Loop Testing

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Outline

- EGLV Introduction
- Testing
  - Goals
  - Facility
  - Loop and Skid
- Results
  - Characterization
  - Bonus Tests
  - Erosion
- Summary

EGLV Introduction

EGLV = Electric Gas Lift Valve

- Originally designed for injection applications (EOR)
- Electrically-controlled GLV (0–100% open)
  - One ¼ in. Tubing Encapsulated Cable (TEC) with 4 conductors
  - GLVs are daisy-chained with TEC, independently addressed
- A control valve for gas flow rather than a pressure regulator

Specifications

- **1 in.** OD conventional GLV form-factor
  - 3/8 in. (24/64 in.) port and hybrid polymer/metal dart
- 3.5 ft mandrel for 2-7/8 in. tubing standard (for 5.5 in. casing)
- Tubing/casing temperature/pressure sensors at each GLV
  - Electronics tested to **300°F**
- Surface controller powered with **<30W**

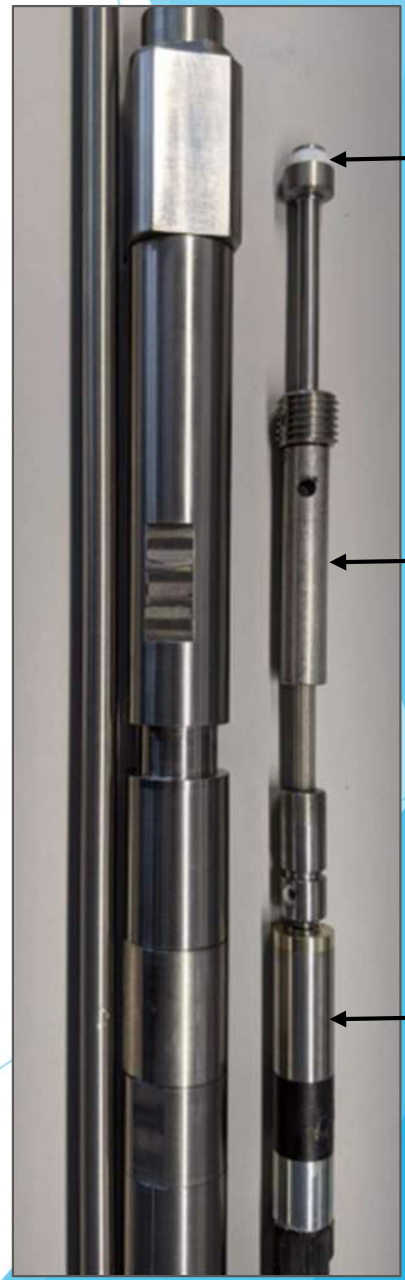
Why Use an EGLV?

Advantages

- Know where you're lifting all the time (eliminate multipointing)
- Full injection pressure available (no Δp per valve, fewer valves needed)
- P/T at each valve (live flowing pressure traverses, save a BHP gauge)
- Fully-adjustable injection rate
- Reduced dependence on surface injection control (rough vs. fine-tuning)
- No prod. pressure effect or temp. sensitivity (less slugging, no chattering)
- Check valve and packer optional (annular and tubing lift?)
- Fully-autonomous, closed-loop GL possible (GAPL/PAGL, too)

Disadvantages

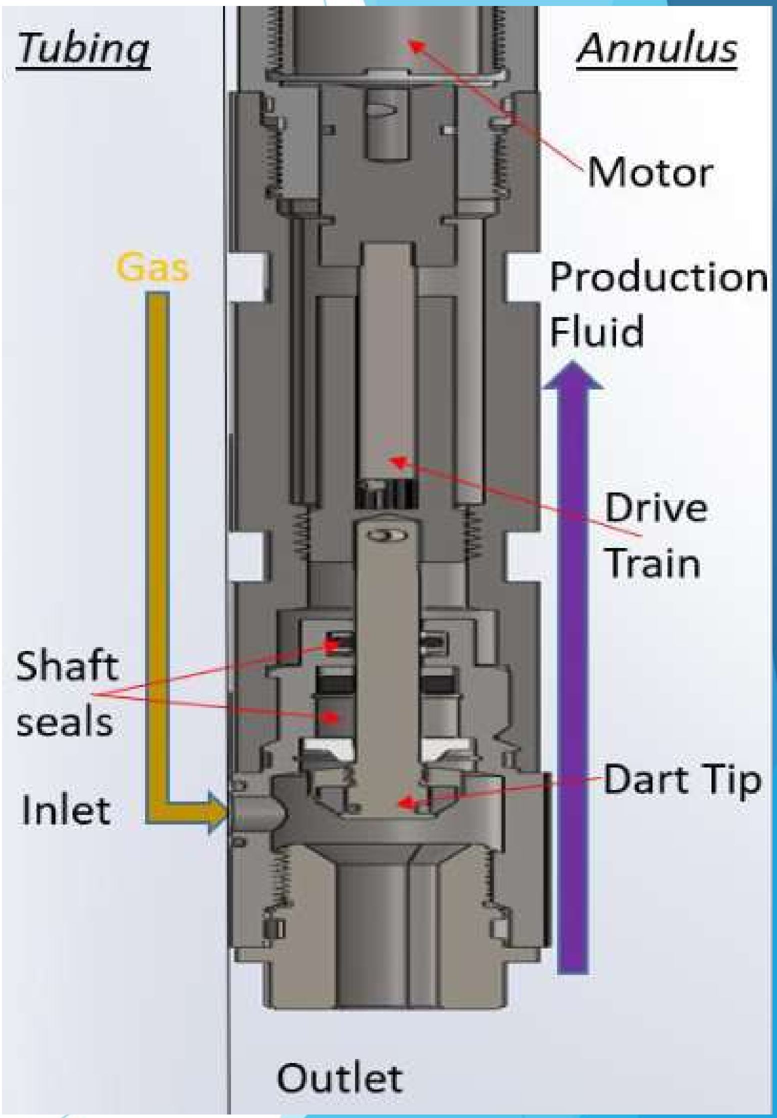
- Higher initial cost
- Reliability of downhole electronics
- Conventional GLVs, so tubing workover to change them



Testing Goals

Goals

- Characterize flow performance
- Evaluate power draw vs. applied Δp
- Simulate well unloading with residual solids
- **Identify the operational envelope** (destructive testing!)



Testing Facility

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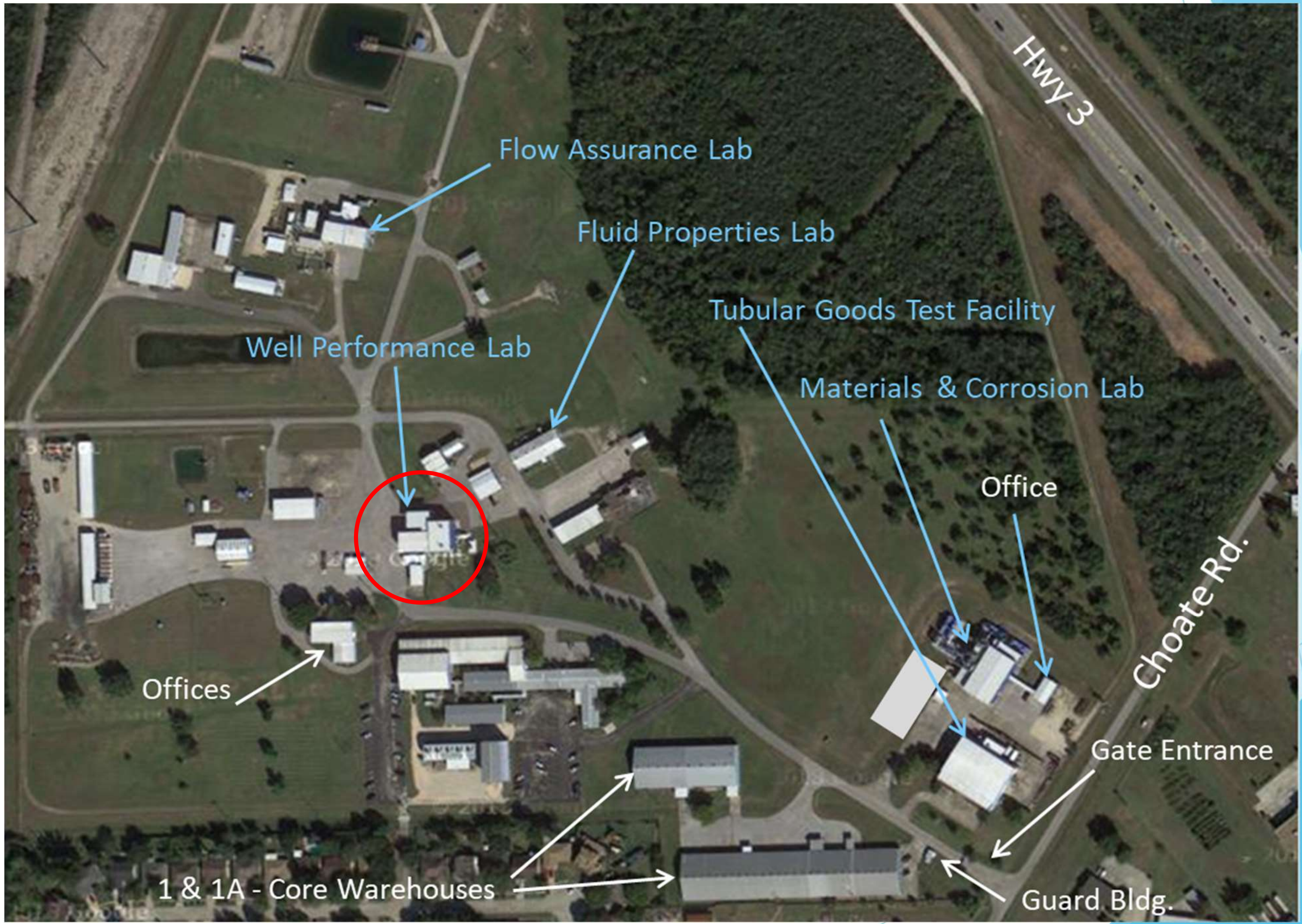
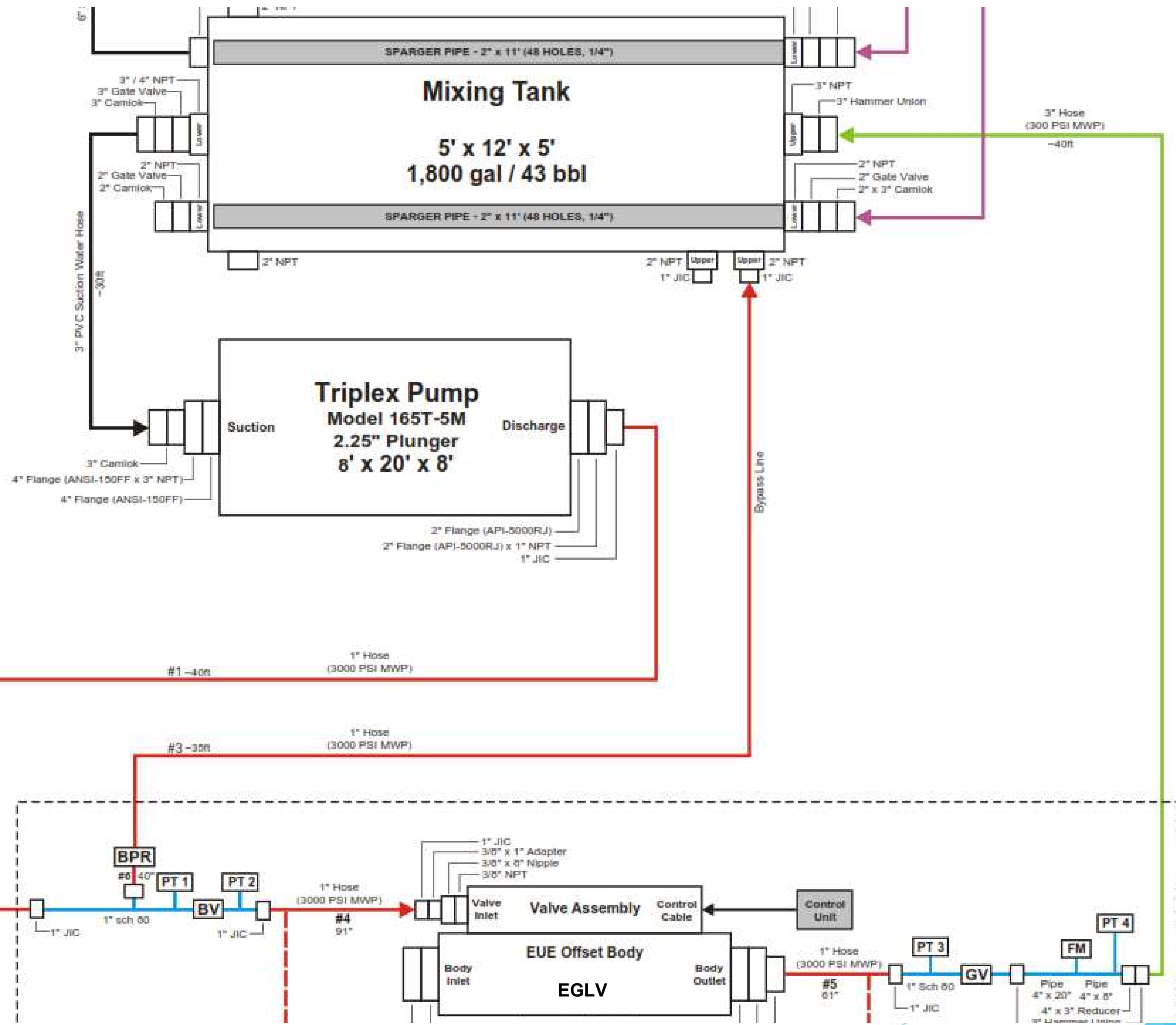
UIS Friendswood Test Facility

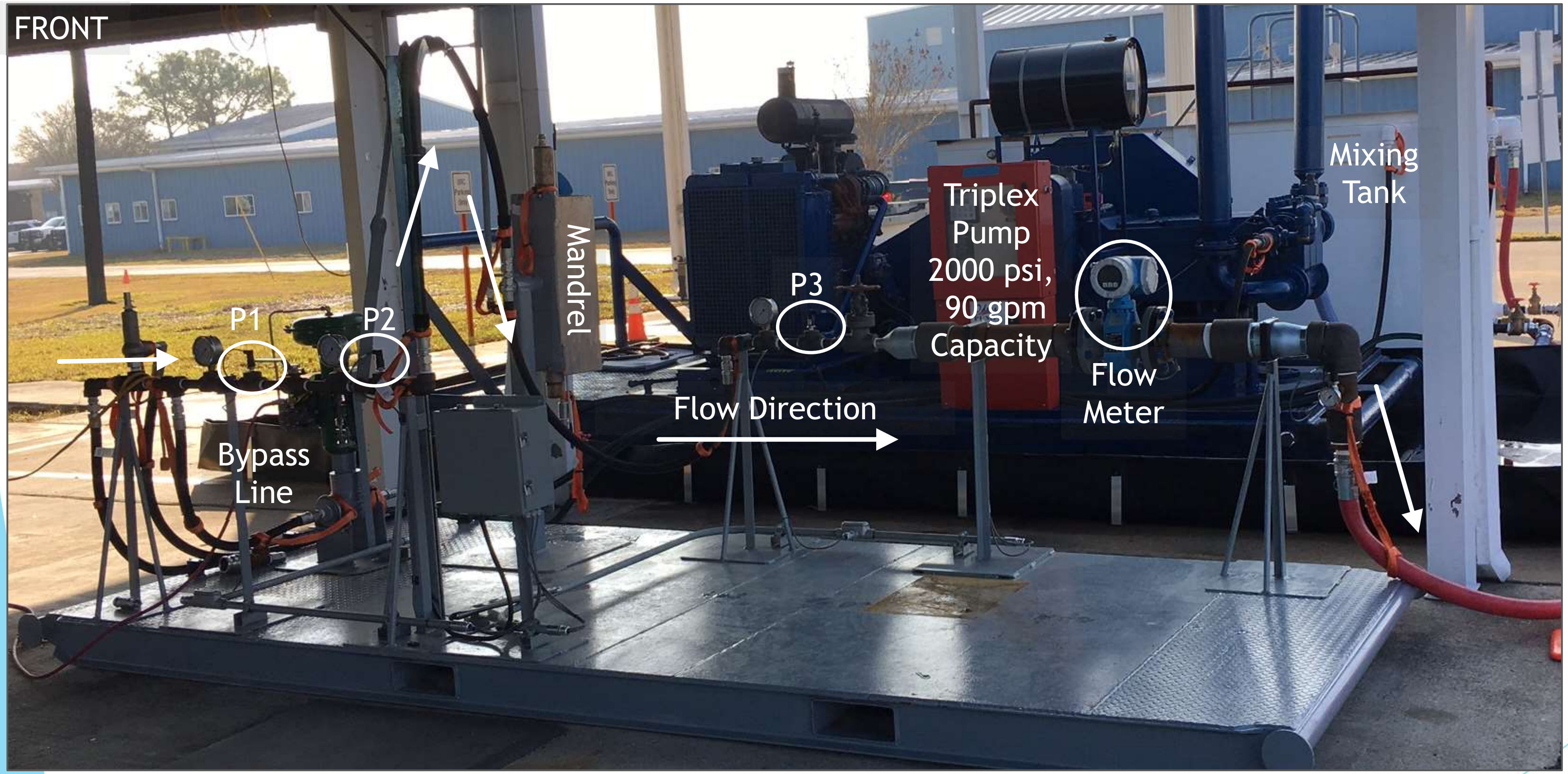


Flow Loop

Mixing Pump to Maintain Sand Suspension

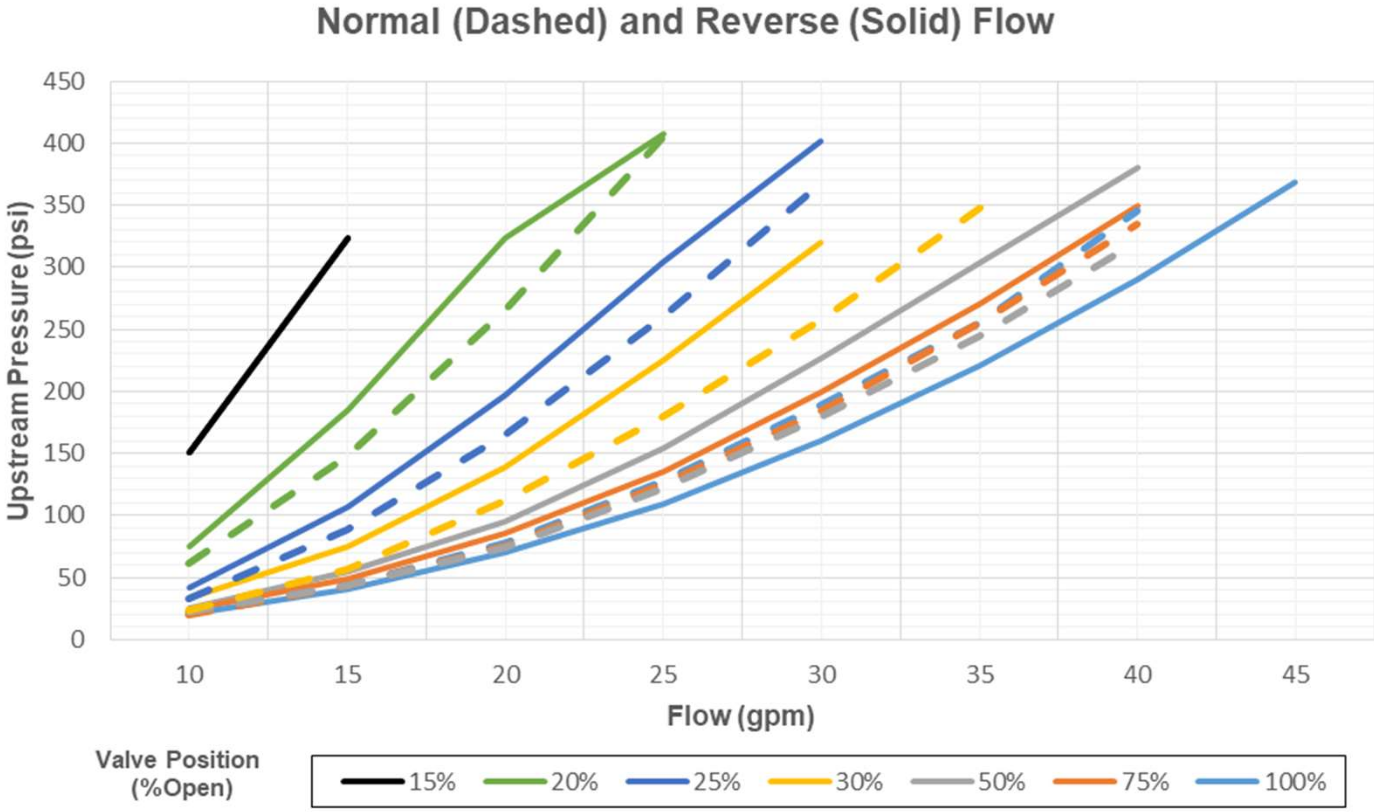


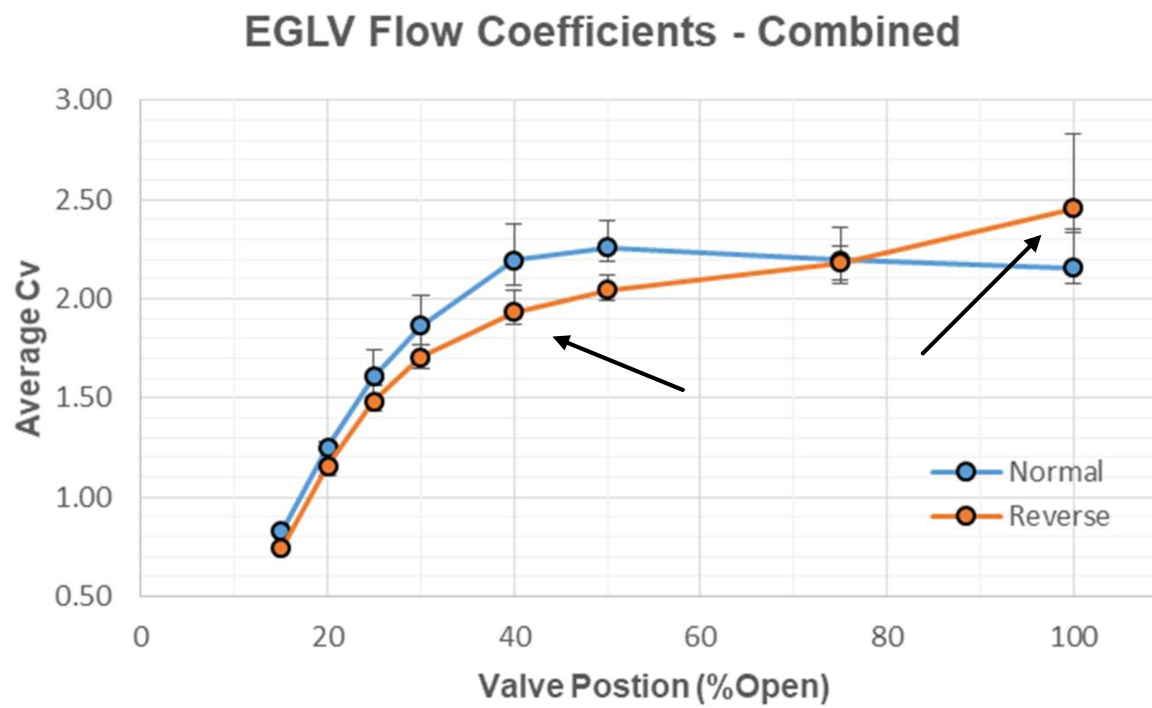
Test Skid


FRONT
P1
P2
Bypass
Line
Mandrel
P3
Flow Direction
Triplex
Pump
2000 psi,
90 gpm
Capacity
Flow
Meter
Mixing
Tank


BACK
Inlet
Power/Control
TEC Line
Bypass
Valve
Mandrel with EGLV
Outlet

Valve Characterization



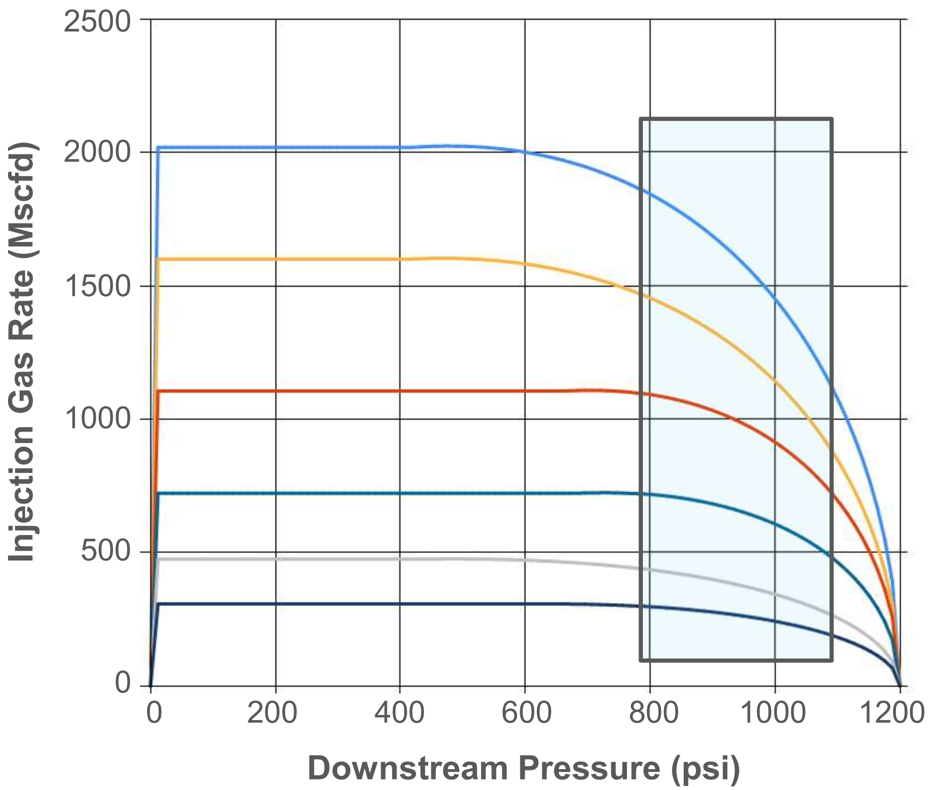


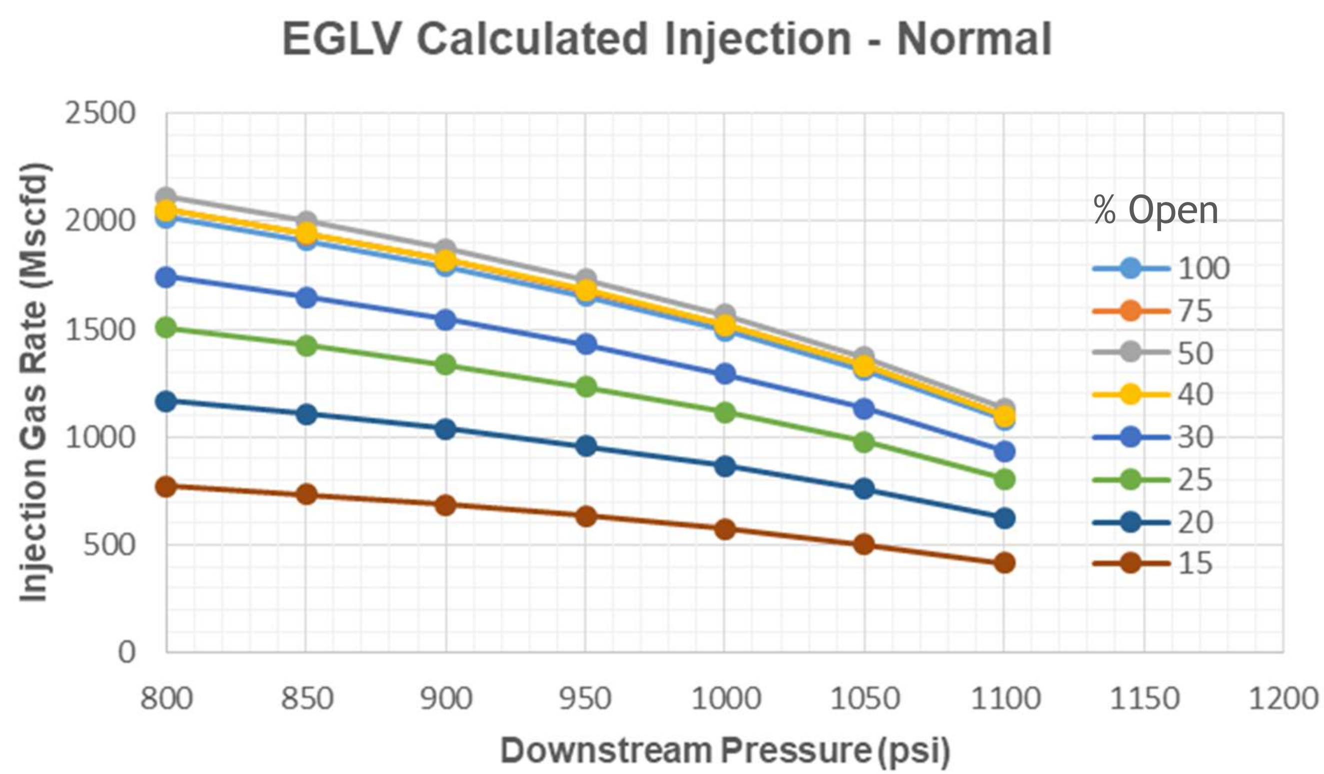
Goal: Characterize valve flow with water

- City water (with some tank rust), downstream pressure atmospheric
- Not much change in the injection performance from 100 to 40% open
- Tested with high (2000 psi) and low pressure (400 psi) pumps to cover full range
- Flow coefficients indicate dart has more impact on tubing-to-casing (reverse) direction
- Can use this data to calculate expected gas throughput under certain conditions

Valve Characterization

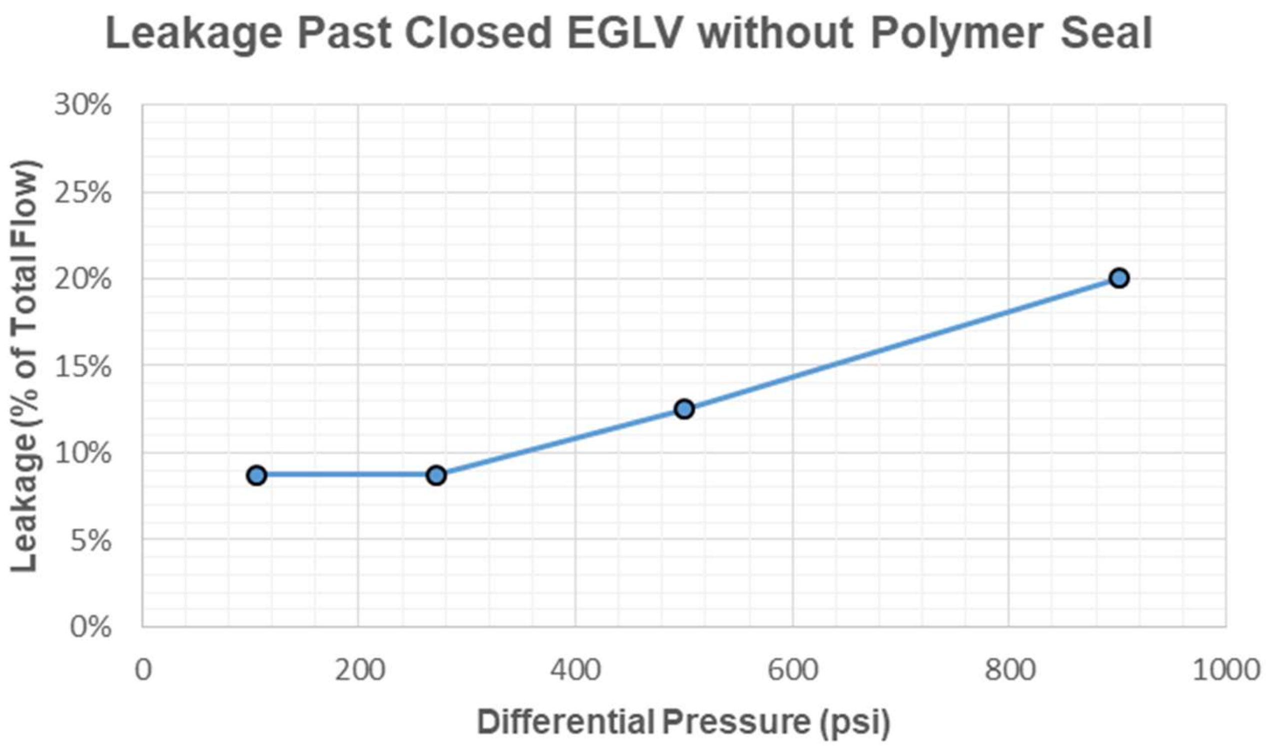
1200 psi Upstream, 200°F





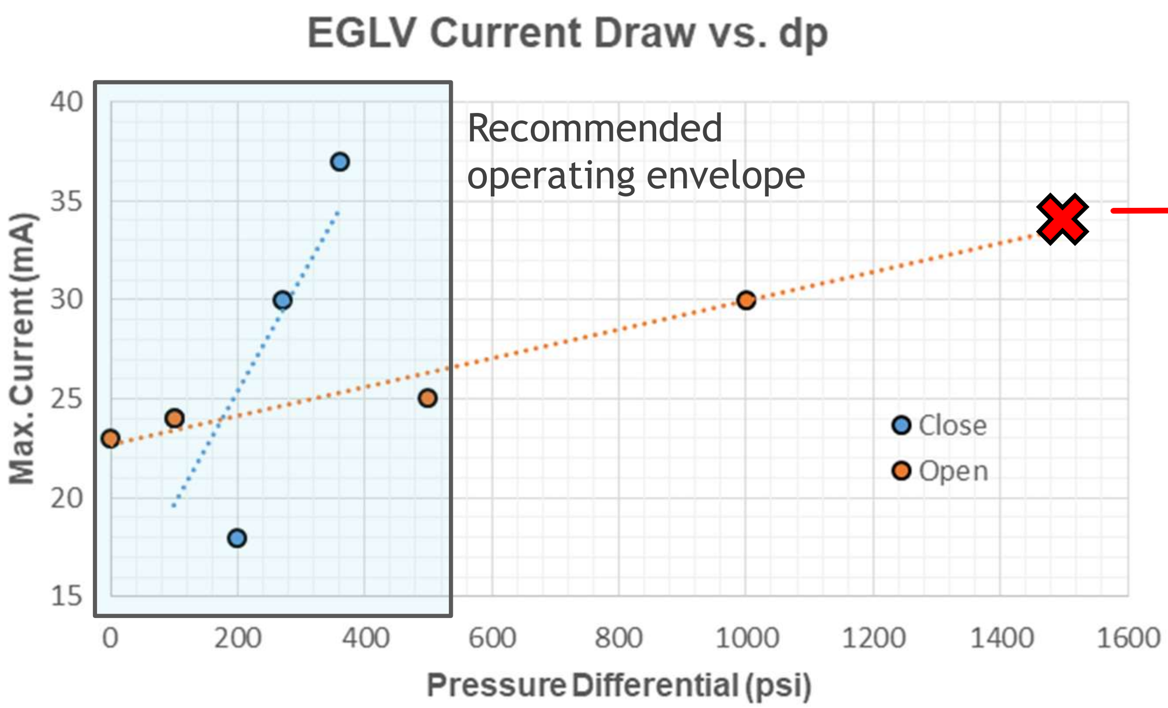
- **Left**: 1 in. Orifice GLV VPC data showing 8, 10, 12, 16, 20, and 24/64 in. ports
- **Right**: A single EGLV from 15 to 100% open
- Stable range of about 300 to 2100 Mscfd for both
- Full characterization would require gas injection at choked flow conditions

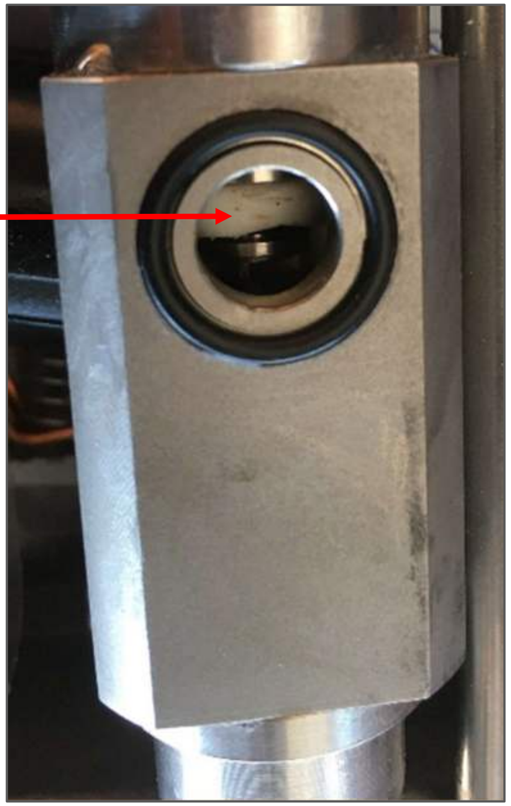
Leaky Valve



- Confirmed that **90 gpm** through a **20% open** EGLV is a bad idea (oops)
- High velocity flow removed the polymer from the dart tip
- **Goal:** Determine how much a leaky valve leaks
- Fluid: City water
- **Result:** 10-20% of total flow leaked through depending on the differential pressure

Current Draw

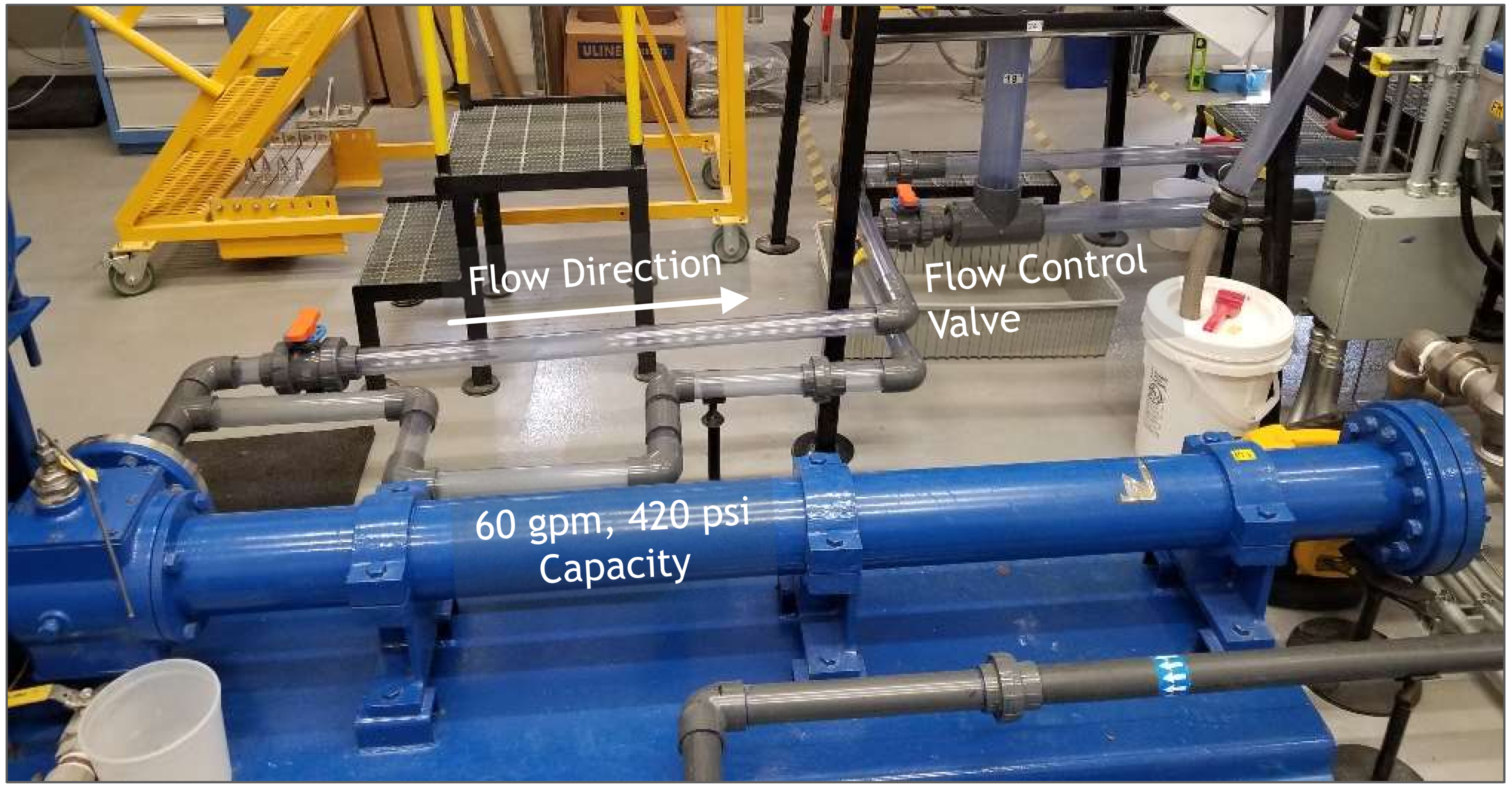




- Opening against 1500 psi Δp is also a bad idea
- Failed leak test, “rolled” polymer
- Reported valve “squealing” during movement and required communications reset—but the motor retained functionality!

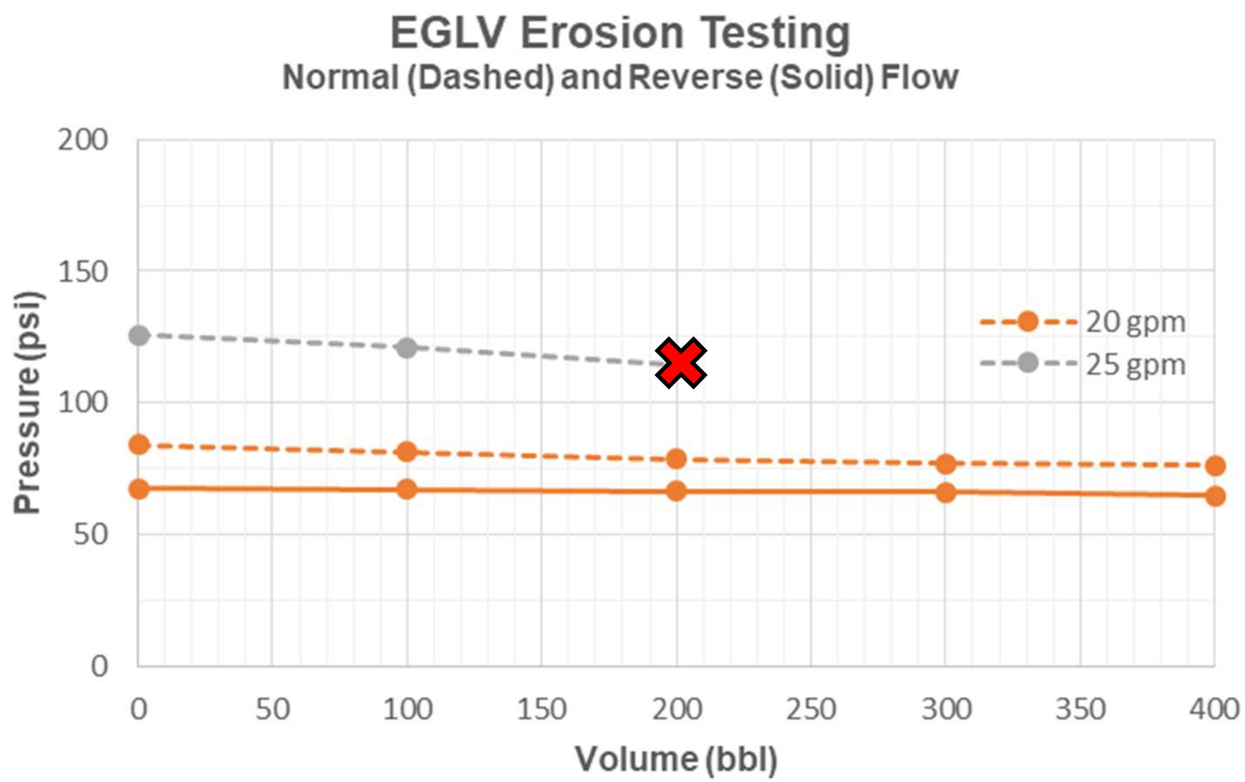
- **Goal:** Determine EGLV current draw at various Δp
- Fluid: City water
- **Result:** Current draw increases roughly linearly with Δp
  - More current required to close against flow than open against static pressure

Erosion Testing

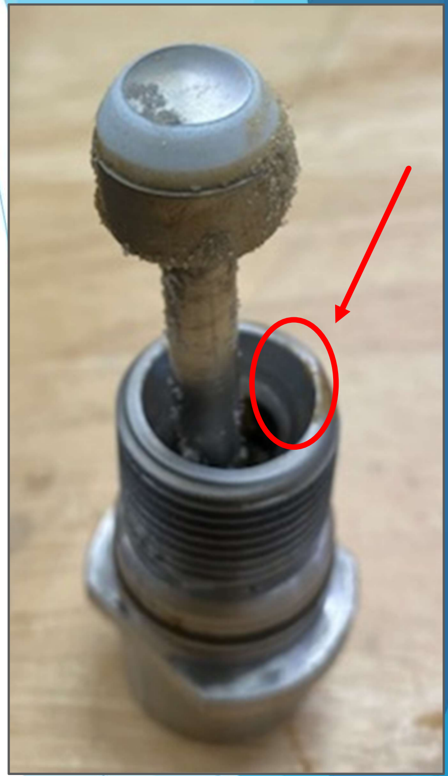


- Transitioned to lower capacity pump for erosion testing
- **Goal:** 400 bbl at constant rate, unloading process simulation
  - 3x the expected annular volume for 2-7/8 in. tubing in 5.5 in. casing, 10kft well
- Valve Position: 100% open
- Fluid: 1% by volume 70/100 mesh sand in city water (residual frac sand)
- Injection Rate: Up to 1 bbl/min (API recommended max. for standard GLV)

Erosion Testing – Round 1



SS0 - Passed at 20 gpm



SS0 - Failed at 25 gpm

- Seal tests performed at 100 bbl injection intervals
- Dart SS0 and standard seat passed 400 bbl test in both flow directions
  - Tested at 20 gpm, 65-80 psi Δp
- Same design failed 200 bbl seal test when injecting at 25 gpm, 120 psi Δp
  - Noted erosion at seat

Erosion Testing – Round 2

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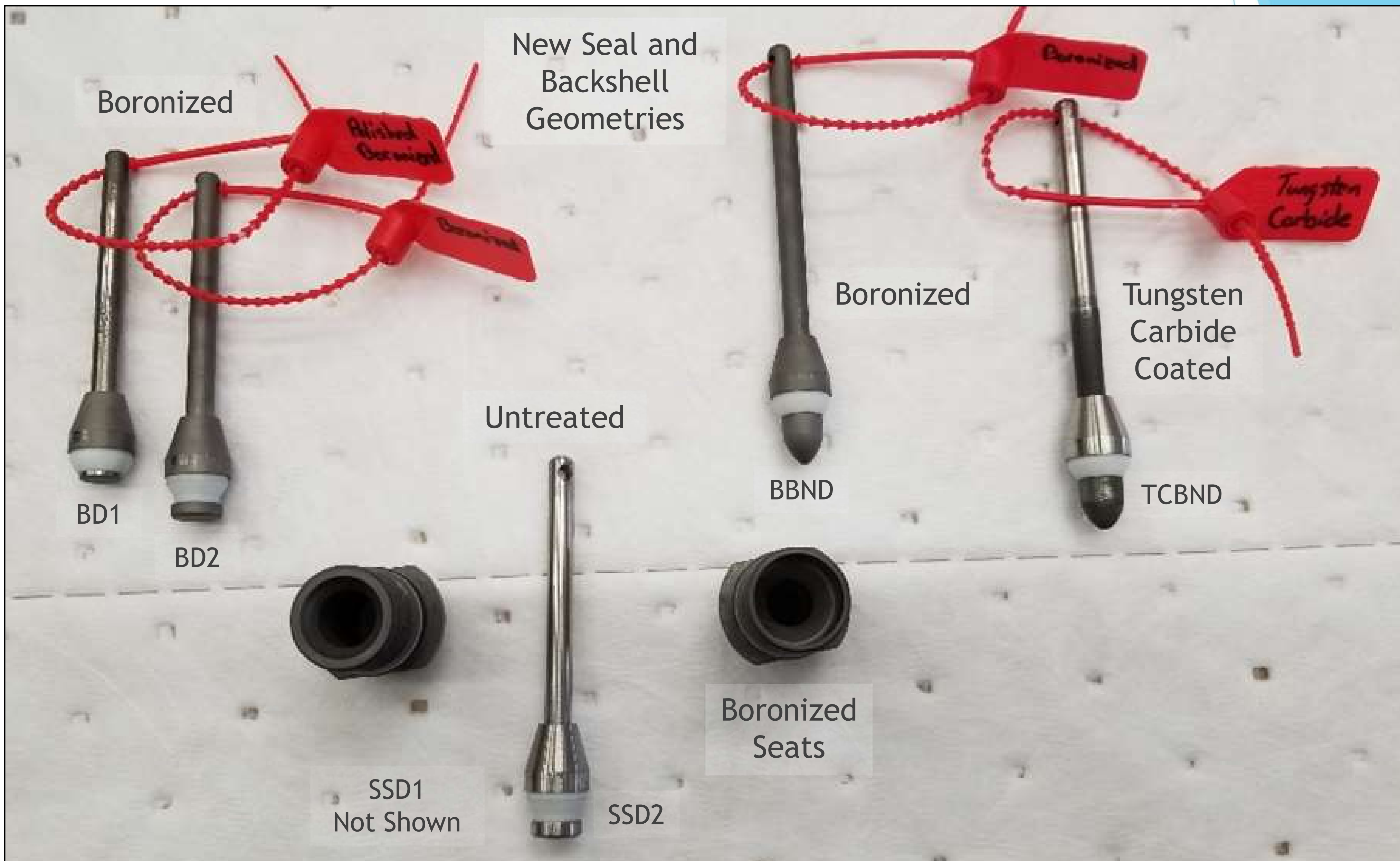


Erosion Testing – Round 2

SSD1 – Passed, Minimal Wear

SSD2 – Passed

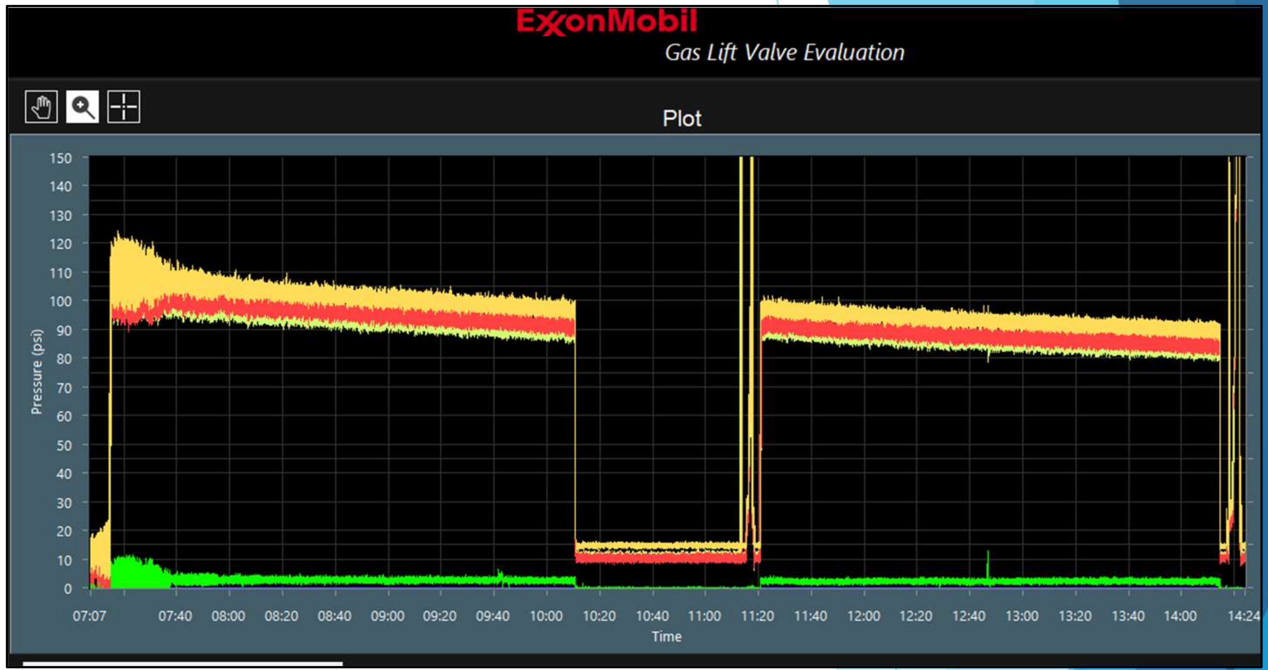
BD2 – Passed

- All new designs tested held a liquid seal (200+ psi) after 400 bbl at 25 gpm, casing-to-tubing
- Taller darts (backshell plus seal) reduced effective flow area, resulting in higher Δp and wear
- Minimal erosion noted in boronized seats

Erosion Testing – Round 2

Before

After 800bbl with 1% sand



Δp Drop Over Time from Outlet Erosion

- Improved seat and dart designs moved wear to the standard valve bodies
- Boronized valve bodies to be tested in Round 3

Summary

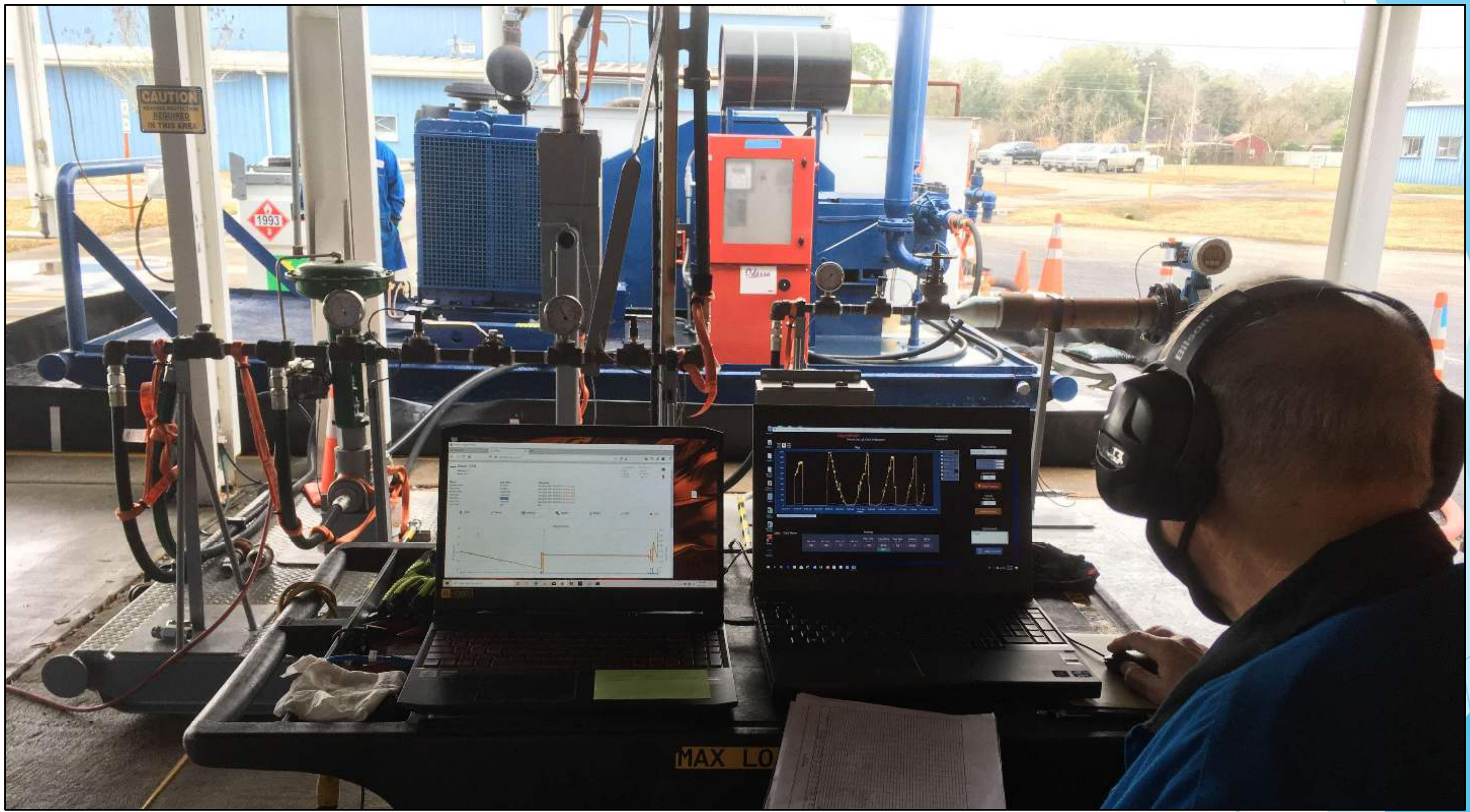
EGLV Testing

- Built a custom flow loop to determine EGLV operational envelope
- Characterization showed the EGLV can simulate a wide range of GLV ports
- Conducted unique leak and power draw tests
- Original design withstood 20 gpm, 80 psi Δp erosion testing
- Design improvement in progress, boronizing shows promise

Next Steps

- Test with boronized valve bodies
- Optimize dart designs for erosion resistance
- Increase injection rate to define new erosion limit

Acknowledgements, Thank You, & Questions



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