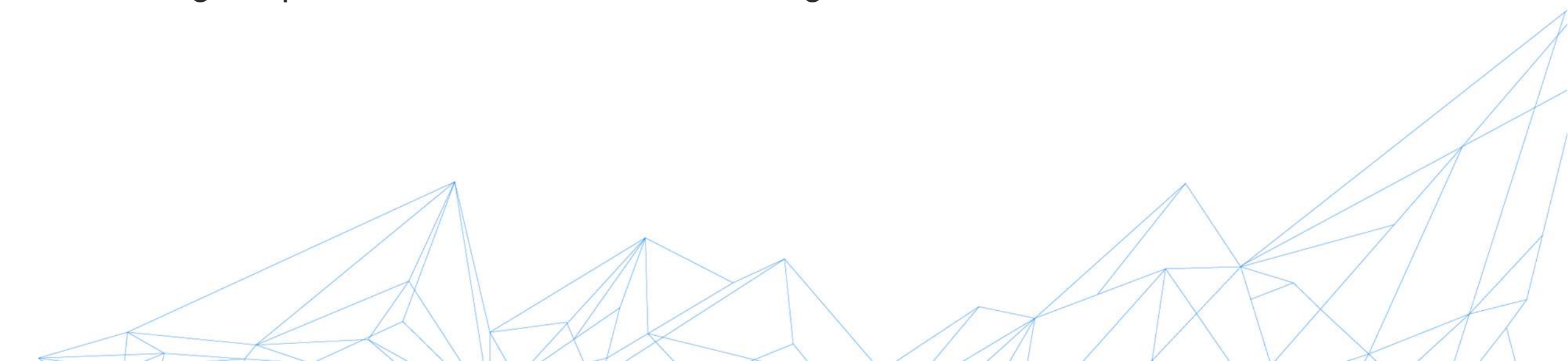
5 JUNE 2022

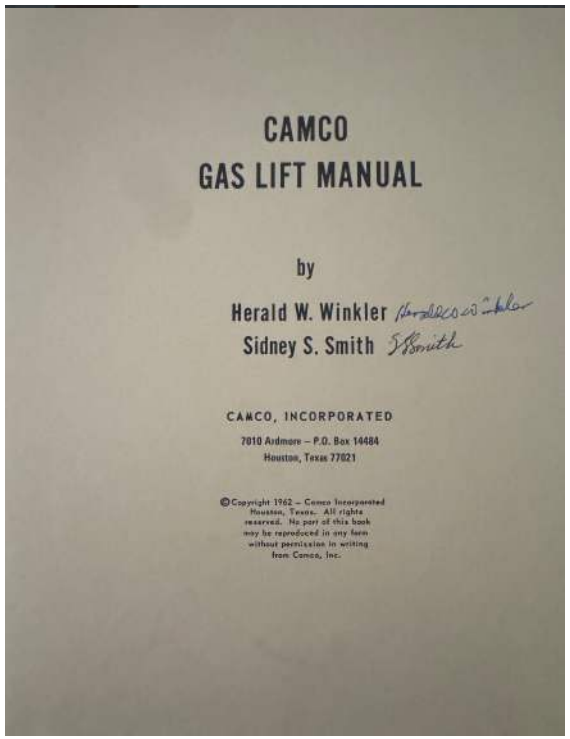
OCCIDENTAL PETROLEUM

LESSONS LEARNED FROM A DECADE OF GAS LIFT IN THE PERMIAN

Greg Stephenson, Chief Production Engineer



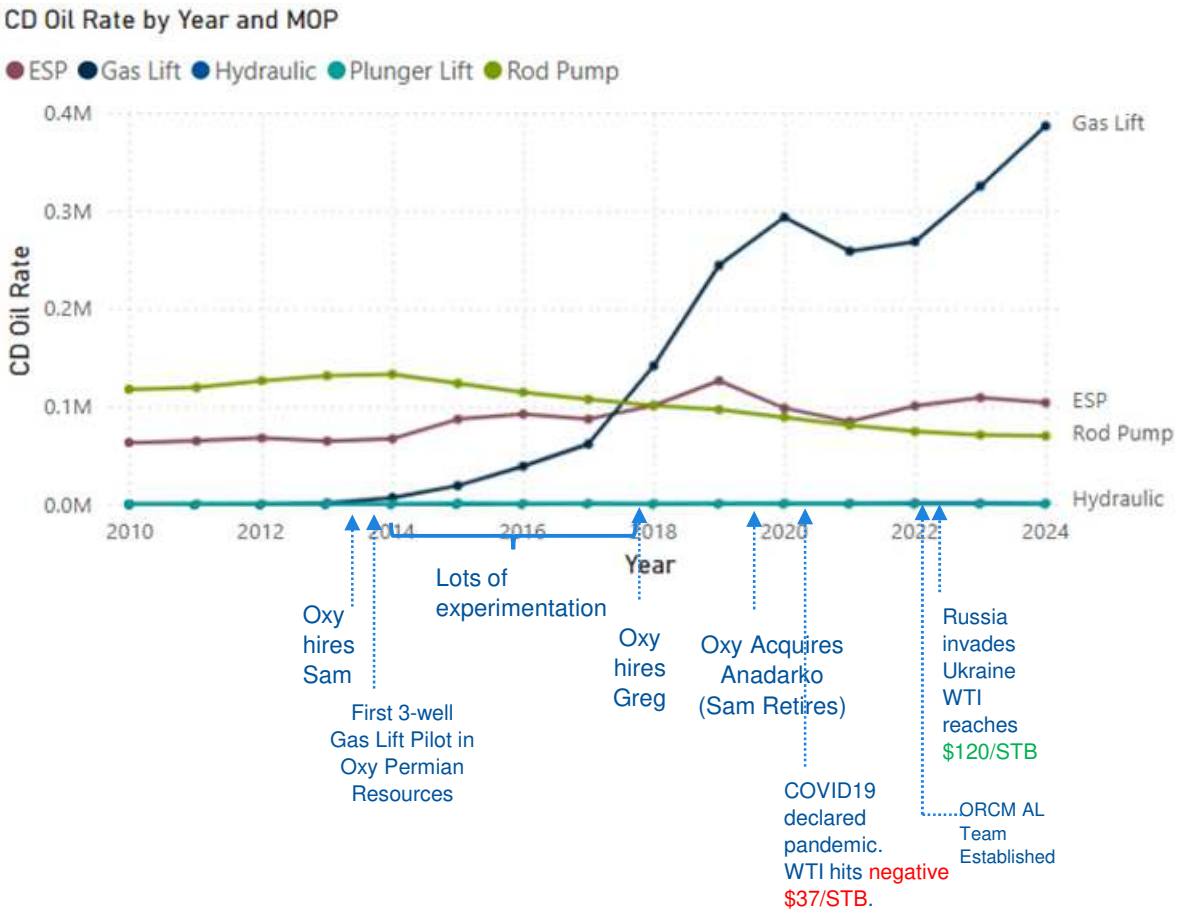
IN CASE YOU HAVEN'T NOTICED, I'M REALLY INTO THIS

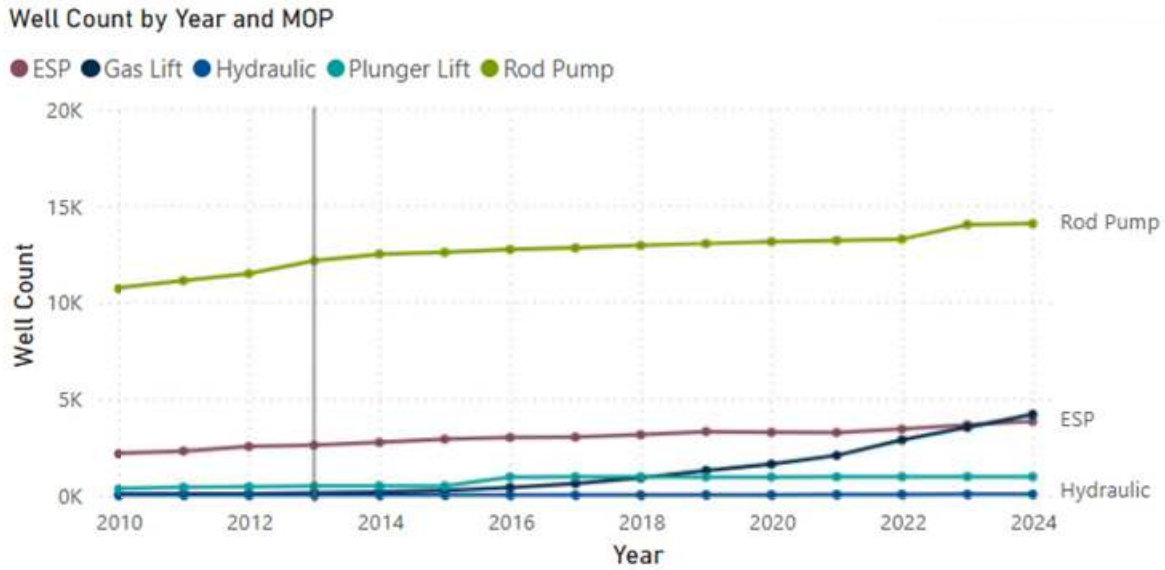


OUTLINE

- Historical Lift Usage
- Why gas lift?
- Challenges
- How we made the transition
- Lessons Learned

ARTIFICIAL LIFT USAGE IN THE PERMIAN





WHY WOULD ANYONE USE GAS LIFT IN THE PERMIAN?

Gas Lift most suitable when:

- Reservoir fluid has high gas content
- ~~Well has good reservoir productivity (PI)~~
- ~~Reservoir pressure can be maintained~~
- Low wellhead pressures can be achieved ?
- Fluid has entrained solids
- ~~Wellbore workover cost is high (offshore, remote operations)~~

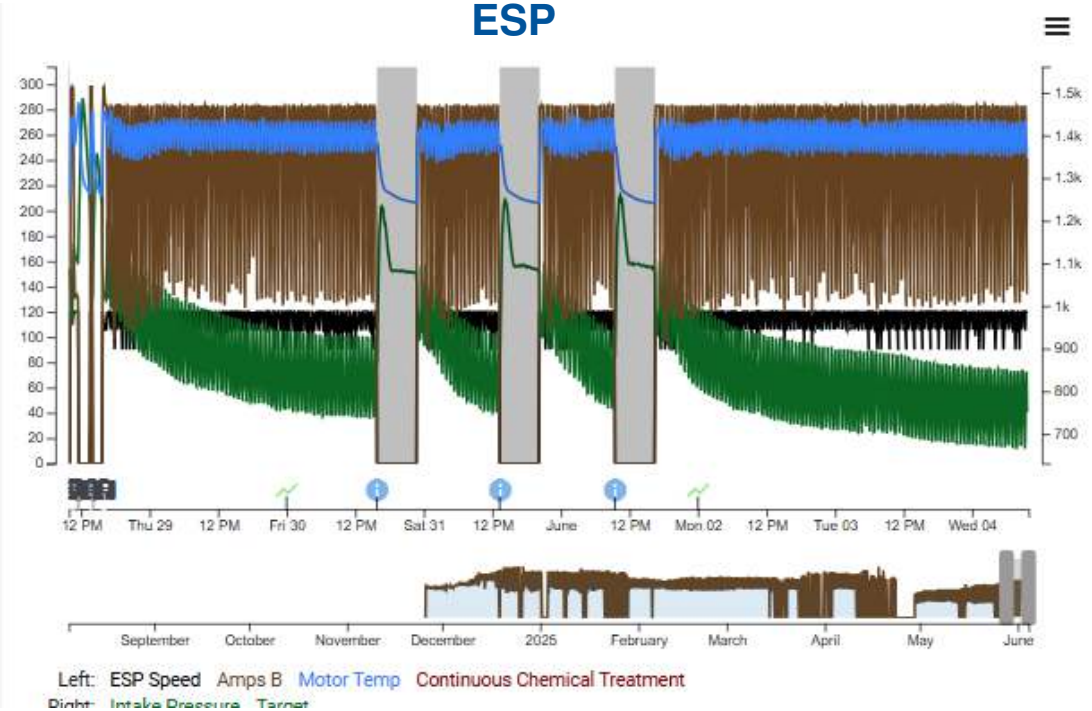
Other advantages:

- Tolerant of high deviation/DLS
- Can produce over wide range of production rates

THIS IS REALLY HARD TO PUMP!

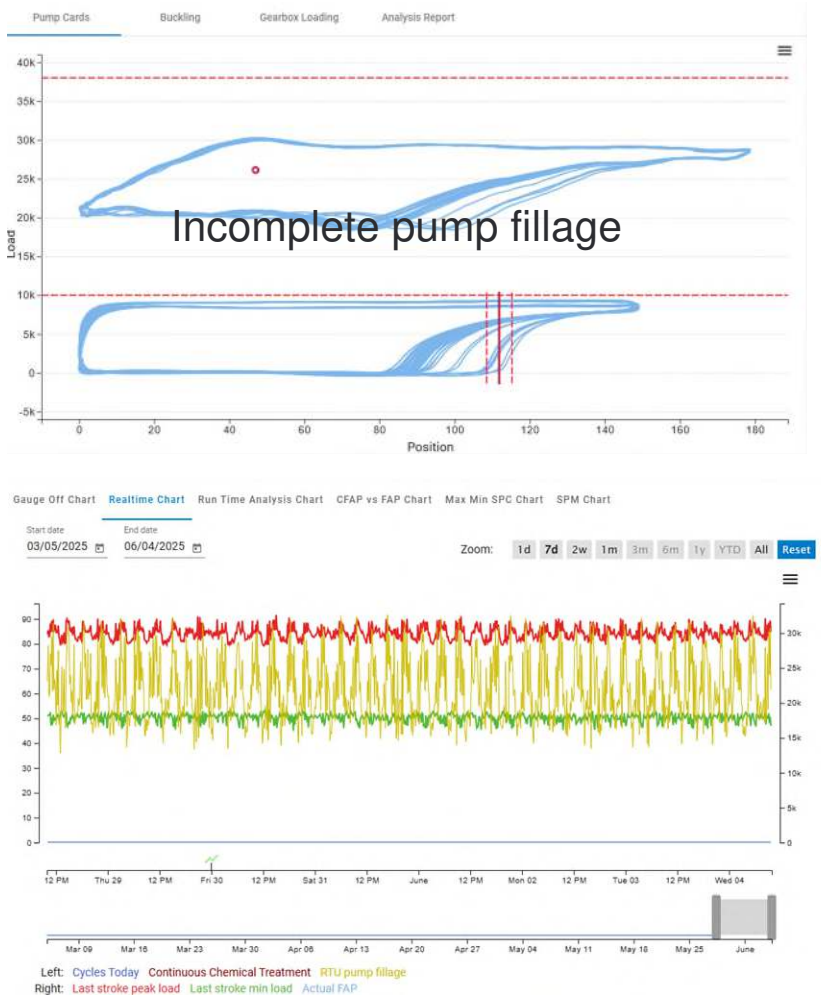
GAS INTERFERENCE ISSUES

ESP



ESP run life will be significantly impacted due to all the shutdowns and motor temperature spikes. The cost impact is not only lost production but needed manpower with each shutdown.

Sucker Rod Pump



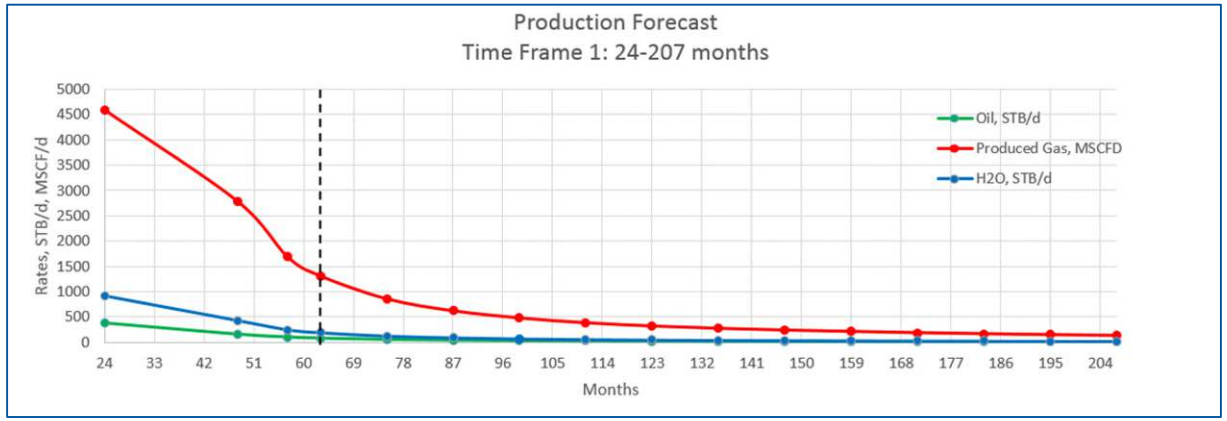
GAS LIFT IS LIKE A HONEY BADGER

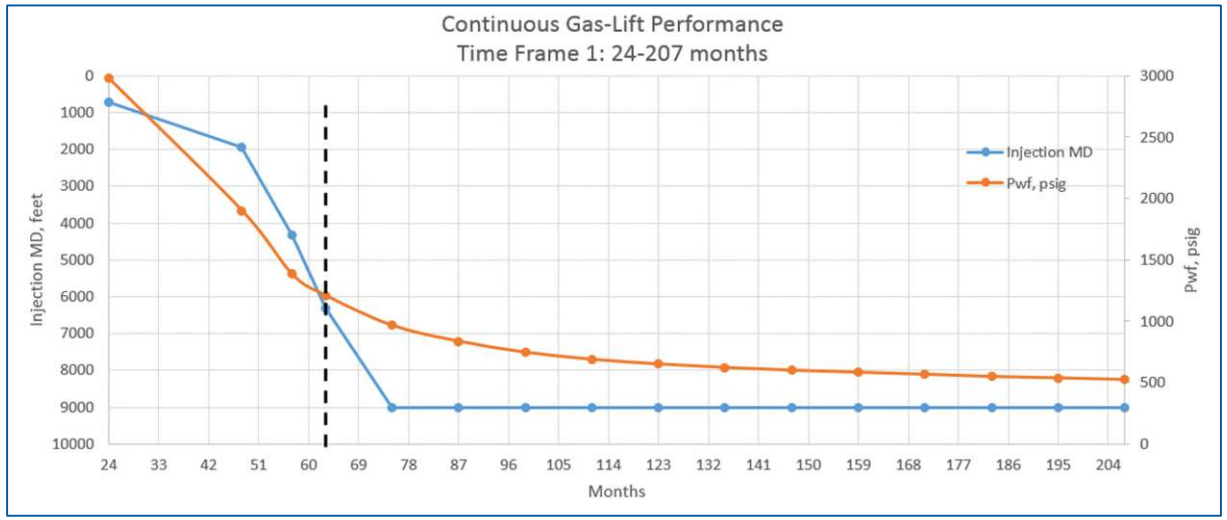
Also: Gas Lift works even when it’s broken.

CHALLENGES

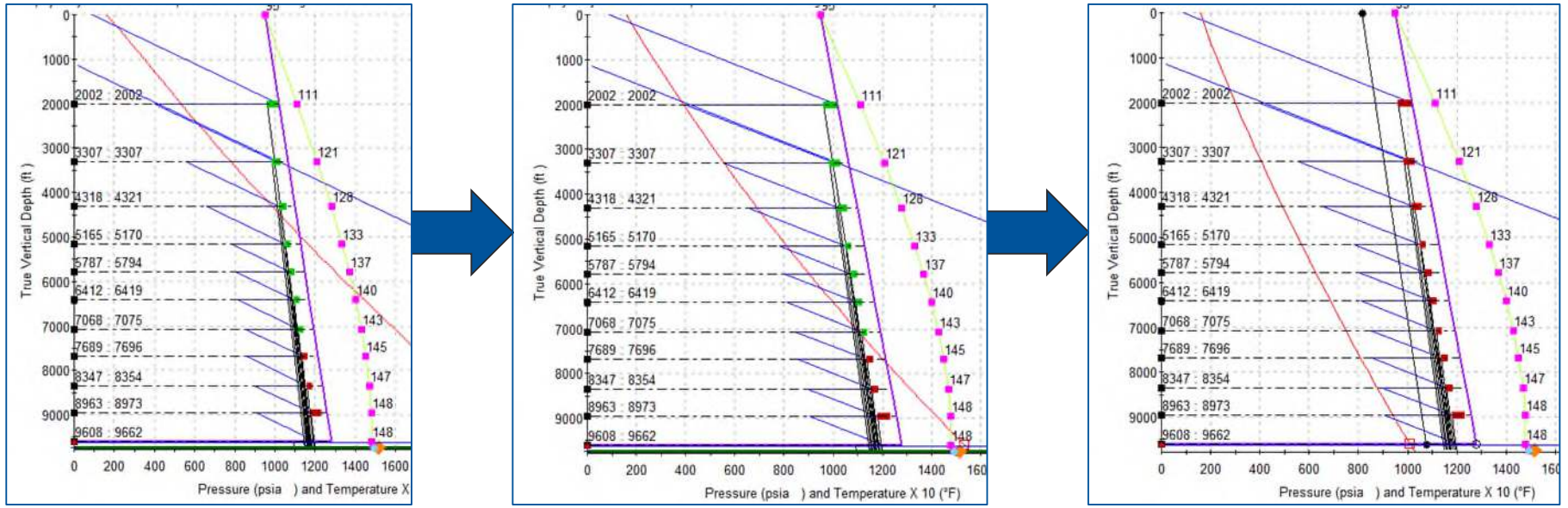
- Lack of surface infrastructure
- Lack of local knowledge
- Lack of qualified service personnel
- Access to equipment
- Remote locations
- Unpredictable well performance

MORE CHALLENGES





MORE CHALLENGES

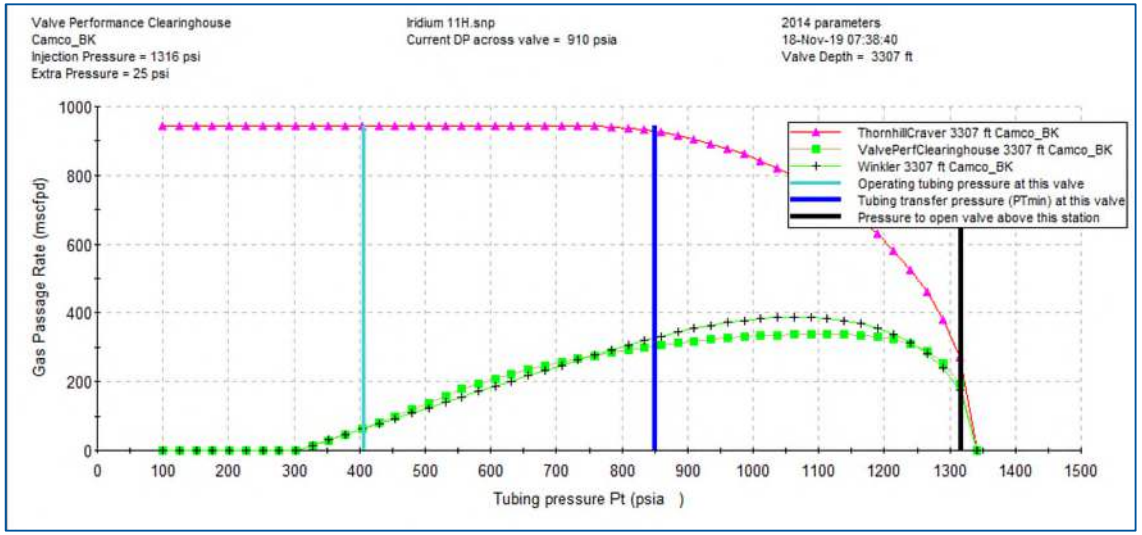


6 mos. 12 mos. 24 mos.

MORE CHALLENGES

Valve Reliability Issues

- Flow Cutting
- Throttling / Chattering
- Bellows Failures
- Plugging
- Elastomer Failures



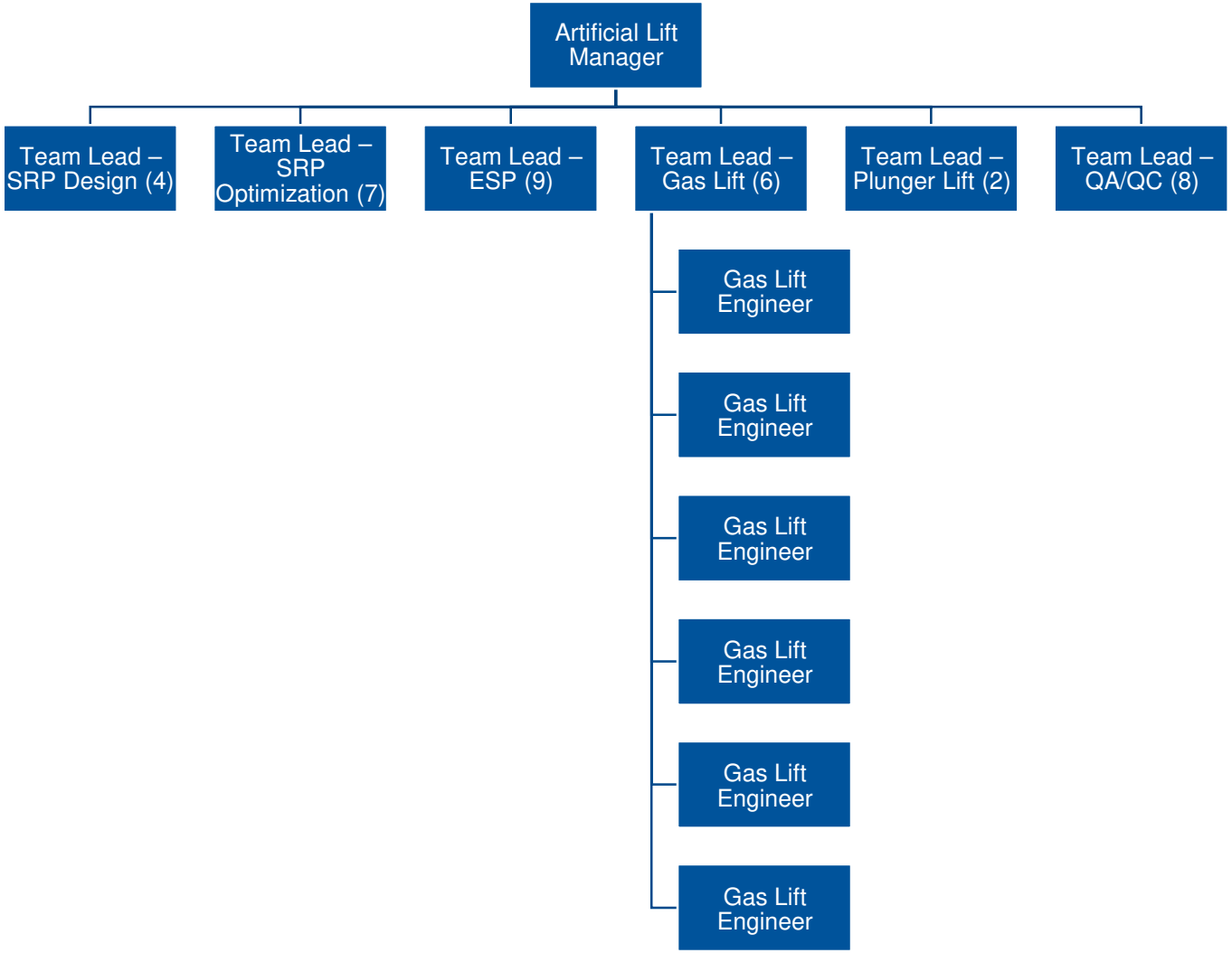
Reduced lift efficiency?

- Deepening lift depth not practical
- Multi-point injection inevitable
- Is this a big deal?

HOW WE MADE THE TRANSITION

- Focused support
- Training
- Standards / Operating Guidelines
- Supply Chain Management
- Automation
- Surveillance
- Experimentation

DEDICATED AL SUPPORT ORGANIZATION



HOW DO YOU BECOME AN ARTIFICIAL LIFT SME?

- Is working for a service company a requirement?
- Can operators grow them from scratch?
- Are petroleum engineering programs providing adequate exposure to AL?

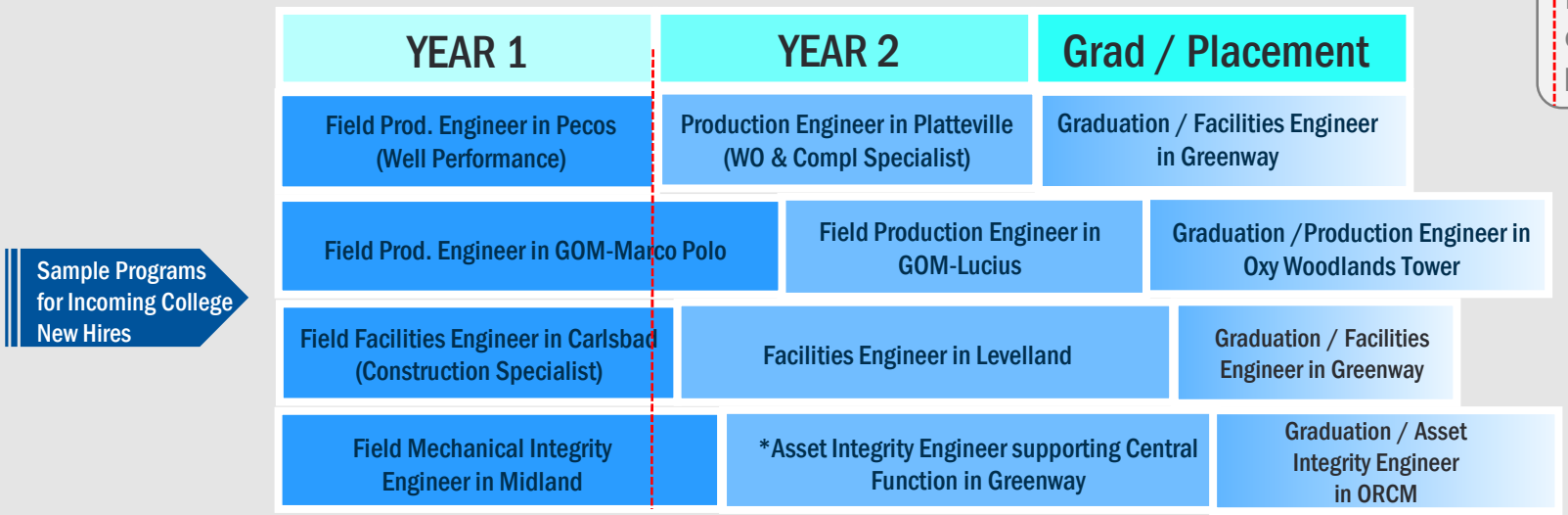
TRAINING

- Gas Lift Operations
  - 2-day course for operations personnel and non-PEs
  - Delivered at Midland Training Center
- Gas Lift Fundamentals
  - Comprehensive 4-day course covering all the basics from AL selection to system design
  - Target audience: production engineers
- Advanced Gas Lift
  - 3-day course covering advanced topics such as true valve performance, intermittent GL and RCFA
  - Prerequisite: Gas Lift Fundamentals + 1 year of soak time

ROTATION MODEL

*Rotations and length will be dependent on internship, BU assignment, and schedule.

Discussion with each participant at end of first year to determine preliminary career path.



*Some programs may include a specialty rotation to a specific discipline. Options for these specialty rotations would be discussed during the interview process or at the end if your first year/rotation.

STANDARDS / OPERATING PRACTICES

Technical

- First lift selection / timing
- Design
- Data Management
- Surveillance
- DIFA/RCFA
- Equipment selection / acceptance criteria
- When to perform lift revision
- Numerous others…

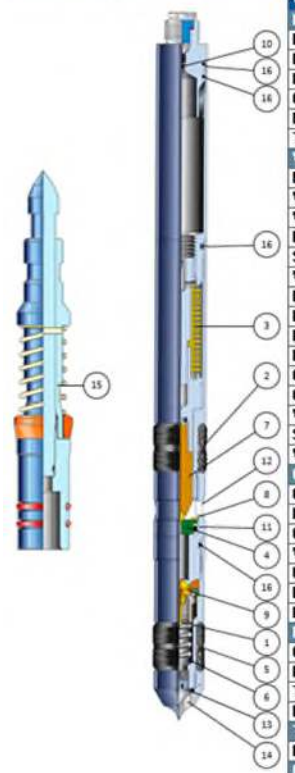
Operational

- Installation
  - Running side-pocket mandrels or conventional mandrels as part of new completion
  - Installing gas lift valves using slickline
  - Installing retrofit (i.e. coiled tubing) gas lift strings
- Commissioning
  - Initial unloading
  - Returning wells to production after shut-in periods
- Retrieval
  - Retrieving gas lift valves via slickline
- Recompletion
  - Pulling tubing to repair HIT failures, replace conventional mandrels, etc.
- Surveillance
  - Running pressure / temperature surveys (both flowing and static)
  - Acquiring acoustic fluid levels
  - Performing CO2 tracer surveys
  - Tagging fluid with slickline

DIFA / RCFA

Well Name:	Avogato 30 314H
API Number or Unique Identifier:	
Field or Reservoir:	Red Tank

Note: It is extremely important that the Ptro and sealing integrity of the valve be tested as received from the well and before disassembly. Do not attempt to repair the valves before final inspection.



Valve ID:	GLV #1	GLV #2	GLV #3	GLV #4	GLV #5	GLV #6	GLV #7	GLV #8	GLV #9	GLV #10	GLV #11	GLV #12	GLV #13	GLV #14	GLV #15
Installation Data															
Date Removed from V	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025	2/20/2025					
Date Inspected:	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025	3/12/2025					
Date Installed in Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Order Pulled from We	10	9	8	7	6	5	4	3	2	1					
Measured Depth:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
True Vertical Depth:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Valve Specifications															
Manufacturer:	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherfor	Weatherford					
Valve Type:	Orifice	IPO	IPO	IPO	IPO	IPO	IPO	IPO	IPO	IPO					
Valve Model:	RO-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1					
Part Number:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Serial Number:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Valve OD, inches:	1	1	1	1	1	1	1	1	1	1					
Latch Type:	BK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Latch Material:	316 SS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Port Size, 1/64":	16/64"	16/64"	16/64"	16/64"	16/64"	16/64"	16/64"	16/64"	16/64"	16/64"					
Ratio of Areas (As/Al	N/A	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166					
Choke installed?	No	No	No	No	No	No	No	No	No	No					
Choke Size, 1/64":	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Valve Body Material:	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS	316 SS					
Seat Material:	Standard/M	Tungsten C	Tungsten C	Tungsten C	Tungsten C	Tungsten C	Tungsten C	Tungsten C	Tungsten C	Tungsten Carbide					
Valve Packing Mater	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene	Neoprene					
Observations															
General Condition:	OK	OK	OK	OK	OK	OK	Low Pressu	Low Pressu	Low Pressu	Low Pressure					
Inlet Port Condition:	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK					
Outlet Port Condition	OK	OK	OK	OK	OK	OK	Eroded	Eroded	Eroded	Eroded					
Valve Body Condition	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK					
Upper Packing Cond	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK					
Lower Packing Cond	OK	OK	OK	OK	OK	Damaged	OK	OK	OK	Damaged					
Latch Condition:	OK	OK	Faulty Clea	OK	OK	OK	OK	OK	OK	OK					
Functional Test															
Original Ptro @ 60F:	Orifice	1130	1130	1135	1140	1145	1155	1165	1175	1180					
Ptro as tested:	Orifice	1110	1110	1120	1130	1125	1120	1125	1115	1120					
Temperature, test ra	60° F	60° F	60° F	60° F	60° F	60° F	60° F	60° F	60° F	60° F					
Leakage Test:	N/A	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Fail	Fail					
Teardown Analysis															
Evaluation Form:	GLV #1	GLV #2	GLV #3	GLV #4	GLV #5	GLV #6	GLV #7	GLV #8	GLV #9	GLV #10	GLV #11	GLV #12	GLV #13	GLV #14	GLV #15
Comments															

Gas lift valves Seven through Ten were found to have seat leaks and low opening pressure during testing procedures. Check valves Three, Four, and Ten were found to have significant flow cutting and material loss of their internal components. The latch ring of valve number Three was found to be inverted at the time of removal from the pocket, reported "being easy to extract." No installation information could be provided by the manufacturer or found in the Nexus.

DIFA / RCFA

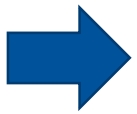
GLV #7 Disassembly & Inspection Report

Valve Specifications

Manufacturer:	Weatherford	Part Number:	N/A	Body Material:	316 SS	Date Removed from Well:	4570
Valve Model:	R-1	Serial Number:	N/A	Packing Material:	Neoprene	Date Inspected:	4572
Valve Type:	IPO	Valve OD, Inches:	1	Port Size:	16/64"	Date Installed in Well:	N/A

Component	Component	Contaminated	Plugged	Material	Mechanical	Comments from Inspector
1	Check Valve Assembly	Unknown Material				
2	Upper Packing					
3	Bellows Assembly	Unknown Material		Excessive Wear	Leaking	Silicone found in tail plug housing and along bellows housing
4	Orifice	Unknown Material				
5	Lower Packing					
6	Check Spring	Unknown Material				
7	Stem and Seat	Unknown Material			Faulty Clearance or Alig	
8	Orifice Snap Ring	Unknown Material		Eroded		No cyclets on snap ring would not allow for extraction of sea
9	Dart	Unknown Material				
10	Dill Core			Extruded		Silicone found in tail plug housing and along bellows housing
11	Seat O-ring					
12	Inlet Body (port)	Unknown Material				
13	Nose (nib)					
14	Outlet Port					
15	Latch Assembly					
16	Body Seals					

Supporting Photographs



INSTALL DETAILS

- Back
- Install
- Packer
- Tubing
- Mandrel & Valve
- Downhole Gauge
- Failure
- Accessories
- Attachments
- Configuration

FAILURE

Reason for Pull: WELL OPTIMIZATION OR RECOMPLETION

Specific Reason: LIFT REVISION

Component

Subcomponent

Failure Category

Failure Descriptor

Failure Cause

Failure Cause Specific

Failure Classification: NO FAILURE

Item

Comments: JOB COMPLETED TO FACILITATE CONVERSION TO GAS STORAGE WELL, NO FAILURE. TBG SHOWED PITTING BUT NO HOLES. VALVES SHOWED SOME WEAR, BUT NO FAILURE.

Well Servicing Pull Job: 26 Feb 2025 - GAS LIFT DESIGN CHANGE - e9VHm

RIG PULL REPORT

Component Name	Location - MD (ft)	Pull Observations	Installati... Date	Primary Failure

Job Driver: PROACTIVE WORK/EQUIPMENT REPLACEMENT

Job Driver Definition:
Any WM job that has planned/unplanned significant proactive equipment replacement or work not associated with failure. This will be more than replacing a few rods or joints of tubing. Examples are: Change out rod taper/string due to age/corrosion Change out 1000'+ of tubing due to age/wear/corrosion Rod taper design changes Bit run/ Tag TD /Clean out

SUPPLY CHAIN MANAGEMENT

- Focused contracts with clear technical requirements
- Manufacturing & Service Center Audits
- API/ISO Standards baked into contracts and audit plans
- DIFA/RCFA
- In-house support from each key vendor

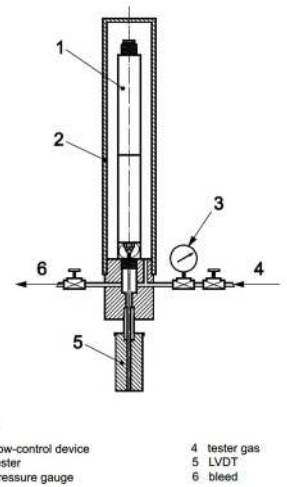
OXY'S NEW ACCEPTANCE CRITERIA

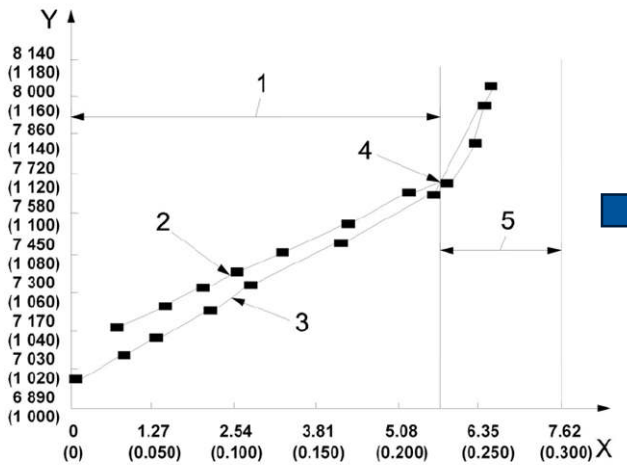
API SPEC 19G2, 2nd Edition – Functional Grade F2

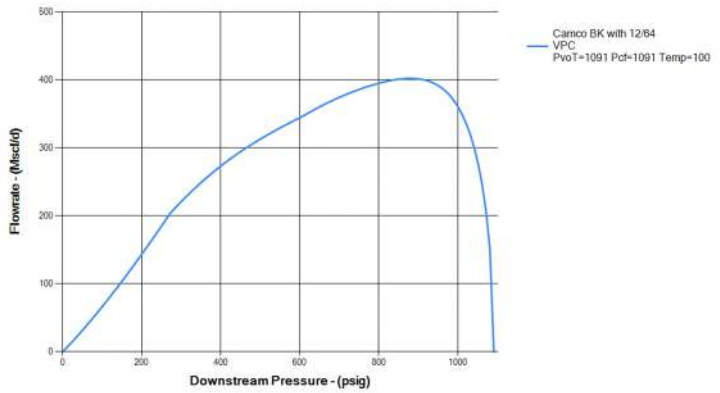
Table C.1—Testing Requirements

Flow-control Device Group and Type (See 6.1.2)		Design Validation Test and/or Device Functional Test	Annex	Design Validation and Device Functional Test Requirements for Each Flow-control Device Grade							
				V3 Basic Grade	V2 Intermediate Grade	V1 Highest Grade	V0 Severe Service	F3 Basic Grade	F2 Intermediate Grade	F1 Highest Grade	F0 Severe Service
I	IPO	Interface	D	D.2.1	D.2.1	D.2.2	D.2.2	—	—	—	—
		Insertion	E	E.2	E.2	E.2	E.2	—	—	—	—
		Probe or travel	F	F.2	F.2	F.2	F.2	—	F.6.2	F.6.3	F.6.3
		Load rate	F	F.3	F.3	F.3	F.3	—	F.7.2	F.7.3	F.7.3
	Balanced IPO	Flow	G	—	G.2.2	G.2.3	G.2.3	—	—	—	—
	IPO w/ choke	Back-check	H	H.2.2	H.2.3	H.2.4	H.2.5	H.3.1	H.3.1	H.3.2	H.3.3
		Open and close	I	I.1.2	I.1.2	I.1.2	I.1.2	I.2	I.2, I.3.1	I.2, I.3.1	I.2, I.3.1
		Actuation life cycle	J	—	—	J.2.2	J.2.2	—	—	—	—
		Erosion	K	—	K.2.3	K.2.3	K.2.4	—	—	—	—
		Shelf	L	L.2.1	L.2.1	L.2.1	L.2.1	L.3.2	L.3.2	L.3.2	L.3.2
		Port/seat leakage rate	M	M.2	M.2	M.2	M.2	M.3	M.3	M.3	M.3

- Probe Test: 5% of any job lot (or 3 valves)
- Load Rate: Determined from probe test.
- Back-Check: 100% of every job lot
- Open and Close: 100% of every job lot
  - (used to determine effective Ap/Ab Ratio)
- Shelf Test: 100% of every job lot
- Port/seat leakage rate: 100% of every job lot
  - In closed position, valve shall not leak more than 35 SCFD.







AUTOMATION

- Extensive instrumentation
- Auto-chokes on every well
- Automatic well testing
- Standard equipment configuration for PLCs and RTUs
- Leveraging IIOT devices and cloud computing for closed-loop optimization, flare mitigation and other advanced features

SURVEILLANCE

Realtime Data

Well Test

Master Well Data

Well Equipment

AngularJS

.NET

Python

Support for multiple MOPs

Surveillance

Analysis

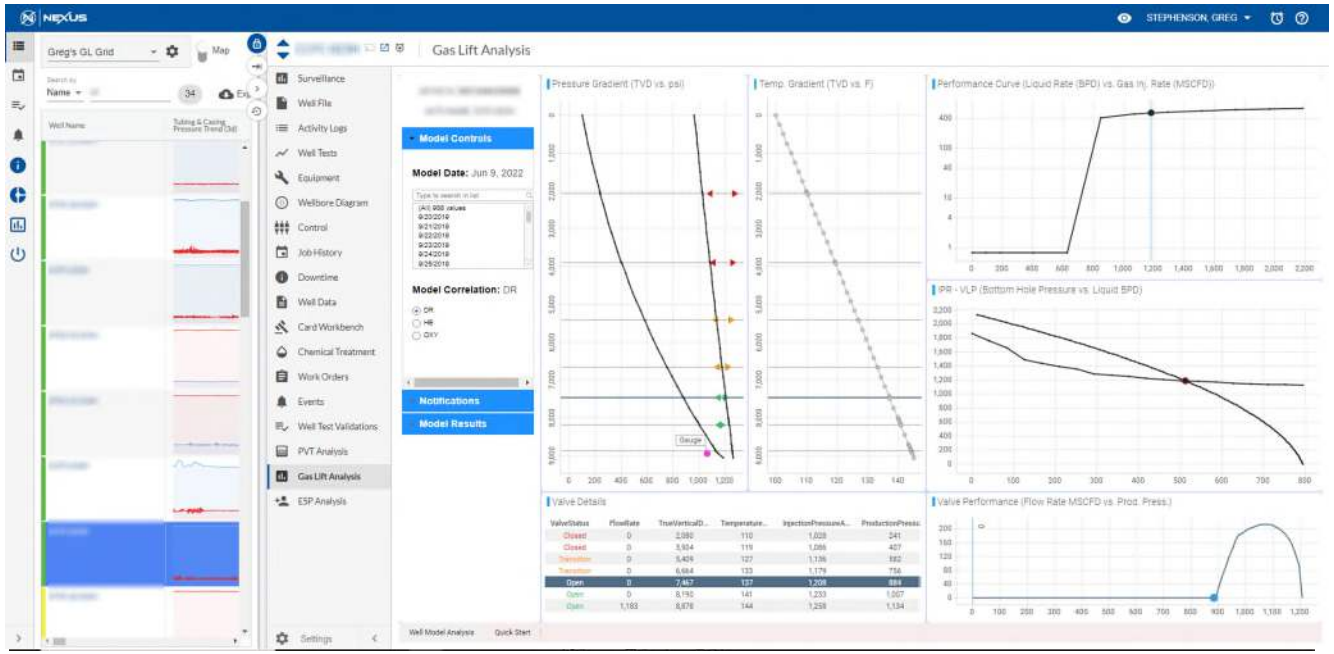
Data capture

Everything all in one place

Viewable in web player

NEXUS OFFERS A WEALTH OF GAS LIFT SURVEILLANCE TOOLS, INCLUDING:

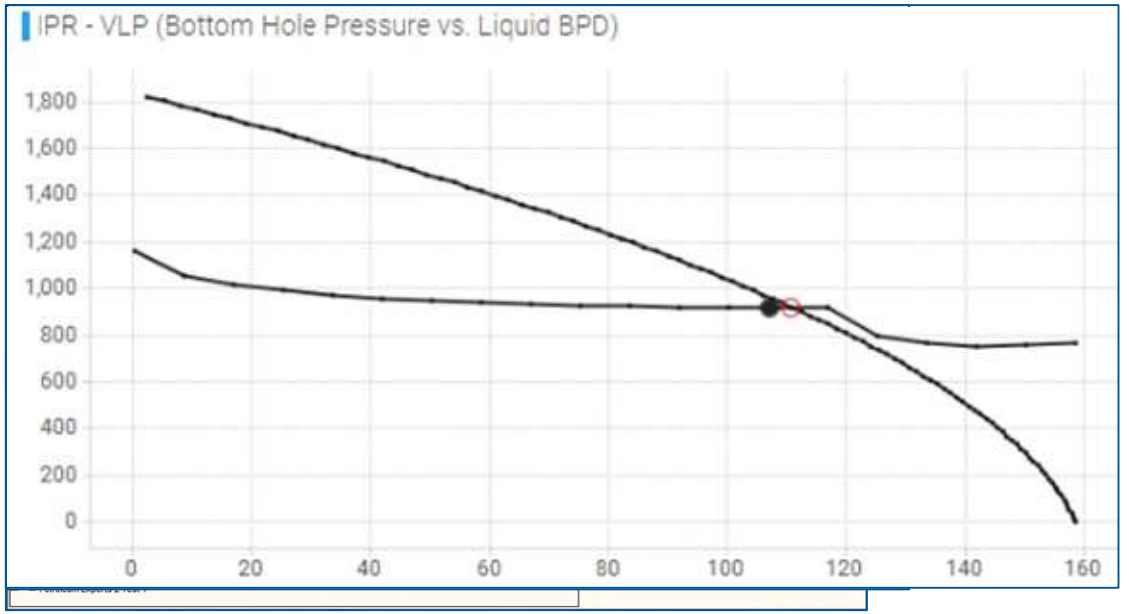
- Screening tools / management by exception
- Trending
- Well Tests
- Fluid Level History
- Job History
- Activity Log
- Downtime Reporting
- Failure Analysis
- GL Analysis Dashboard



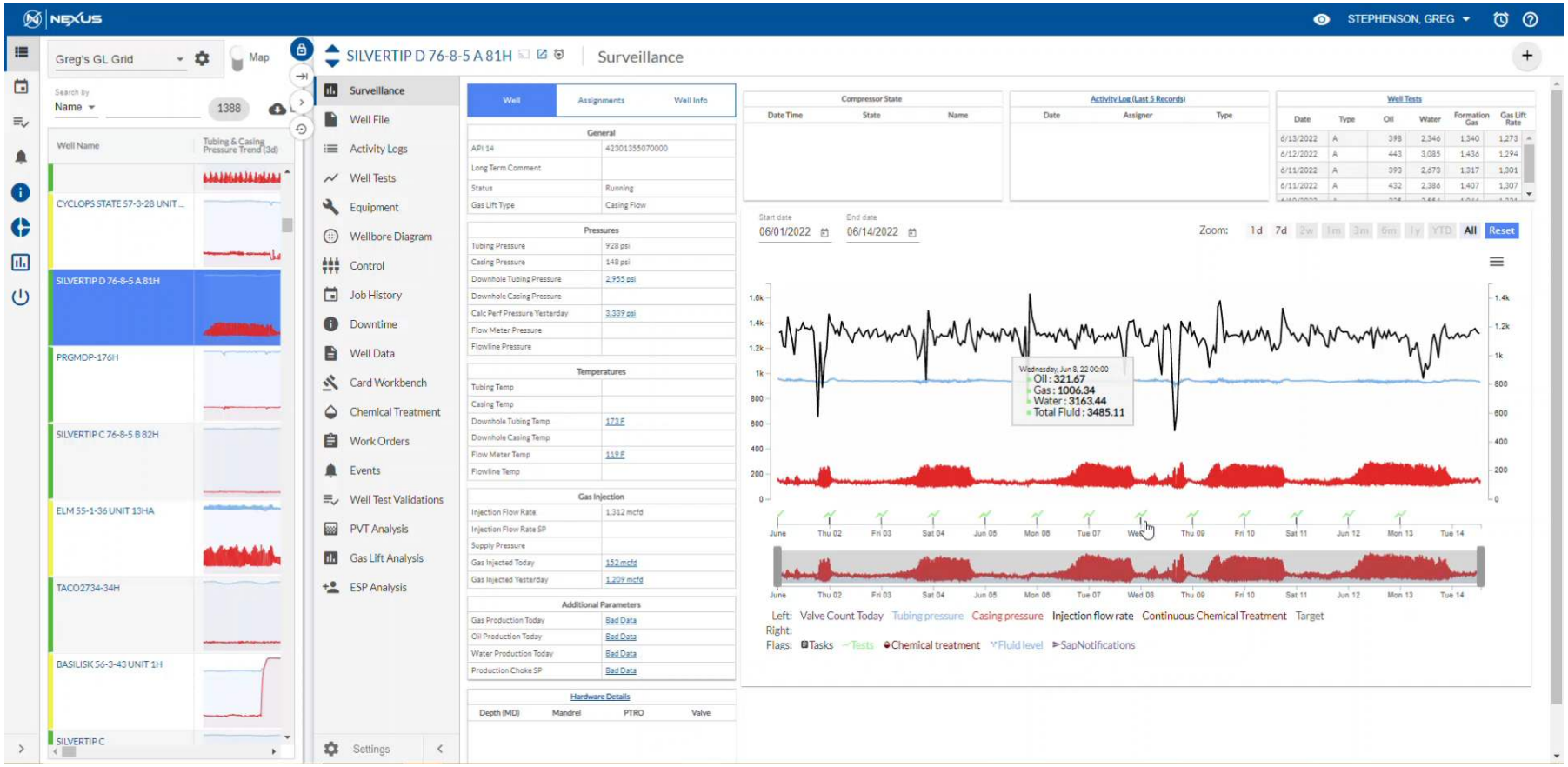
AUTOMATIC MODEL GENERATION

Once data is populated in Nexus, models can be generated automatically through:

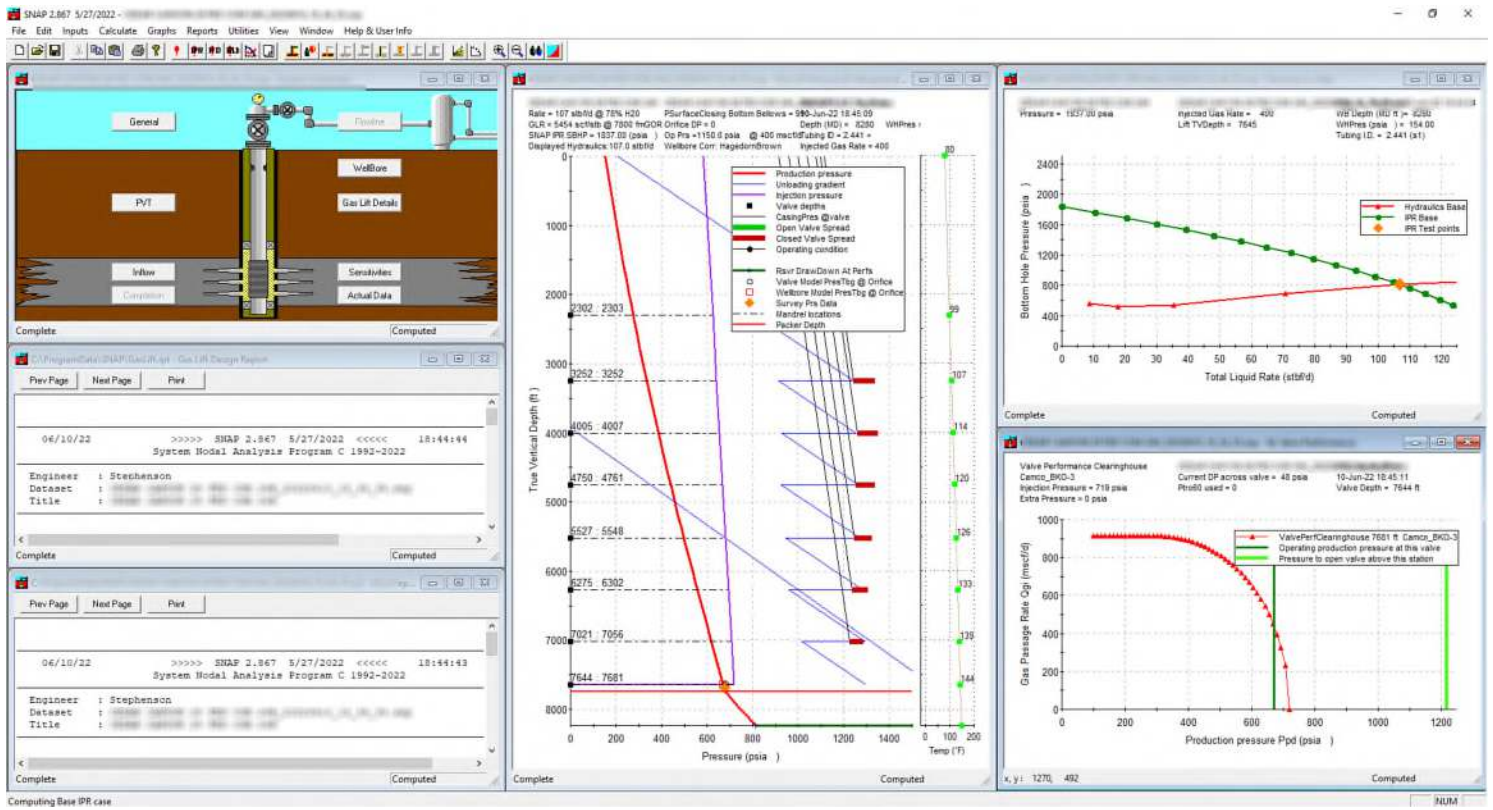
- Prosper
- SNAP
- NexusNodal

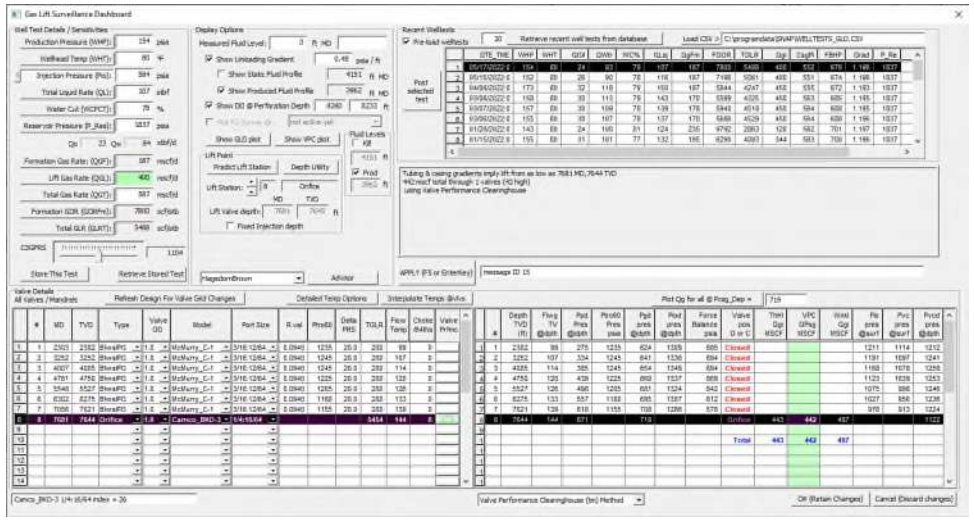


WE'VE COME A LONG WAY FROM BARTON RECORDERS…

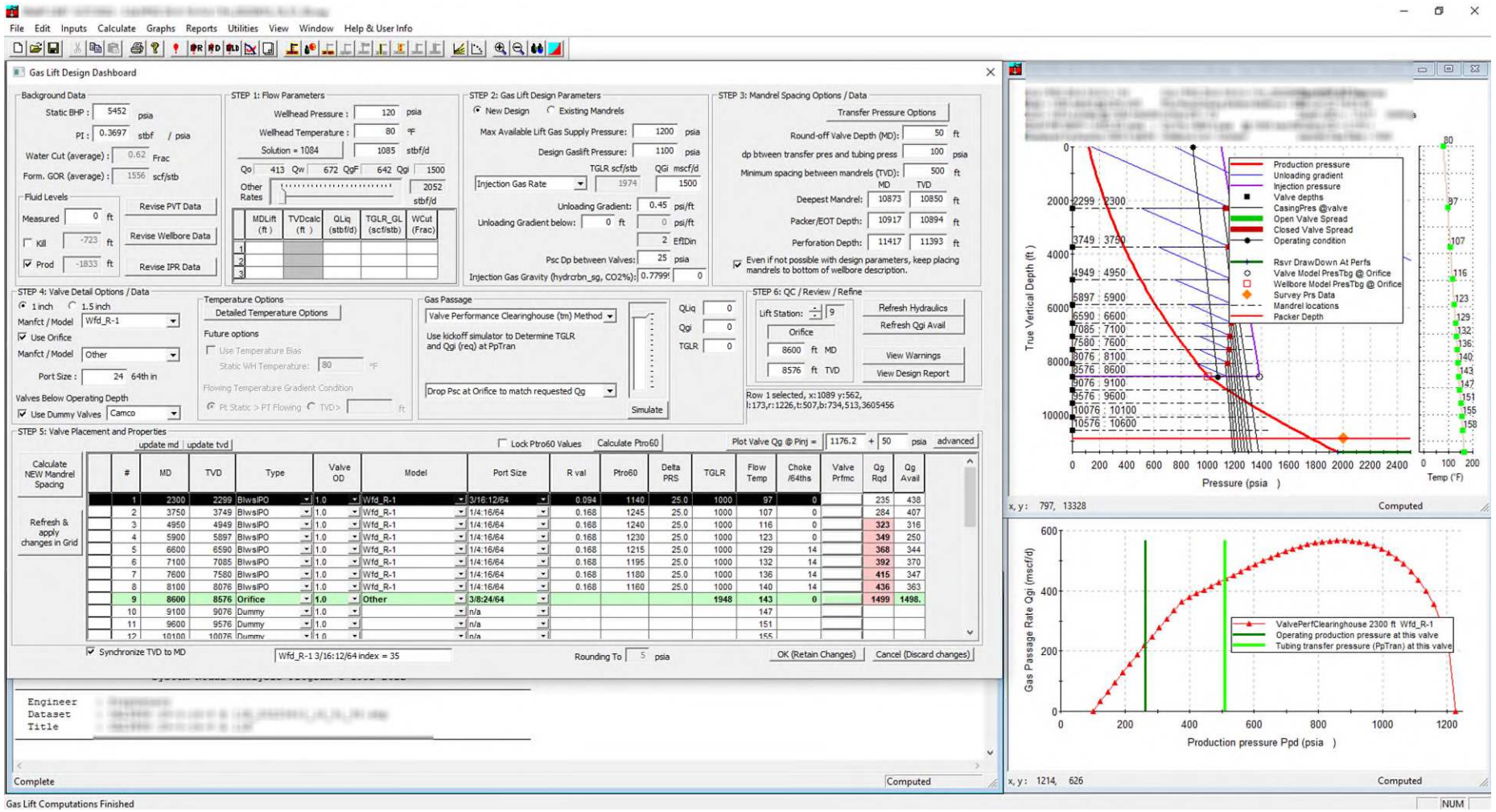


GAS LIFT DIAGNOSTICS USING SNAP

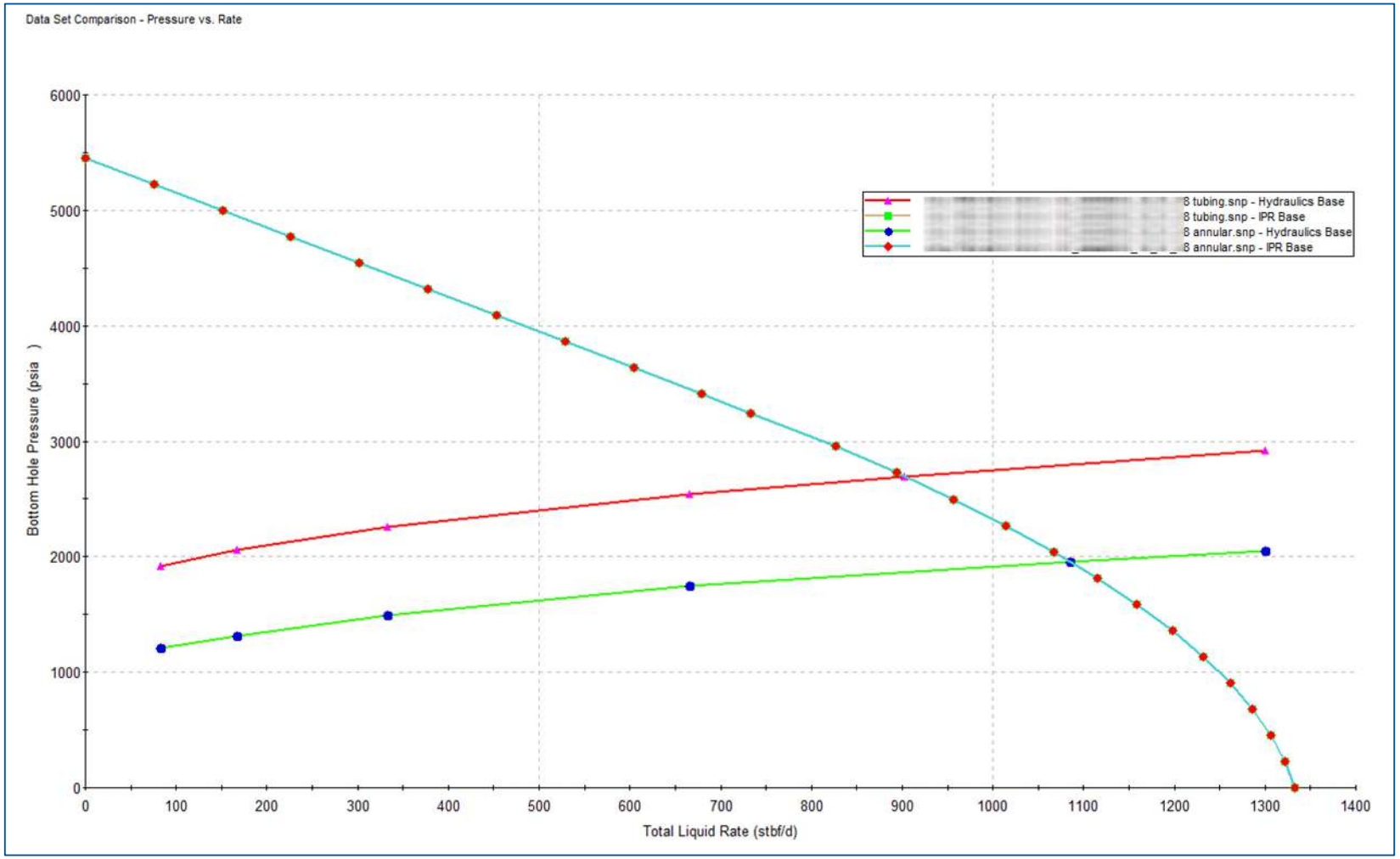




USING VALVE PERFORMANCE IN DESIGN



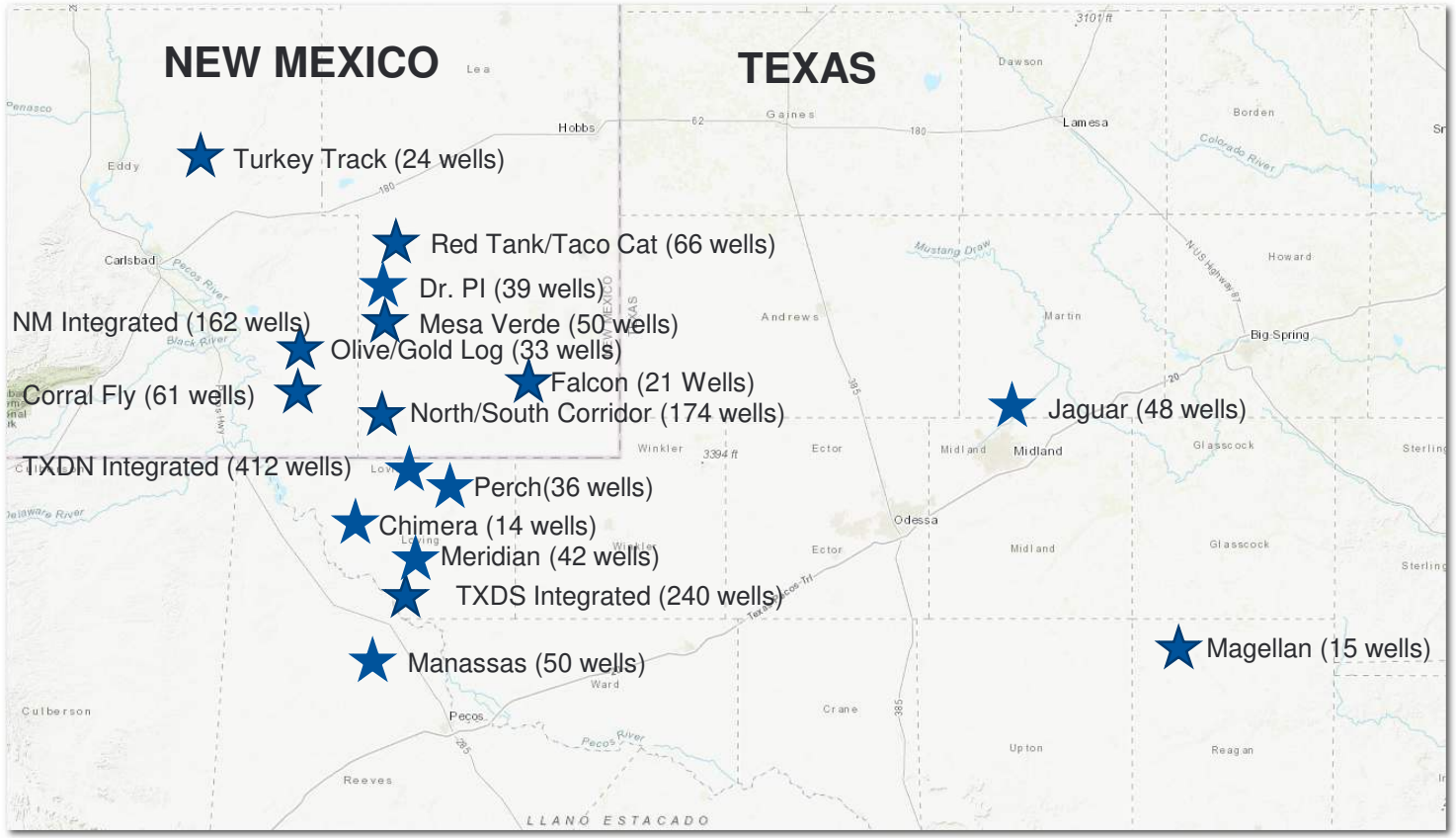
USING SNAP TO EVALUATE COMPLETION OPTIONS



OTHER RELATED SURVEILLANCE ACTIVITIES

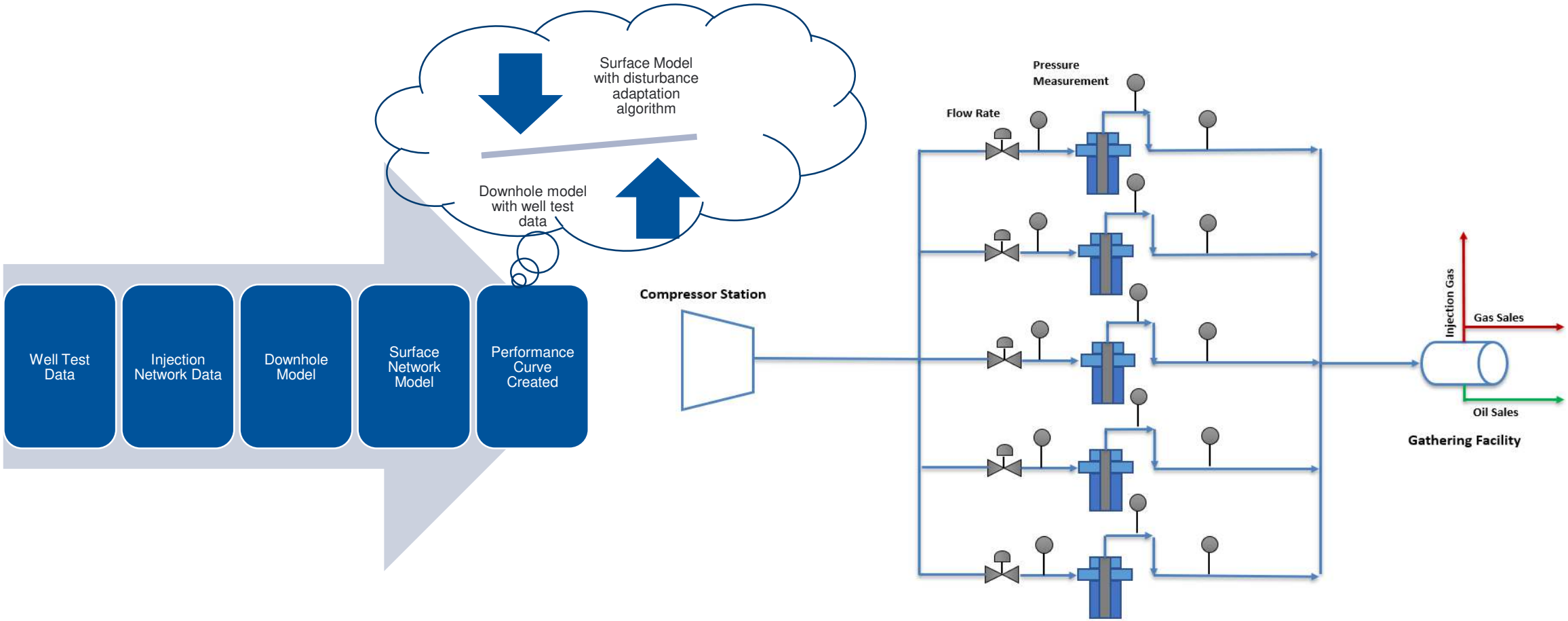
- Closed-loop GL Optimization (see SPE 209756-MS)
- Realtime Diagnostics
- Dedicated AL Team
- Failure Reviews
- Well Reviews
- Vendor Audits
- Corrosion Management
- Emissions Monitoring and Reduction

AUTOMATED GAS LIFT OPTIMIZATION



- Currently operates on 18 sites with 1497 gas lift wells currently under GLO control
- ~2.0 BCFD of injection gas is controlled by the GLO system
- Downtime Reduction of ~3% averaged across 1497 wells
- Production uplift performance
  - Uplift assuming the average of 6% realized on previous analysis = 30 MBOED

HOW THE CLOSED LOOP SYSTEM WORKS



- New injection set points can be made every minute if needed
- Pressures and Rates are read every 30 seconds
- Models can be run at desired frequency selected in the user interface
- Performance Curve is fed to the PLC from the edge device to make network changes automatically
- Total system gas is measured and honored when generating new setpoints

EXPERIMENTATION

- Annular flow gas lift
- Intermittent gas lift / pilot valves
- PAGL/GAPL
- Chamber lift
- Surface controlled gas lift – both electric and hydraulic
- High-pressure single point and intermediate-pressure gas lift
- Alternative valve designs
- Alternative completion configurations / life-of-well completions
- GALLOP
- Closed-loop optimization using AI
- Gas Lift Diagnostics using AI

LESSONS LEARNED

- Seek out the experts.
- Find best practices and adopt them.
- Don’t assume you know everything.
- Be willing to try new things.
  - Dare to do what others won’t!
- Always look for ways you can do better.
- Have fun!

LEAD WITH PASSION • OUTPERFORM EXPECTATIONS
DELIVER RESULTS RESPONSIBLY • UNLEASH OPPORTUNITIES • COMMIT TO GOOD