

Gas-Lift Troubleshooting and Optimization with WellTracer & Gas Lift Performance Check Surveys

June 2020



www.kaizenws.com | www.appsmiths.com



PRESENTATION AGENDA

- What is WellTracer
- An overview of the WellTracer process
- What information does WellTracer provide
- How can WellTracer be used
- WellTracer Data Collection
- WellTracer Reports
- Gas-Lift Performance Check Report
- What a typical Life-of-Well process might look like
- WellTracer and Gas-Lift Heath Check comparison

What is WellTracer?

- WellTracer is a patented gas-lifted well diagnostic and surveillance technology originally developed by Shell.
- Shell assigned WellTracer patent rights to AppSmiths Ventures LLP and tasked them with the responsibility of commercializing and developing WellTracer for the benefit of the Oil & Gas Industry.
- Shell developed WellTracer as a non-invasive, low risk surveillance and troubleshooting tool able to provide a snapshot of a well's performance and production potential.



- Today Kaizen Well Solutions and AppSmiths work together to offer WellTracer in Canada, the United States and elsewhere.
- WellTracer is well suited to both single and dual completion gas-lifted wells and can be easily deployed both onshore or offshore.
- WellTracer equipment is highly portable and requires simple surface wellhead connections to rig in.
- No well intervention and no production deferment are required whatsoever when carrying out a WellTracer survey.

What is WellTracer®?

Gas-Lift Solutions



WellTracer® Gas-Lift Surveillance Solution

WellTracer surveys combined with the power of WinGLUE software creates an expert model for optimizing performance for an under-performing well or group of wells.

WellTracer is a patented gas-lifted well diagnostic and surveillance tool, well suited to finding the primary point of gas injection, even in high gas-oil-ratio (GOR) or low injection-rate wells. WellTracer creates an accurate snapshot of the well performance by introducing a small volume of CO₂ into the injection line, then measuring CO₂ concentration at the well head. One of the greatest strengths of this approach is that there

is no need to shut-in or run any type of well intervention, resulting in greatly reduced risks to field personnel and reduced risk to the well. The equipment is highly portable and requires only simple surface wellhead connections. This cost-effective gas-lift troubleshooting solution can result in significant production improvements and/or injection gas savings.

Applications

- Detecting operating lift depth
- Detecting if multiple points of injection are occurring
- Detecting tubing leaks
- Identifying lift gas rate through each injection point

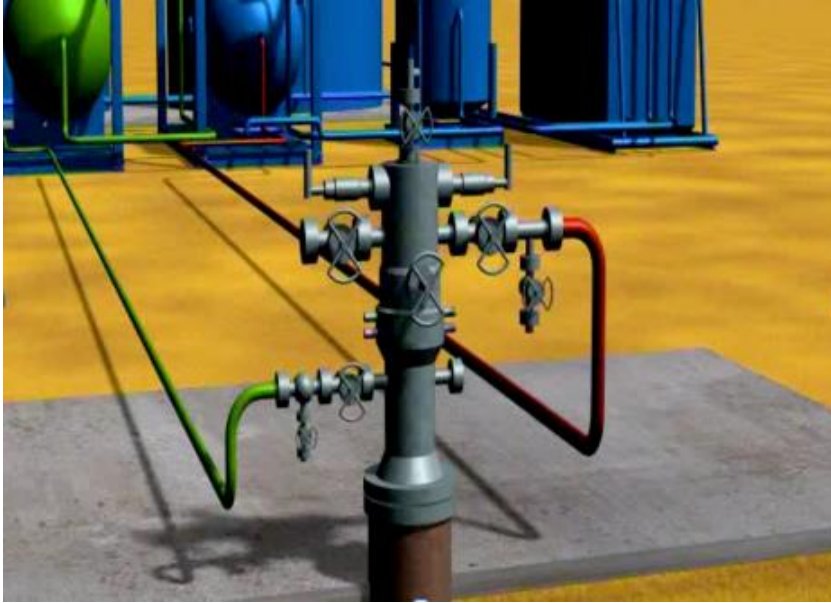


Description	WellTracer	FGS*
Identify primary point of gas injection	●	●
Identify tubing leaks, including leaks passing small amounts of gas	●	○
Verify gas-lift models	●	●
Identify injection rates and how much lift gas is injecting into each point of injection	●	○
Reasonable results in high GOR or low-injection rate well	●	○
Accurately determine flowing bottom-hole pressure	○	●
Does not require well intervention	●	○
Easily handles highly deviated or horizontal wells	●	○

*Flowing Gradient Survey

WellTracer Overview...

- A small amount of produced gas & fluid is slip-streamed to the WellTracer equipment
- The gas is separated from the liquids and sent to the analyzer
- The concentration of CO₂ is determined and used to identify the depth of any leak paths (eg. open or leaking gas-lift valves and tubing leaks).



- Liquid CO₂ is injected into the well and travels downhole in the lift gas stream
- As the CO₂ slug travels down the casing-tubing annulus portions of it enter any leak paths
- Eventually all CO₂ returns up the tubing to surface



What does WellTracer provide?

- WellTracer can:
 - ✓ Identify single or multiple points of gas injection.
 - ✓ Identify failed or leaking gas-lift valves.
 - ✓ Identify lift depth of operating valves.
 - ✓ Identify leaks in the tubing
 - ✓ Identify rate of lift gas through each point of injection.
 - ✓ Identify well test and/or SCADA measurement errors.
 - ✓ Identify where gas is going for dual wells.



How can WellTracer be used?

WellTracer should be used when:

- ✓ verifying the operation of a well after an initial gas-lift system installation, re-design, gas valve change-out or work-over.
- ✓ verifying the tubing integrity in a well.
- ✓ troubleshooting production or operating problems, for example wells outside their operating envelope or wells with mechanical problems.
- ✓ troubleshooting and optimizing Gas-Lift, PAGL and GAPL wells.
- ✓ evaluating a well or group of wells for production enhancements or operational savings (eg., performance optimization).
- ✓ used as a key component in routine surveillance programs.

WellTracer Production Benefits

- Typical production gains can range from 5% to 15%.
- In Louisiana, USA, replacing tubing to fix leaks less than 300 meters depth resulted in oil production increasing from 40 bbls/d to 250 bbls/d.
- In SE Asia, WellTracer was used to redesign gas lift and stabilize a well resulting in 450 bbls/d increased oil production which was maintained for over 1 year.
- ExxonMobil worldwide have realized over 3000 bbls/day of increased oil production over 3 ½ years running WellTracer surveys and fixing problems identified.
- In the Middle East WellTracer has identified potential oil gains in excess of 2000 bbls/d and over 21.8 mmscf/d in potential gas savings.
- In Alberta, Canada during a 25 well campaign WellTracer identified 3.74 mmscf/d in potential gas savings and was used to optimize point of injection and lift gas injection rate for several Gas-Lift and PAGL/GAPL wells.

WellTracer Data Collection

- Wellhead Manifold rigged into the wellhead tree cap.
- The wellhead manifold allows a small amount (slip stream) of produced gas & liquids to be diverted to the WellTracer separator.
- Production (tubing) pressure is measured by both electronic and analog gauges.
- All WellTracer manifolds are designed with at least two pressure barriers present at each point.



- Lift Gas Manifold rigged into the lift gas injection line.
- The Lift Gas Manifold allows CO₂ to be injected into the well.
- Lift gas & CO₂ injection pressure are measured by both electronic and analog gauges.
- Lift gas & CO₂ injection temperature are measured electronically.

WellTracer Data Collection



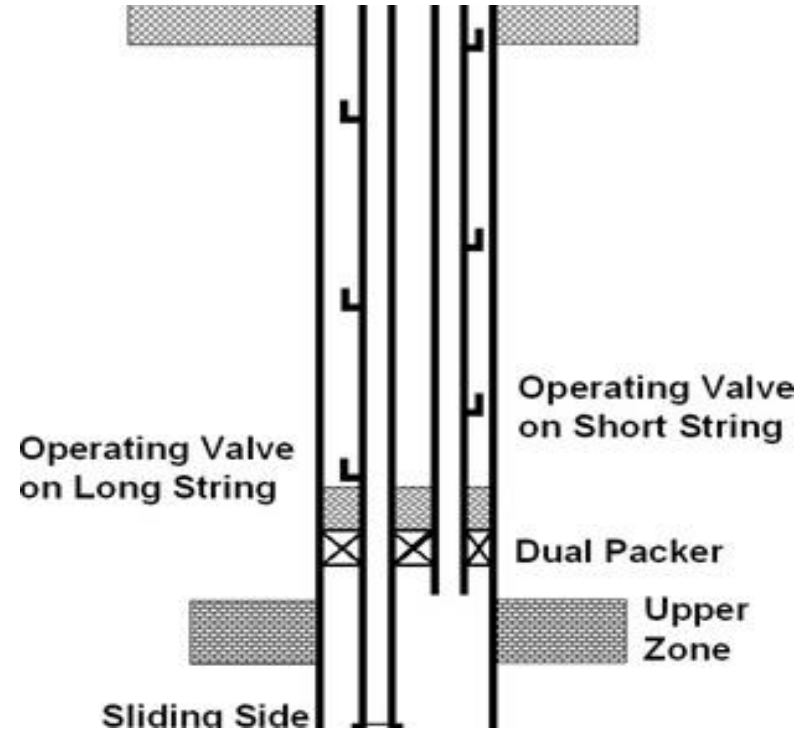
WellTracer Data Collection

- WellTracer equipment is compact and highly portable, because of this WellTracer is well suited for use in offshore environments.
- Each set of WellTracer equipment is rated Class I Division 2 Groups A, B, C, D with a Type Z purge also suitable for use in Class I Zone 2 AEx pZ IIC; Ex pZ IIC; T6 for use in hazardous areas.
- Multiple WellTracer surveys can often be performed on a single pad or platform in a day and the equipment can easily be transported to other nearby wells.



- WellTracer is ideally suited for monitoring, troubleshooting and optimizing dual string gas-lifted wells:
- To understand a dual string, well data needs to be collected on both strings at the same time.
- WellTracer shows us the allocation of gas between both strings in a dual completion well.
- There is no other technology available to identify and optimize dual string wells.

WellTracer on Dual String Wells



WellTracer on Dual String Wells

- Conducting WellTracer surveys on Dual String Gas-lifted Wells is a straightforward process.
 - ✓ Run a WellTracer survey on the well as a dual collecting data off each string with two WellTracer® units. Both strings should be on test.
 - ✓ Shut in upper string and survey the lower string as a single, well should be stable and on test
 - ✓ Shut in lower string and survey the upper string as a single, the well should be stable and on test.
- This data allows us to:
 - ✓ Determine current operation as a dual.
 - ✓ Determine what each string should be producing and the differences between current dual production and single production.
- The target is to produce both strings together and achieve the same production that the strings produce as singles.

WellTracer Survey Field Data

- Following each survey a job report along with the raw survey data are sent by email for analysis.
- Each report contains details of the crew & location, well conditions, quantities of CO₂ and N₂ used, a survey timeline and a post job report.
- Raw data is sent as a binary file that is compatible with WinGLUE, AppSmiths' state-of-the-art Gas Lift software.

WellTracer Site Worksheet

Customer: Excellent Resources **Operator:** Jake Doe **Date:** 1-Jan-2019
Field: Midland **Lease:** 100/01-01-001-01W1 **Well:** Big Bend 001

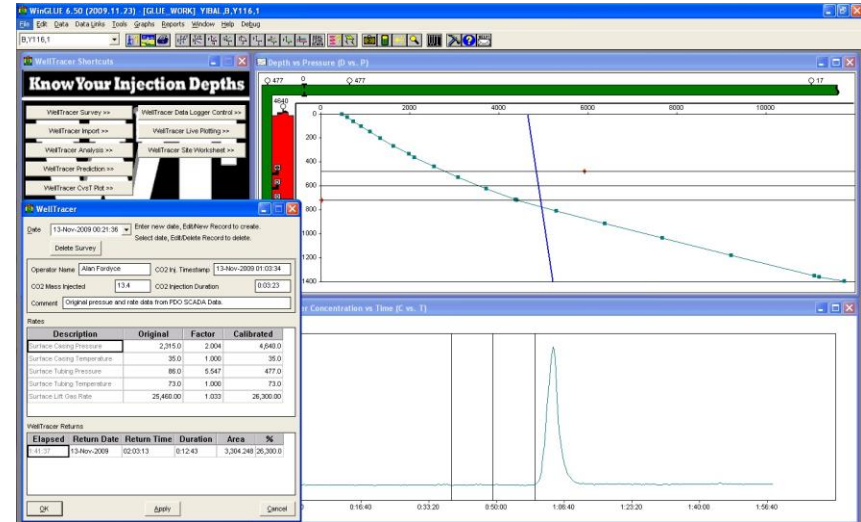
Rate	Quantity	Unit of Measure
Tubing (Production) Pressure	428	psig
Tubing (Production) Temperature		°F
Casing (Injection) Pressure	805	psig
Casing (Injection) Temperature	35	°F
Lift Gas Rate	600	MCF
Ambient Temperature	72	°F
Baseline CO ₂ Concentration	0.4	%
CO ₂ Cylinder Pressure	1700	psig
+N ₂ Pressure	2300	psig
CO ₂ Injection Start Time	8:54:00	
Baseline CO ₂ Injection End Time	0:01:26	
Quantity of CO ₂ Injected	31	lbs

Returns	From WinGLUE	Clock Time
Lifting Mandrel Number(s)		
Return Time for Lift Mandrel(s)		
Deepest Mandrel		
Return Time for Deepest Mandrel		
WellTracer Run Duration		

Mandrel	MD	TVD	Time	Notes and Observations
1				Start survey @ 8:49am, dump CO ₂ @ 8:54am, first spike @ 12:24pm, second spike @ 12:57pm, third spike @ 2:15pm, finished test at 3:57pm.
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

WellTracer Analysis Report

- Prior to each WellTracer survey a well model is built in WinGLUE.
- WinGLUE models are used to predict WellTracer survey times & for the analysis of the WellTracer survey results.
- Each Analysis report includes Remarks on the well's condition and Recommendations to improve the well's performance.
- Recommendations are aimed at increasing oil production and/or reducing operating cost.

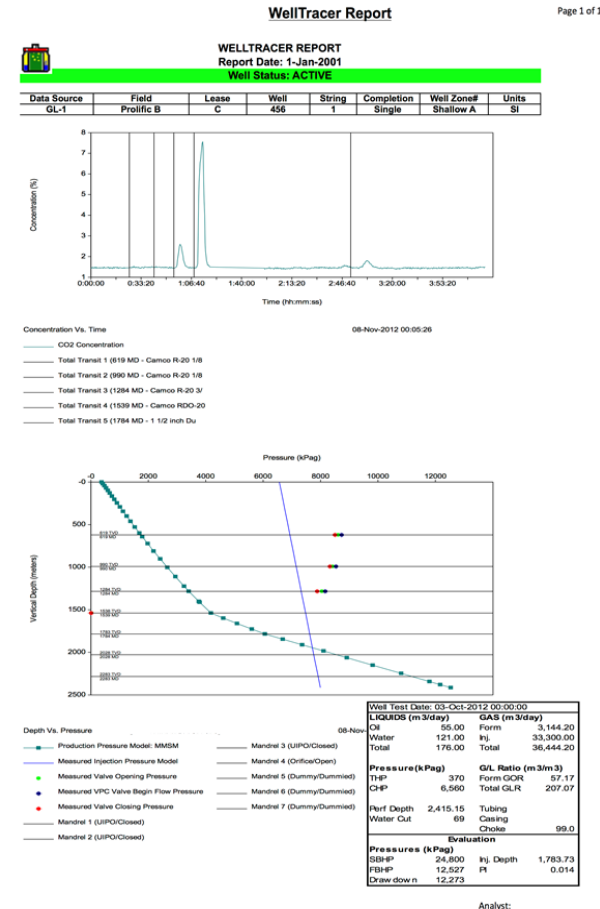


- WellTracer Analysis Reports are emailed to clients in soft copy Microsoft Excel format.
- WellTracer results can be stored online in WinGLUE models for clients with an existing WinGLUE environment.

WellTracer Analysis Report Report Graphs

- ✓ Each WellTracer report contains a graph showing CO₂ returns and their location.
- ✓ Also included is a graph showing the calibrated production (tubing) pressure, the casing injection pressure and the valve opening and closing pressures.
- ✓ Production rates, Production & Injection Pressures and certain Productivity information are also shown for easy reference.

WellTracer Report Graphs



WellTracer Remarks & Recommendations

WellTracer Analysis Report Recommendations

- ✓ Remarks and recommendations are written in a clear and concise manner making them easy to quickly review.
- ✓ Because WellTracer reports are issued in soft copy Excel format, they can be easily stored on networked drives, viewed and/or transmitted to others.
- ✓ All WellTracer report information can also be easily accessed and used in other office applications such as Word and PowerPoint.

WellTracer Evaluation

Remarks	Recommendations
WinGLUE analysis indicates the POI is through the RDO-20 Orifice Valve @ the 4 th mandrel depth (1539m).	Confirm the tubing/mandrel leaks in the vicinity of the 5 th mandrel depth and repair as necessary.
Well Tracer analysis indicates the installation is multi-pointing through a leaking R20 GLV @ the 3 rd mandrel depth (1284m), the orifice valve @ the 4 th mandrel depth and several ill-defined leaks in the vicinity of the 5 th mandrel depth (1784m), with no other apparent leaks above the 3 rd mandrel depth.	A redesign of the installation and GLVCO are recommended moving the RDO-20 Orifice Valve down to as deep as the 7 th mandrel depth (2283m). This should result in an oil production uplift in excess of 10 M3/day.
SCADA instrumentation for THP & CHP is in calibration while the instrumentation for LGR was not recorded with the SCADA data during the well tracer survey.	Check the instrumentation for LGR for operability and recalibrate if necessary.
Following remedial action to repair leaks and a redesign of the GLV installation moving the orifice valve down the hole to as deeply as the 7 th mandrel depth (2283m) should result in a significant uplift in oil production (See the Equilibrium Rates – Installed data on Sheet 1).	

Additional WellTracer Report Data

- Also contained in each WellTracer report is the following additional information:
 - ✓ WellTracer real time (i.e. SCADA) data
 - ✓ Gas-lift valve analysis
 - ✓ Well Test information
 - ✓ Production & Injection string information
 - ✓ Production Output Data
 - ✓ Injection Throughput Data
- Included in this information is:
 - ✓ Productivity Information
 - ✓ Liquid & Gas Velocities
 - ✓ Liquid & Gas Gradients
 - ✓ Fluid Friction & Friction Gradients

Gas Lift Performance Check Report – Report Information

- ✓ Each Gas Lift Performance Check Report contains a summary of reservoir information and fluid properties used in the well model.
- ✓ Production rates, production & injection pressures and well test calibration information are also shown for easy reference.
- ✓ Contact information appears at the top of each report for easy reference.

Service Report:

Gas-Lift System Health Check

Well Name: 100/01-01-001-01W1/00
Field: Oilfield
Date Run: January 1st, 2000
Report Date: January 2nd, 2000
Customer Contact: John Doe
 john.doe@customer.com
 (555) 123-4567
 (555) 890-1234
Phone Cell

Sales Contact: Jack Doe
 (555) 123-4567
Field Technician: James Doe
 (555) 890-1234
Cell

Reservoir Data

Well Properties		Comments
Bottom Hole Pressure (kPa)	12,000	January 2 nd , 2000
Formation Gas SG	0.75	
Injection Gas SG	0.72	
Water SG	1.08	
Oil (API)	40	
Bubble Point Pressure (kPa)	25,000	Estimated
Top Perforation (m MD)	3700.00	
Surface Temperatures (°C)	10.0 / 12.0	Static / Injection
Bottom Hole Temperature (°C)	80	

Well Test Summary

Date	Oil Rate (m ³ /d)	Water Rate (m ³ /d)	Form. Gas (m ³ /d)	Lift Gas Rate (m ³ /d)	Production Pressure (kPa)	Injection Pressure (kPa)	Choke Size (64ths)
1/1/2000	22.8	12.9	21600	12550	2793	6004	32
12/21/1999	25.3	14.1	19820	12950	2793	6004	32
11/10/1999	24.2	15.4	21600	12550	2793	6004	32
10/5/1999	19.5	20.1	21410	15000	2793	6004	32

Gas Lift Performance Check Report – Report information

- ✓ All GLHC reports contain an easy to understand summary of the survey results.
- ✓ Included is a plot showing mandrel depths, injection points and CO₂ concentration during the survey.
- ✓ Also included are the amount of gas through each injection point, depth of any tubing leaks and whether further analysis is recommended.

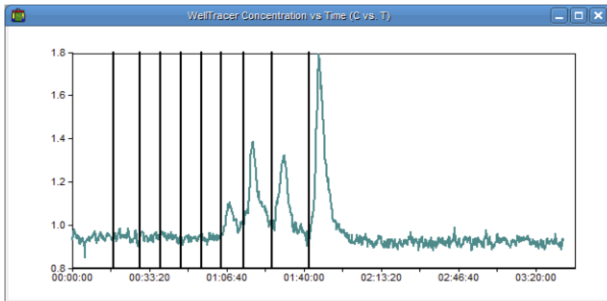
Background

- Oilfield 1001/01-01-001-01W1/00 is a gas lifted well operated by Excellent Resources, Inc.
- Kaizen Well Solutions conducted a Gas Lift System Health Check to understand the performance of the well's gas lift system.
- The Gas Lift System Health Check was performed on January 1st, 2000.

Health Check Results

Oilfield 1001/01-01-001-01W1/00	
Gas Lift Injection from Bottom Mandrel	No
Gas Lift Injection from Unloading Valve(s)	Yes
Multipoint Injection	Yes
Tubing Leak Detected	No
Echometer	Echometer was not performed.
Injection from Mandrel #	Mandrel #6 (8% return) Mandrel #7 (23% return) Mandrel #8 (19% return) Mandrel #9 (50% return)
CO ₂ Baseline	0.95%
In-Depth Engineering Analysis Recommended?	Yes

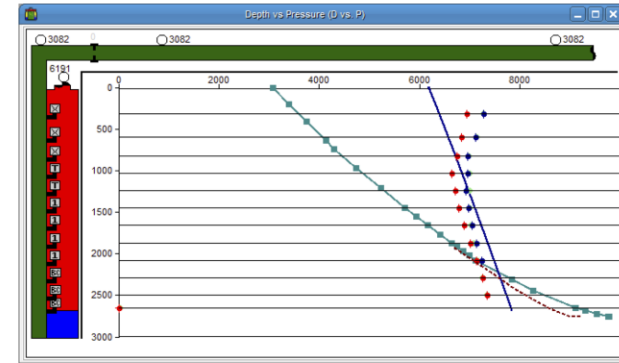
Concentration vs. Time Plot



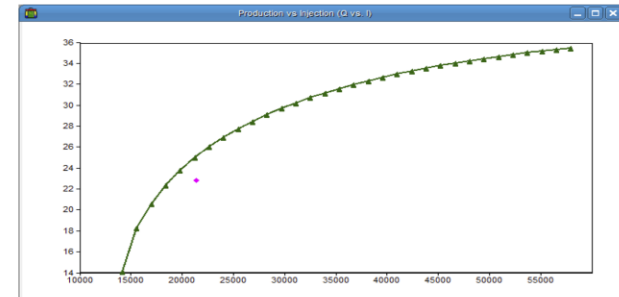
Gas Lift Performance Check Report – Report Information

- ✓ Each Gas Lift Performance Check Report also contains Depth vs. Pressure and Production vs. Injection plots.
- ✓ The D vs. P plot shows production and injection pressure models, mandrel & leaks depths and valve opening & closing pressures.
- ✓ Depending on well conditions and survey results other plots may also be included

Depth vs. Pressure Plot

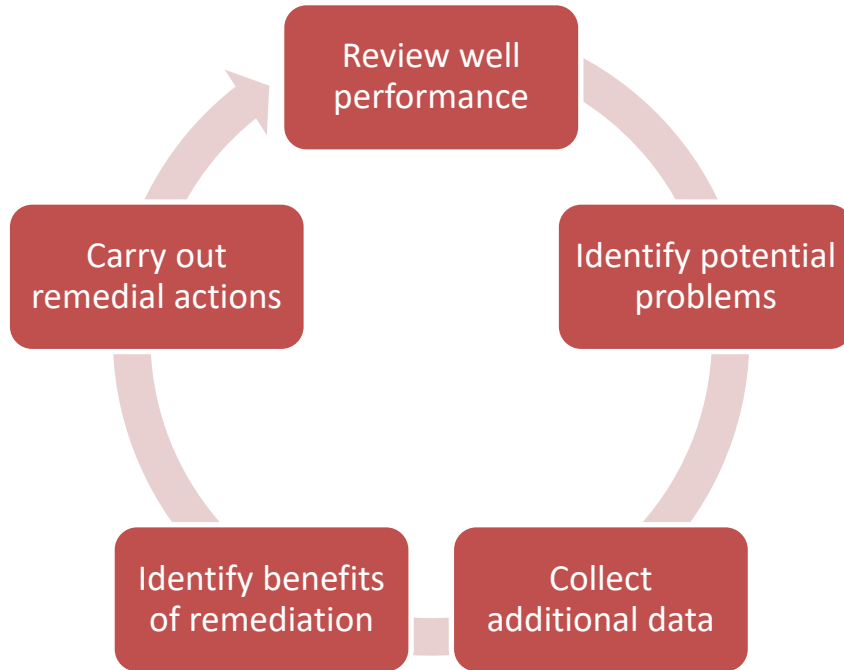


Production vs. Injection Plot

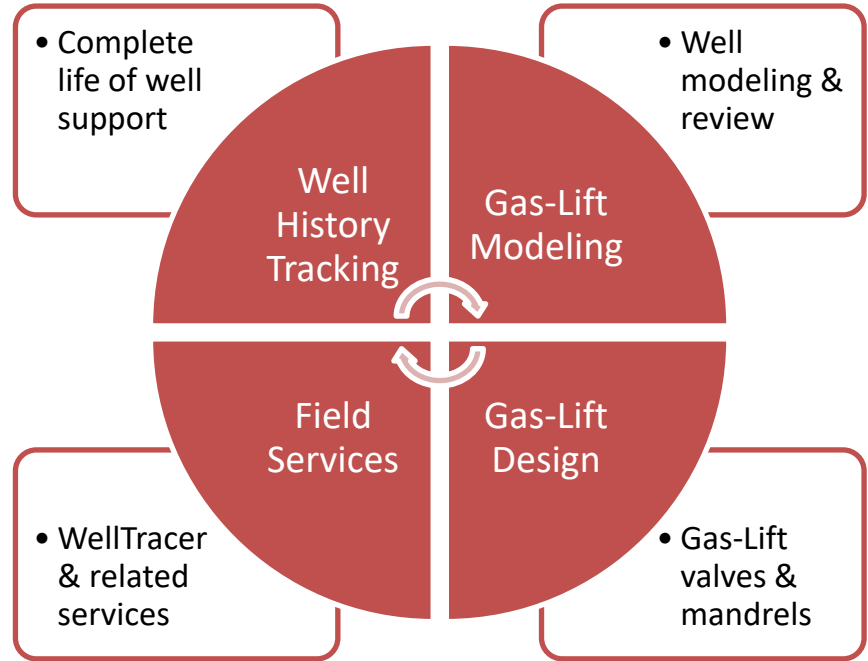


Kaizen Gas-Lift Services

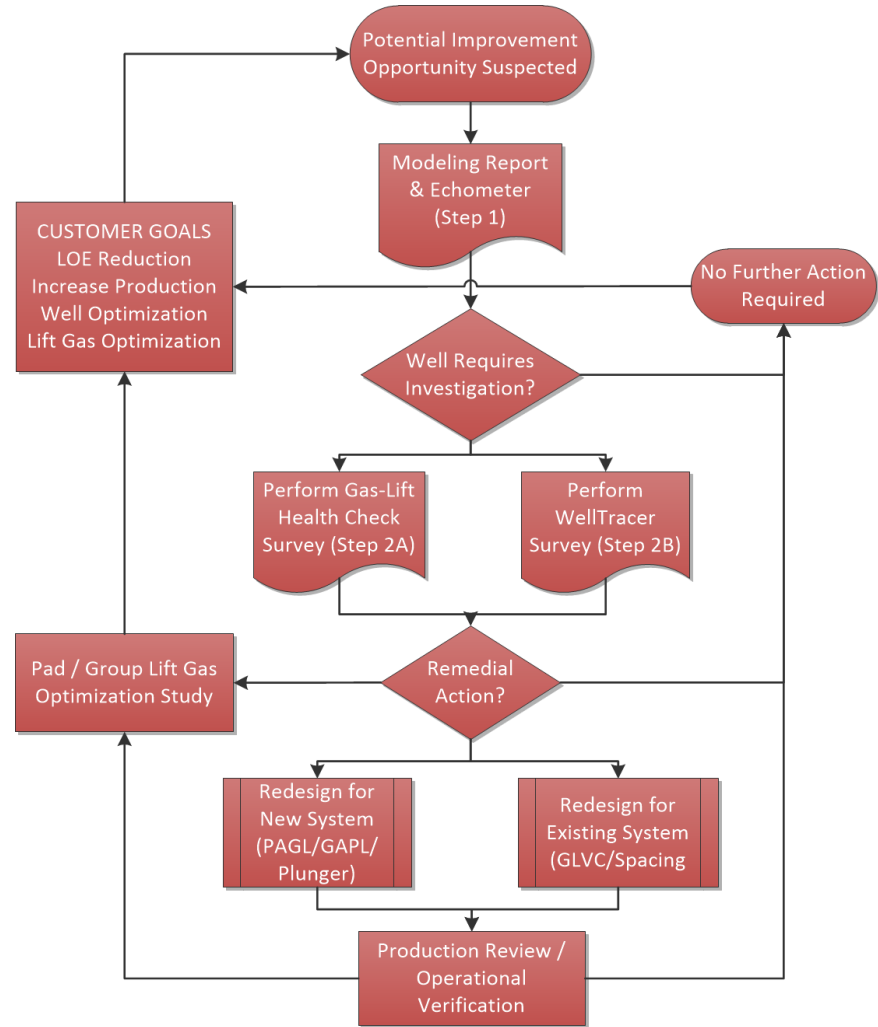
Surveillance Process



How can Kaizen help?



- Kaizen provides complete Life-of-Well Support for Gas-Lifted wells, including:
 - Well Modeling & Design
 - Gas-Lift Troubleshooting & Optimization
 - WellTracer & Echometer
 - Gas-Lift Mandrels (Made in USA)
 - Gas-Lift Valves (Made in USA)
 - Plunger Lift Equipment (including PAGL/GAPL)
- Step 1 - Life-of-Well Support starts with Well Modelling
- Step 2 - Modeling will reveal some wells that need more investigation
- Step 3 - Gas-Lift System Designs / Redesigns may be needed to improve operation on some wells
- This process will likely be repeated more than once during the life of the well
- *The next few slides highlight what a typical process might look like...*



Step 1 – Modeling

- Well Modeling Report with Echometer
 - Larger sample ~100 Wells
 - Key Equipment Required
 - WinGLUE Gas-Lift Evaluation Software
 - Echometer Fluid Level Recorder
 - Well Modeling Report
 - Review well completion and recent well test information
 - Review Production and Injection Pressure Models
 - Confirm fluid level and identify obvious GLV or operational problems
 - Review gas-lift injection performance (Q vs. I, TGLR, etc.)
 - Identify wells needing further investigation

Step 2A – Performance Check

- Gas-Lift Performance Check Survey
 - Medium sample ~20-30 wells
 - Key Equipment Required
 - WellTracer Unit
 - WinGLUE Gas-Lift Evaluation Software
 - Echometer Fluid Level Recorder
 - Gas-Lift Performance Check Report
 - Ideal for routine troubleshooting & surveillance on Gas-Lift, PAGL & GAPL wells.
 - Determine primary POI, multi-point injection, tubing leaks, mechanical problems, and percentage of gas through each injection point.
 - Typical report turnaround in 1-2 days, same day reporting with advanced planning.

Step 2B – WellTracer

- WellTracer Survey
 - Small sample ~7-10 wells
 - Key Equipment Required
 - WellTracer Unit
 - WinGLUE Gas-Lift Evaluation Software
 - Echometer Fluid Level Recorder
 - Optional lift gas rate flow meter (extra cost)
 - WellTracer Report
 - Ideal for in-depth troubleshooting, gas-lift system review, best option for optimizing gas-lifted wells.
 - Determine primary POI, multi-point injection, tubing leaks, GLV erosion, other mechanical problems, and percentage of gas through each injection point.
 - Written recommendations for improvement and detailed system observations.
 - Typical report turnaround in 3-4 days.

Step 3 Design & Install

- Gas-Lift System Design & Installation Support
 - Small sample ~10 wells
 - Gas-Lift Design created using WinGLUE
 - Design based in customer input and requirements.
 - Depth of optimal point of injection (Gas-Lift, PAGL, or GAPL).
 - Recommended mandrel spacing, valve settings, and equipment specifications based on customer and system requirements.
 - Kaizen Gas-Lift and Plunger Lift Equipment
 - Mandrels, gas-lift valves & plunger lift equipment are made in USA.
 - Timely delivery of mandrels, valves, plunger lift and other equipment.
 - Qualified tool hand for system installation and start up.
 - Field technician to support installation and well unloading/startup.

Feature Comparison

Feature	WellTracer	Gas-Lift Performance Check
Identify primary point of gas injection	●	●
Identify multipoint injection due to open or failed gas-lift valves	●	●
Identify tubing leaks, including leaks passing small amounts of gas	●	●
Verify injection rates and how much gas is injecting into each point of injection	●	●
Verify lift gas injection vs. production performance	●	●
Verify gas-lift models	●	If model exists
Gas-lift valve analysis, including identifying erosion or plugging	●	Contact us
Report includes gas-lift system operation and performance observations	●	
Report includes recommendations to fix problems, increase production, and/or reduce lease operating costs	●	



KAIZEN WELL SOLUTIONS

THANK YOU!

www.kaizenws.com | www.appsmiths.com