Artificial Lift R&D Council

Co2 Tracer Technology GAPL well evaluation and Application

Clint Mason

ALRDC Artificial Lift Workshop

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Introduction

- **Clint Mason**
- President of Kaizen Well Solutions Ltd. – Well optimization
- Managing partner in Trido Industries, Trido Solutions LLC (solar drive platform development) and Appsmiths LLC (Well Tracer Co2 technologies)
- Started working Oil and gas in 1987, Pipeline & plant construction, well/plant operation, wireline, downhole production tools, optimization

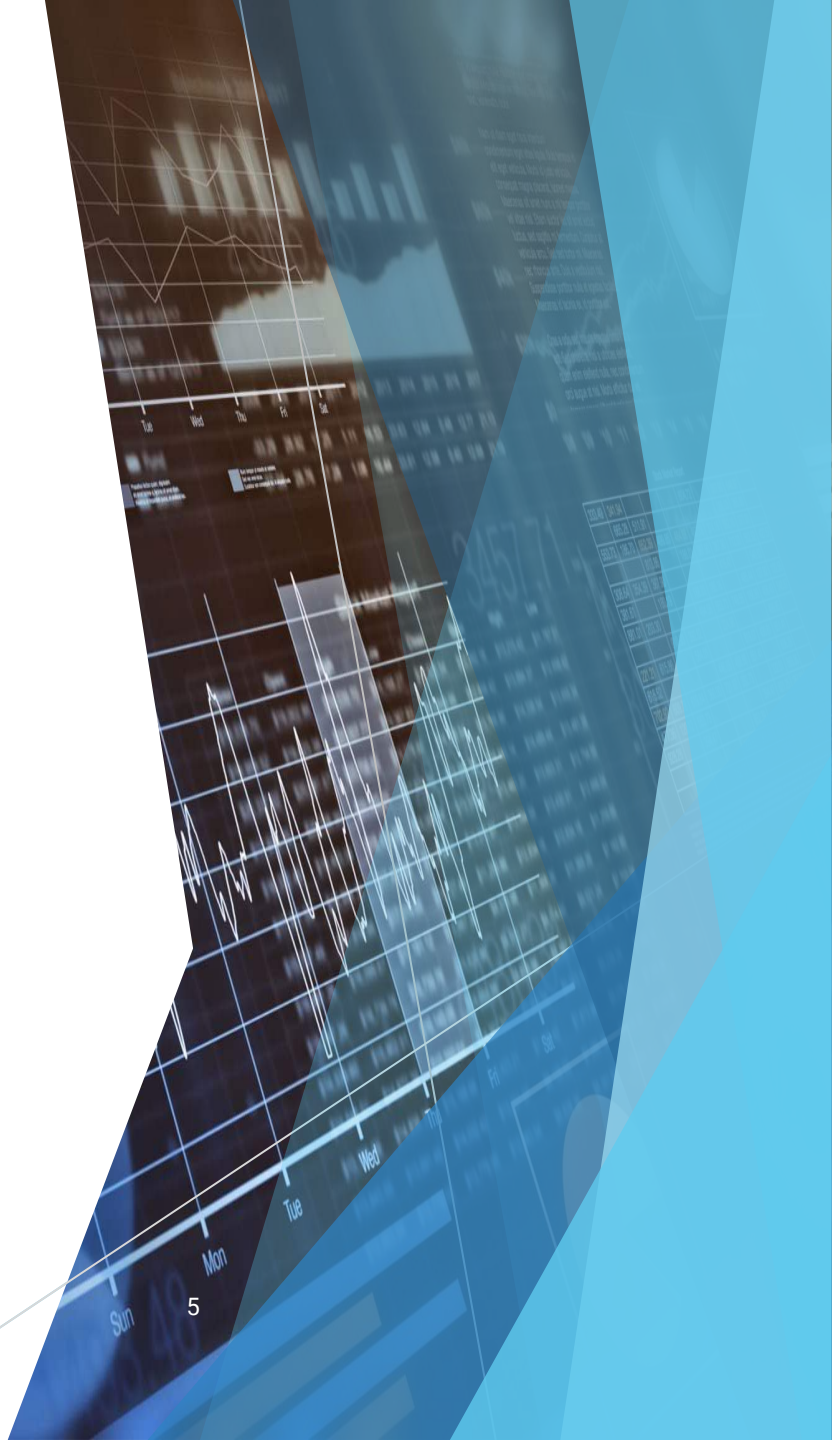
What is the CO2 well tracer Technology

- Co2 well tracer is a simple system that injects a Co2 slug into the injection gas stream
- This slug travels down the injection conduit until it reaches an opening into the return conduit
- A small amount of the Co2 will enter and is returned to surface at this point
- The volume of the return can be used to calculate the size of the opening
- The time from Co2 injection to Co2 return identifies the return depth from surface

Well Tracer Video

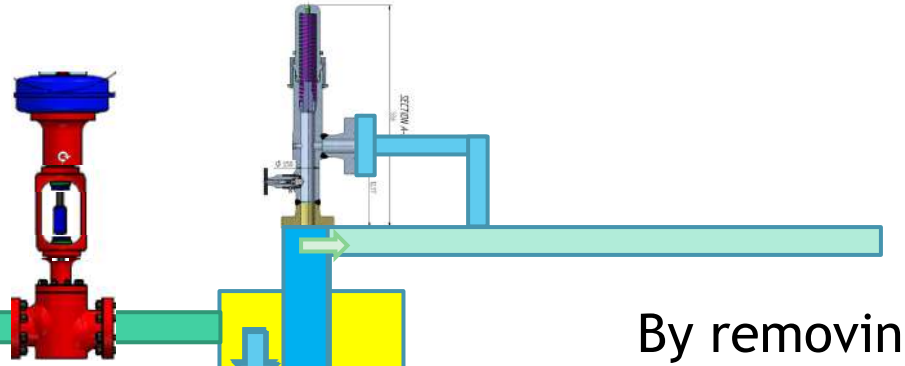
Well Tracer basic information

- To use WellTracer it is required to build a well model in our Winglue software evaluation tool, with conduit size, depth deviation and gas lift design etc.
- Monitor Injection volumes while performing test SCADA data or test information
- Monitor production volume during test
- This data allows Win Glue software to calculate velocities throughout the well
- At the end of the test the return volumes are balance it allows us to identify distribution of gas injection thorough out the entire tube string and depth of each point
- Win Glue software and Well Tracer was a technology developed by Shell specifically for gas lift diagnostic services

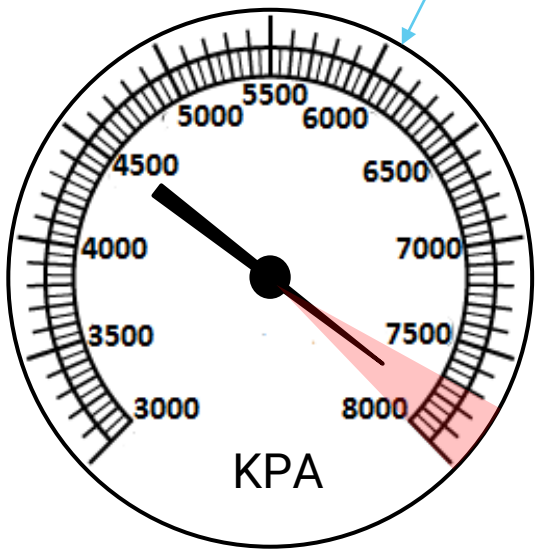


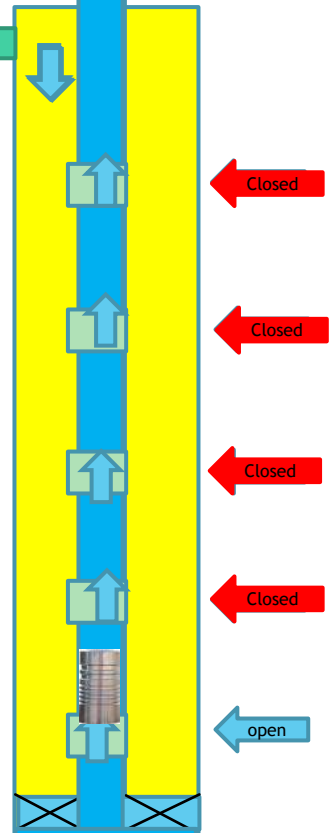
Using Well Tracer in GAPL applications

- GAPL or Gas assisted Plunger lift requires a gas lift system to be operating properly or at least you need to know where your gas injection is going
- Looking at operating surface pressures does not always give you a good indication of valve condition or the depth where you are injecting
- Finds unexpected injection points I.E holes in tubing
- Provide total tubing gas volumes/velocities through the tubing based on injection points and % of injection gas entering at those points



Injection Pressure At Orifice



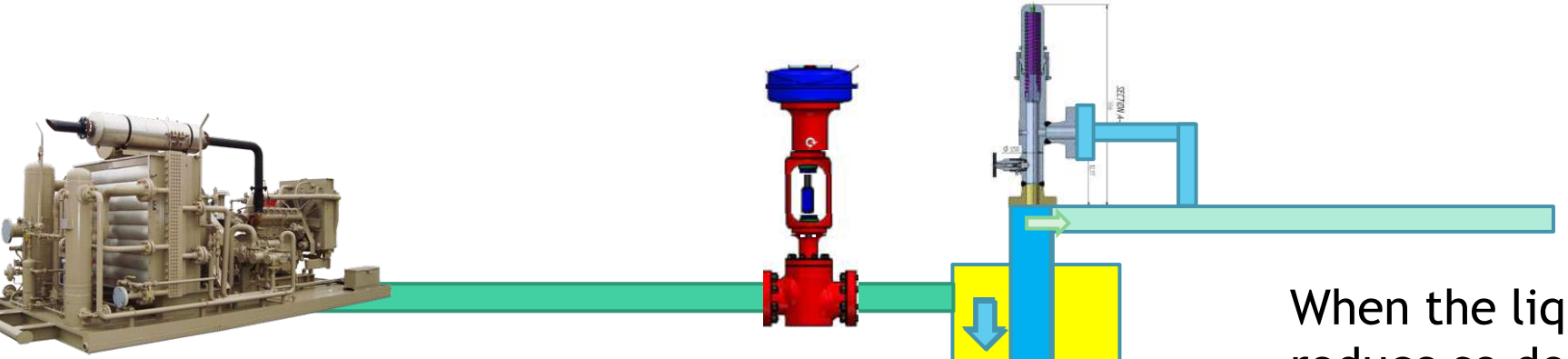


By removing the fluid in the tubing, the casing pressure drops and the valves close from the top to bottom

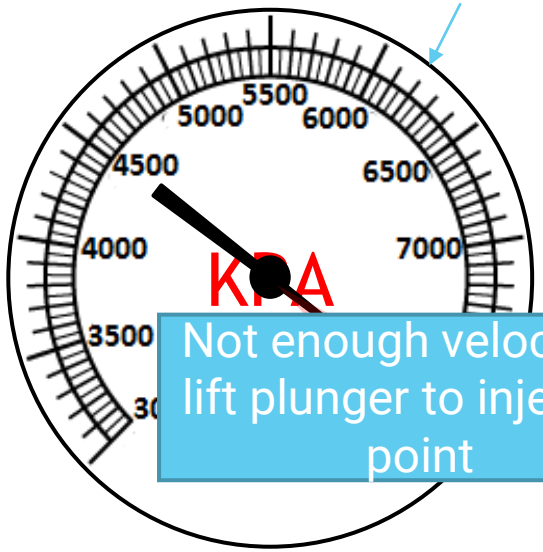
Once all the fluid is removed, the gas injected at the deepest port will help push the plunger to surface, lifting fluid more effective than gas lift alone.

Common issues

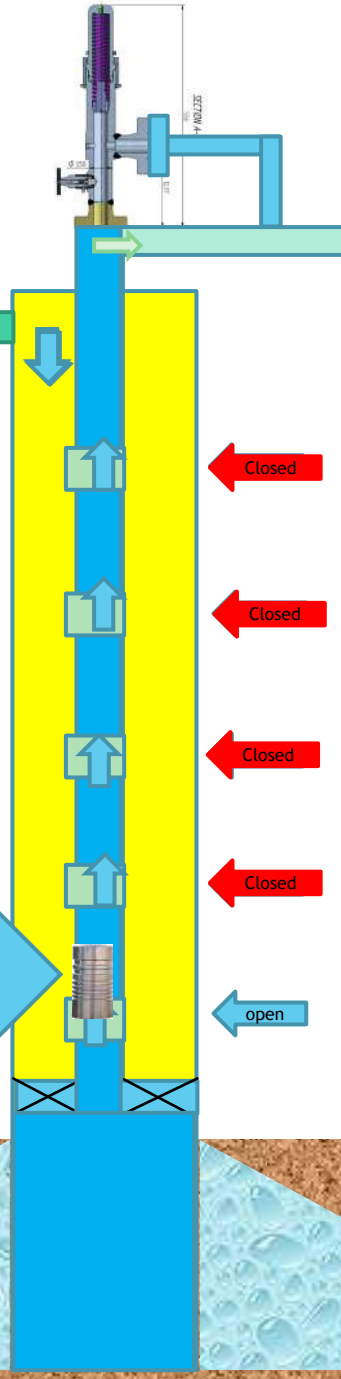
- After Gas lift valves have been installed for a few years, there is a good potential they are no longer functioning as when they were first installed.
- Some common issues
  - Washed or failed valve and seats
  - Bellow issues: Failure, scale build up other issues impacting the free movement
  - Reduction in temperature due to well condition changes- such as reduction in fluid production will impact dome pressure in valves which can well result in valves moving out of sequence
  - Hole(s) in tubing



Injection Pressure At Orifice?



Not enough velocity to lift plunger to injection point



When the liquid volumes reduce so does the temperature around the valves which significantly impact the opening/closing pressures

Valve 2-3 cannot close because the lower temperature has reduced the opening pressure to below valve #4

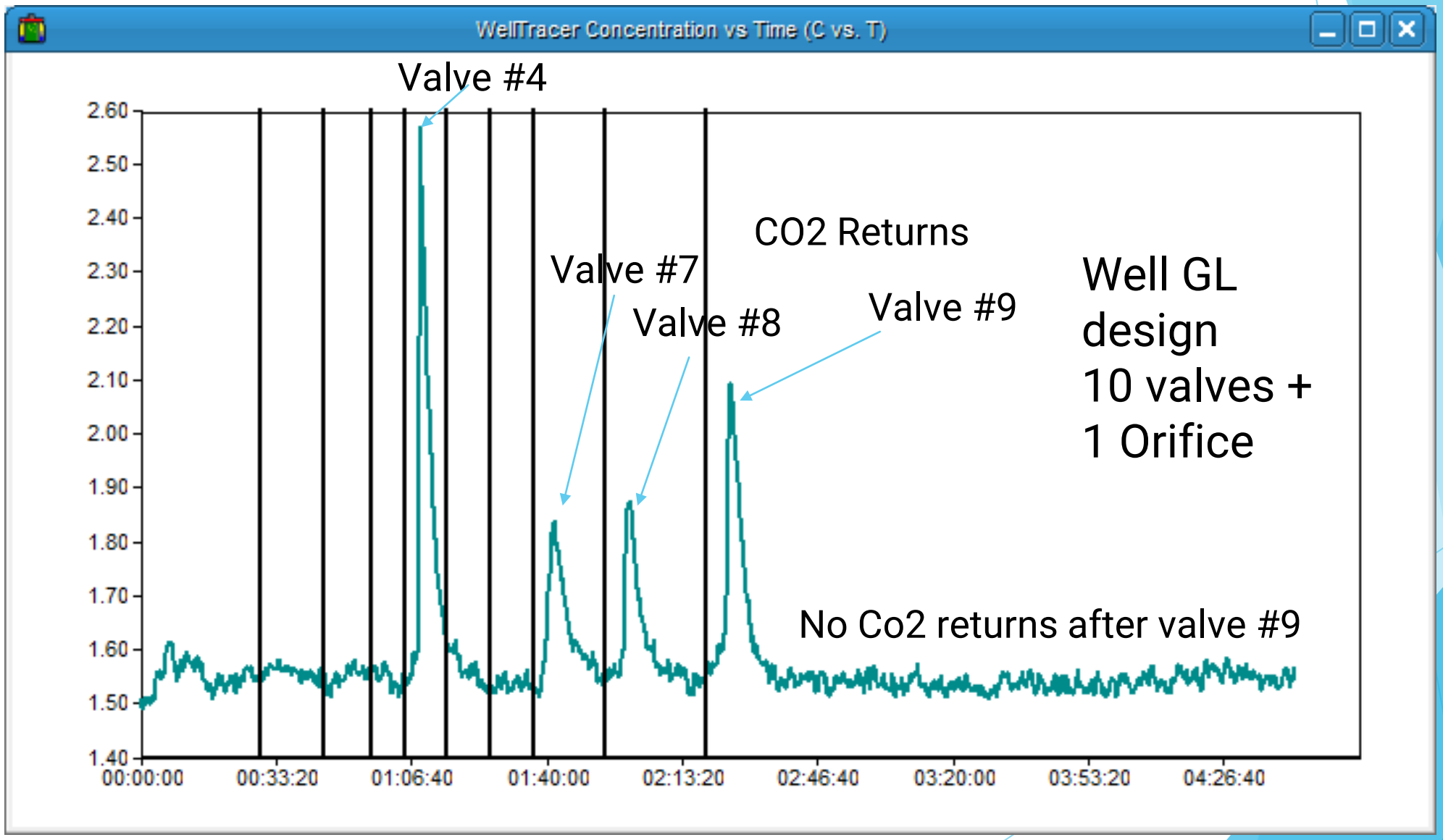
GAPL/PAGL - #1 mistake is using injection pressure as the benchmark on injection depth

- A gas-lifted well may not be operating from the orifice just because the operating pressure is low. Knowing points of injection due to open or failed valves and the amount of gas going through each injection point is important when choosing plunger type and when operating PAGL/GAPL systems.

Well example #1

Valve failure, plugged valves and multipoint

WellTracer test on Multi point/Failed Valves



Well Details 10 Valves 1 Orifice
60 bbl. fluid 345 MCF/D formation

Artificial Lift R&D Council

KAIZEN WELL solutions

CONDUIT FLOW DETAIL REPORT

Report Date: 15-Feb-2022

Well Status: ACTIVE

Data Source	Field	Lease	Well	String	Completion	Well Zone#	Units
	Eagleville			Other	01	Eglfrd	Oil Field

Gas Lift Valve Analysis

Mnrl No.	Mnrl MD	Mnrl TVD	Mnrl Dev.	Mnrl Prod Press	Mnrl Inj Press	Valve Temp	Close Press	Open Press	VPC Begin Flow Press	Surf Close Press	TRO	Est Rate	Valve Model	Choke	Valve Status	User Flow Assigned	Flow Rate By %
	feet	feet	degrees	psig	psig	dg.F	psig	psig	psig	psig	psig	MCF/day		64ths		%	MCF/day
1	2,762	2,762	0.76	380	918	138.0	1,012	1,075	1,078	933	945	0.0	Priority Energy IPOR-1 3/16 (Winkler)	0	Closed	0.0	0.0
2	4,255	4,254	0.76	432	955	164.4	937	987	992	831	835	0.0	Priority Energy IPOC-1 3/16 (Winkler)	0	Transition	0.0	0.0
3	5,348	5,337	7.82	470	981	187.8	953	1,001	1,008	824	815	0.0	Priority Energy IPOC-1 3/16 (Winkler)	0	Transition	0.0	0.0
4	6,179	6,159	8.66	499	1,000	203.5	960	1,006	1,015	814	800	0.0	Priority Energy IPOC-1 3/16 (Winkler)	0	Transition	38.0	266.0
5	6,811	6,784	8.66	525	1,015	216.0	968	1,012	1,021	809	790	0.0	Priority Energy IPOC-1 3/16 (Winkler)	0	Open	0.0	0.0
6	7,477	7,442	8.66	554	1,031	228.8	969	1,010	1,021	798	775	56.7	Priority Energy IPOC-1 3/16 (Winkler)	0	1% open	0.0	0.0
7	8,143	8,100	8.66	583	1,046	241.5	976	1,015	1,025	792	765	114.3	Priority Energy IPOC-1 3/16 (Winkler)	0	1% open	27.0	189.0
8	8,775	8,726	8.66	619	1,060	253.8	981	1,017	1,028	786	755	176.9	Priority Energy IPOC-1 3/16 (Winkler)	0	1% open	10.0	70.0
9	8,775	9,384	8.66	662	1,075	269.6	991	1,024	1,035	783	745	214.7	Priority Energy IPOC-1 3/16 (Winkler)	0	2% open	25.0	175.0
10	10,073	10,014	4.37	720	1,090	280.9	1,001	1,029	1,039	780	740	254.9	Priority Energy IPOC-1 3/16 (Winkler)	0	2% open	0.0	0.0
11	10,706	10,629	13.71	779	1,104	288.9	N/A	N/A	N/A	N/A	N/A	607.0	1 Inch Orifice 3/16 (THC)	0	Open	0.0	0.0

Well Test Properties

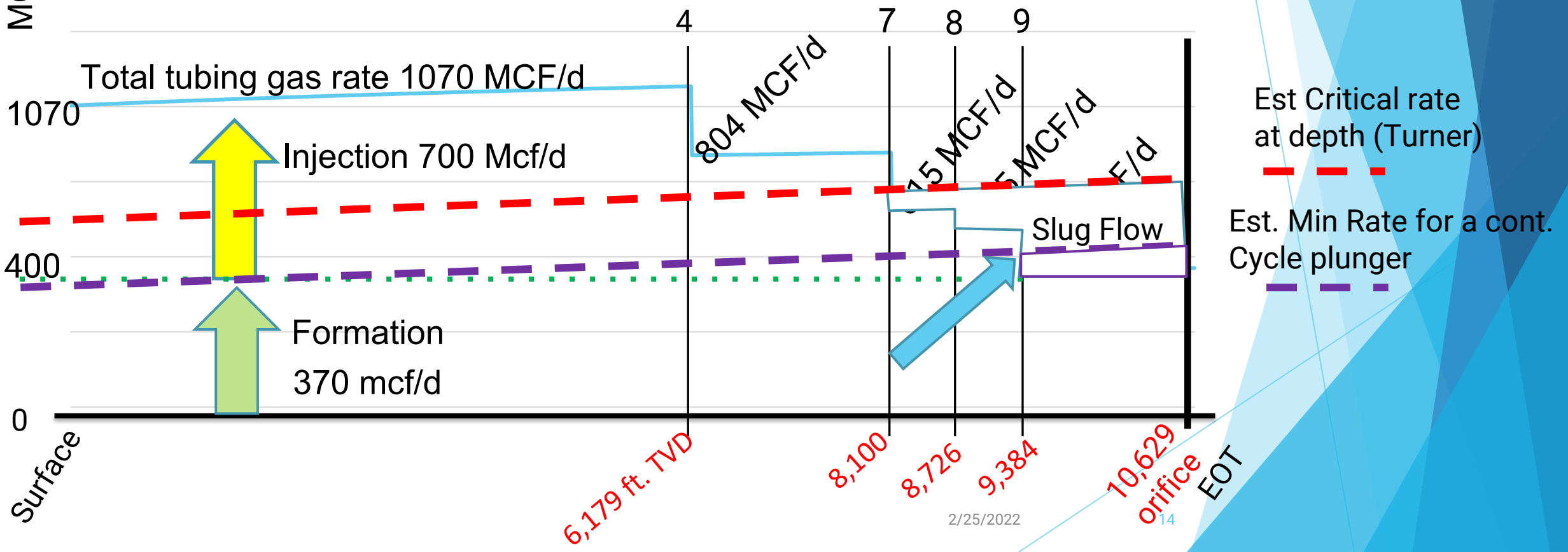
	Timestamp	Test Length	Test Sep. Pressure	Manifold Pressure	Choke Size	Oil Rate	Water Rate	Form Gas Rate	Lift Gas Rate	Production Pressure	Injection Pressure
	dd-MMM-yyyy hh:mm:ss	hours	psig	psig	64ths	bbls/day	bbls/day	MCF/day	MCF/day	psig	psig
Calib	12-Jun-2021 00:00:00	0.0	0	288	0	39.3	21.9	345.0	700.0	288	847
Orig					0	39.3	21.9	344.8	662.0	274	826

Will this well function as a gas lift? NO - in Slug flow below Valve #7

Will this well operate a Cont. Cycle plunger lift? Might be difficult below Valve #9

Potential Injection gas reduction ? -620 Mcf/d Only requires est. of 80 MCF/d for PL if gas lift was operating correctly

This well is likely operating below the minimum liquid volume for Gas lift and is in the "deliquification" range where CR must be maintained to lift fluid to surface effectively



Suspected Valve issues

The evaluation of this well indicates that this well should be injecting at the Orifice - Summary of valve issues

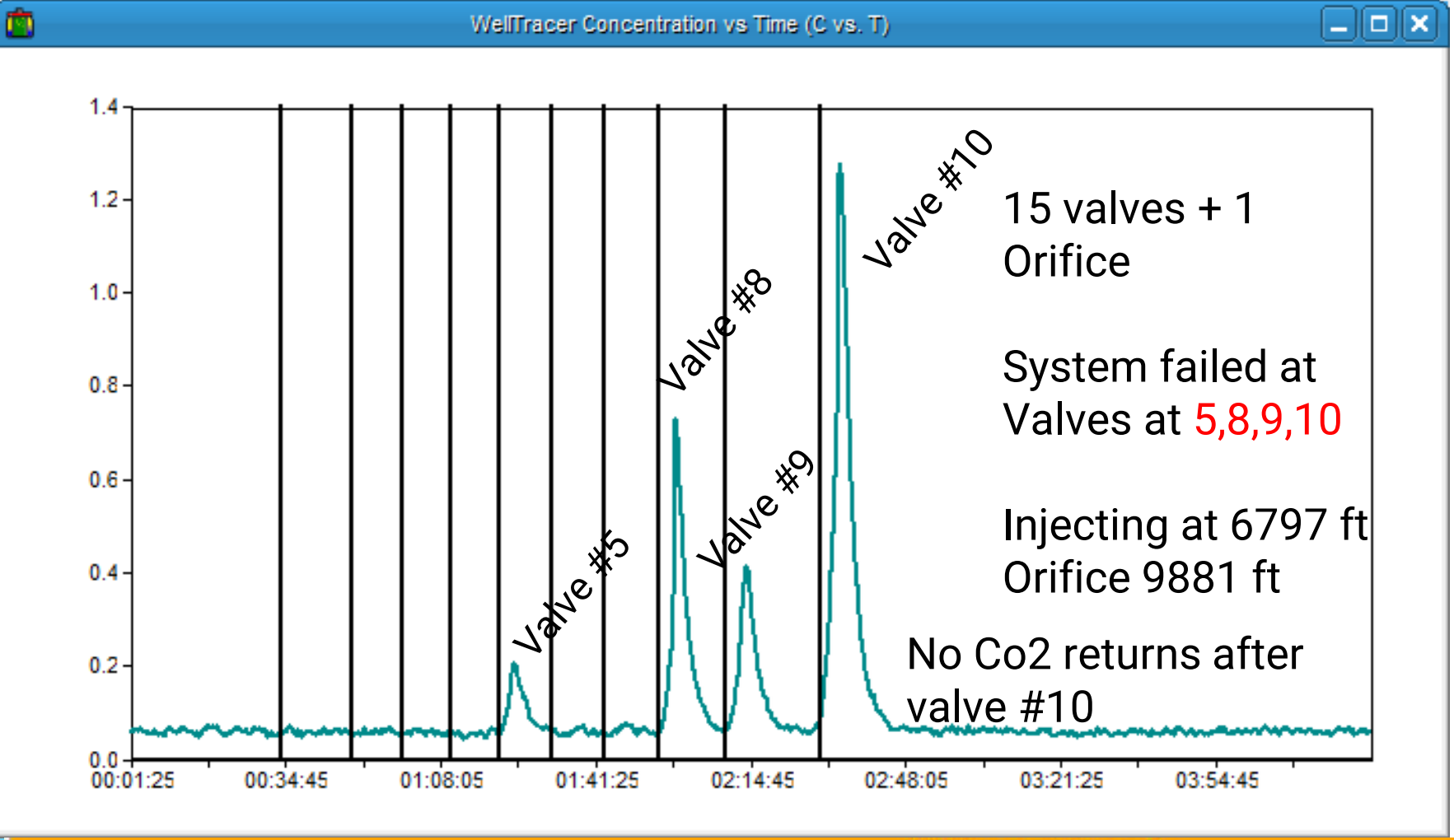
- Valve #4 is Closed but injecting - Damaged and **should not** be allowing gas to enter the tubing.
- Valve #7 is Open - Injecting, condition unknown - higher than expected injection pressures from issues in Valve #10 and orifice
- Valve #8 & #9 Open – Injecting, condition unknown - higher than expected injection pressures from issues in Valve #10 and orifice
- Valve #10 is closed - plugged/damaged. Not allowing injection gas to enter tubing.
- Orifice is plugged/damaged. Not allowing injection gas to enter tubing.
- This gas lift system requires a redesign and valves to be fixed to maximize operation of a plunger lift & take maximum advantage of injection gas reduction.

Well in review

- Based on the information we gathered from our Well Tracer test
- The liquid rate is below the minimum liquid rate for tubing size for continuous gas lift, and requires you to flow above CR to effectively lift the fluid from the Orifice to valve #9
- The failed valves do not allow injection to deepest POI, the velocity below valve #9 is 100% formation gas dependent. 38% of lift gas is injecting at valve #4 far up hole
- The velocity below valve #9 is likely too low to effectively operate a continuous cycle plunger – Free Cycle, two piece etc.
- In a GAPL application we should only need to inject about 80 Mcf/D to meet our minimum velocity to make a two-piece plunger to operate
- **This is a potential injection rate reduction of 620 MCf/d**

Well example #2

High valve failure



Well requires redesign and work over/Valve replacement

Valve design analysis indicates well should be injecting at Valve 14-15

WellTracer Return Data

#	Return Time	Return Duration	Return Elapsed	Calc Trav Time	Casing Trav Time	Tubing Trav Time	Total Gas Vel	Mand MD	Calcd Inj MD	Pct Error	Man No.	Area	Pct Of Area
	dd-MMM-yyyy hh:mm:ss	*hh:mm:ss*	*hh:mm:ss*	*hh:mm:ss*	*hh:mm:ss*	*hh:mm:ss*	*feet/sec*	*feet*	*feet*	%		*sq. inches*	%
1	04-Jun-2021 10:41:09	00:12:27	01:21:08	01:20:30	01:17:52	00:02:38	1.74080	4,204	4,237	1%	5	37.043	7%
2	04-Jun-2021 11:14:53	00:12:44	01:54:52	01:54:46	01:50:08	00:04:38	1.67847	5,779	5,784	0%	8	136.973	24%
3	04-Jun-2021 11:29:02	00:13:09	02:09:01	02:09:20	02:03:54	00:05:26	1.61635	6,272	6,256	0%	9	92.662	16%
4	04-Jun-2021 11:48:16	00:16:36	02:28:15	02:29:40	02:23:15	00:06:24	1.51390	6,797	6,733	1%	10	299.267	53%

Upper valve failure

This well Tracer test indicated a significant issue in the upper valves

This well once repaired, is still in the effective Gas Lift window and Plunger lift/GAPL is not required at this time

This well is injecting 32% of the injection gas 5152 ft. above the expected injection point based on production volumes and injection rates

Where we should be injecting

Gas Lift Valve Analysis

Mnrl No.	Mnrl MD	Mnrl TVD	Mnrl Dev.	Mnrl Prod Press	Mnrl Inj Press	Valve Temp	Close Press	Open Press	VPC Begin Flow Press	Surf Close Press	TRO	Est Rate	Valve Model	Choke	Status	Assigned	Cl	ow Rate By %
	feet	feet	degrees	psig	psig	dg.F	psig	psig	psig	psig	psig	MCF/day		64ths		%	4ths	MCF/day
1	1,814	1,813	1.77	341	1,052	134.9	1,290	1,290	1,290	1,218	1,135	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
2	2,600	2,591	8.31	448	1,077	138.5	1,317	1,317	1,317	1,211	1,175	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
3	3,154	3,138	9.01	524	1,095	140.9	1,327	1,327	1,327	1,199	1,195	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
4	3,679	3,650	12.86	597	1,113	143.2	1,324	1,324	1,324	1,176	1,205	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
5	4,204	4,153	16.64	671	1,129	145.4	1,320	1,320	1,320	1,156	1,215	0.0	Altec AT1-CF-BK 5/16	10	Closed	6.5	2.48	31.2
6	4,729	4,656	16.64	749	1,147	147.6	1,322	1,322	1,322	1,142	1,230	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
7	5,254	5,159	16.64	829	1,164	149.7	1,317	1,317	1,317	1,121	1,240	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
8	5,779	5,662	16.64	913	1,181	151.8	1,311	1,311	1,311	1,100	1,250	0.0	Altec AT1-CF-BK 5/16	10	Closed	24.2	5.01	116.2
9	6,272	6,138	15.00	997	1,197	153.7	1,310	1,310	1,310	1,083	1,265	0.0	Altec AT1-CF-BK 5/16	10	Closed	16.4	4.32	78.7
10	6,797	6,647	14.35	1,092	1,215	155.8	1,307	1,307	1,307	1,065	1,280	0.0	Altec AT1-CF-BK 5/16	10	Closed	52.9	8.54	253.9
11	7,322	7,158	13.27	1,203	1,233	157.3	1,296	1,296	1,296	1,041	1,295	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
12	7,815	7,640	12.13	1,314	1,250	158.6	1,285	1,285	1,285	1,019	1,310	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
13	8,341	8,160	7.94	1,440	1,268	159.9	1,269	1,269	1,269	993	1,325	0.0	Altec AT1-CF-BK 5/16	10	Closed	0.0	0.00	0.0
14	8,831	8,646	7.94	1,564	1,285	161.1	1,246	1,246	1,246	964	1,335	0.0	Altec AT1-CF-BK 5/16	10	Back Checkec	0.0	0.00	0.0
15	9,356	9,166	7.94	1,704	1,304	162.3	1,225	1,225	1,225	936	1,350	0.0	Altec AT1-CF-BK 5/16	10	Back Checkec	0.0	0.00	0.0
16	9,881	9,686	7.94	1,850	1,323	163.4	N/A	N/A	N/A	N/A	N/A	0.0	Altec AT1-O 3/16 (THC)	0	Back Checkec	0.0	0.00	0.0

Well Example #2

- In this last test example, the casing/injection pressure was 993 PSI
- Based on the injection pressure and valve design, it could easily be assumed that this well is injecting at the orifice.
- Customer wanted to evaluate for potential GAPL
- WellTracer test indicated this was an incorrect assumption
- After evaluation, a better solutions was to redesign & repaired existing Side pocket system
- With the expected well production increased, this will put this well back into the “true gas lift” range for fluid production and likely would not see a benefit from the implementation of GAPL/PAGL

Questions?

Please …. Don’t ask me to do the math ☺

Slide 3 Acknowledgements/Thanks & Questions

- Thanks to my team at Kaizen Well Solutions/Appsmiths and Trido Industries
- Thanks to all of our customers that have worked with us to gather data and work together to identify some best practices and the opportunity to expand my understanding of Hz wells.
- Thank you to the ALRDC and its members for hosting this valuable event

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