Ask Echometer Online Session – June 17, 2020

Acoustic Techniques for Gas-Lift Wells

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Q & A: with Lynn Rowlan and Gustavo Fernandez

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((ECHOMETER))

"Acoustic Techniques to Monitor and Troubleshoot Gas-lift Wells", Taylor, Rowlan, McCoy SPE-169536-MS
"Dual Shot Acoustic Technique", Province, Taylor, Rowlan, McCoy, SWPSC 2018

Ask Echometer Session 5:

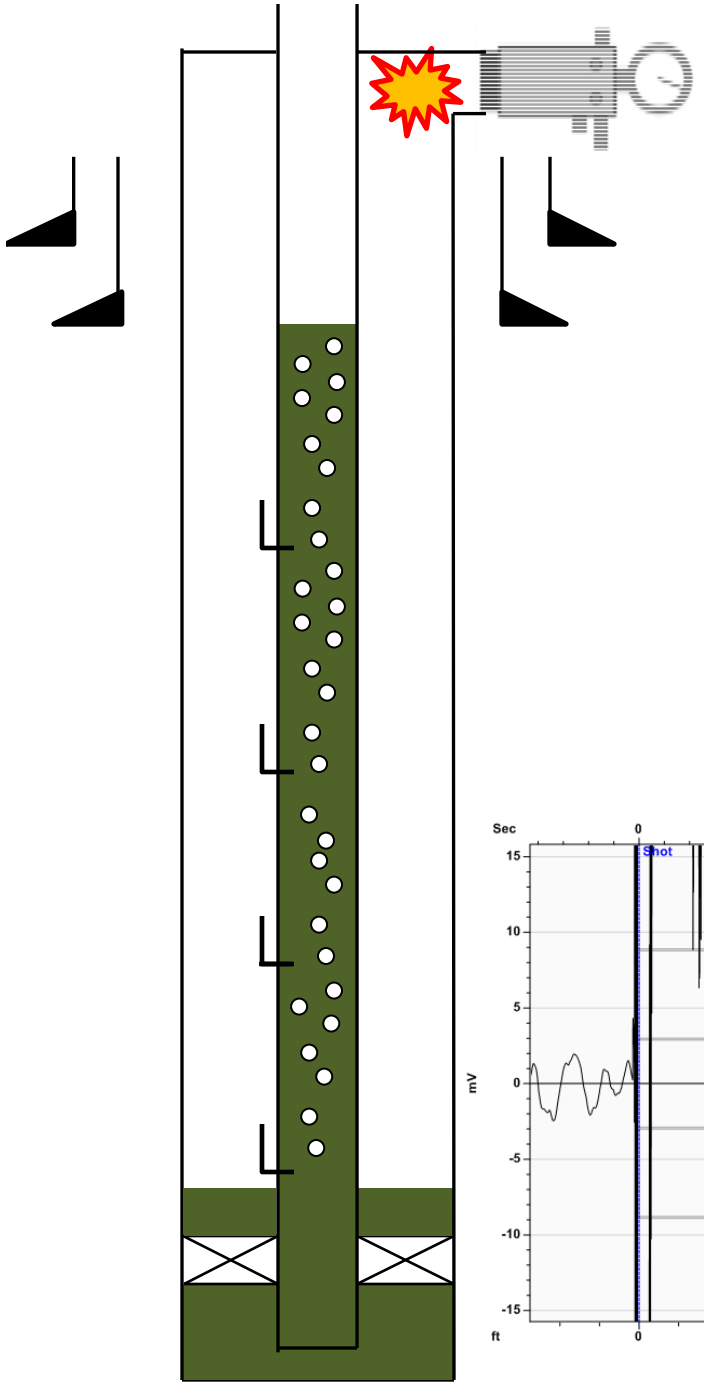
- Benefits of Fluid Levels on gas-lift wells.
- Introduction to Dual Shot Acoustic Technique
- Gas-lift well file set up in TAM
- Analyzing gas-lift fluid levels shots and tips for analyzing difficult shots with multiple reflection kicks

Benefits of Fluid Levels on Gas-Lift Wells

The distance to the fluid level provides beneficial information throughout the life of a gas-lift well.

- Fluid level depth with respect to the valve
- Depth to the deepest mandrel uncovered
- Verify Unloading process is proceeding properly
- Find holes, restrictions
- Wellbore problem or equipment malfunction?
- How can acoustics aid in Troubleshooting?

Fluid Levels During Unloading Sequence

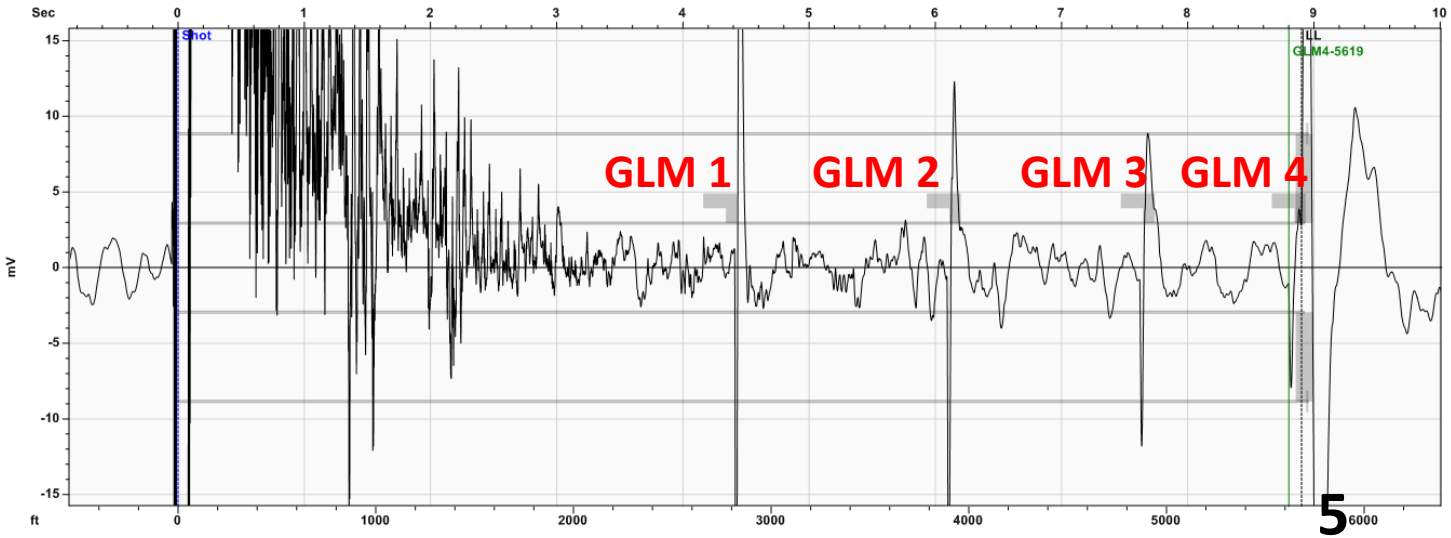


Acoustic Shots Provide Valuable Details During the Gas-lift Well Unloading Sequence

Shots down the casing annulus provide a quick look at uncovered mandrels as the annular fluid level drops during the unloading process.

The operating valve is quickly and easily identified.

Or the depth to the deepest valve above the annular fluid level, when checks valves are present.

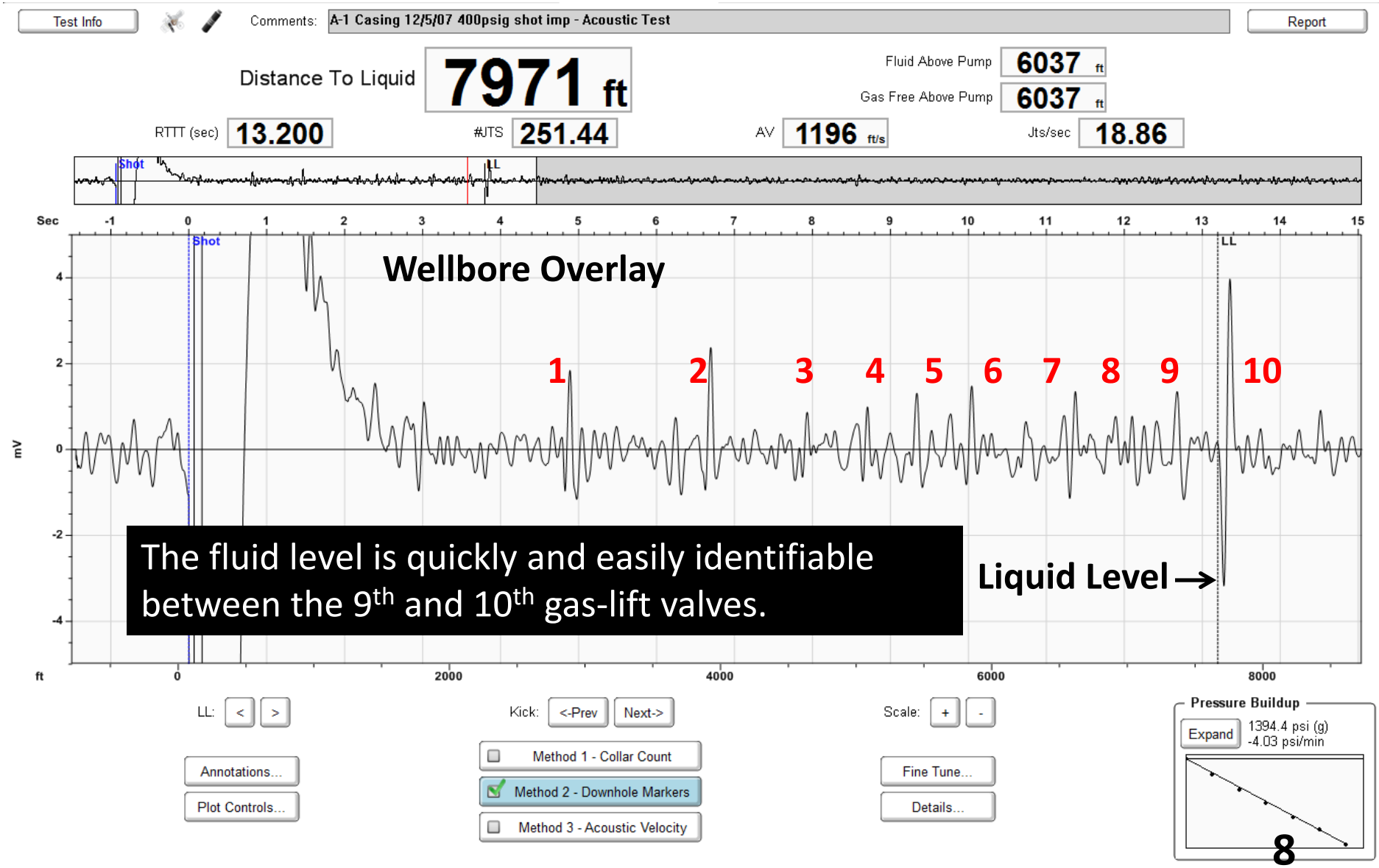


Fluid Levels on a Stabilized Gas Lift System

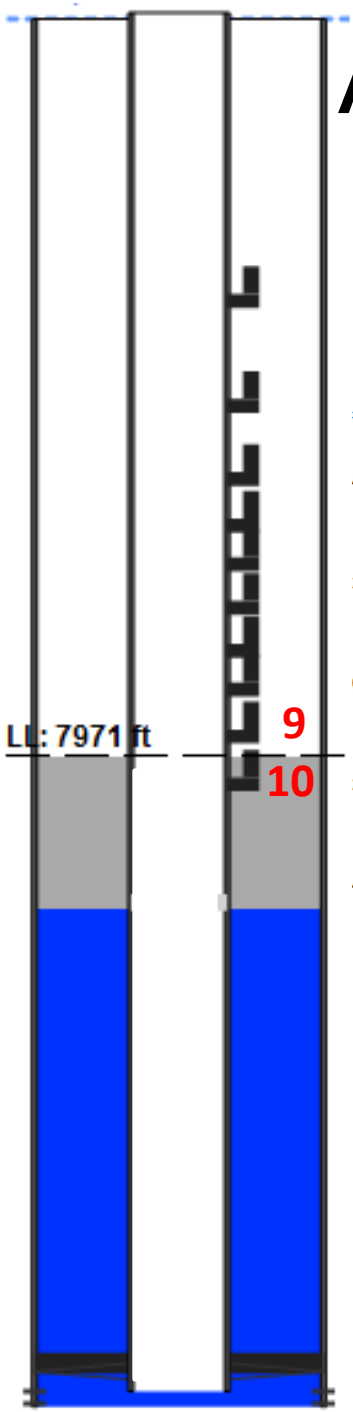
Monitoring Fluid Levels on Gas-lift

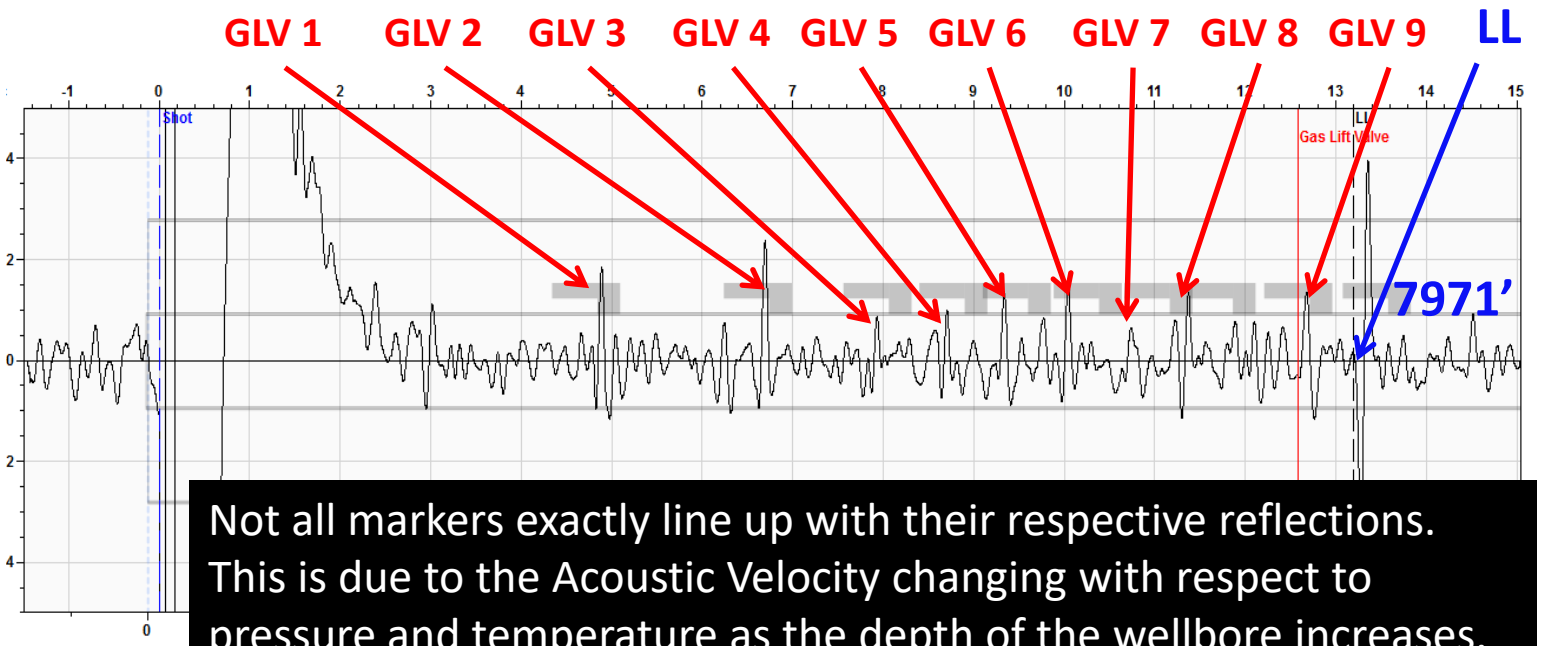
- Annular fluid levels should remain constant with respect to the operating valve.
- Oscillations of the liquid level depth may indicate valve operation or gas injection rate problems.
- In a well with a packer, the deepest liquid level indicates the deepest mandrel uncovered from the unloading process.
- Wellbore integrity problems can be detected – Valves stuck open, Leaking packer, leaking check valves
- During workovers – stability of kill fluid depth

Find fluid levels with respect to valves



Acoustic pulses reflect off gas-lift valves and other anomalies.



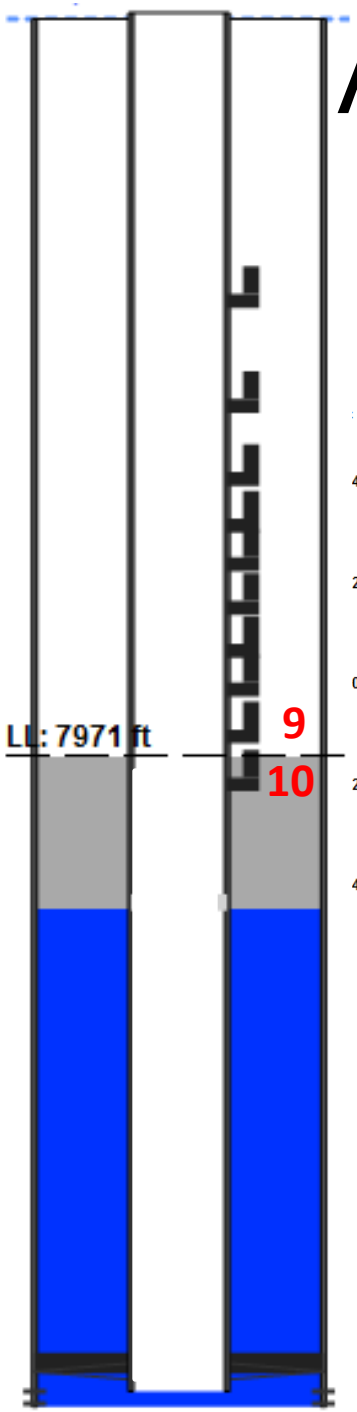


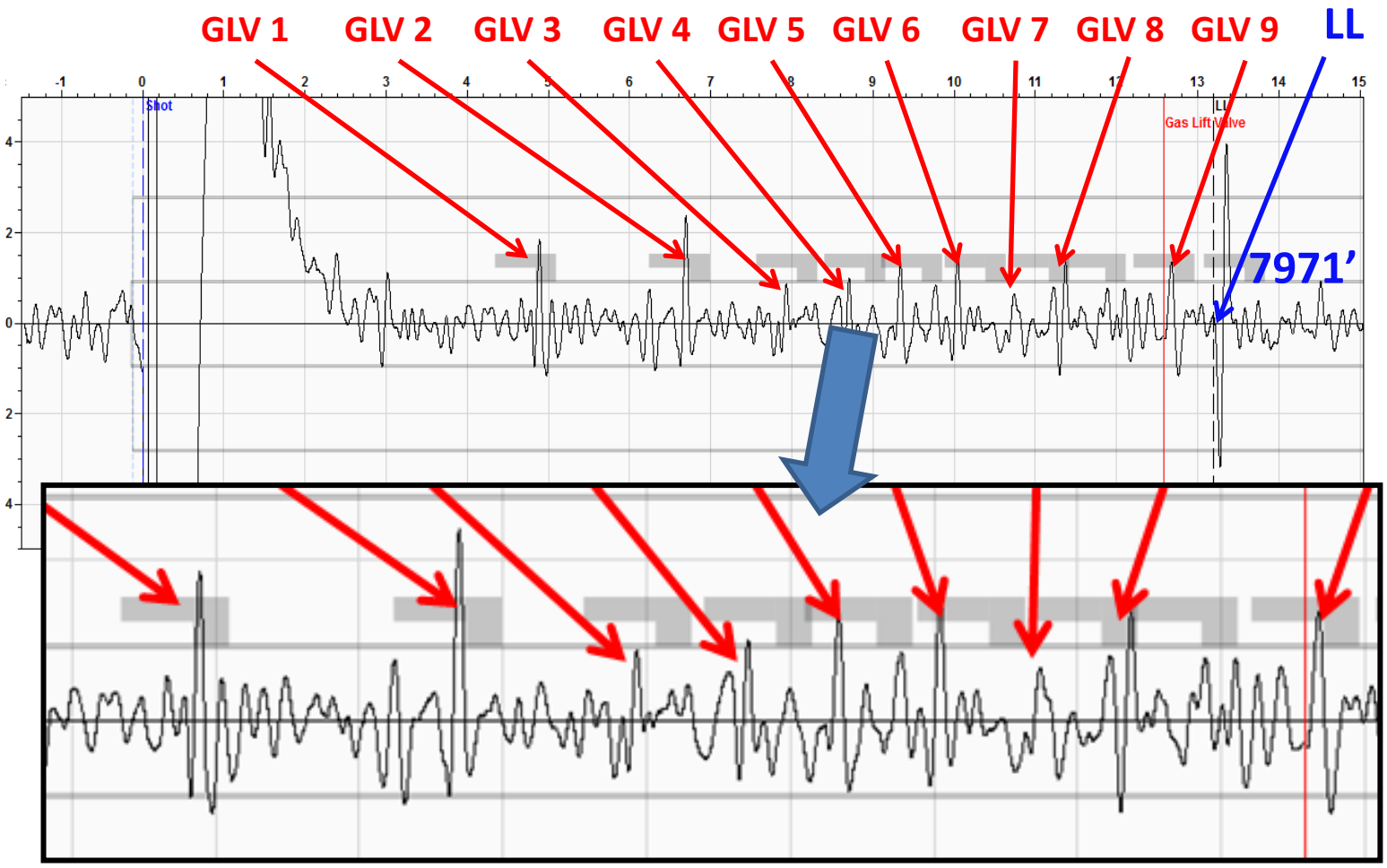
Not all markers exactly line up with their respective reflections. This is due to the Acoustic Velocity changing with respect to pressure and temperature as the depth of the wellbore increases.

Gas-lift Valve Depths from Wellbore Schematic:

GLM 1 – 2894'	GLM 5 – 5738'	GLM 9 – 7598'
GLM 2 – 4028'	GLM 6 – 6208'	GLM 10 – 8117'
GLM 3 – 4819'	GLM 7 – 6675'	
GLM 4 – 5320'	GLM 8 – 7091'	

Acoustic pulses reflect off gas-lift valves and other anomalies.



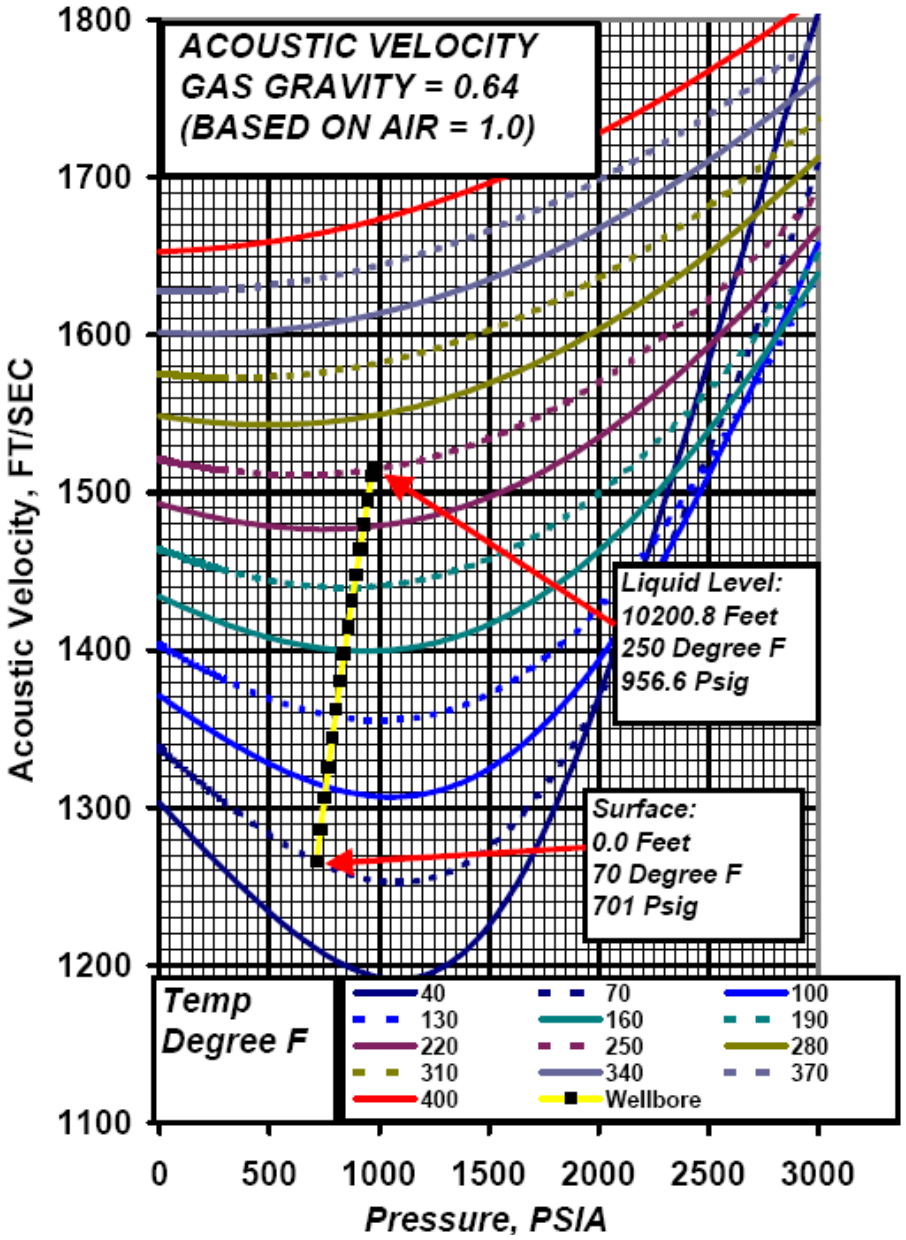


Acoustic Velocity between Downhole Markers

Gas-lift Mandrels are Excellent Downhole Markers

- Purpose – Accurately calculate the distance to the liquid level plus other downhole reflectors such as gas-lift valves and mandrels, tubing collars, subsurface safety valves and possible holes or other problems.
- Distances – Determined using echoes from gas-lift valves at known distances from the wellhead.
- Accounts for – Variations of acoustic velocity commonly observed in most wellbores due to variations of temperature, pressure and gas composition as a function of depth.

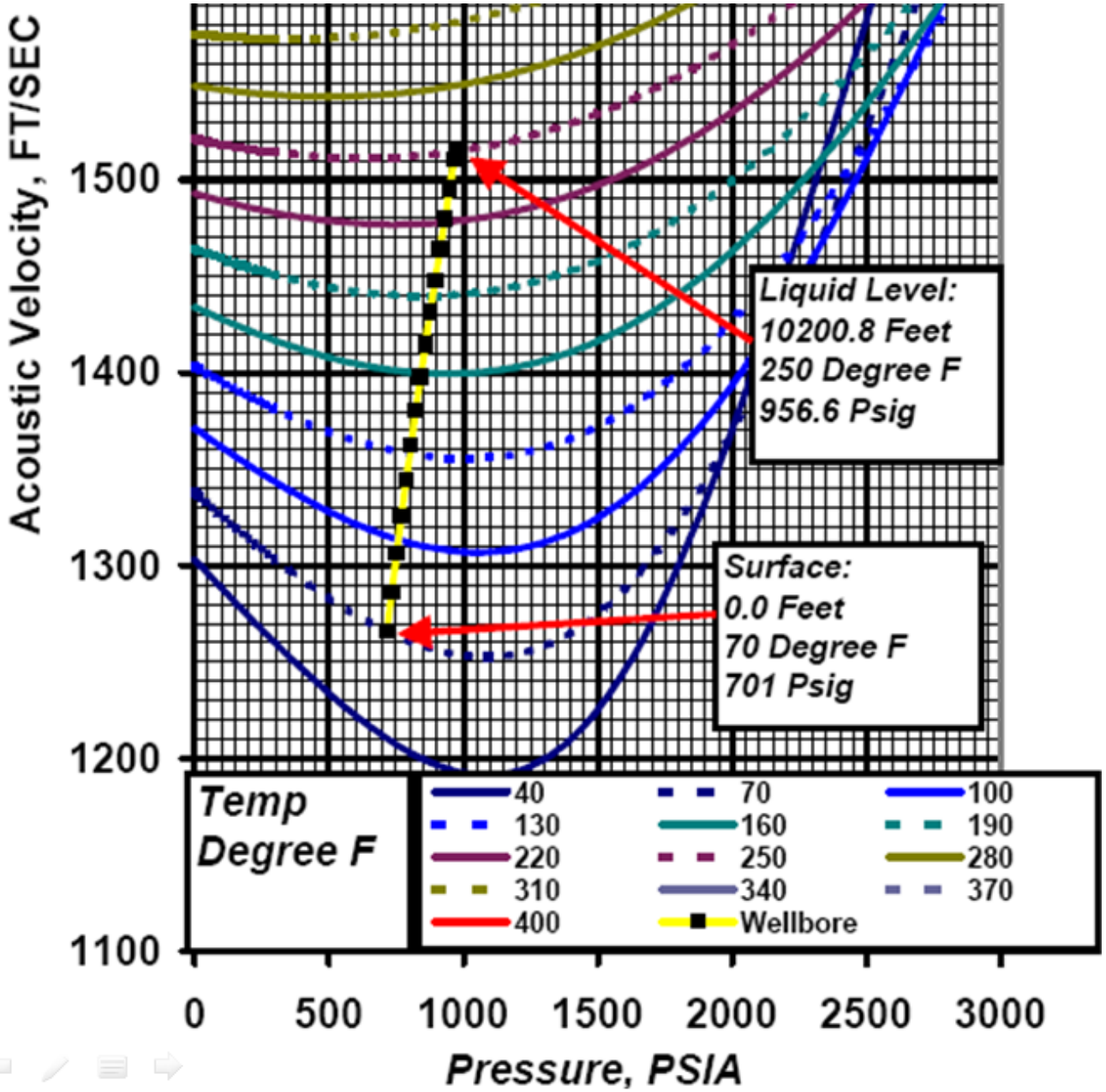
Acoustic Velocity Profiles in Gas-lift Wells



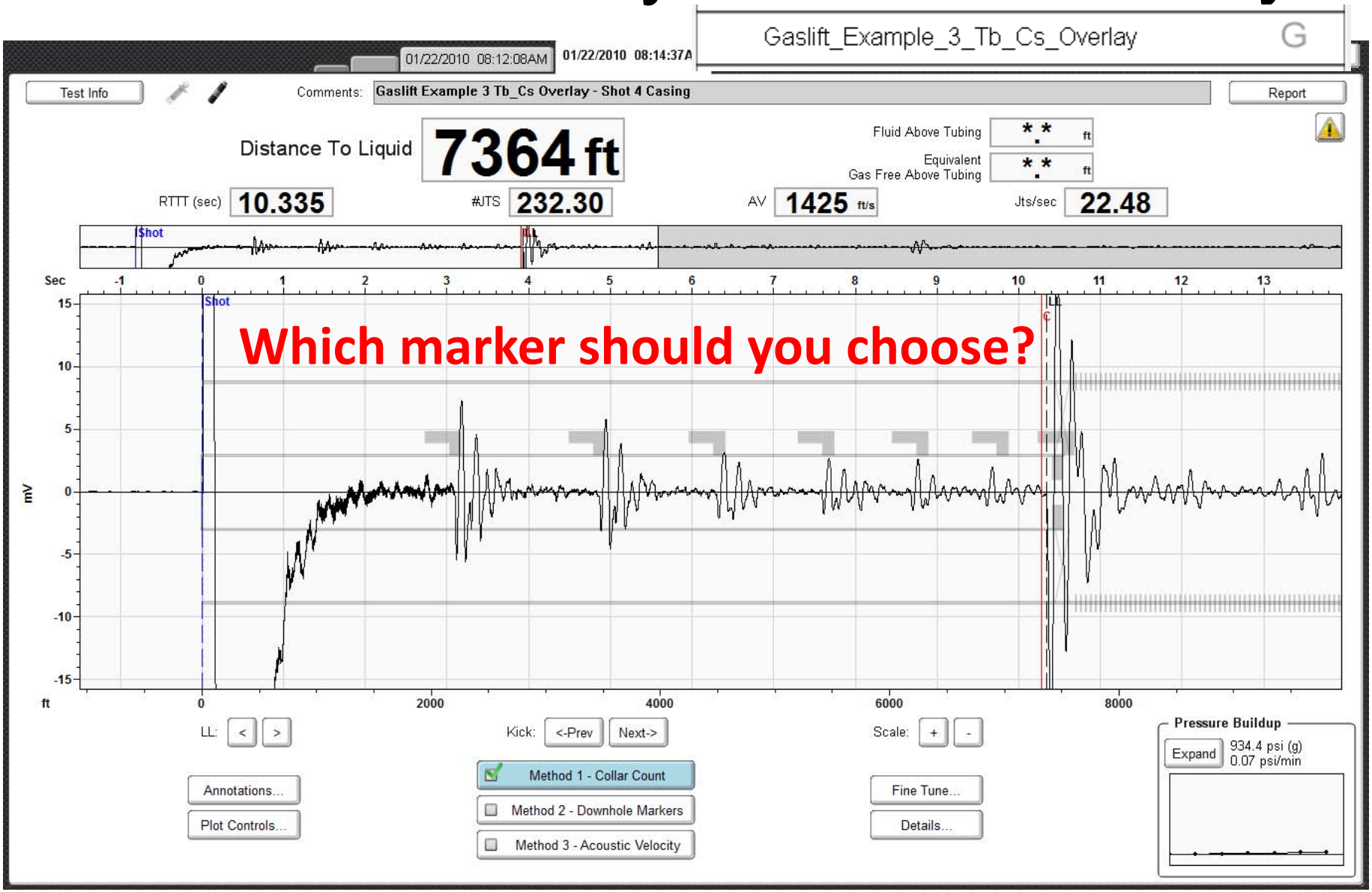
Depends on:

1. Gas gravity / composition
2. Temperature along wellbore
3. Pressure profile in well
4. Can be determined from counting collar echoes or identifying downhole markers detected during a shot
5. Uniform Gas Composition when Gas is Flowing
6. Acoustic Velocity Usually Increases with Depth Due to Higher Temperature

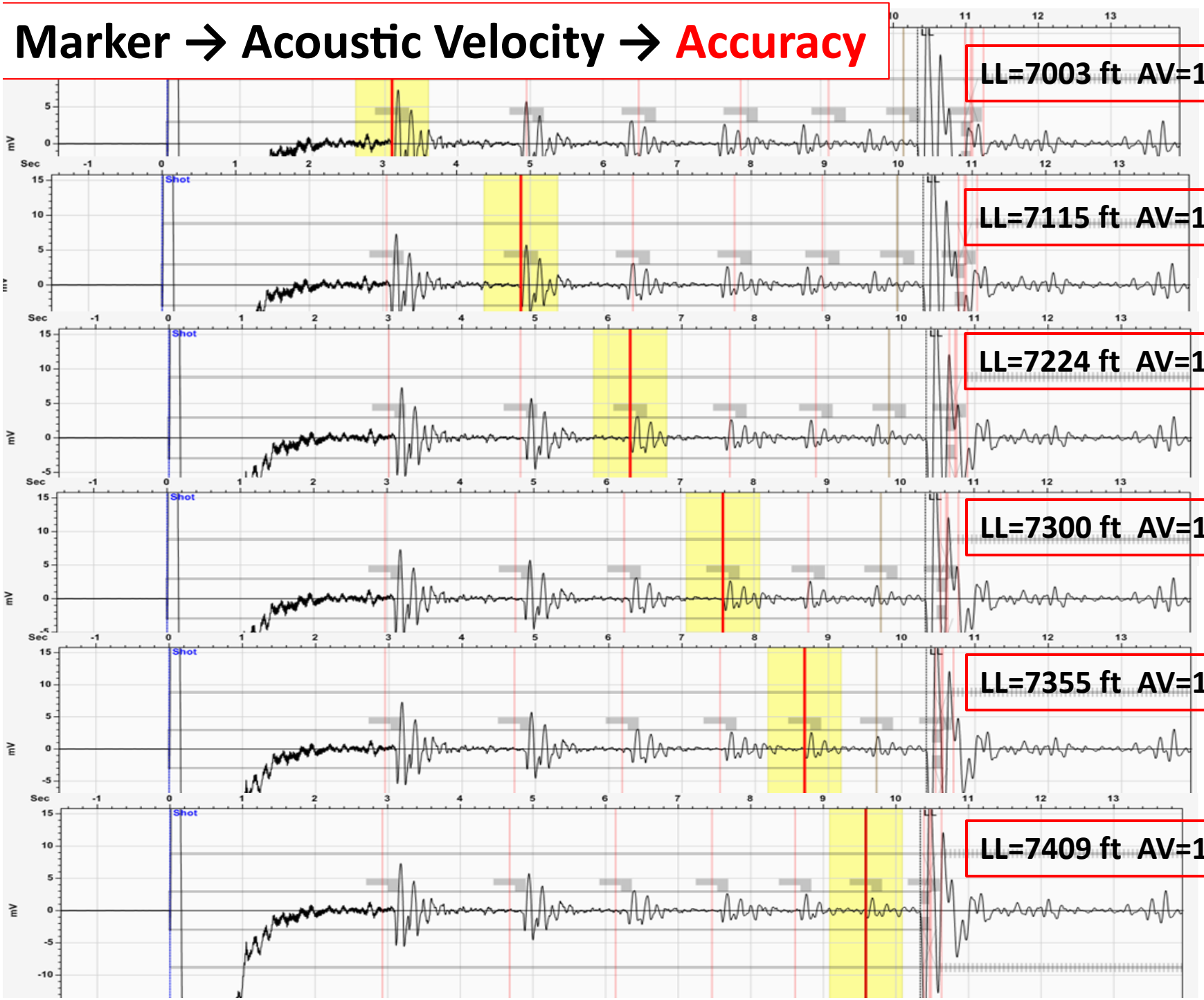
Acoustic Velocity Profiles in Gas-lift Wells



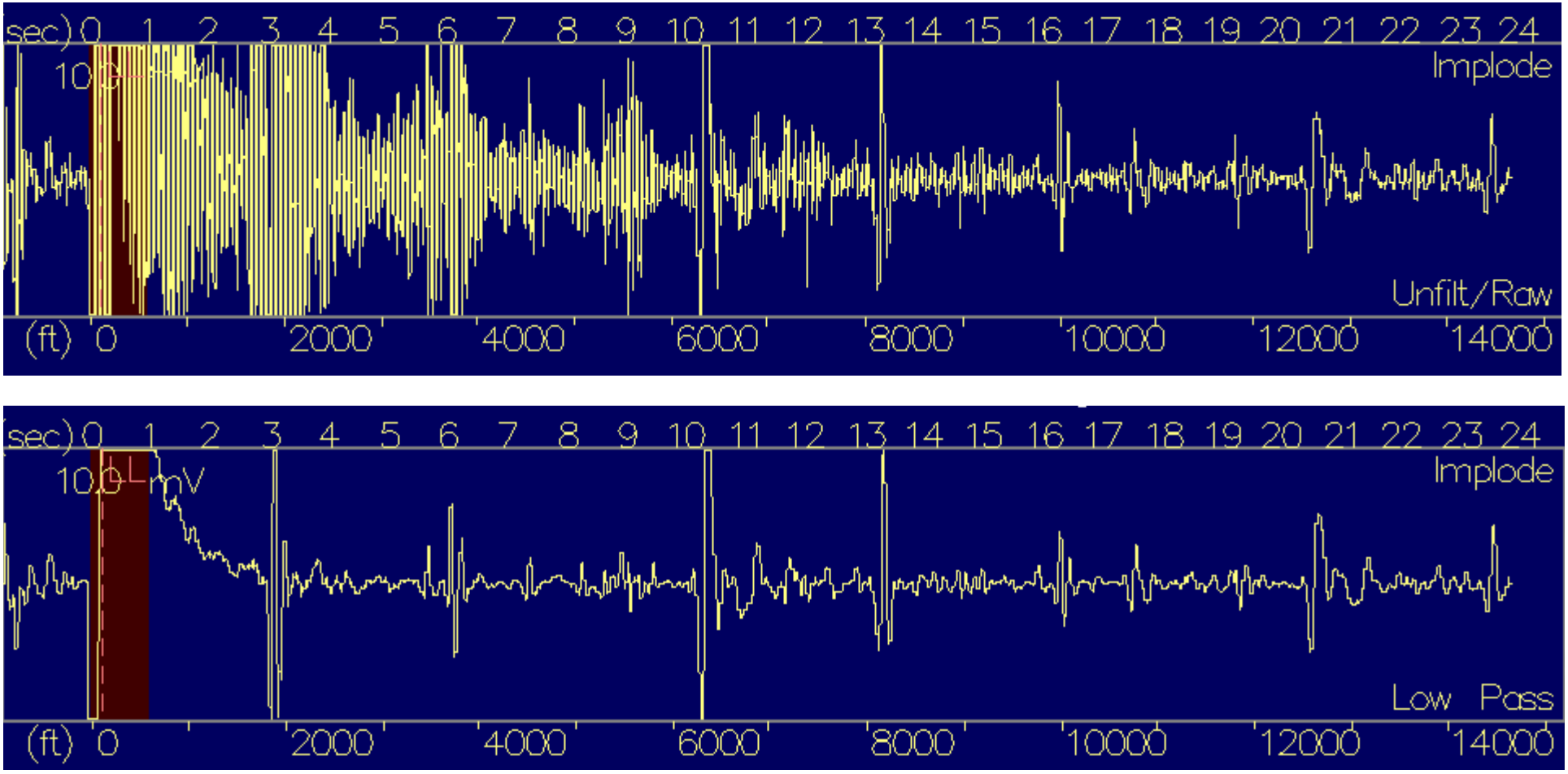
Acoustic Velocity Affects Accuracy



Marker → Acoustic Velocity → Accuracy

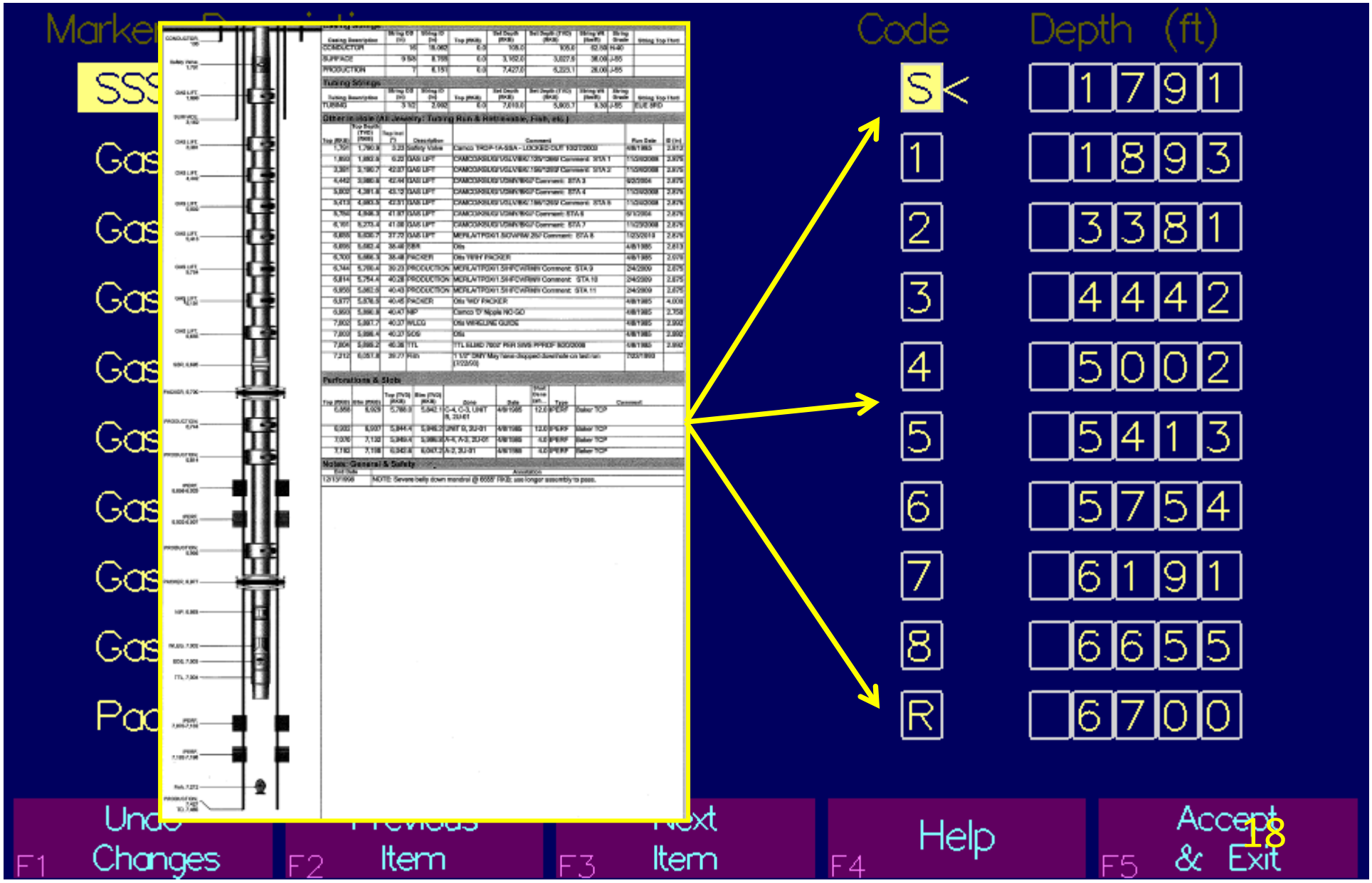


Use Downhole Markers for Accurate Acoustic Velocity and Fluid Level Calculations

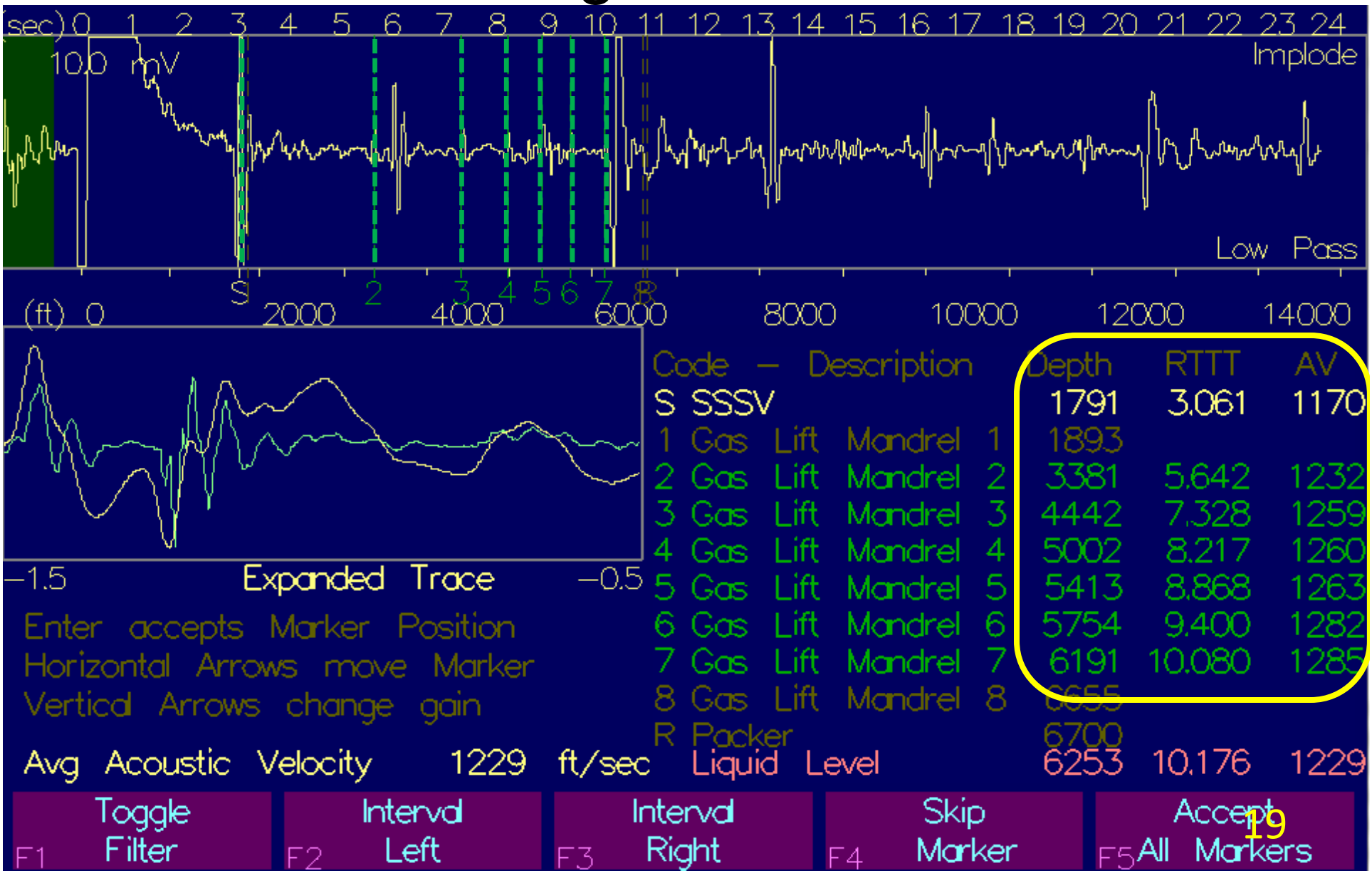


Apply Low Pass Filter to reduce high frequency noise and see detail.

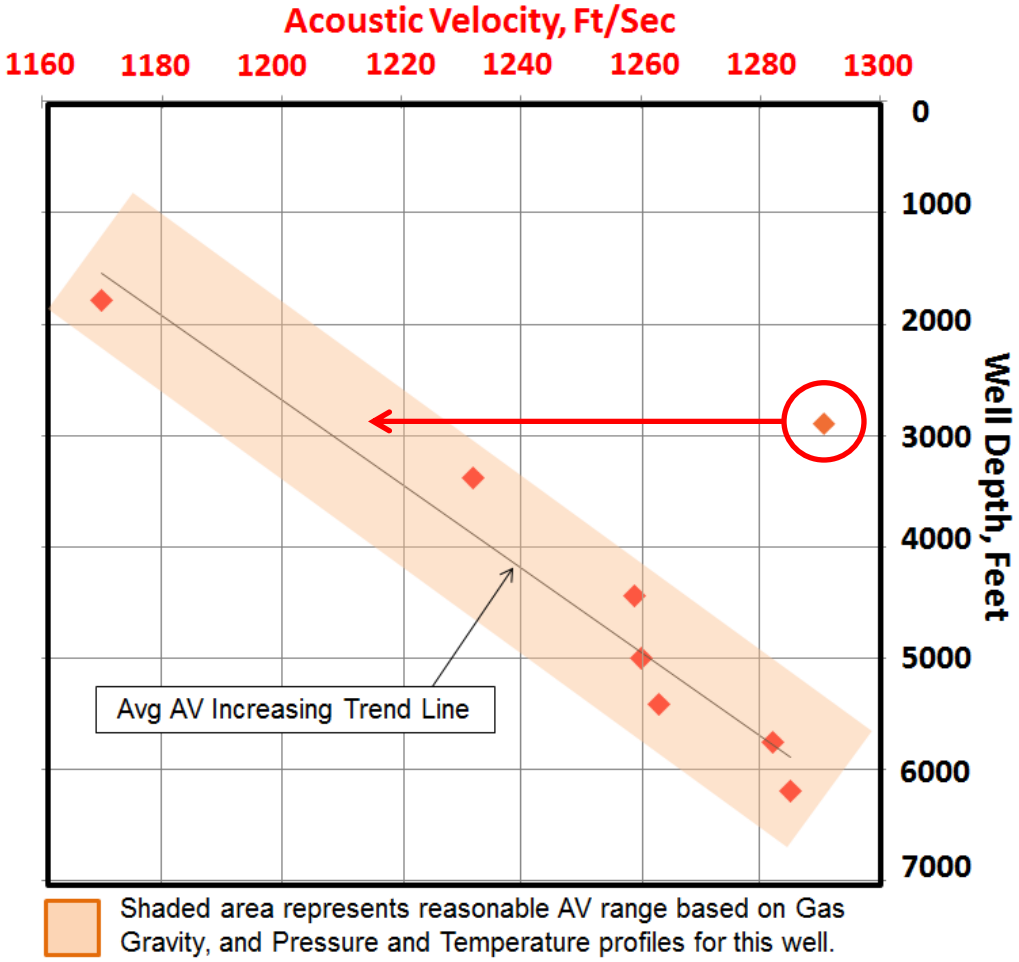
Wellbore Schematics Provide Downhole Markers



Acoustic Velocity is calculated between markers along the acoustic trace.



If the Acoustic Velocity is out of "Range," THERE IS A PROBLEM.

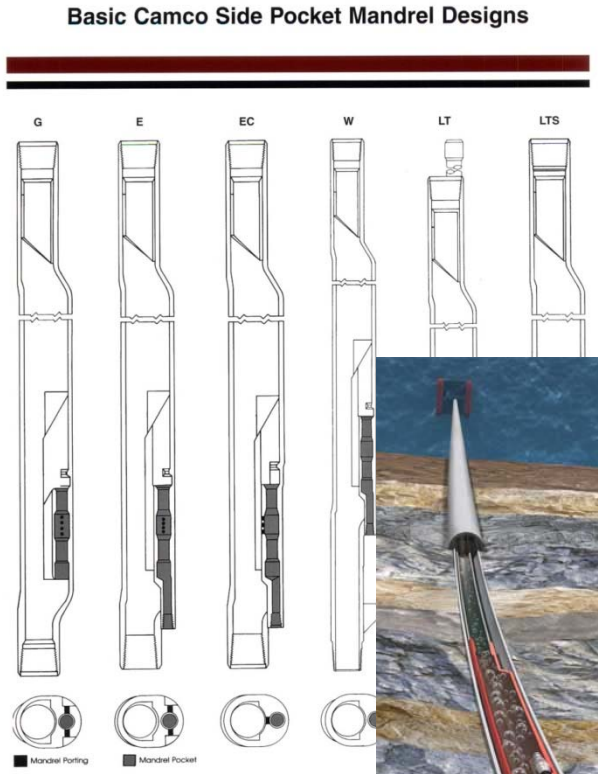


Awareness of the calculated Acoustic Velocity is important:

- Quality check for correct marker selection.
- Verify gas-lift valves are spaced correctly
- Accurate fluid level calculations.
- Verify gas gravity and uniform gas composition in the well.
- Acoustic Velocity typically displays an increasing trend in producing gas-lift wells.

Direction of Kick Across Mandrels

Shape and Direction of Echoes from Valves and Mandrels



Two factors determine the direction of kick of gas-lift Mandrels on the acoustic trace:

1) Physical characteristics of the mandrels
2) Is the operator shooting down the tubing or the casing?

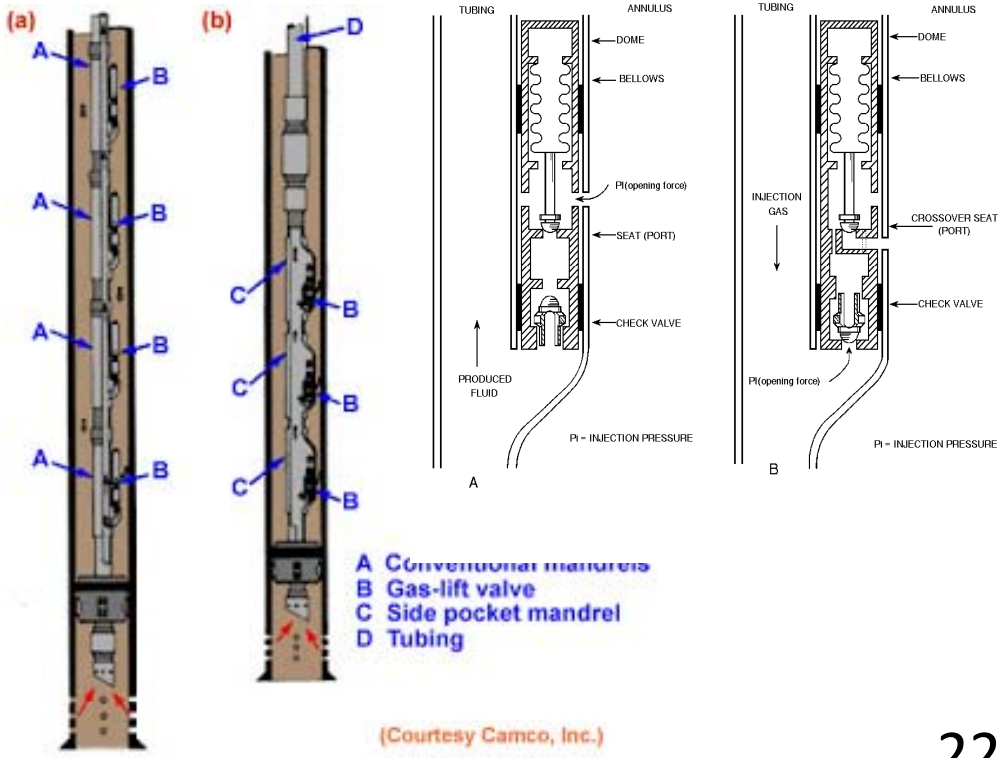
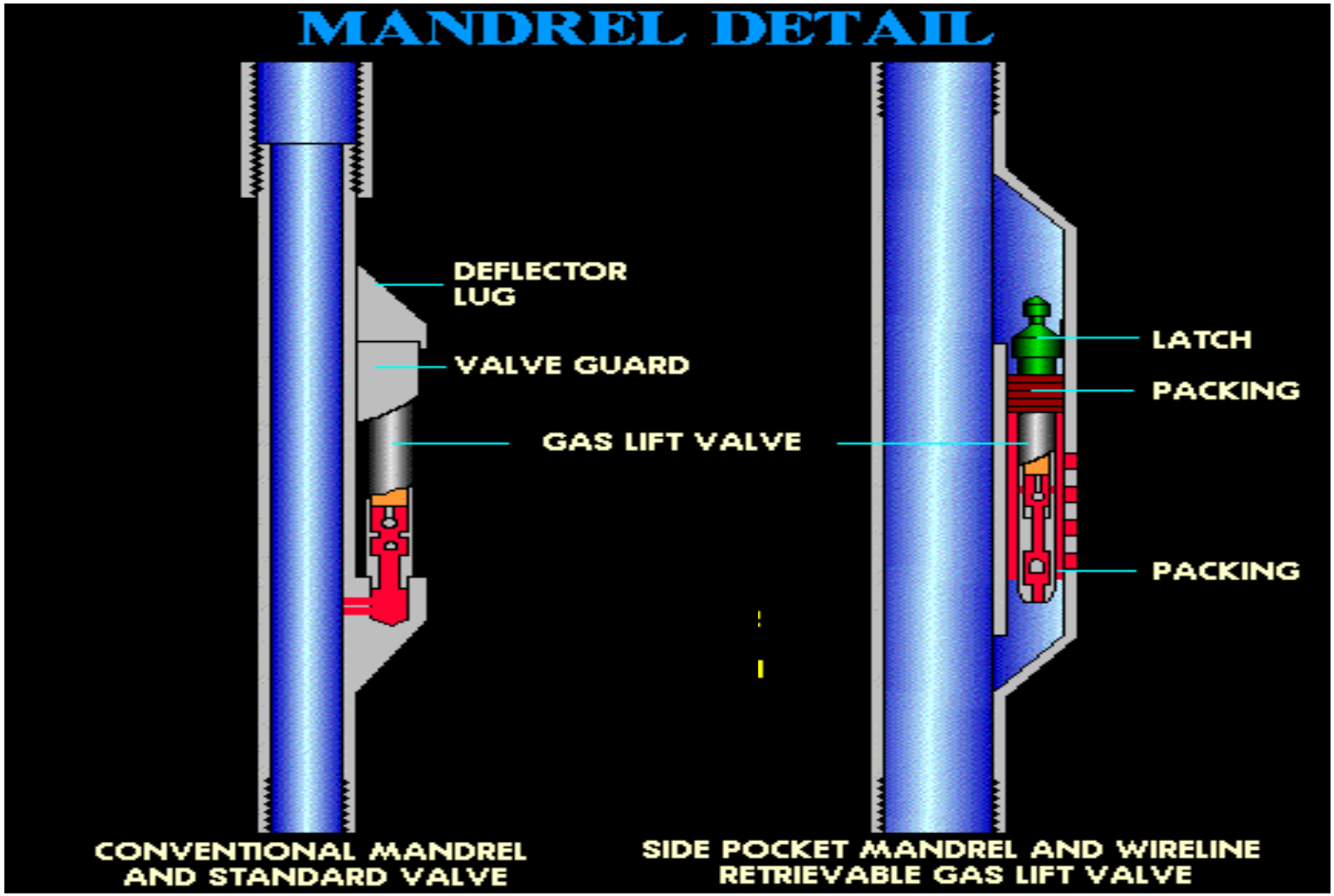


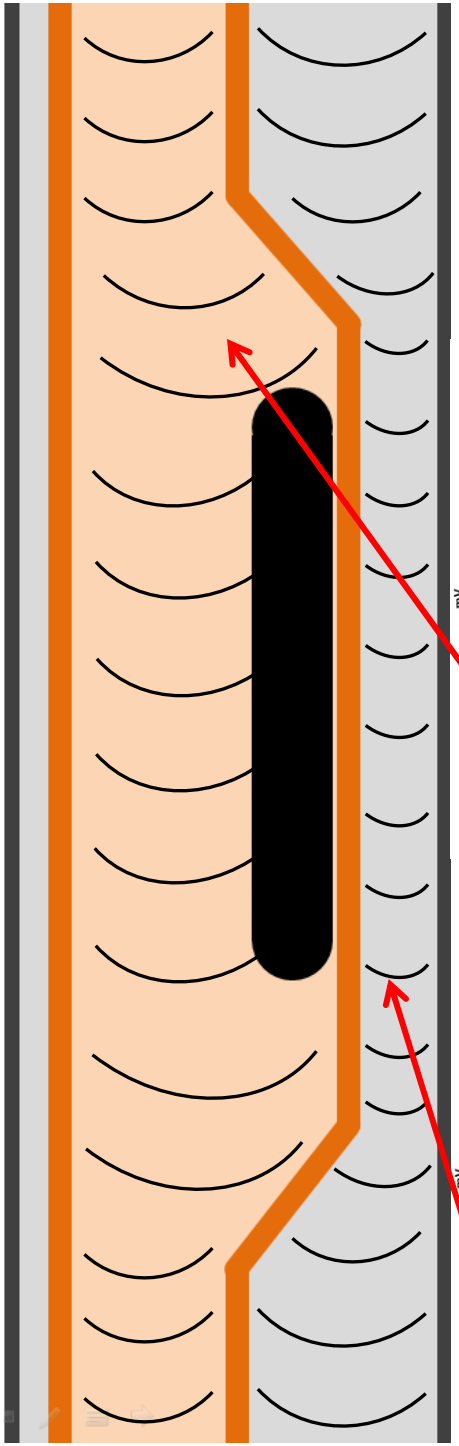
Photo: courtesy of Lufkin Industries

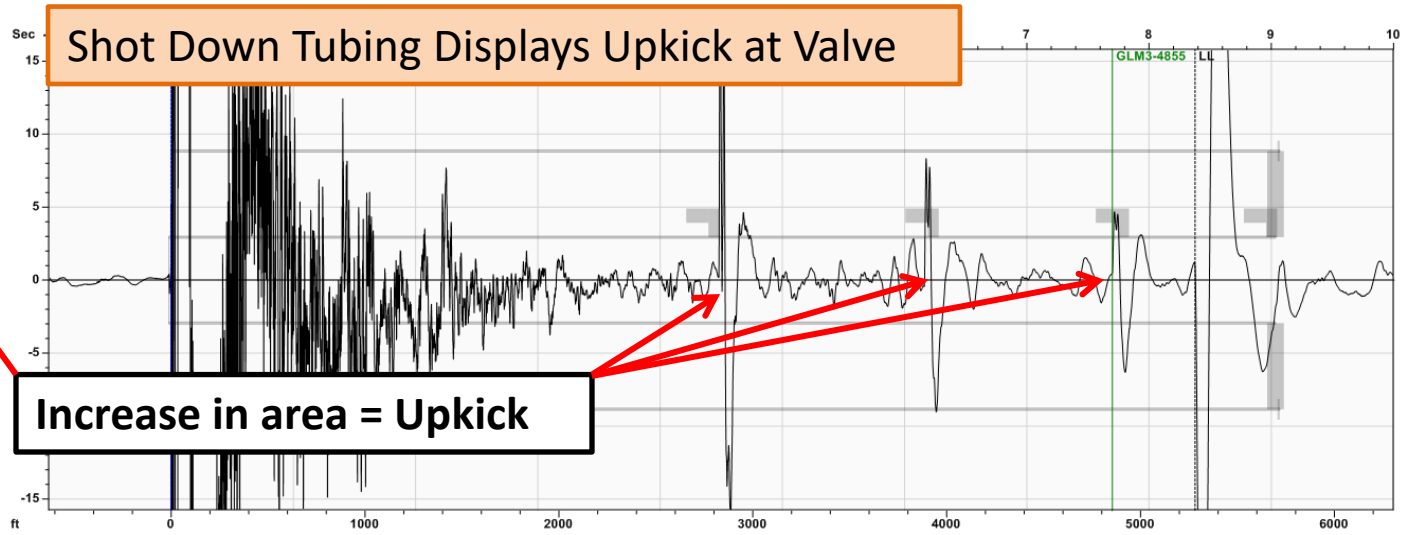
Conventional vs. Side Pocket Mandrel Profiles

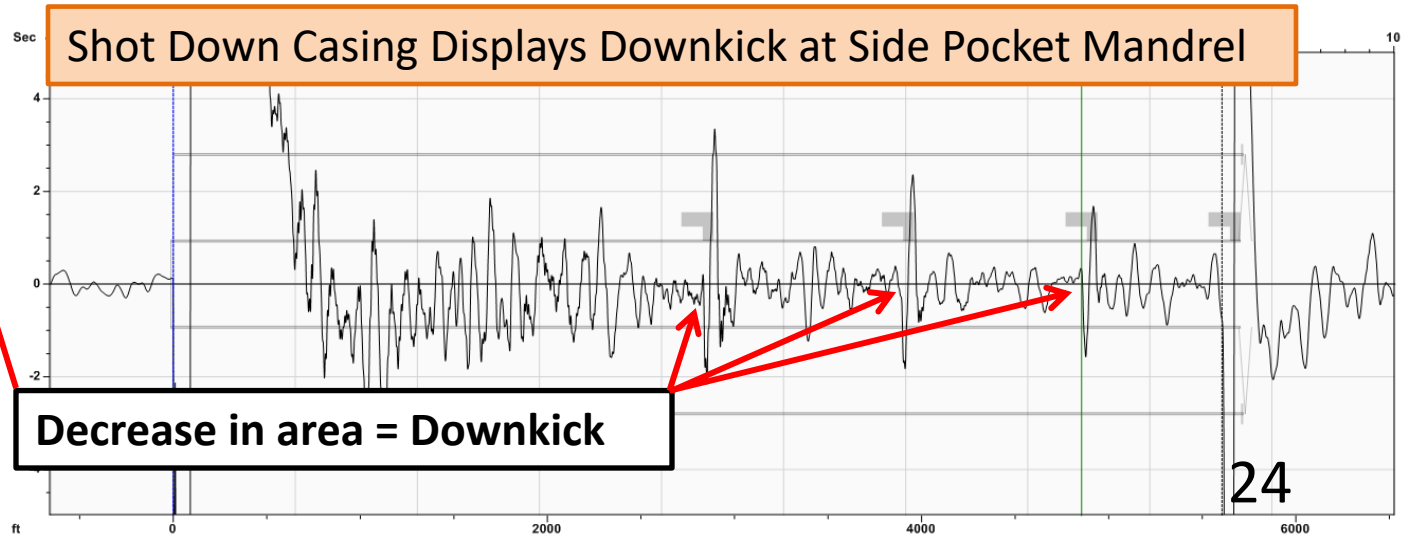


Picture courtesy of Jim Lea

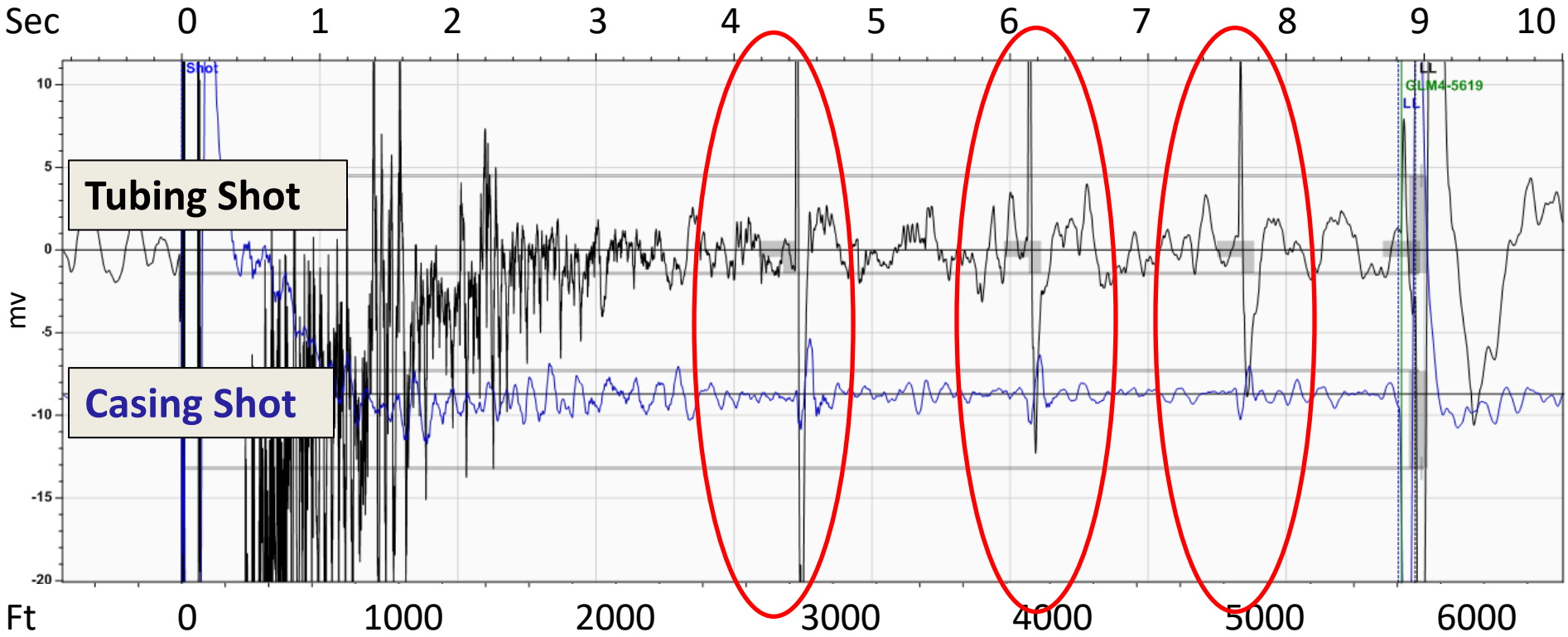
Side Pocket Mandrels Evident Down Tubing and Casing







Use the “Previous Shots…” Annotation to Overlay Casing and Tubing Shots



Can help identify problems by answering questions:

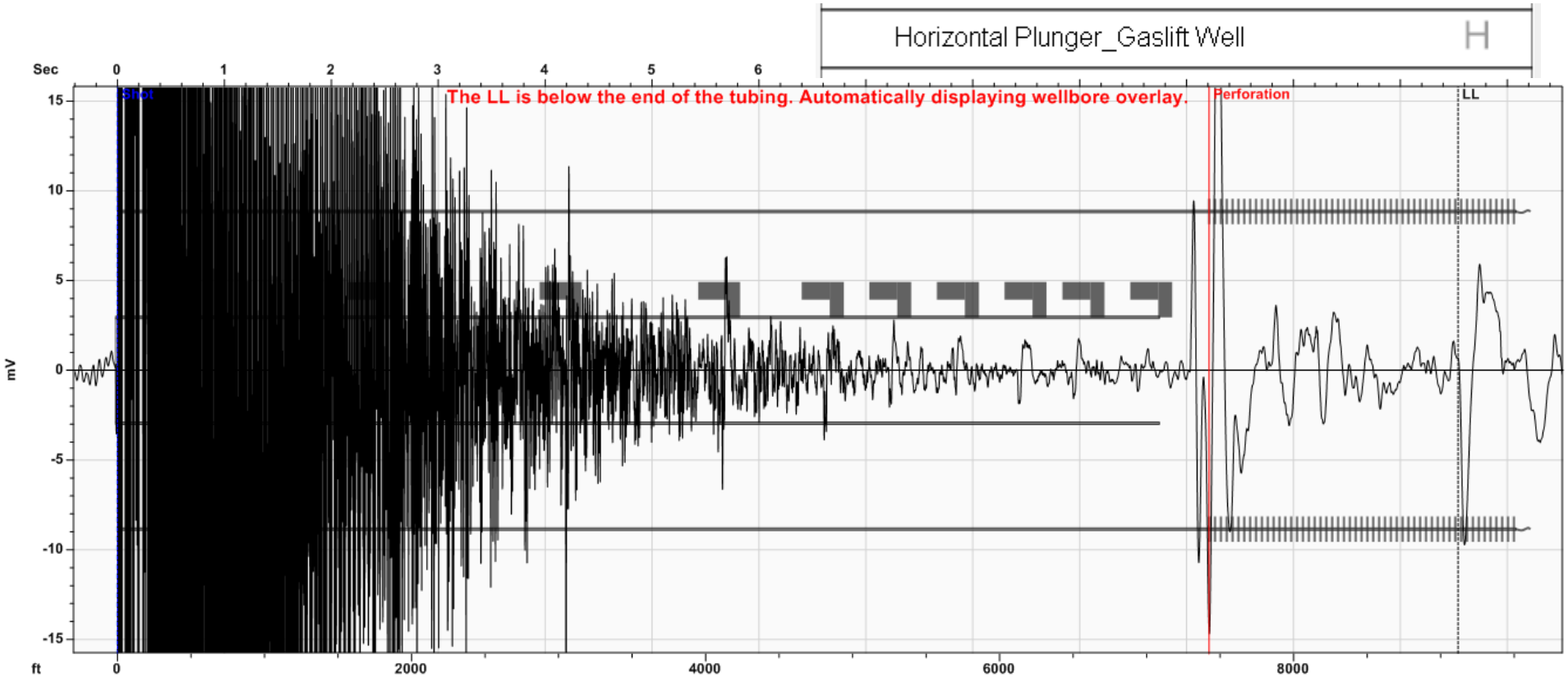
- Do the mandrel reflections line up?
- Are there additional upkicks or downkicks indicating possible holes, restrictions or other problems?

Horizontal Gas Lifted/Plunger Lifted Well

Stratified Gas Flow Regimes Exist in Horizontal Gas Wells

1. Fluid level shot down the tubing/casing annulus shows a liquid level at a MD of 9287 ft.
2. The ability to see past the end of the tubing is unusual in a vertical plunger lift well, because the liquid level is normally at the end of the tubing.
3. In horizontal wells, stratified flow exists; it is not uncommon to see features in the wellbore in the horizontal section past the end of the tubing.
4. Horizontal section appears to be relatively dry (no liquid level); but a significant amount of liquid enters the tubing.
5. Differential tubing and casing pressure do not indicate much liquid loading, but liquid exists in the horizontal and causes more liquid loading than expected (based on tubing and casing psi).

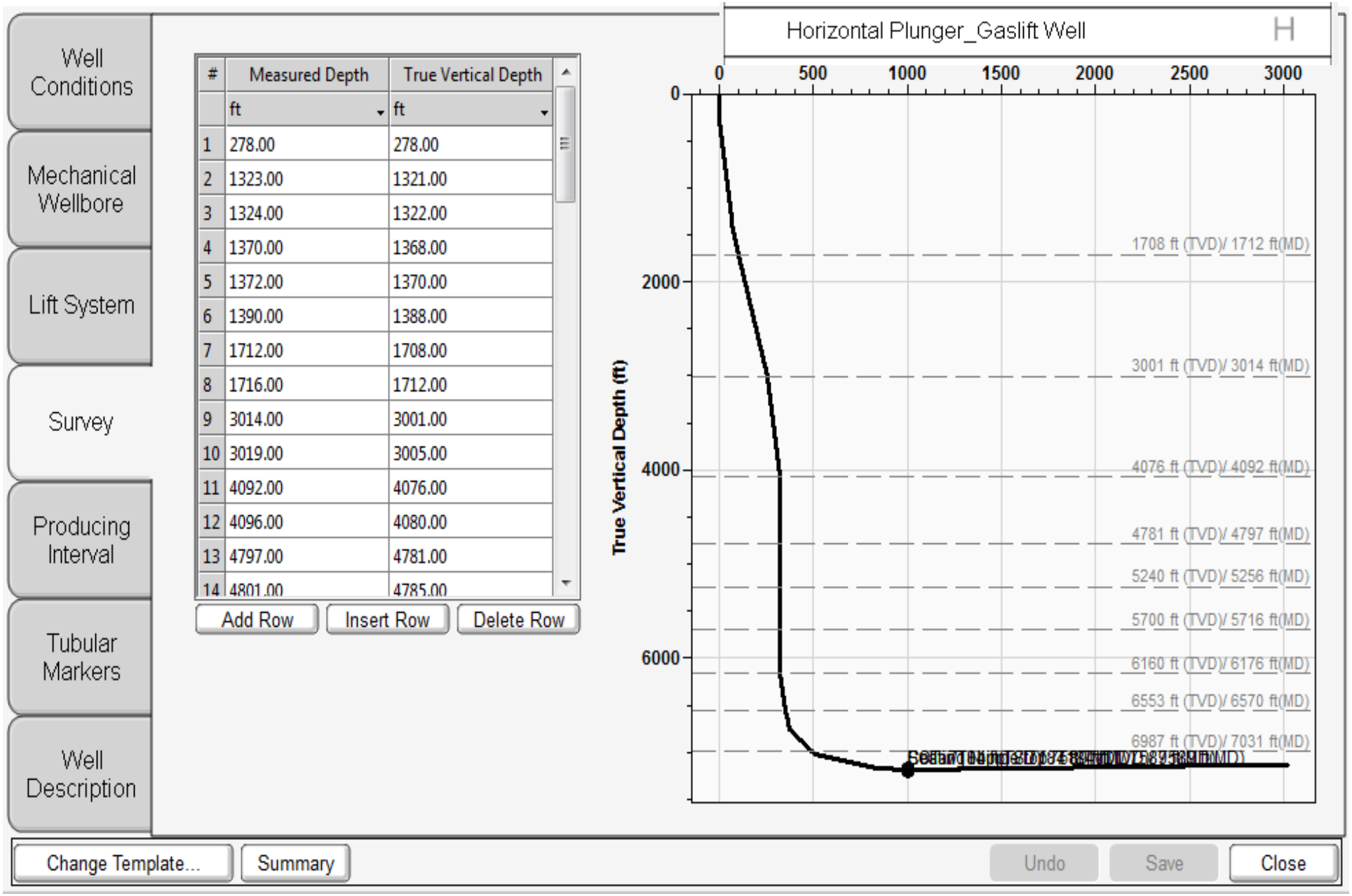
Overlay Wellbore Profile



Quick placement and verification of:

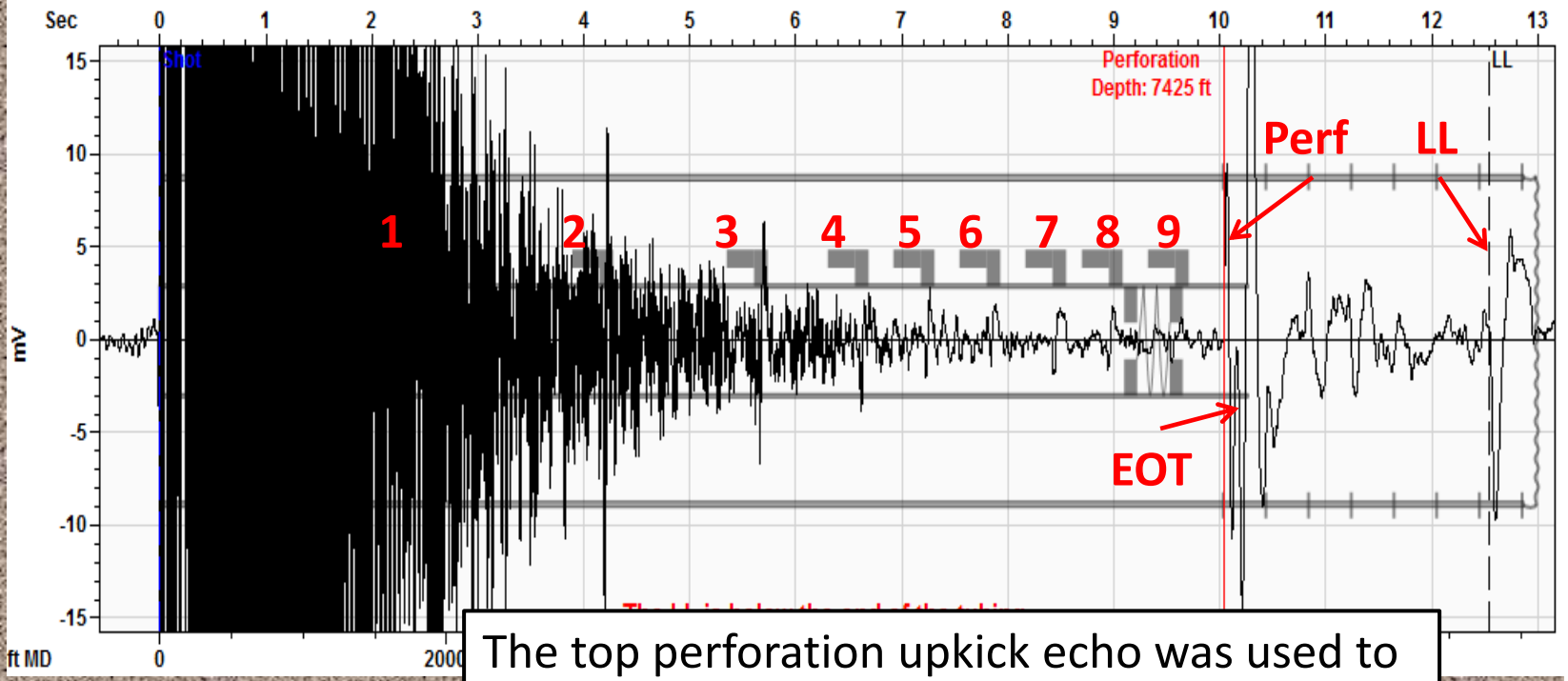
- Gas-lift valves and mandrels
- End of the Tubing
- Perforation Intervals

Horizontal Plunger Lifted Well



#	Measured Depth	True Vertical Depth
	ft	ft
1	278.00	278.00
2	1323.00	1321.00
3	1324.00	1322.00
4	1370.00	1368.00
5	1372.00	1370.00
6	1390.00	1388.00
7	1712.00	1708.00
8	1716.00	1712.00
9	3014.00	3001.00
10	3019.00	3005.00
11	4092.00	4076.00
12	4096.00	4080.00
13	4797.00	4781.00
14	4801.00	4785.00

Reflections can be identified to the Toe Due to Stratified Gas Flow in the Horizontal section of the well.



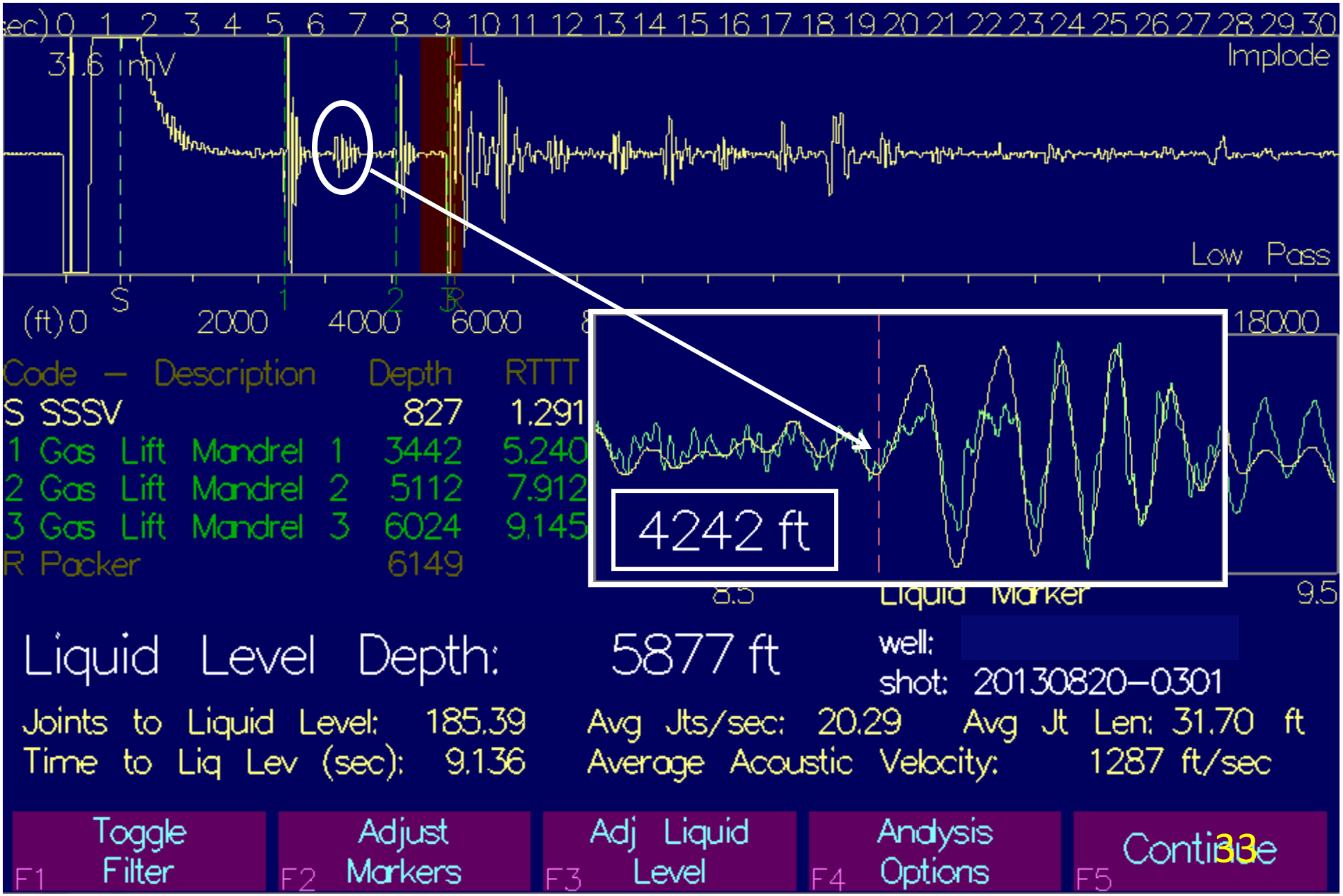
The top perforation upkick echo was used to determine the depths in the well.

Problems in the Tubing String

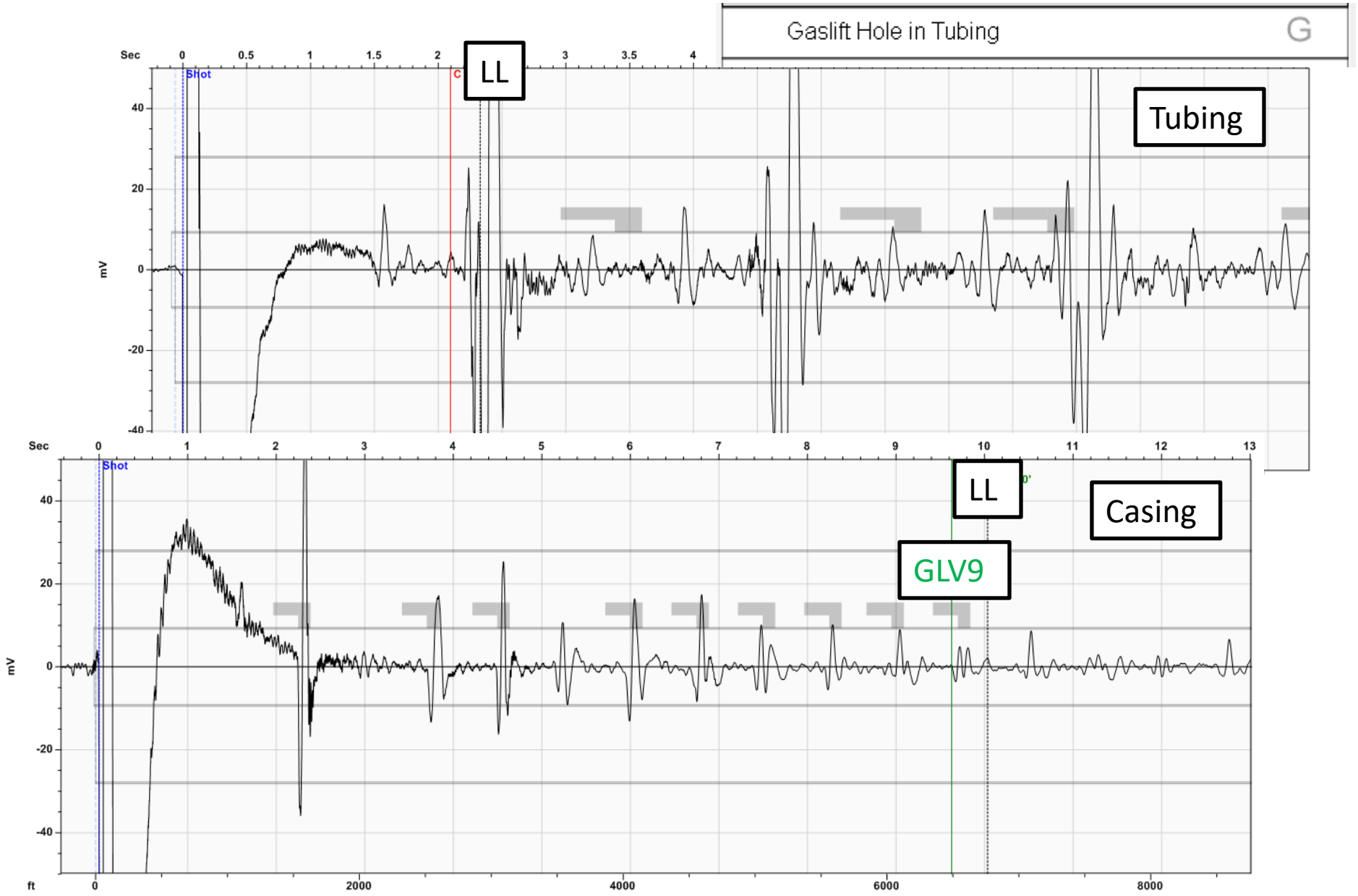
Identifying Holes in Tubing in a Gas-Lift Well

- In general, if lower valves are open OR the orifice is open and fluids can move into the casing annulus without a check valve stopping flow back into the annulus, then the liquid level will raise to maintain equilibrium with the gas pressure in the annulus.
- In this case, the liquid level will rise to the level of the deepest active injection point.
- If liquid flow back into the annulus is checked, then the liquid level will be below the deepest injection point previously obtained.
- If there is a hole in the tubing, then the liquid level in the annulus will rise to the hole in the tubing.

Upkick Identifies Hole in Tubing



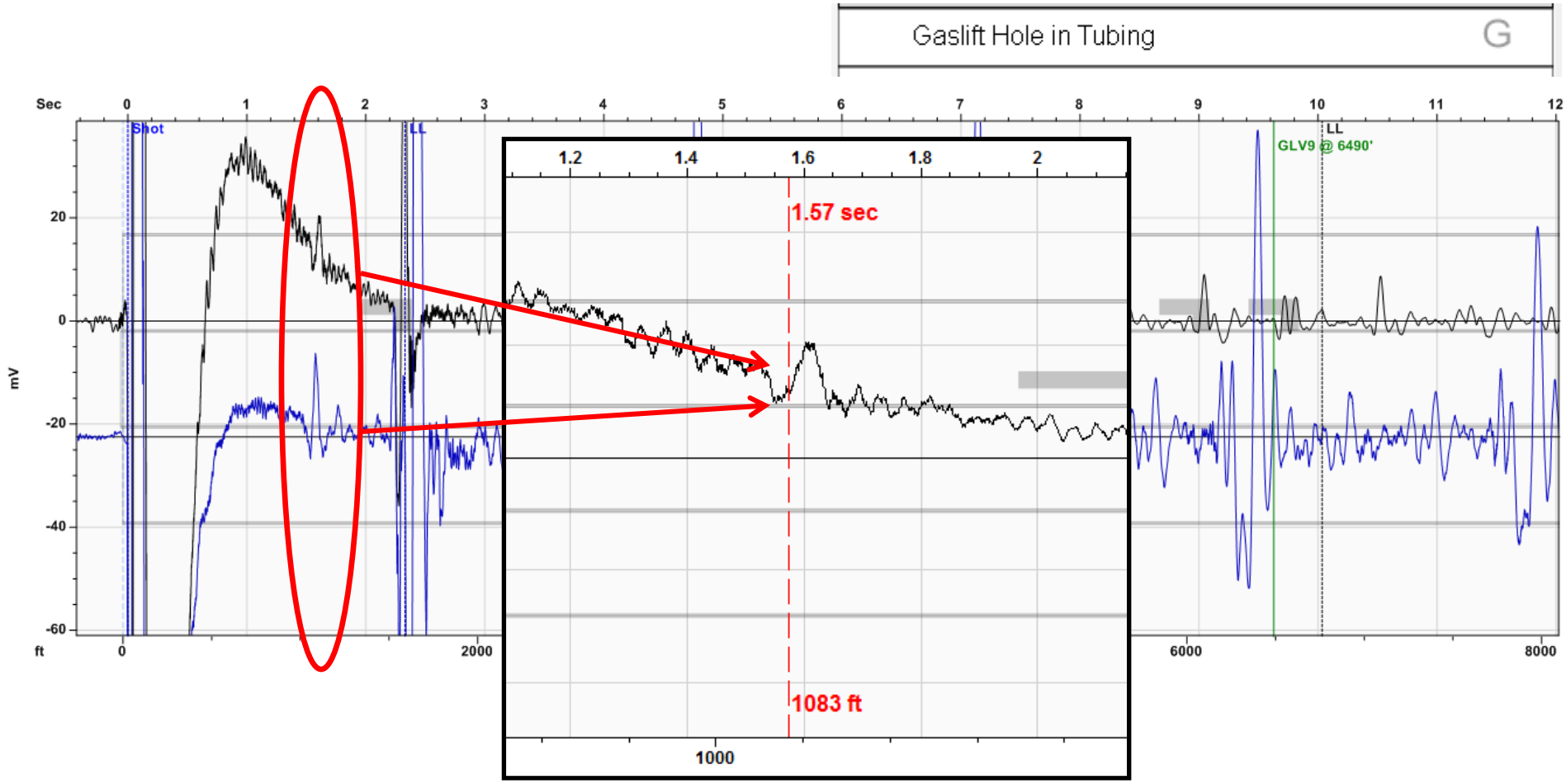
Compare Shots Down Tubing & Casing



Compare Shots Down Tubing & Casing

To Overlay shots: Annotations... → Previous Shots... → On

Compare Shots Down Tubing & Casing



Overlaying the Tubing and Casing shots based on time verifies an upkick at the hole in the tubing in both shots.

The Depth Reference line gives an accurate depth to the hole of 1083 ft.

Tips and Techniques for Troubleshooting

QUESTION:

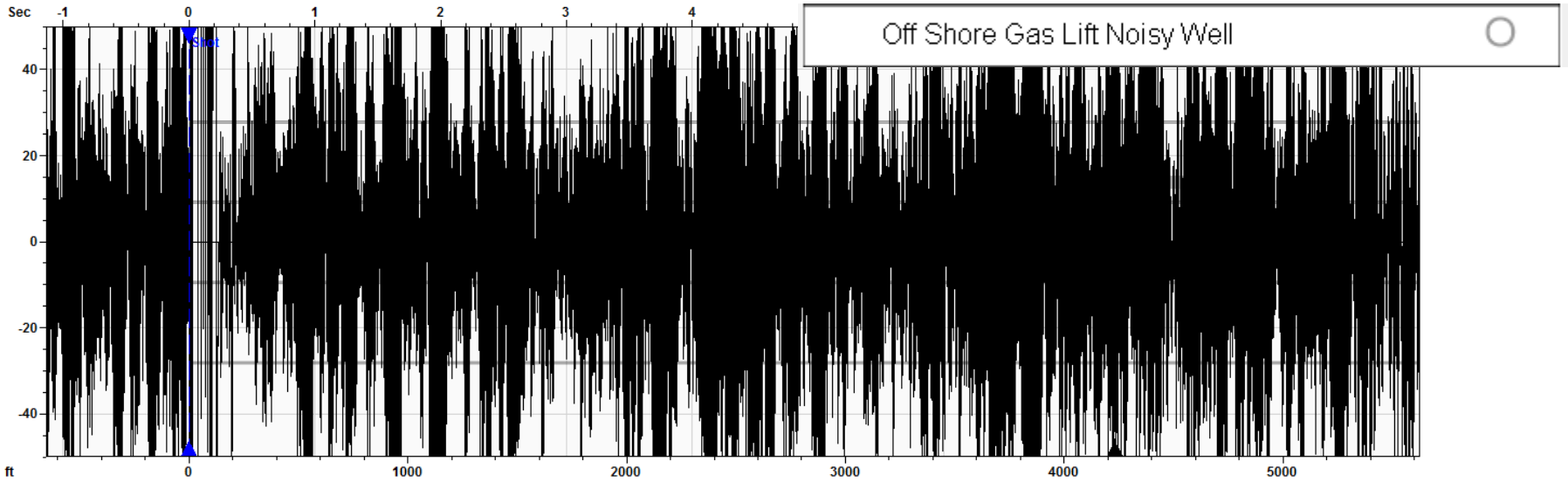
DO I HAVE TO TURN GAS-LIFT INJECTION OFF BEFORE I SHOOT A FLUID LEVEL?

ANSWER:

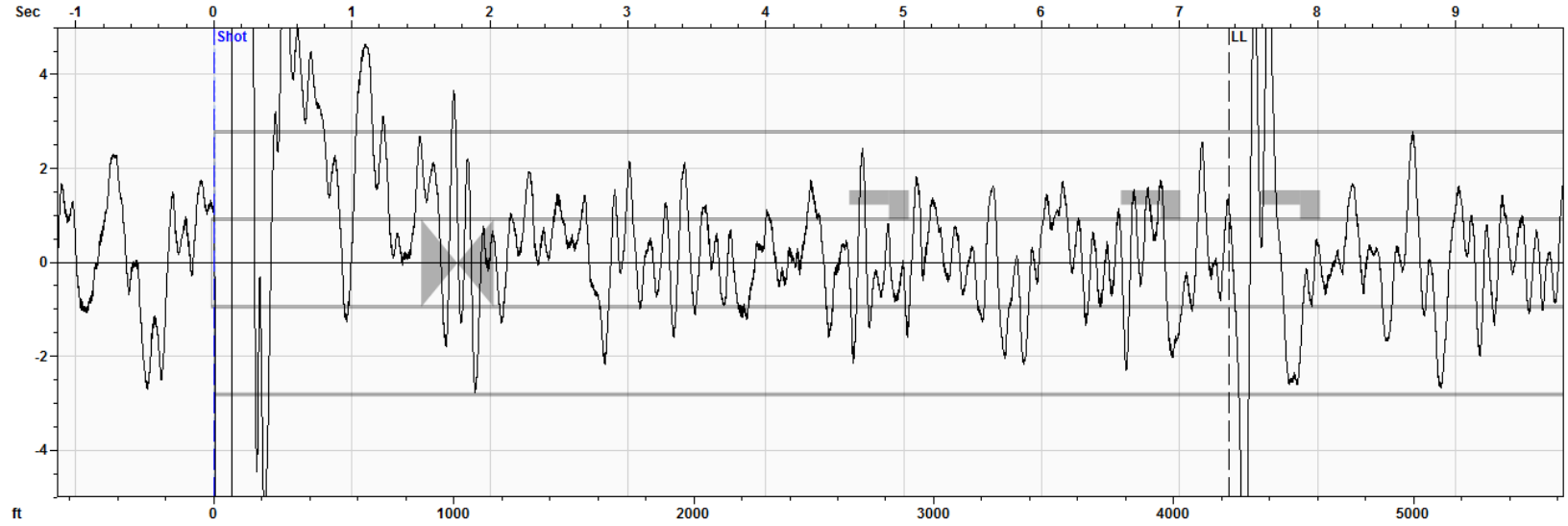
NO. UNLESS EXCESSIVE NOISE PROHIBITS ACCURATE FLUID LEVEL ANALYSIS.

Example: Off Shore Gas Lift Noisy Well

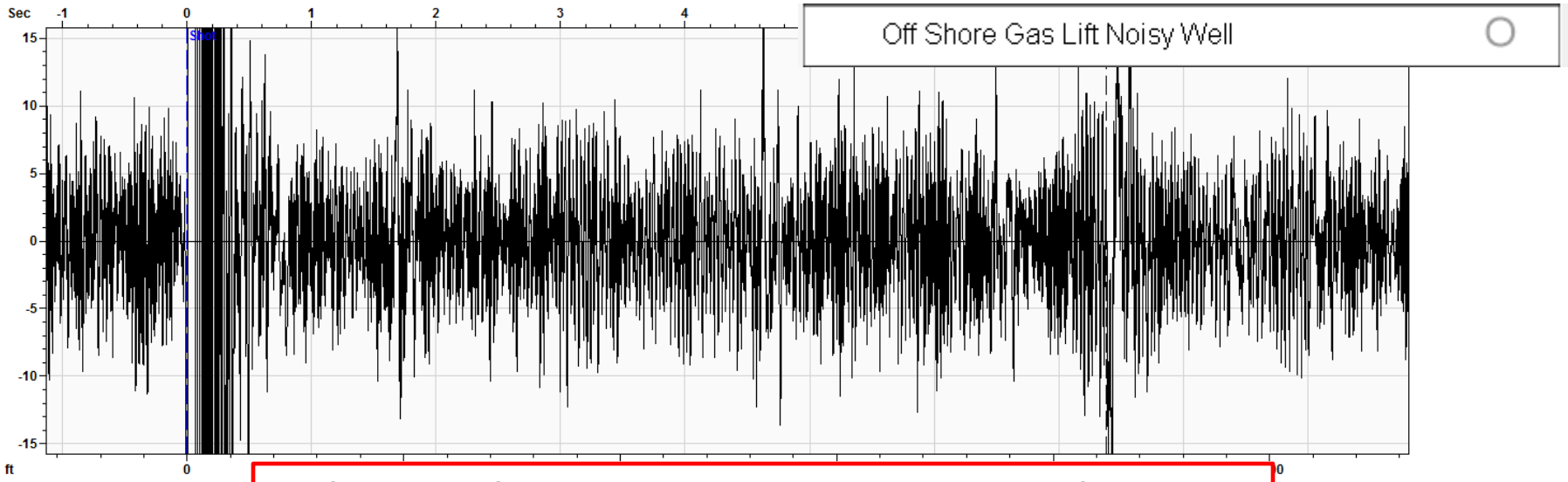
Implosion Shot down Casing – 600psi Gas-Lift Injection ON



Reflections from mandrels can be difficult to identify even with wellbore overlay.

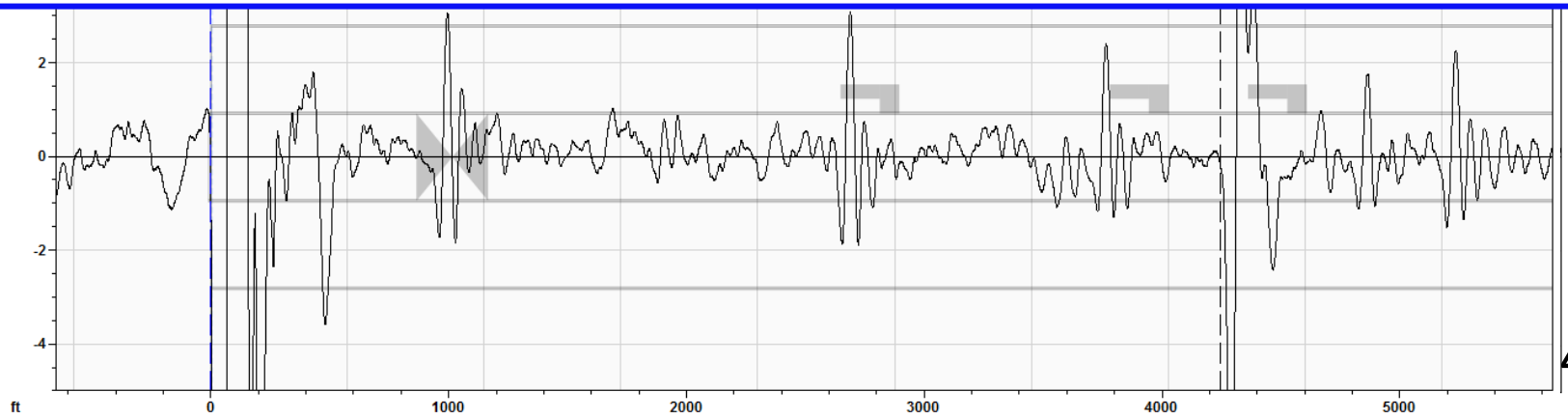


Implosion Shot down Casing – 600psi Gas-Lift Injection OFF



Reflections from mandrels are clearly identifiable.

Other sources of background noise in gas-lift installations include compressors, reciprocating pumps, and wave-induced vibrations in offshore platforms.



QUESTION:

HOW CAN I TELL A QUALITY FLUID LEVEL SHOT HAS BEEN ACQUIRED?

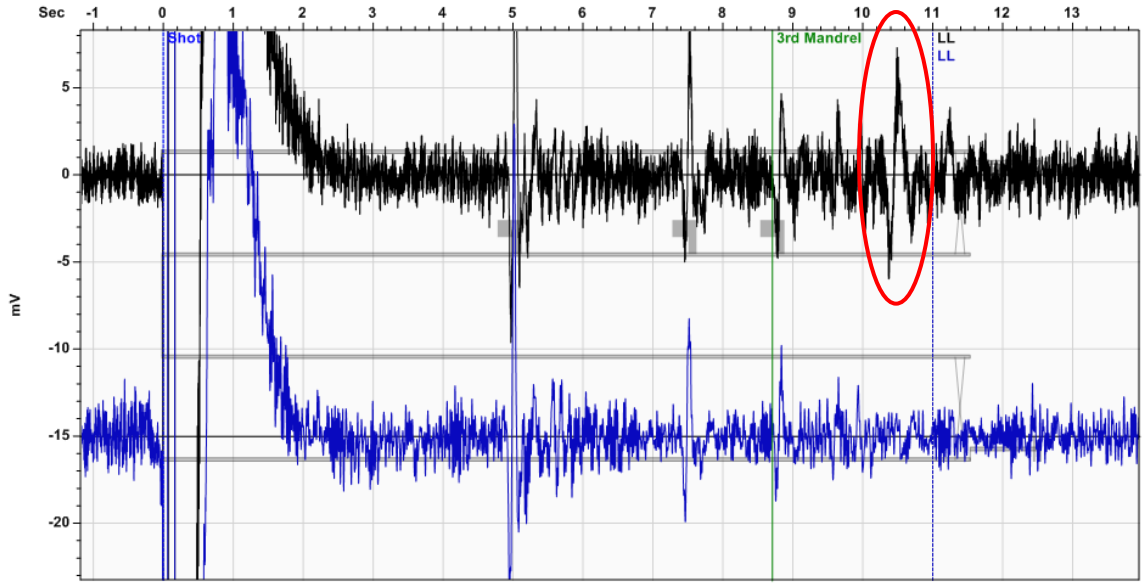
ANSWER:

TAKE A SECOND SHOT FOR COMPARISON. ALWAYS.

If the shot doesn’t make sense, changes conditions and keep taking shots until you understand.

Always Compare “At Least” Two Shots

- Check for repeatability.
- Compare the Acoustic Velocity to WHAT YOU KNOW TO EXPECT.
- Compare/Overlay the shot traces. Identify anomalies in the reflections.

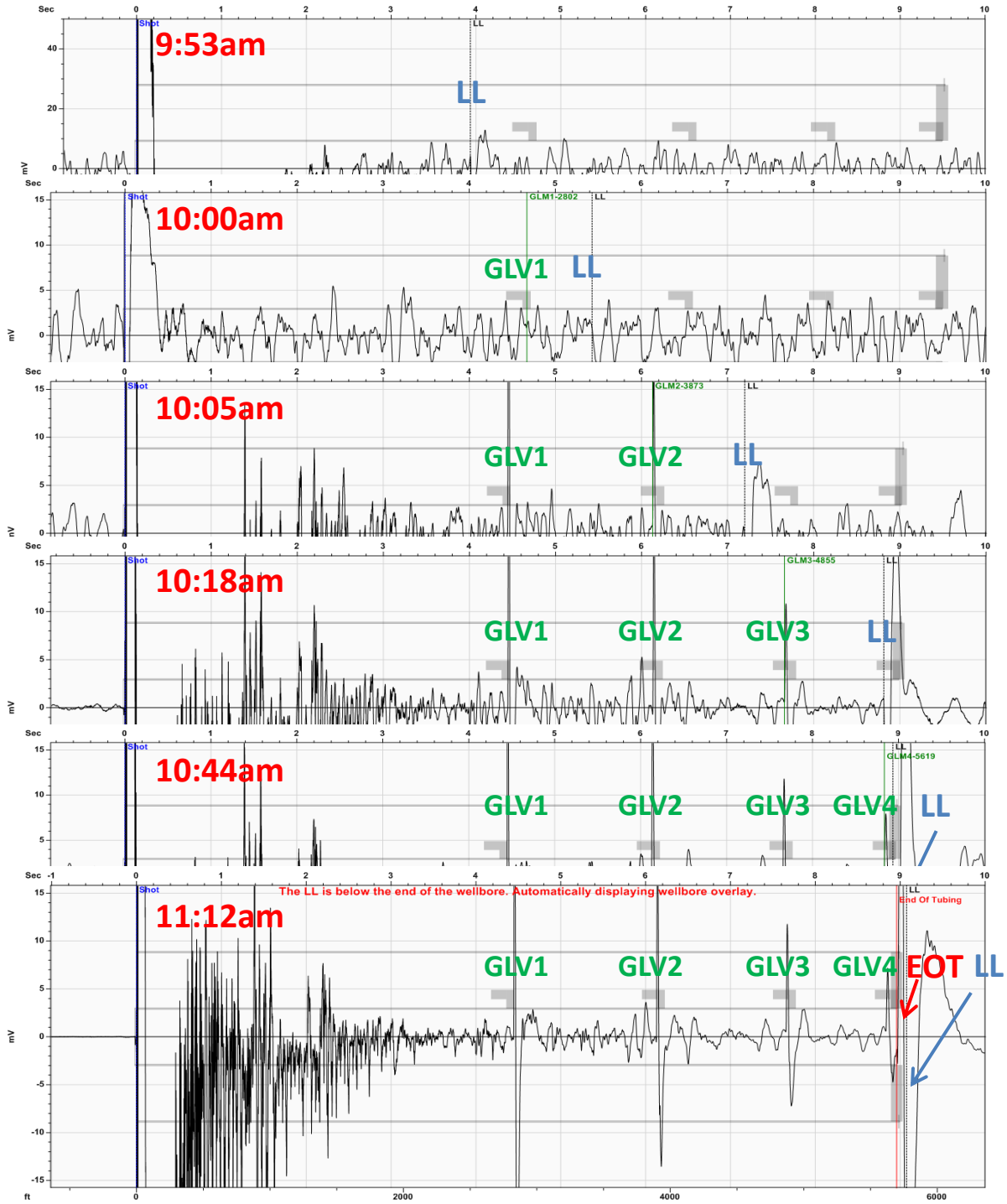


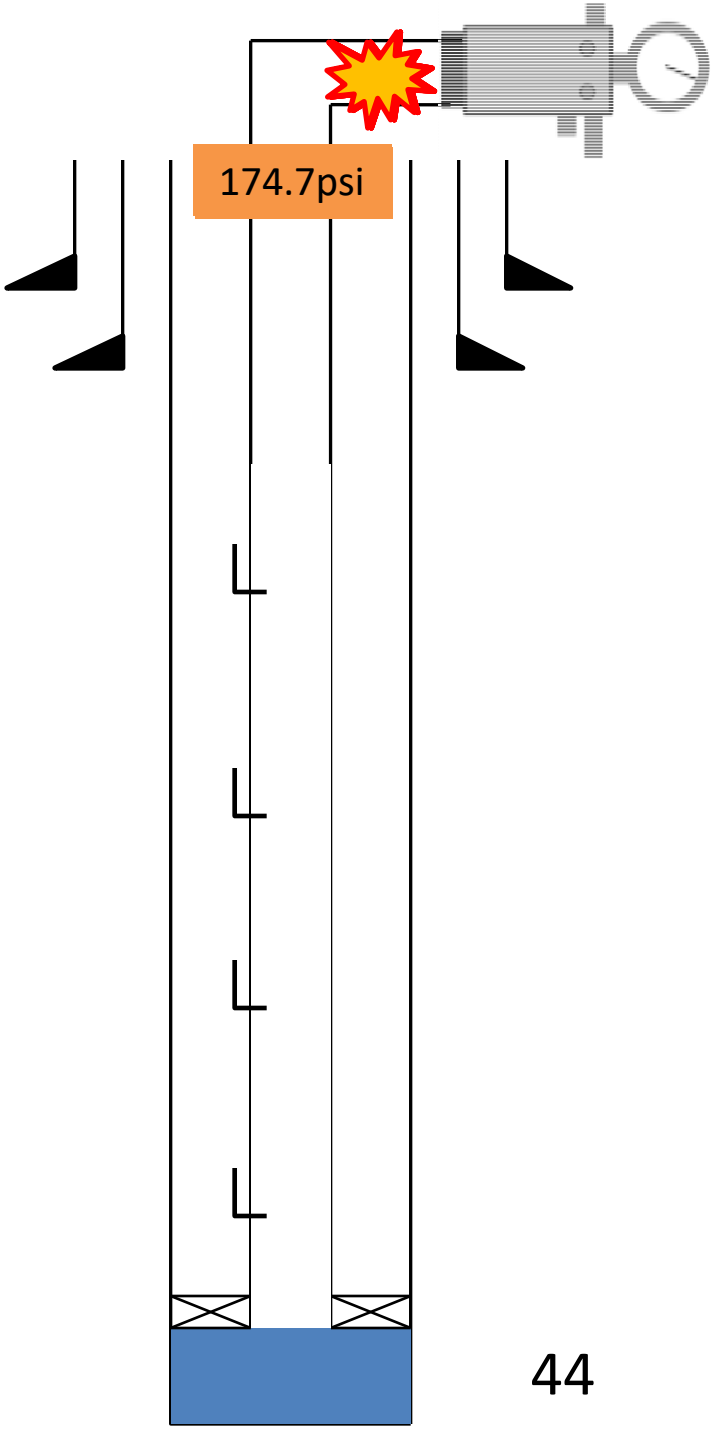
QUESTION:

What are some troubleshooting techniques used in the industry to check integrity?

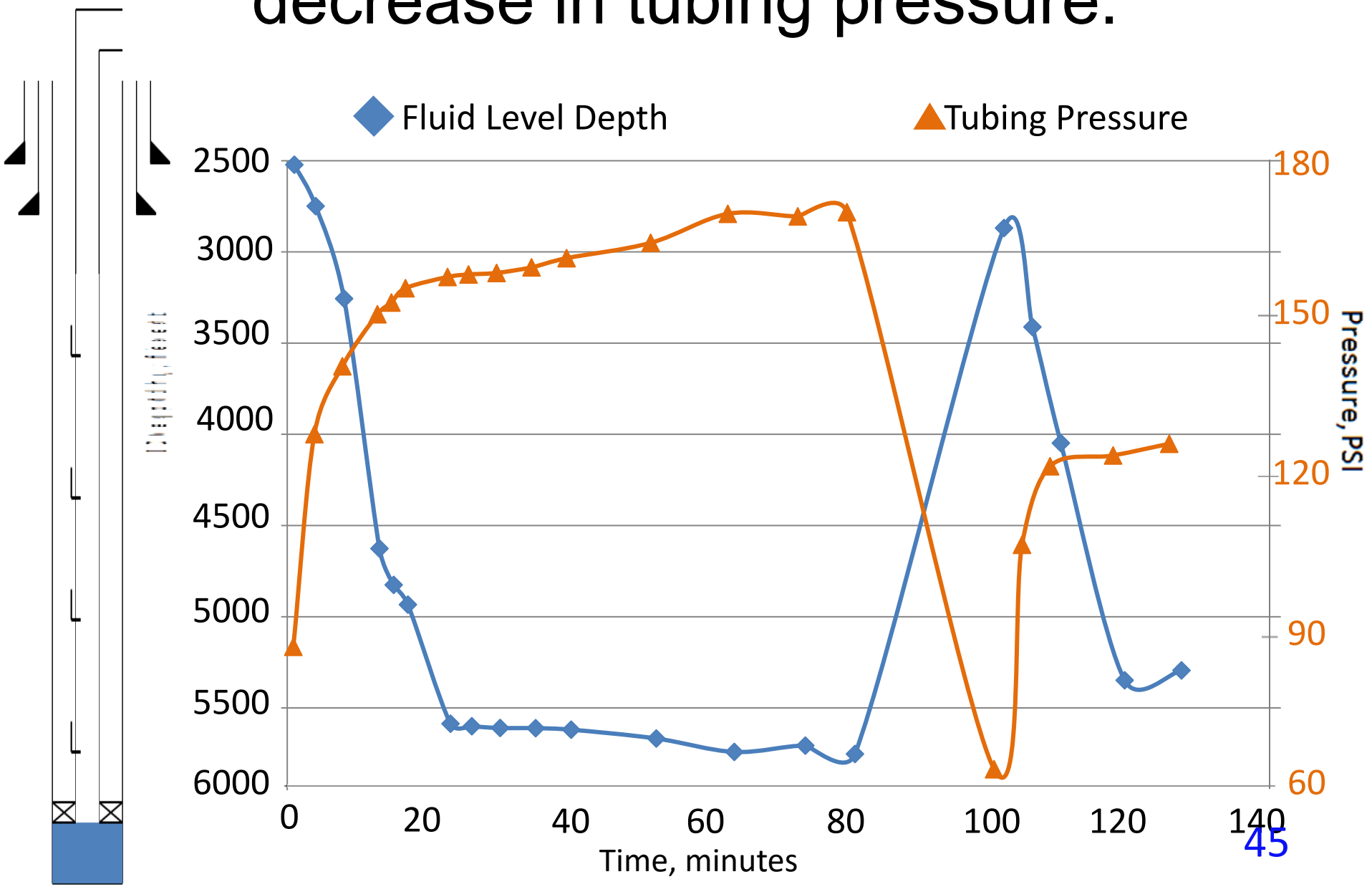
ANSWER:

The following example illustrates the use of a complete fluid level analysis to validate the gas lift design and verify the artificial lift system is operating efficiently.


9:53am
LL
10:00am
GLV1
LL
10:05am
GLV1
GLV2
LL
10:18am
GLV1
GLV2
GLV3
LL
10:44am
GLV1
GLV2
GLV3
GLV4
LL
The LL is below the end of the wellbore. Automatically displaying wellbore overlay.
11:12am
GLV1
GLV2
GLV3
GLV4
EOT
LL


174.7psi

Fluid Levels fluctuate with an increase or decrease in tubing pressure.



QUESTION:

CAN A LEAKY GAS-LIFT VALVE BE DETECTED WITH AN ACOUSTIC SHOT?

ANSWER:

YES, USING CERTAIN TECHNIQUES.

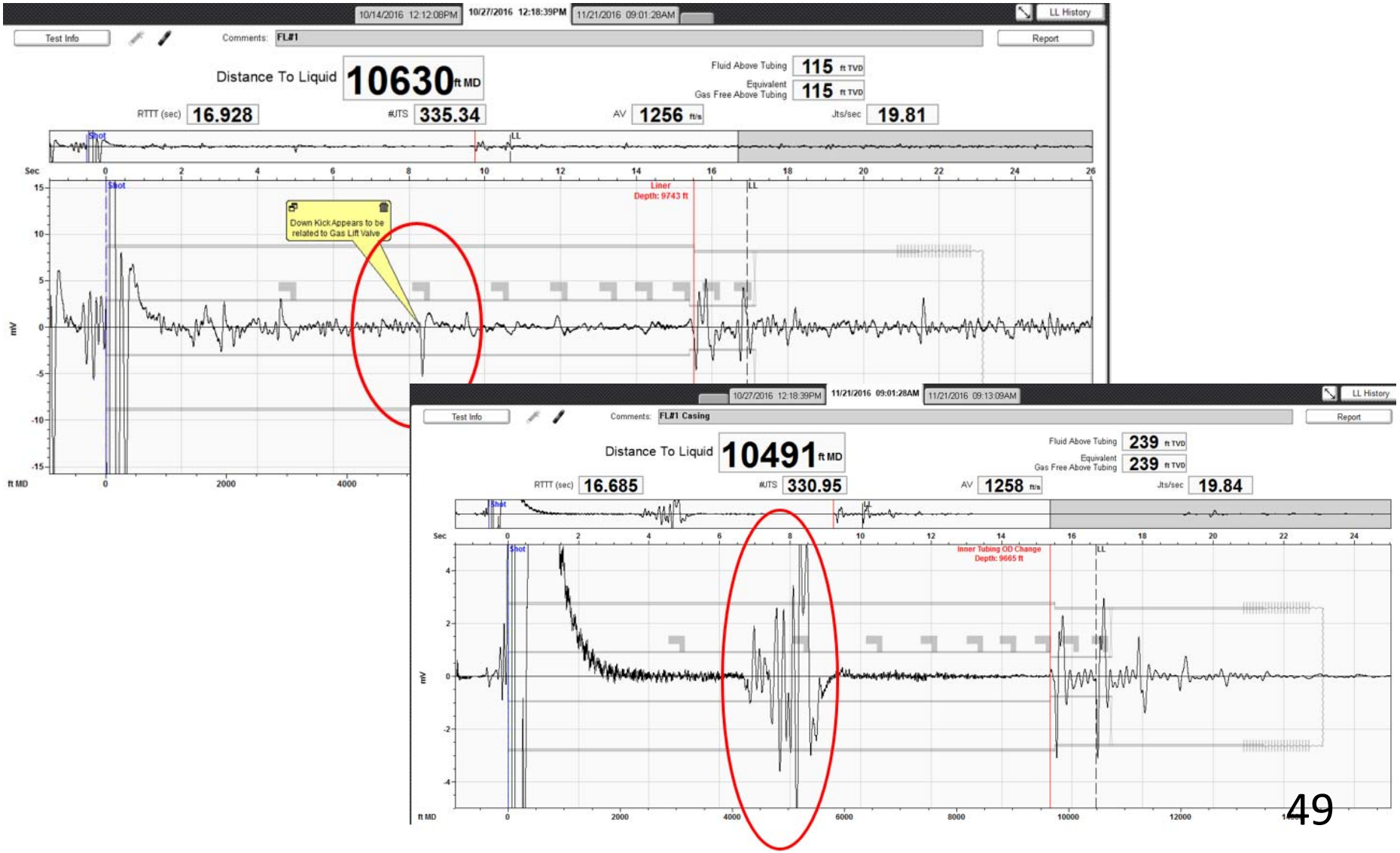
1 - Problem Gas-Lift Valve Identified Using Valve Reflection Study

- In a very high rate, high pressure gas-lift well, there was a problem, and the gas-lift system would not lift the well.
- After the well was shut in for a few weeks, the liquid level was acquired on the well.
- Due to high pressure and quiet well, the gas-lift valves/mandrels were easy to see and the shape of the echoes was exactly the same for each valve – with the exception of one.
- The problem valve was identified using the acoustic instrument. Required some detailed study of each valve echo.

2 - Problem Gas-Lift Valve Identified Due to Physical Damage

- If the unloading valve has some type of physical damage and the echo is different, you will see it.
- However, if the internal parts of the valve are the same size and there is a pressure seal at the valve, then the echo at the valve will be the same and no difference will be seen.
- If the pressure seal fails, then it is likely that the echo at the valve will show a “strange kick” and you may be able to identify a valve with a problem.

2 - Problem Gas-Lift Valve Identified Due to Physical Damage



3 – The Dual Shot Method

Identifies communication between Tubing and Casing using Two Gas Guns

Dual Shot Method

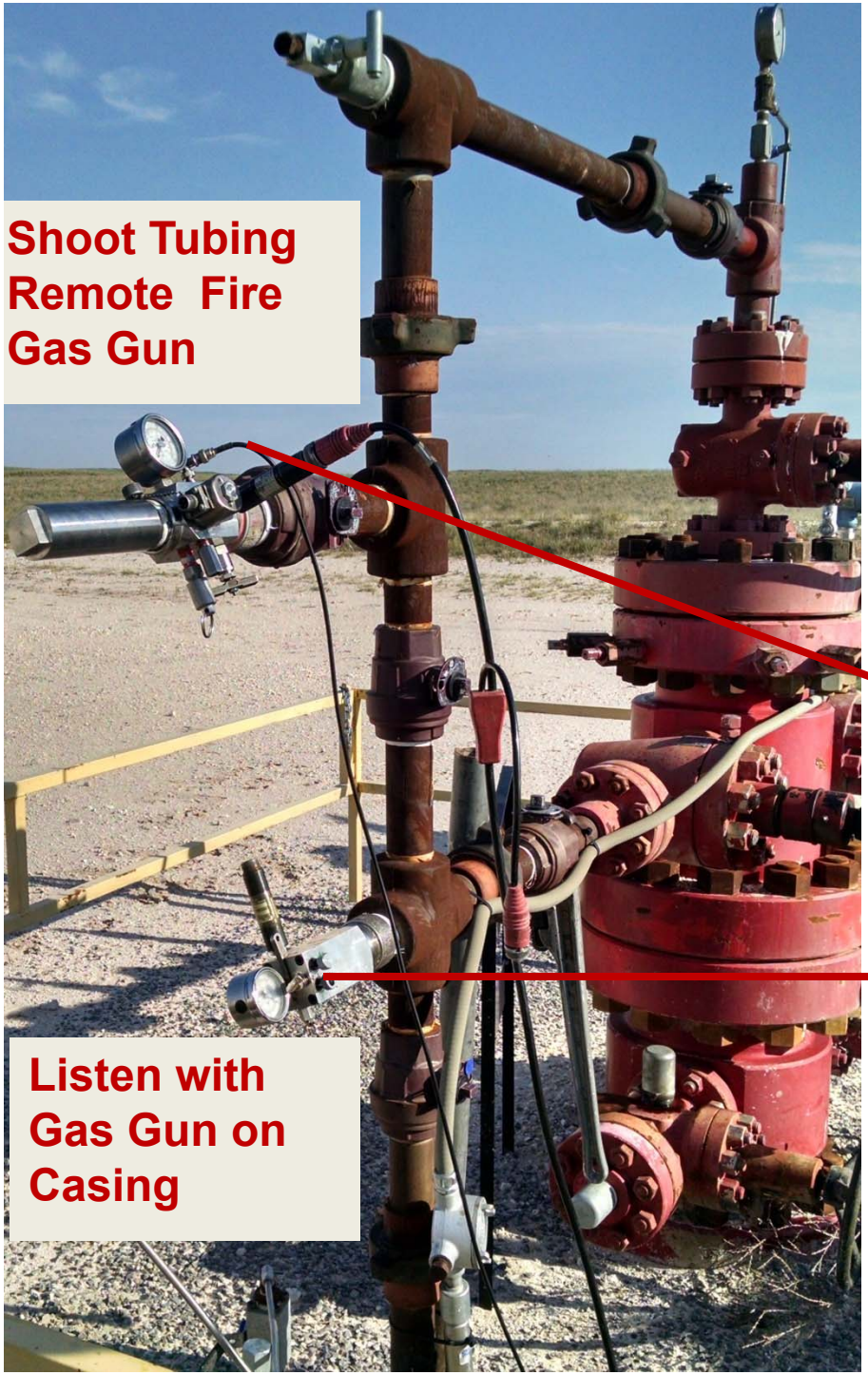
Look for Communication between Tubing and Casing on a Gas-lift Well.

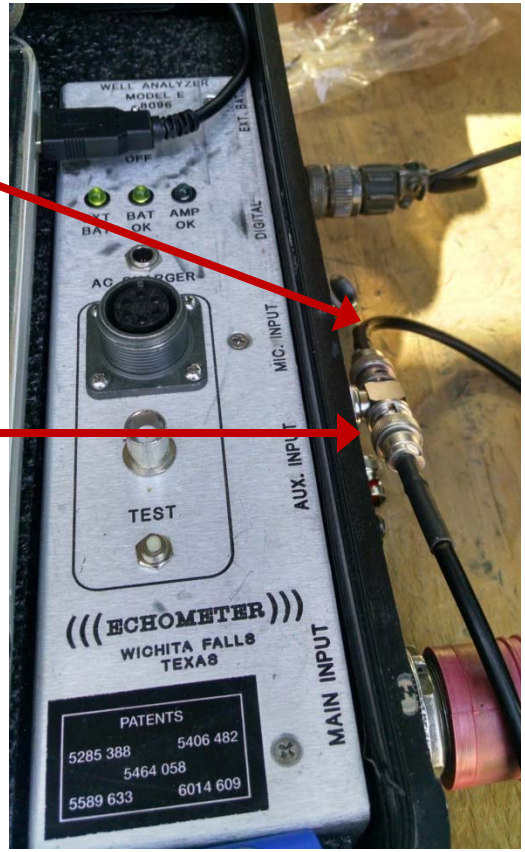
- Shoot down Tubing and simultaneously Listen on Casing.
- Fire the Tubing Gas Gun to send a pressure wave down Tubing.
- Unplug the Tubing microphone cable from T after shot is fired, and leave the Casing microphone cable plugged into the Well Analyzer.
- Acoustic Signal is created in Tubing. Holes, malfunctioning check valves, and malfunctioning gas-lift valves pass pressure wave into casing.
- For calculating Depth on Listen gun, use an average of the Tubing and Casing Acoustic Velocities from just prior Tubing and Casing shots.

Connect Both Guns to Analyzer for Shot Fire

Look for Communication between Tubing and Casing on a Gas-lift Well.

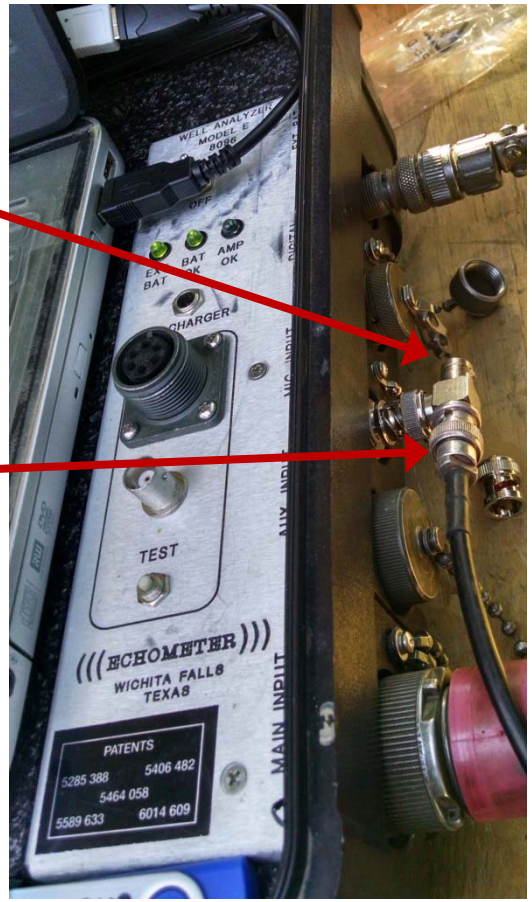
- Shoot down Tubing and Simultaneously Listen on Casing





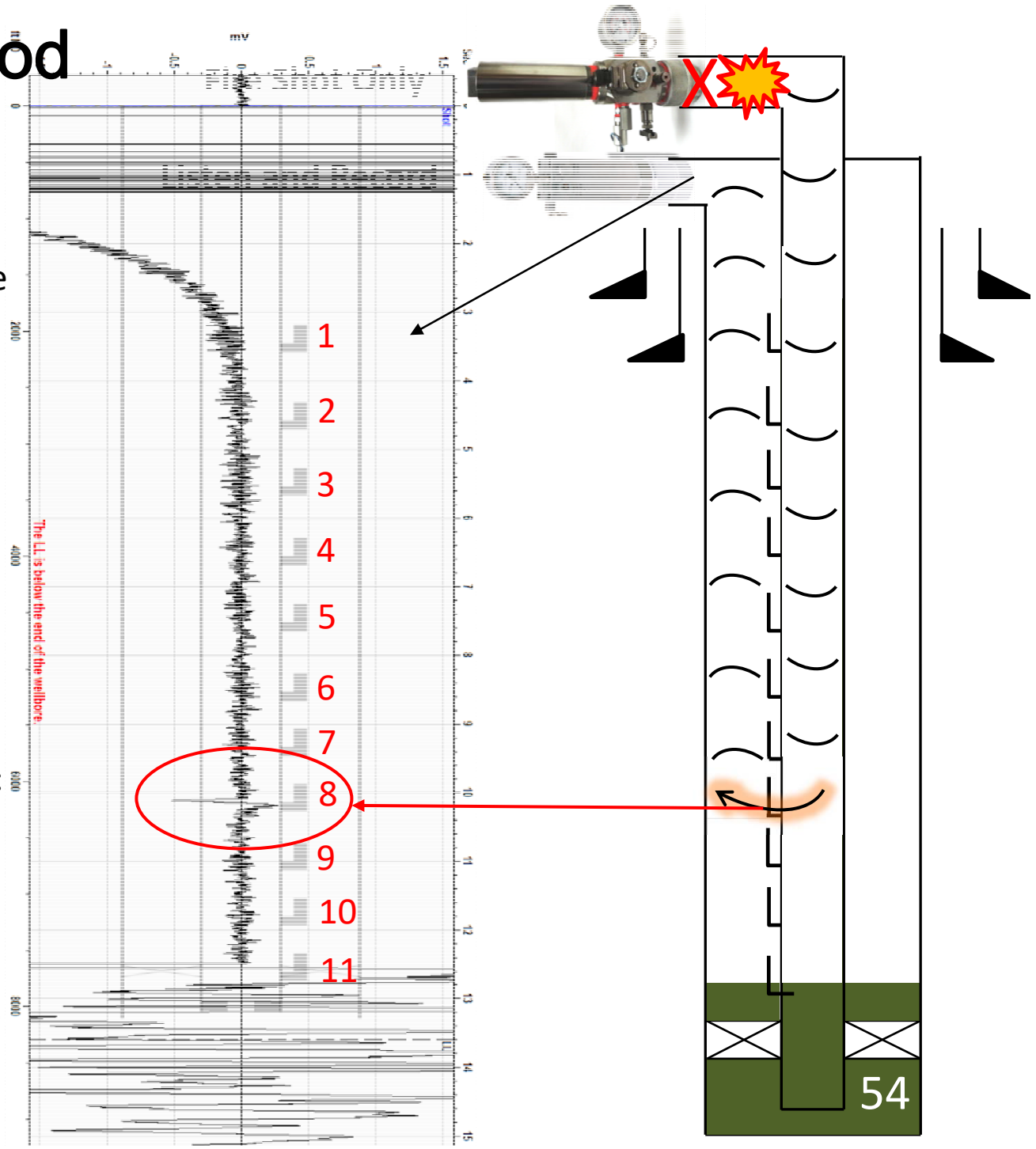
After Shot Fire Listen Only on Casing Gun

As soon as Tubing Shot is fired Unplug the Tubing microphone cable from “T” and leave the casing microphone cable plugged into the Well Analyzer.

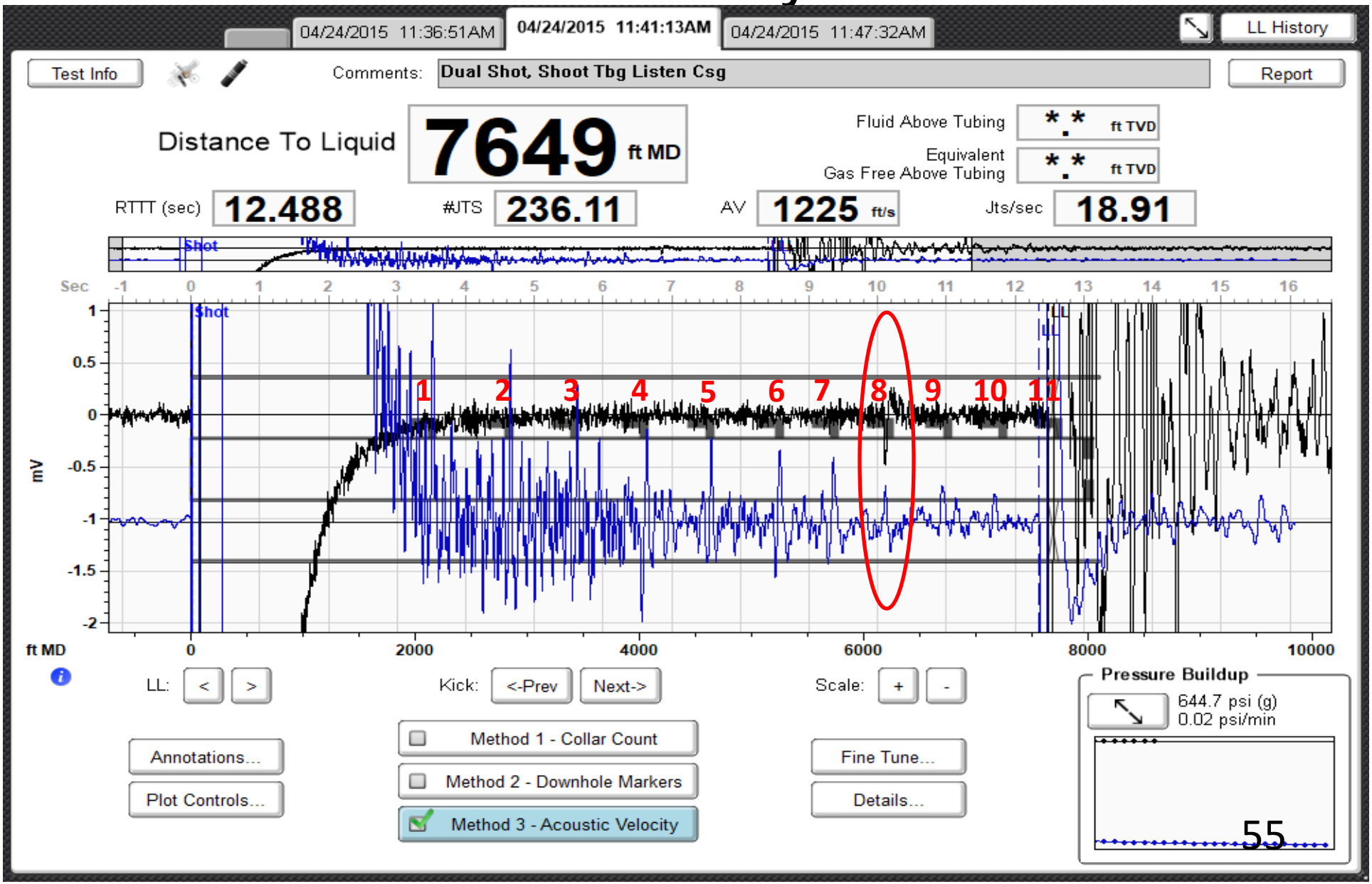


Dual Shot Method

1. Displace liquid out of Tubing down to the operating valve.
2. Fire Shot using Remote Fire Gun on Tubing. Disconnect Tubing microphone cable after Shot is fired.
3. Listen and Record Shot using Compact Gas Gun on Casing.
4. Watch for Kick identifying communication between Tubing and Casing.
5. Using the average of the Tubing and Casing Acoustic Velocities, calculate the Depth to the Kick.
6. Using the Wellbore Schematic or Overlay, identify the Problem Valve.

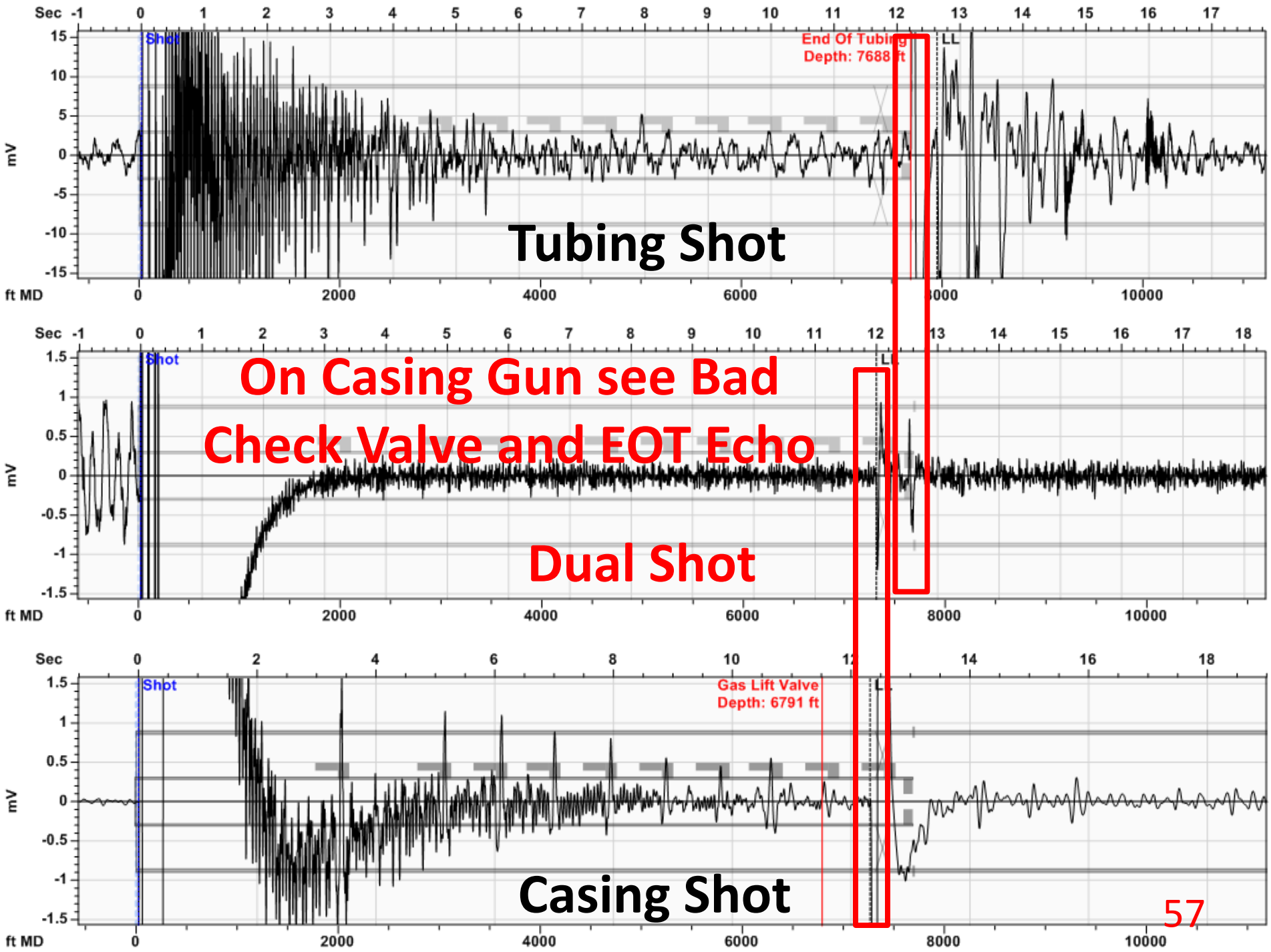


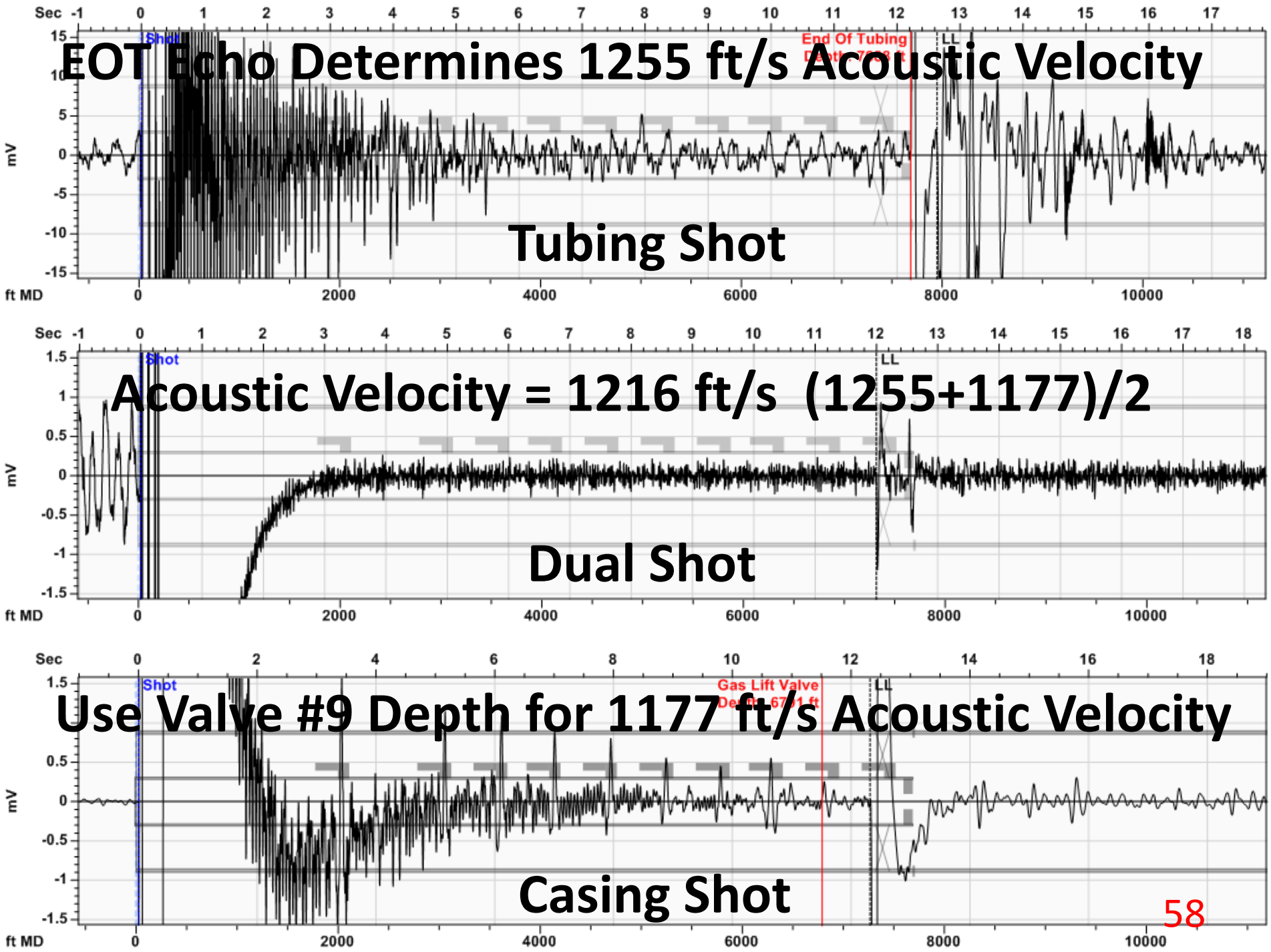
Overlay Casing Setup Shot onto Dual Shot to Verify



Dual Shot Results

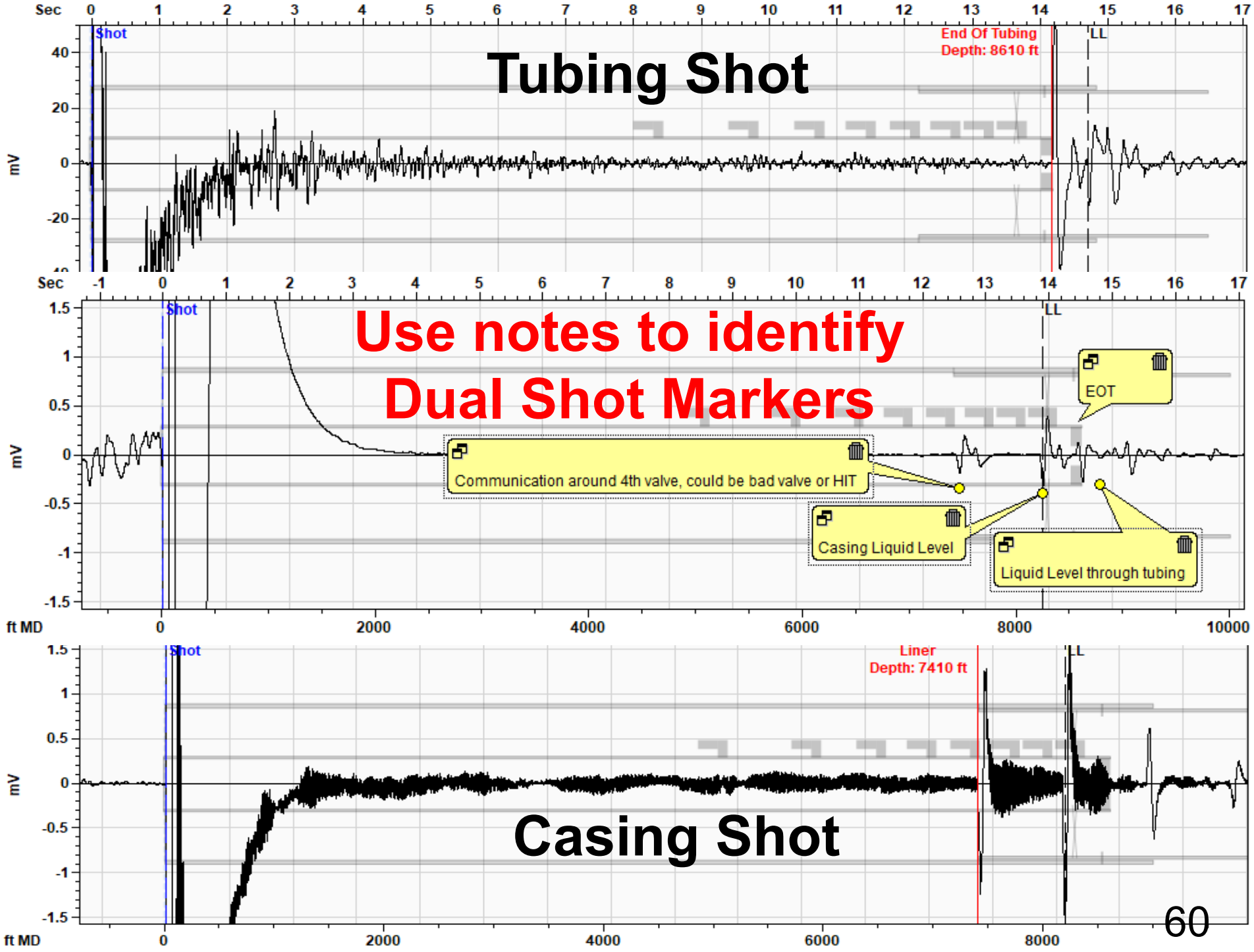
Example 1


Sec
Shot
End Of Tubing
Depth: 7688 ft
LL
mV
ft MD
Tubing Shot
On Casing Gun see Bad
Check Valve and EOT Echo
Dual Shot
Gas Lift Valve
Depth: 6791 ft
Casing Shot

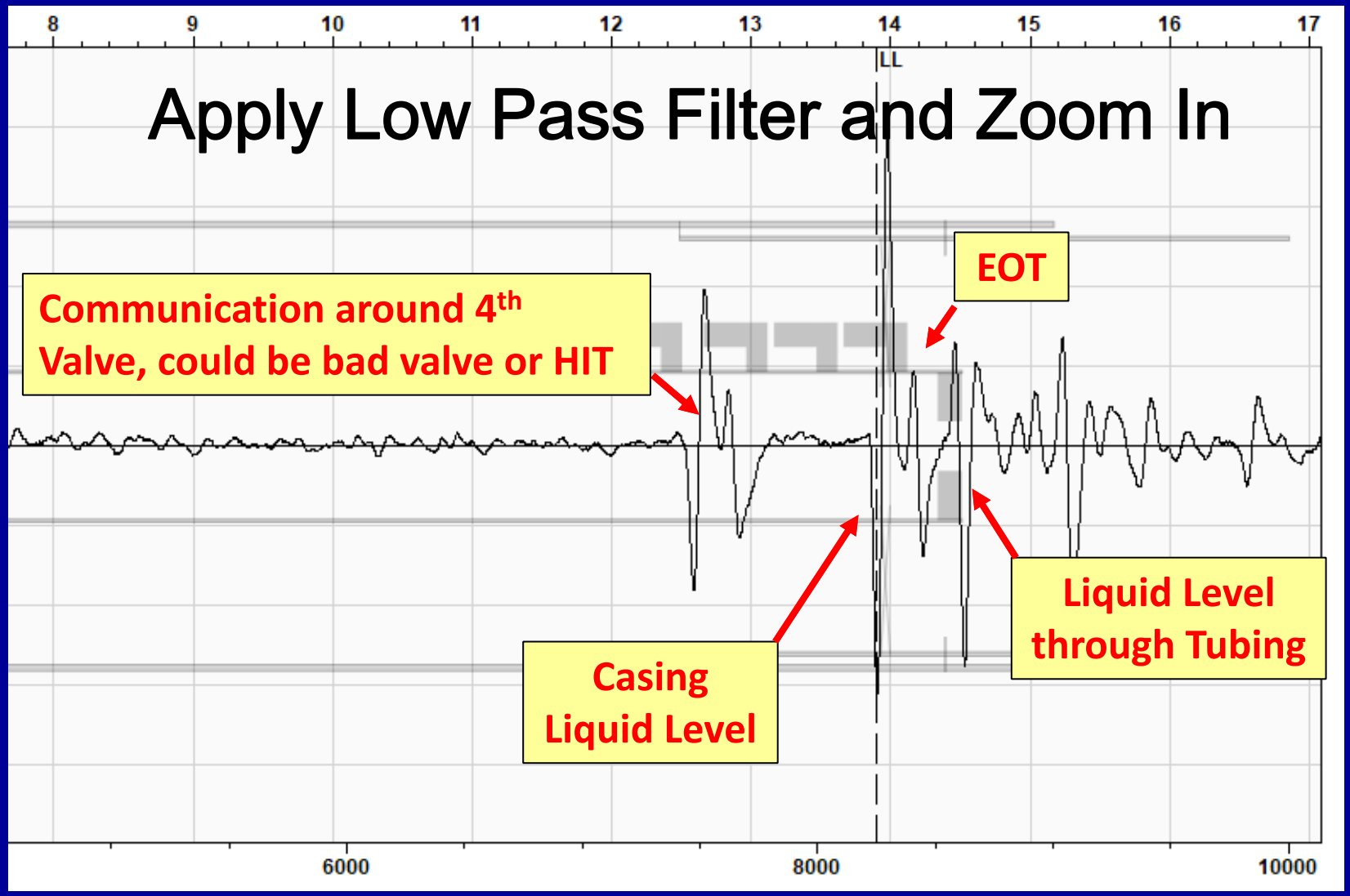

EOT Echo Determines 1255 ft/s Acoustic Velocity
Shot
End Of Tubing
LL
Sec
mV
ft MD
Tubing Shot
Acoustic Velocity = 1216 ft/s (1255+1177)/2
Dual Shot
Use Valve #9 Depth for 1177 ft/s Acoustic Velocity
Gas Lift Valve
Casing Shot

Dual Shot Results

Example 2


Tubing Shot
Use notes to identify
Dual Shot Markers
Casing Shot
Shot
End Of Tubing
Depth: 8610 ft
LL
EOT
Communication around 4th valve, could be bad valve or HIT
Casing Liquid Level
Liquid Level through tubing
Liner
Depth: 7410 ft
Sec
mV
ft MD

Echoes from Both Tubing and Casing are seen in Dual Shot.



Dual Shot Results

Example 3 – Wireless Equipment

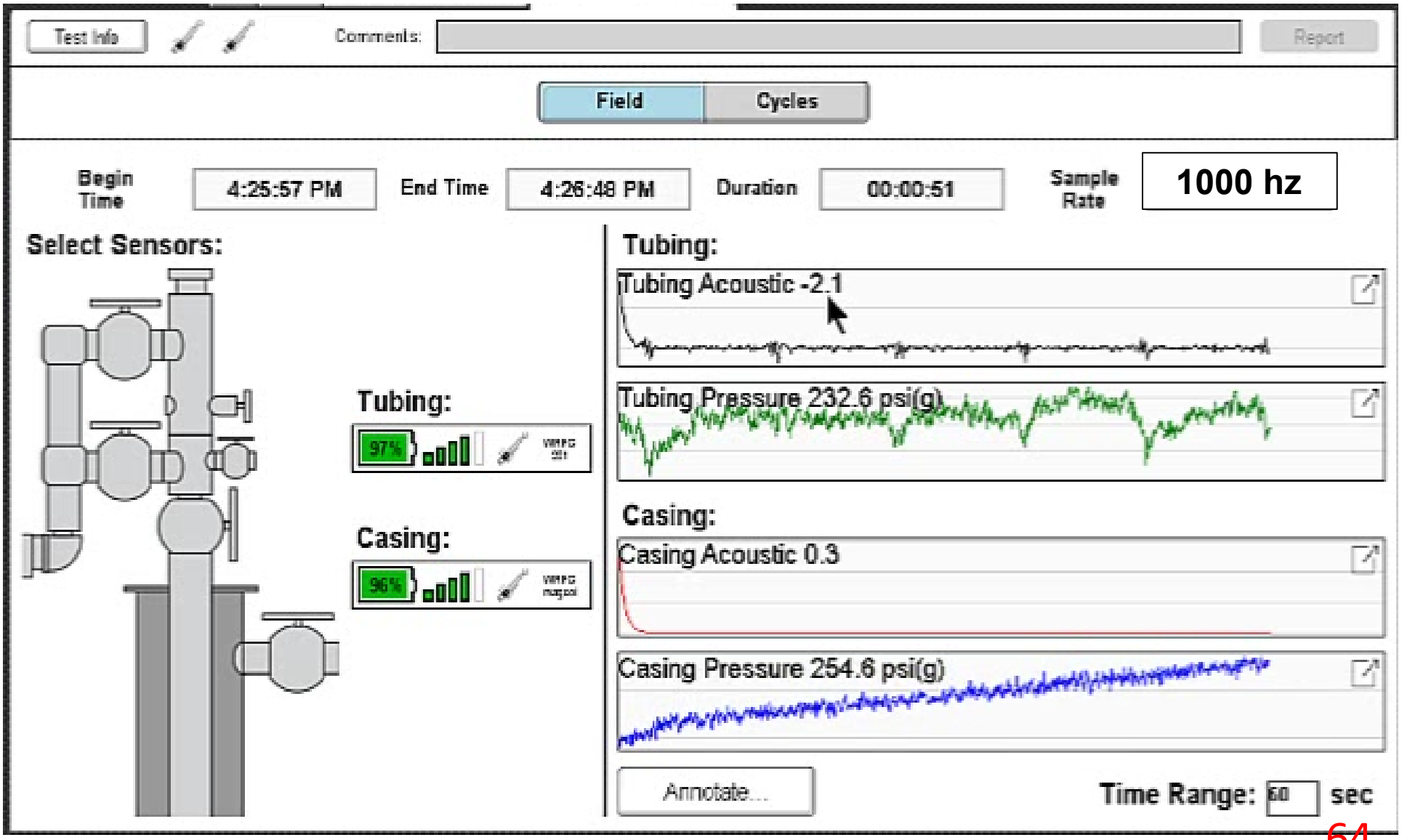
Method Using Plunger Lift Application

Dual Shot - Wireless

Look for Communication between Tubing and Casing on a Gas-lift Well.

- Using TAM Plunger Lift Application Simultaneously Acquire High Speed Acoustic and Pressure Data.
- Press Fire Shot button on Tubing Gun while Listening for Pass Through Echo on Casing Gun.
- Acoustic Signal is created in Tubing. Holes, malfunctioning check valves, and malfunctioning gas-lift valves pass pressure wave into casing.
- For calculating Depth on Listen gun, use an average of the Tubing and Casing Acoustic Velocities from just prior Tubing and Casing shots.

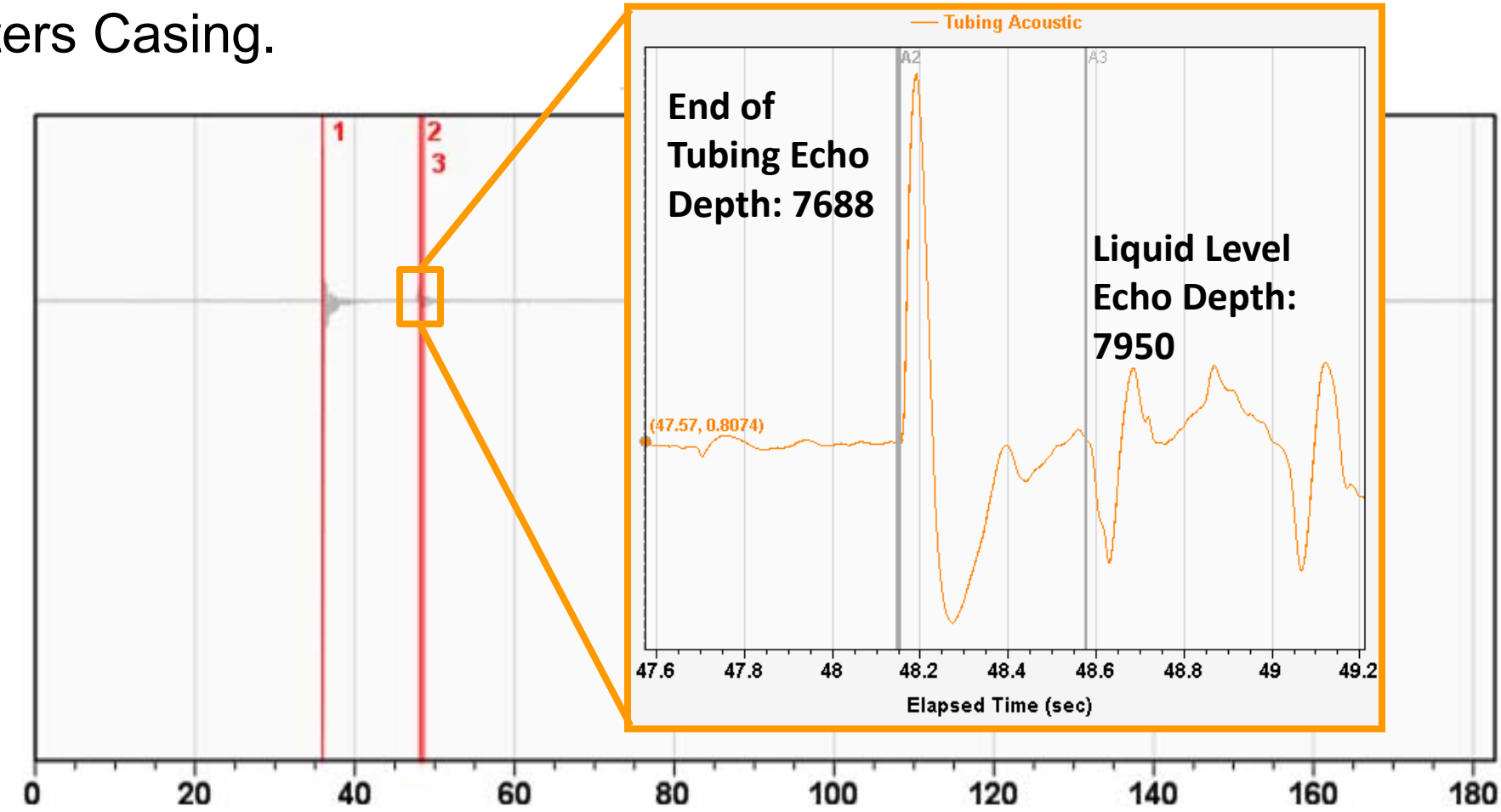
Using TAM Plunger Lift Application Simultaneously Acquire High Speed Acoustic and Pressure Data



Press fire shot button on Tubing Gun while Listening for Pass Through Echo on Casing

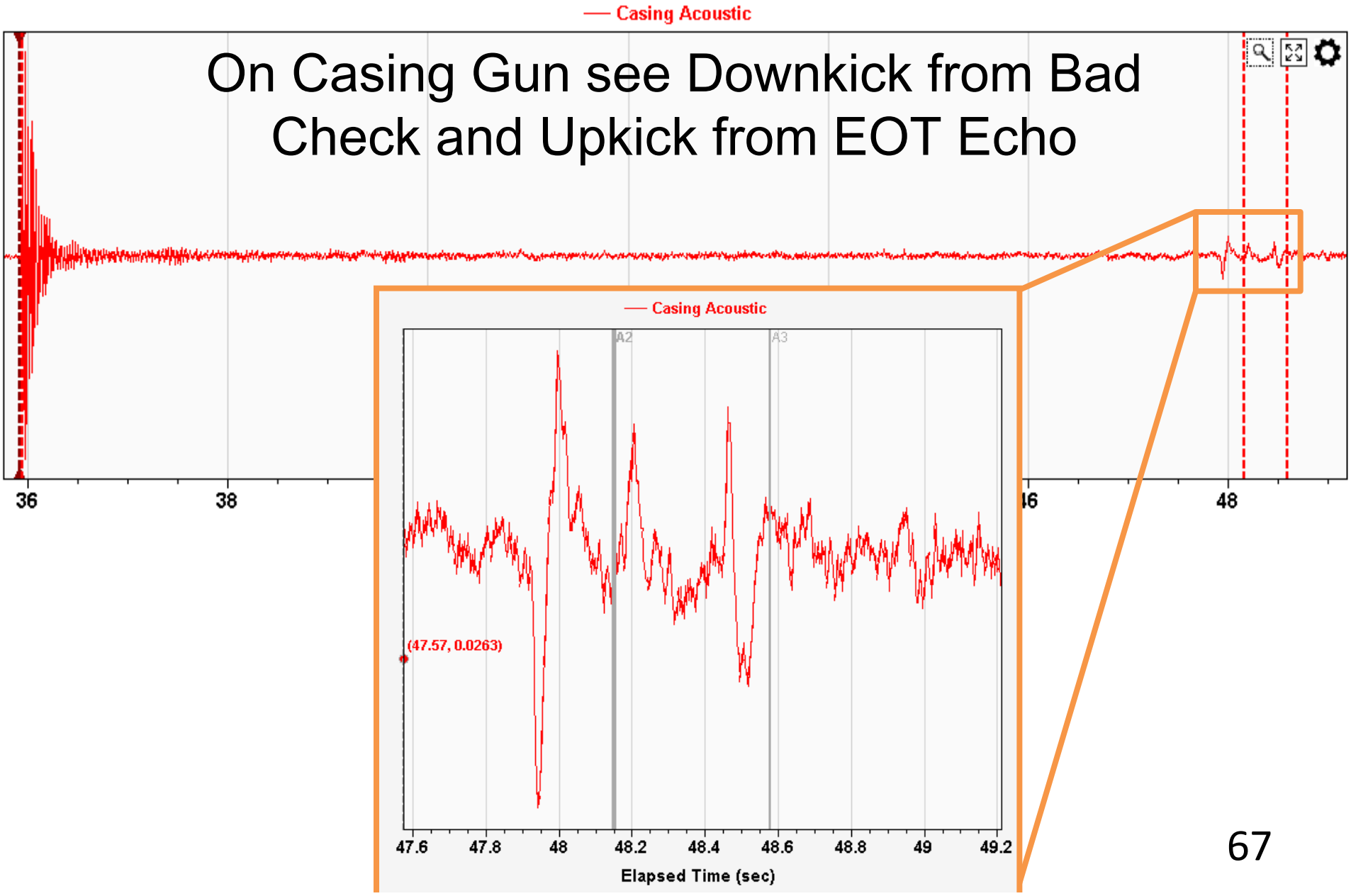
Press "**Fire**" button when ready to shoot and make sure the chamber pressure is greater than the well pressure.

Acoustic Signal is created in Tubing. If holes, leaky check valves, leaky gas-lift valves are present, then Tubing Pressure Wave enters Casing.



#	DESCRIPTION	TIME	TUBING psi (g)	CASING psi (g)	ACOUSTIC
1	Fire Shot Button Pressed to Release Pressure Wav	35.93	381.9	729.0	-8.120e+002
2	Upkick EOT	48.15	362.5	728.5	2.971e-001
3	Liquid Level on Tubing Acoustic	48.58	362.4	728.4	1.299e+000

Acoustic Signal Recorded in Casing shows holes, leaky check valves & leaky gas-lift valves when tubing pressure wave can pass into casing.



Conclusion

- Beneficial information is obtained throughout the life of a gas-lift well by determining the distance to the fluid level.
- Knowing the Acoustic Velocity profile of a well provides critical information for verifying gas composition and fluid level accuracy.
- Identifying reflection kicks across valves and mandrels result in more accurate depth analysis.
- Operating valves are identified quickly and easily .
- Troubleshooting techniques aid in identifying downhole problems.

(((ECHOMETER)))

Thank you for joining us for today!

Ask Echometer Online Session – June 17, 2020

Acoustic Techniques for Gas-Lift Wells

Questions?