Ask Echometer Online Session – August 19, 2020

Best Practices for Shooting Fluid Levels on Difficult Wells

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Download the Session 14 PDF Bundle and TAM Example Data from
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BEFORE OPENING CASING VALVE

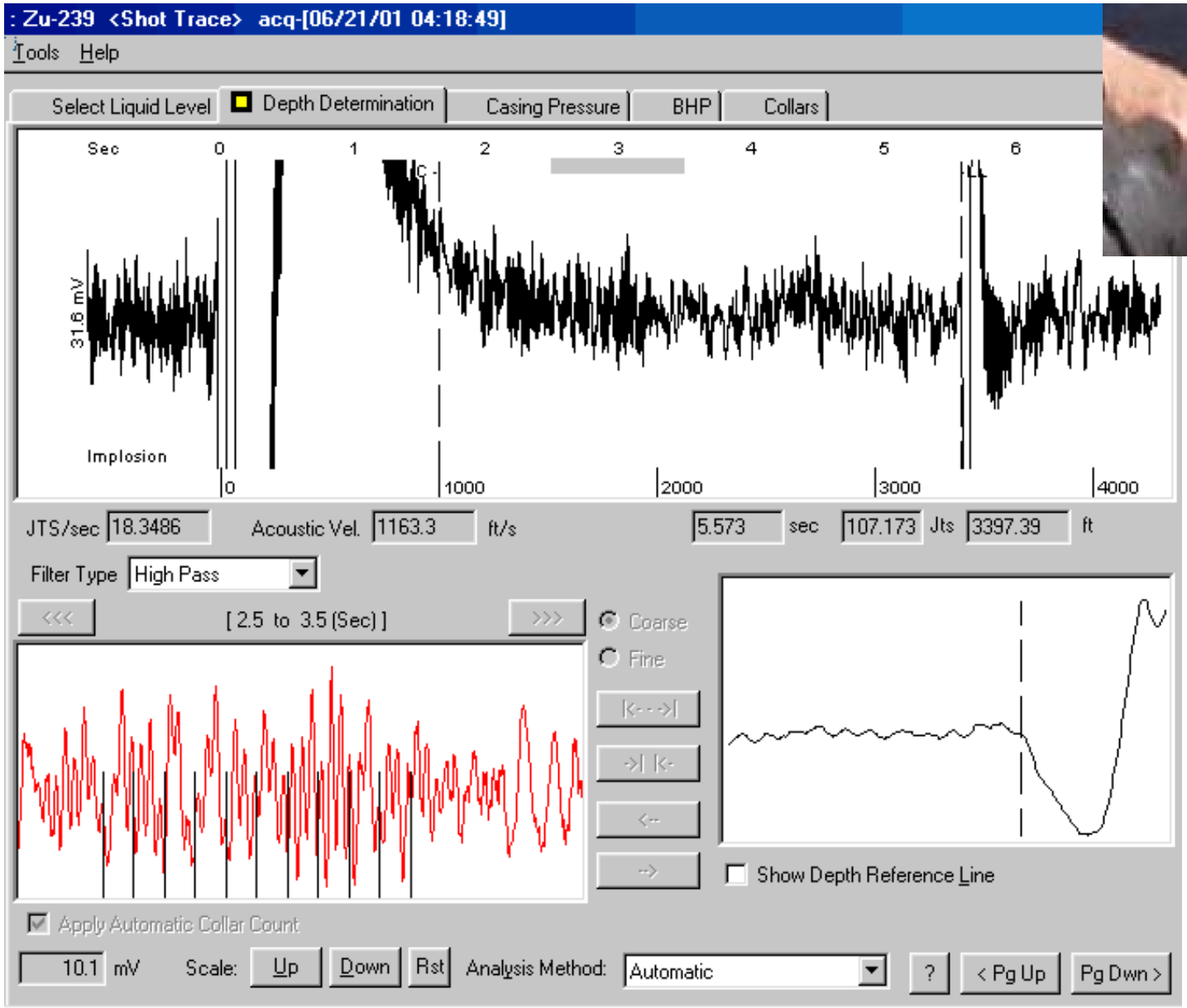
1. Know the pressure on the well at the surface.
2. Be alert that equipment ratings exceed well pressure.
3. Check the threads on the wellhead valve for corrosion , wear, or damage.
4. For 2” NPT make 4 1/2 turns for SAFE connection to Wellhead.
5. Close off other connections to casing annulus.
6. CHARGE gas gun volume chamber ABOVE the estimated casing pressure.
7. Make Sure Casing Valve between Gas Gun and Casing annulus is Open before shot is fired.

Effect of Gun Type and Connection

OPTIMUM RESULTS WILL BE OBTAINED

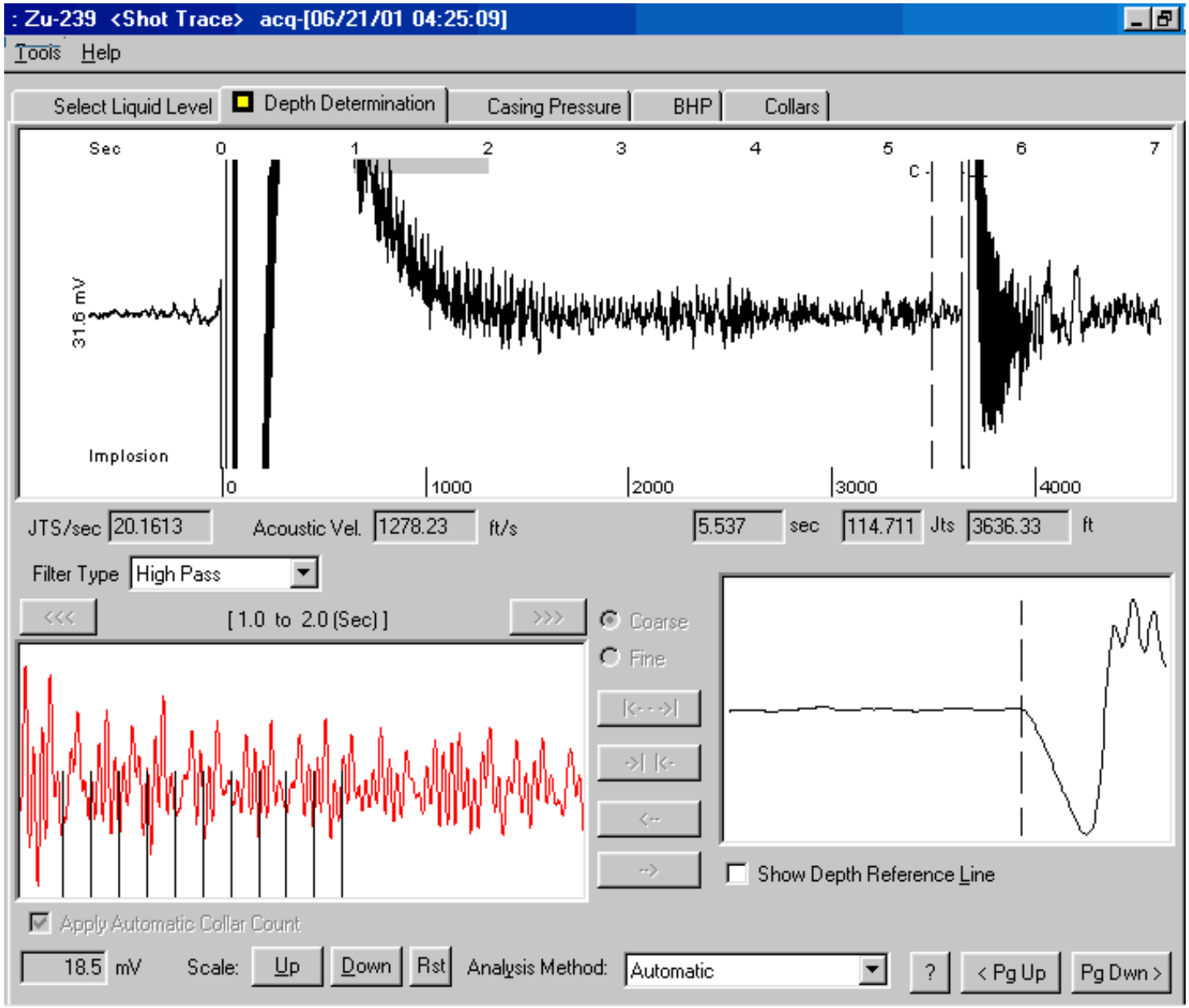
1. When the gas gun is connected to a ½” or larger fully opening valve.
2. When the gas gun is connected with the shortest possible distance (less than 5 feet) between the gun and the casing.
3. Adaptors and pipe size reducers may be used if necessary but they will result in reduced signal amplitude.
4. Shooting through a needle type valve can obstruct or block the signal and is not recommended.
5. Shooting through a chemical pot will cause a resonating signal and will give poor results.

5000 psi gun - Through Needle Valve



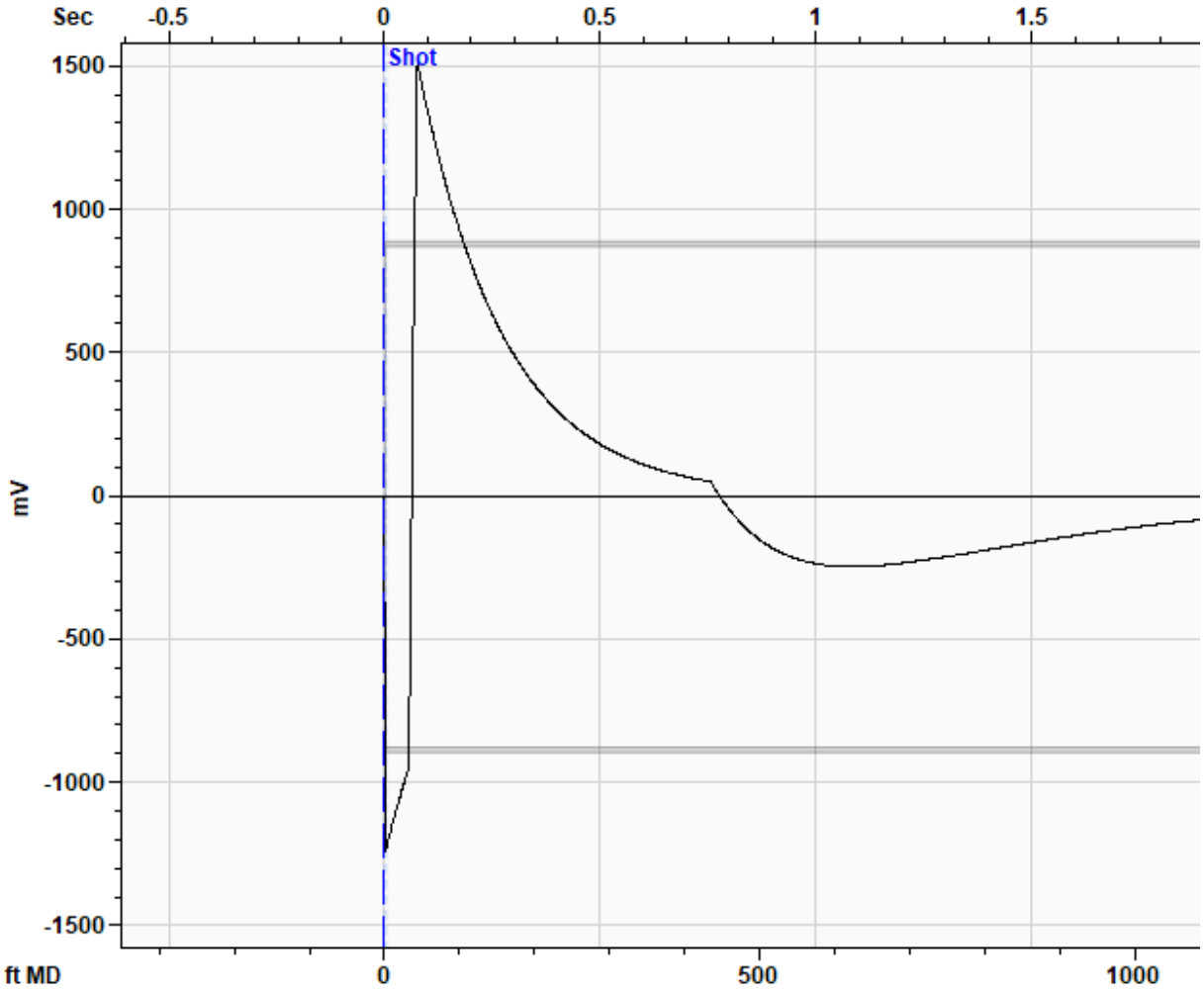
- 1163 ft/sec
- FL at 3397 ft

5000 psi gun - Removed Needle Valve

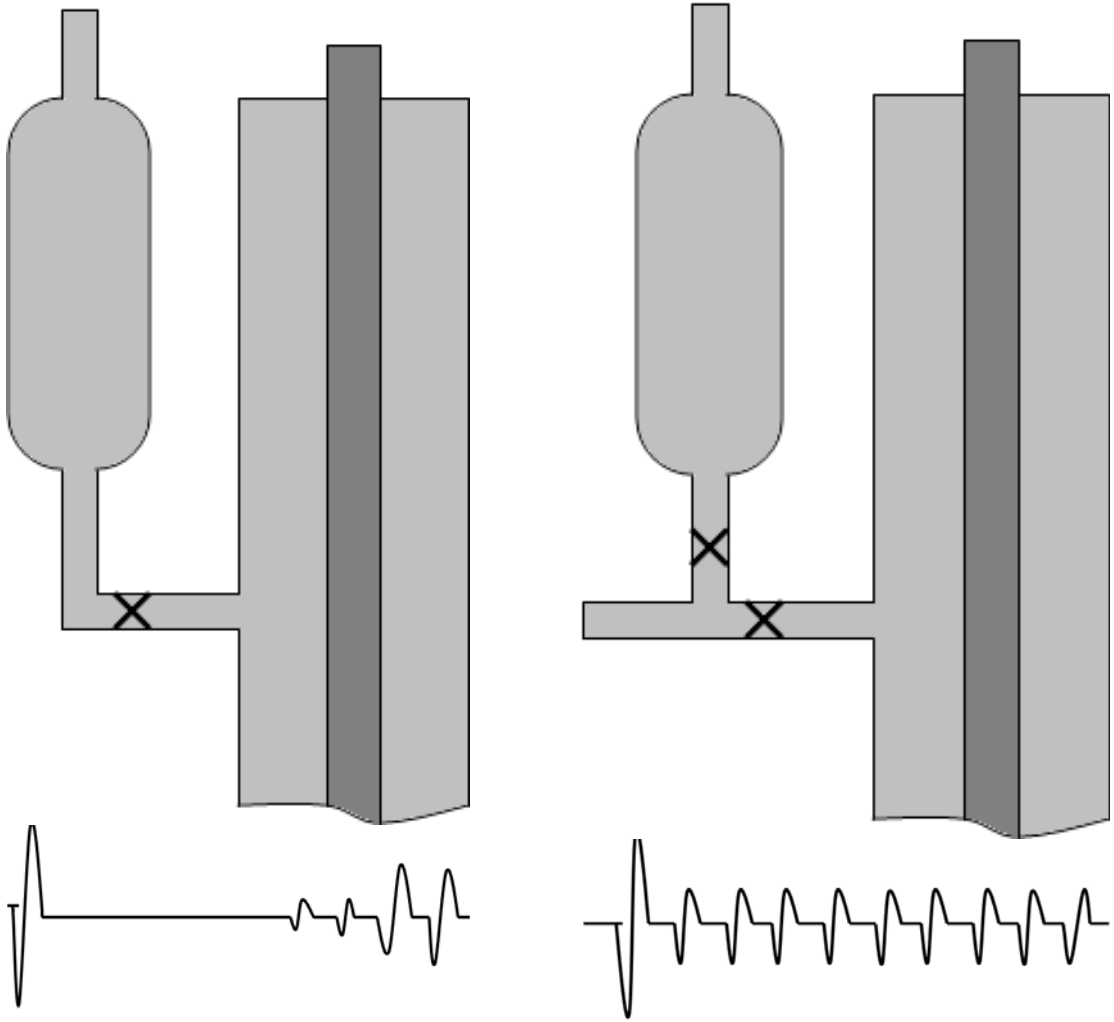


- 1278 ft/sec
- FL at 3636 ft

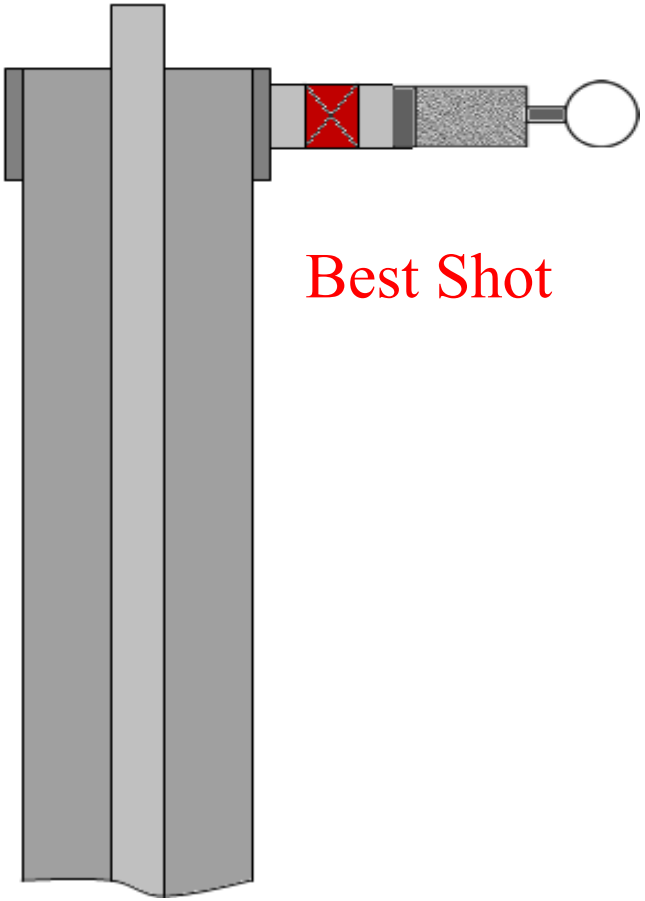
Shooting through a needle type valve can obstruct or block the signal and is not recommended.



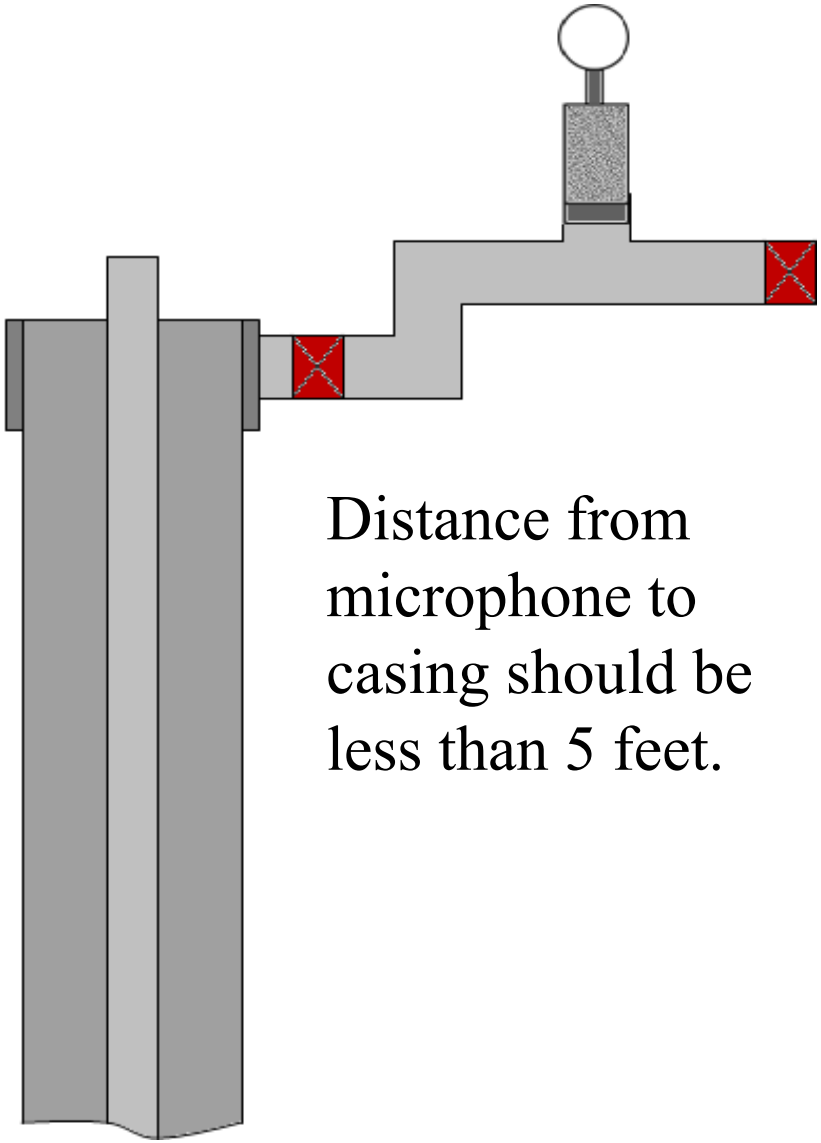
Avoid Chambers That Could Muffle Shots



Connecting to Well



Best Shot

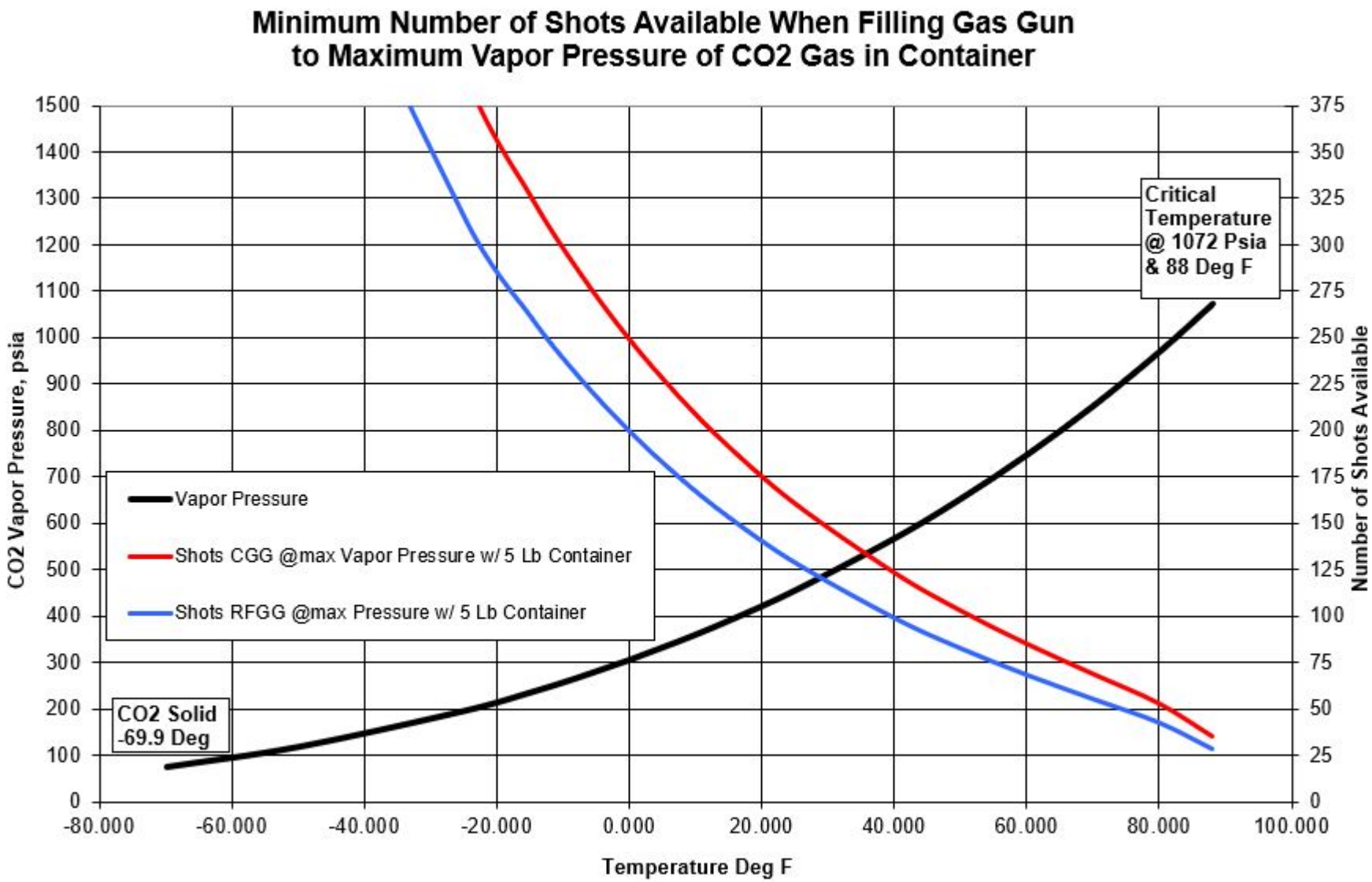


Distance from microphone to casing should be less than 5 feet.

CO_2 Gas & N_2 Gas Advantages

1. 5# CO_2 bottle will provide a lot of shots depending on charge pressure used. (See chart on next slide.)
2. Fill CO_2 from siphon-type bottle. (Instructions provided.)
3. CO_2 critical temperature is 88 Deg F & 1070 PSIA.
4. If the bottle contains liquid, the pressure is 650 PSI at 50 ^{o}F, 300 PSI at 0 ^{o}F and 120 PSI at –50 ^{o}F.
5. As long as the temperature of the CO_2 gas is high enough that the vapor pressure exceeds the well pressure, CO_2 is the most convenient gas to use for acoustic testing.
6. If the well pressure exceeds the vapor pressure of carbon dioxide, nitrogen gas is the most common gas to use for acoustic testing.
7. Nitrogen gas supplied at pressure in excess of the rating of gas gun. (May need Pressure Regulator)

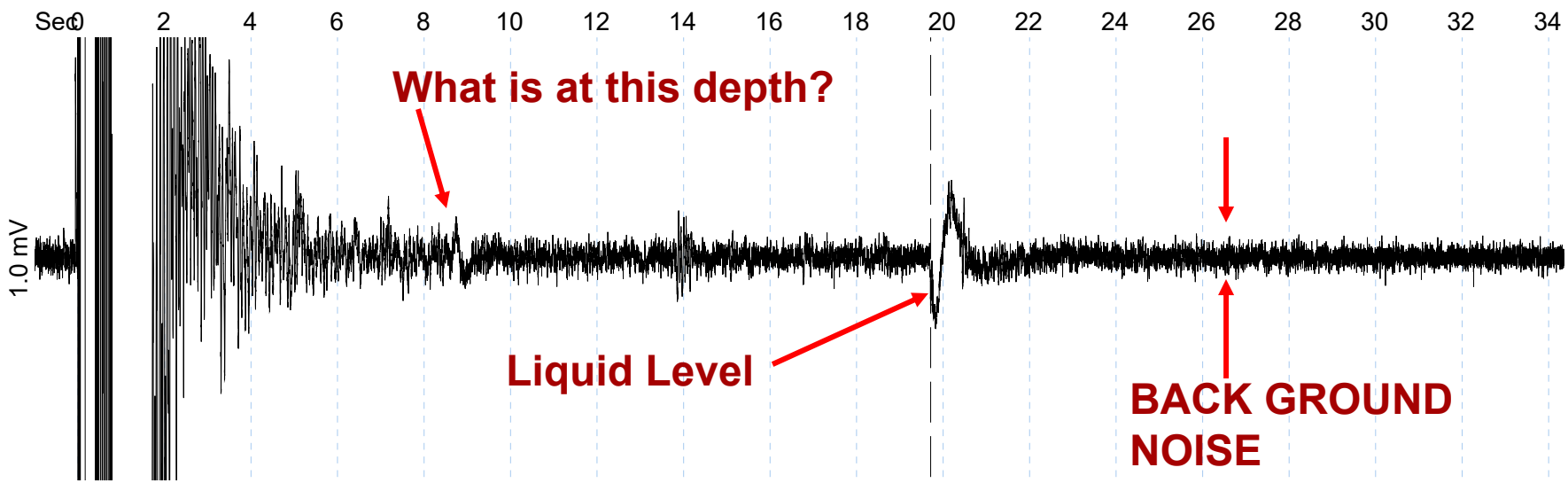
CO2 Gas – Shots per 5# bottle



SAFETY

1. Bleed off well pressure, before removing gas gun from well.
2. Keep threads clean and in good shape
3. DO NOT exceed working pressure of gun. Check casing pressure before connecting gun to well:
   - Compact Gas Gun Working Pressure ~~~~~~~~~~~~ 1500 PSI
   - Remote Fire Gun Working Pressure ~~~~~~~~~~~~ 1500 PSI
   - 5000 Psi Gas Gun Working Pressure ~~~~~~~~~~~~ 5000 PSI
   - High Pressure Gas Gun ~~~~~~~~~~~~15000 PSI
   - 10 Gauge Working Pressure ~~~~~~~~~~~~ 1000 PSI
   - Quick Load Working Pressure ~~~~~~~~~~~~ 1000 PSI
4. Make sure gun is securely attached to well.
5. Make sure casing valve is open before firing gun.

Background Noise



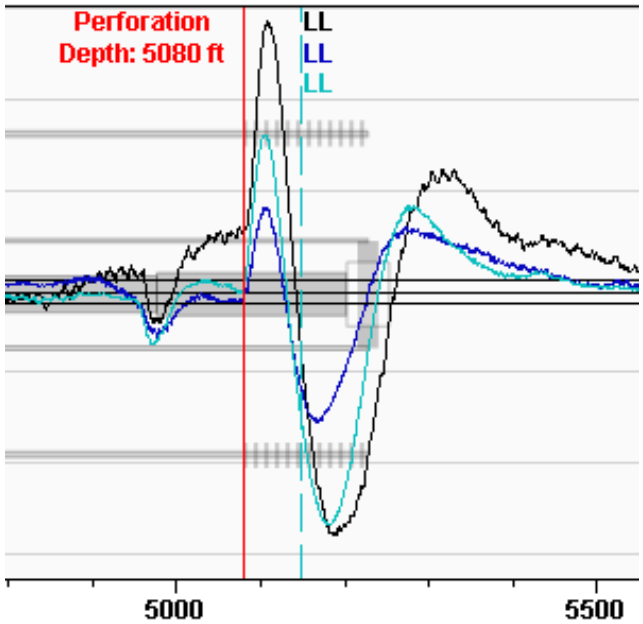
1) Increase the pressure in the volume chamber

2) Additional wellhead pressure improves collar and liquid level response.

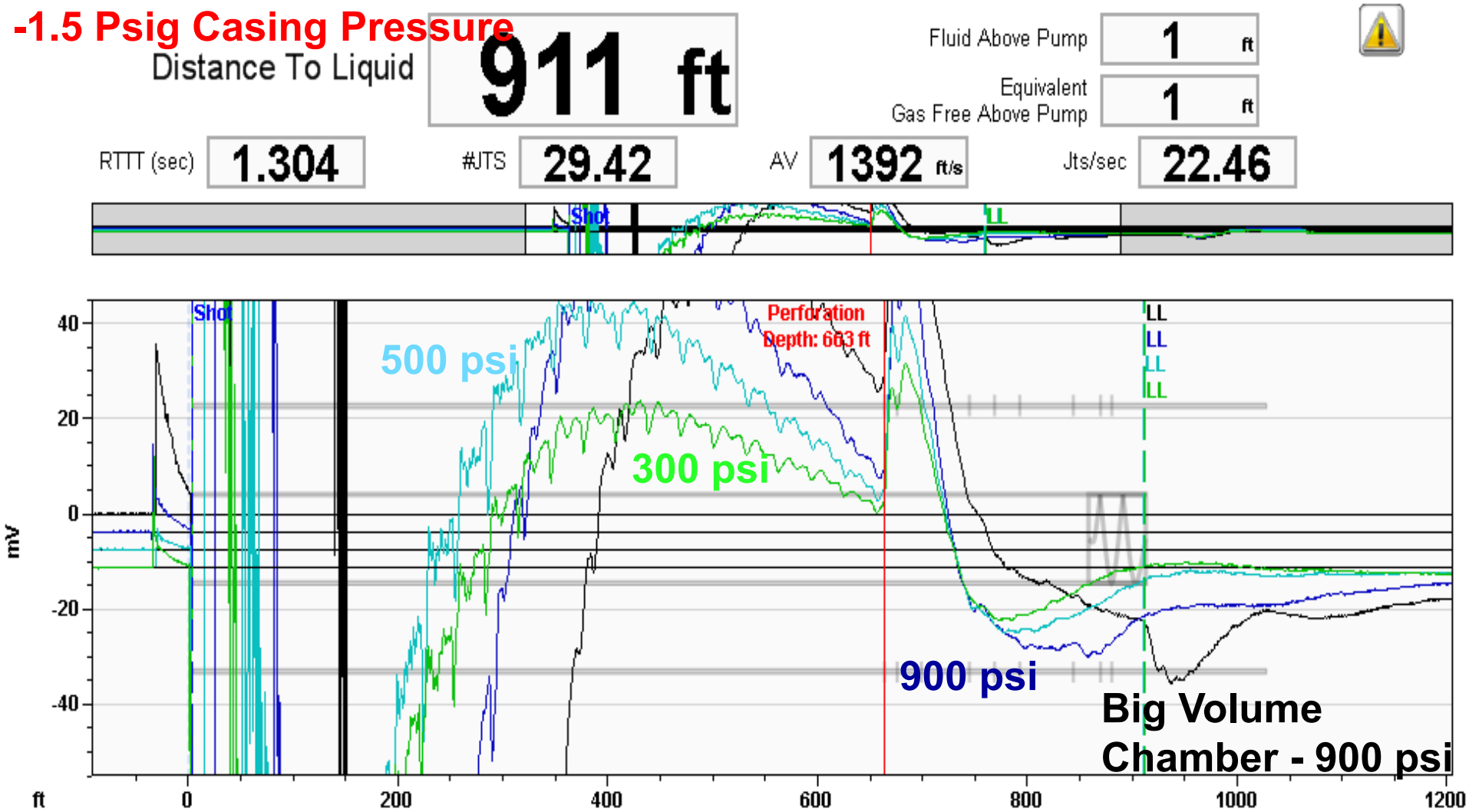
Increase Echo Size Using More Charge Pressure and/or Large Volume Chamber

Volume Chamber
12.5 VS 36 CU IN.

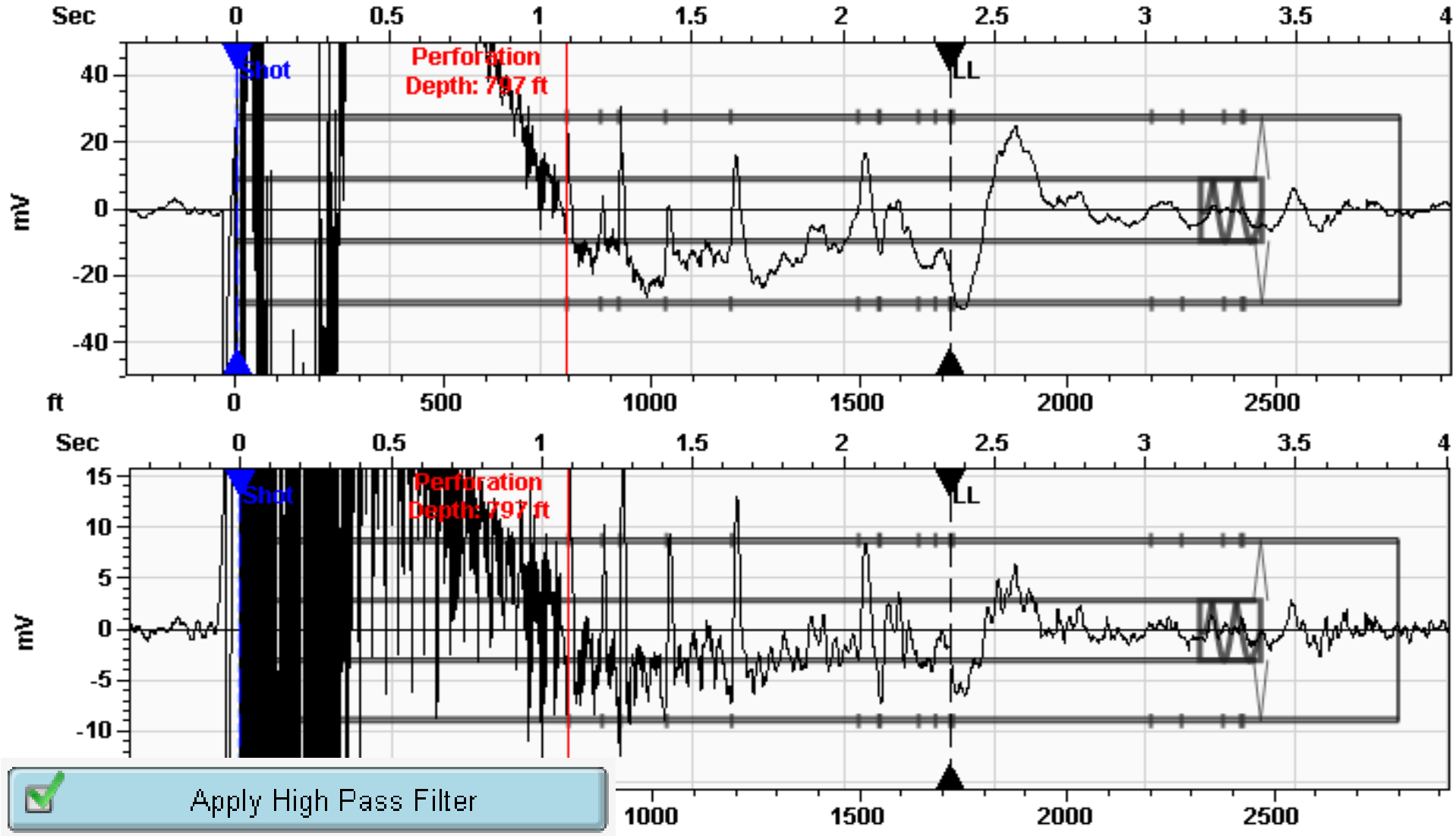
Pressure Charge
100 Psi
350 Psi
900 Psi



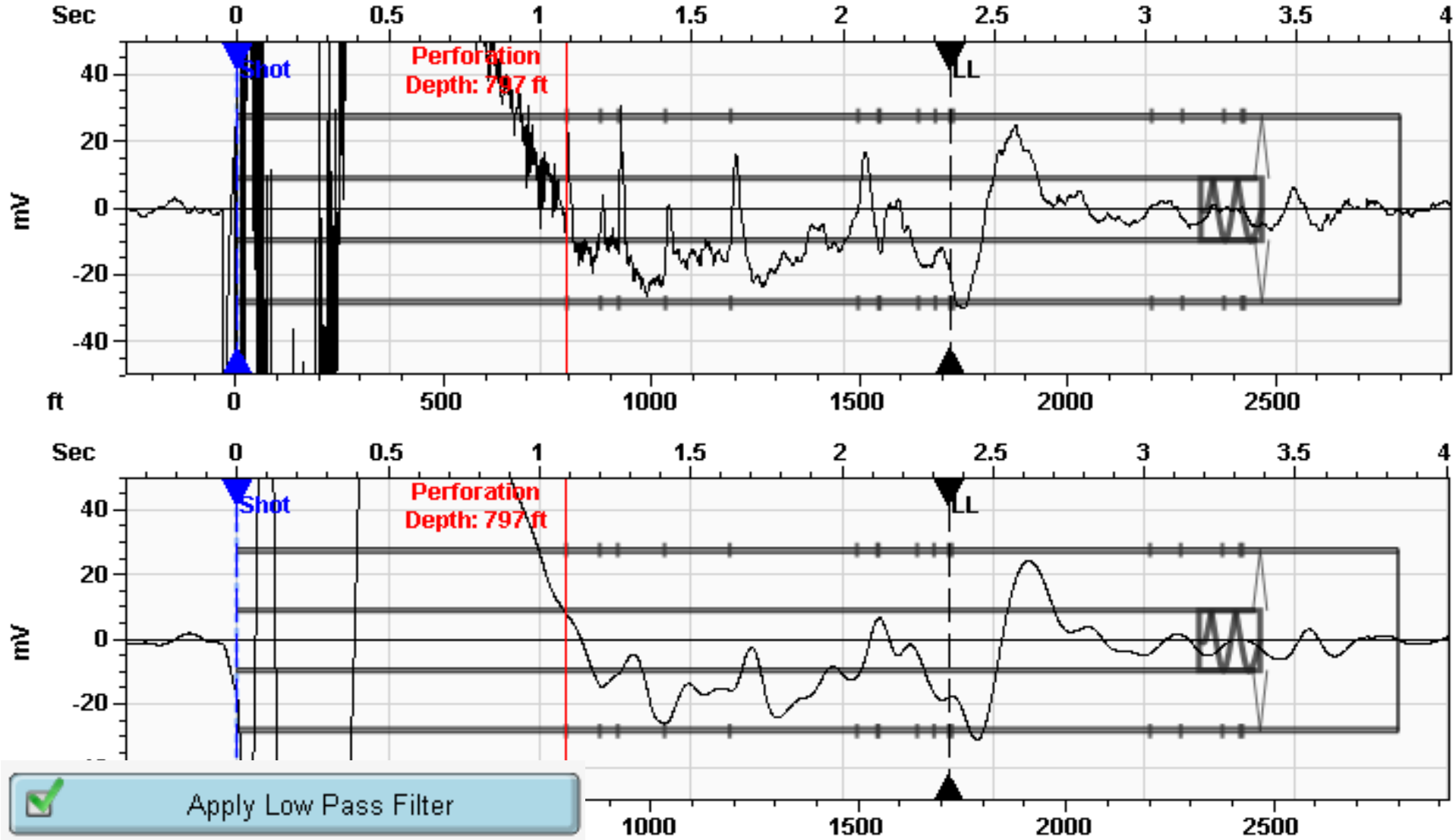
Liquid Level Echo Not Visible with Low Charge Pressure or Small Gas Volume



To See LL Apply High Pass Filter: Emphasizes Perfs and Flattens Trace

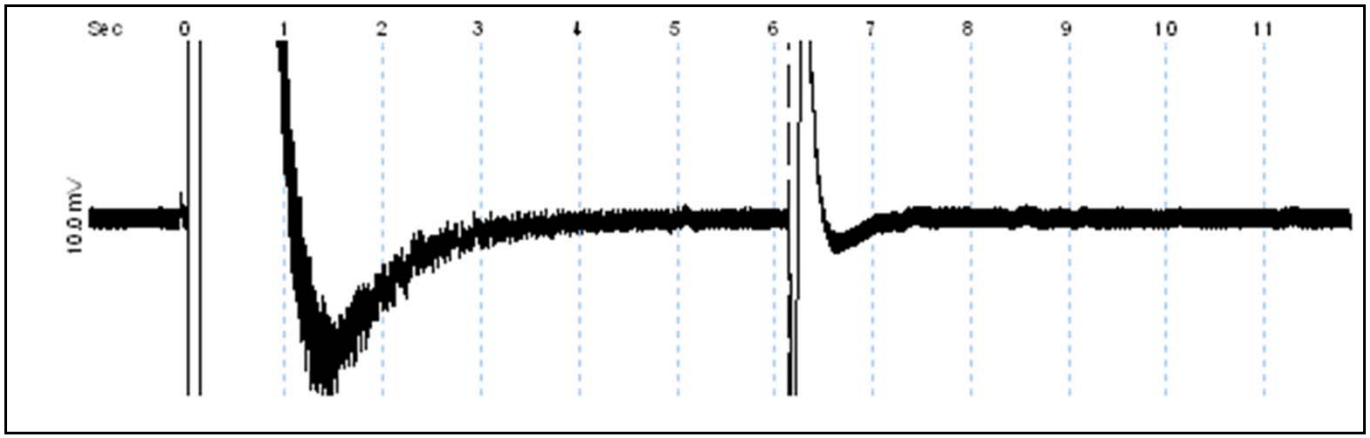


To See LL Apply Low Pass Filter: Removes High Frequency Noise Spikes

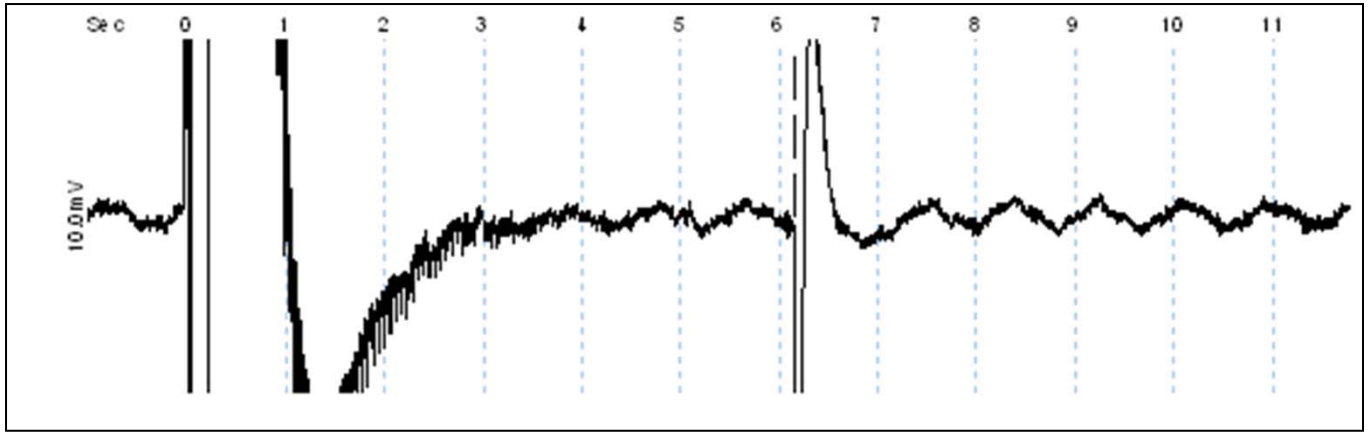


AC Charger Noise

Connection of AC charger to AC or DC-AC inverter, while acquiring data may cause additional noise on acoustic trace.

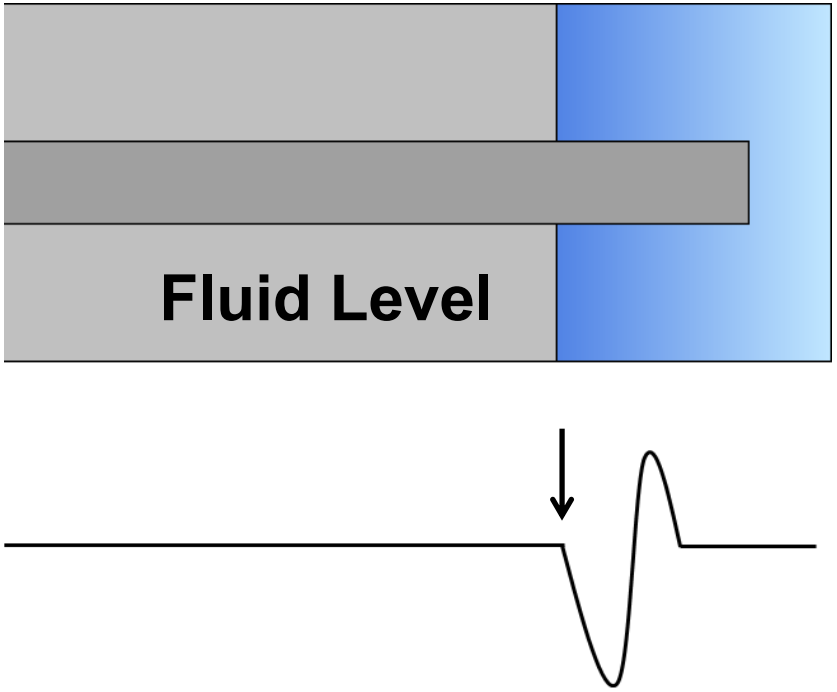


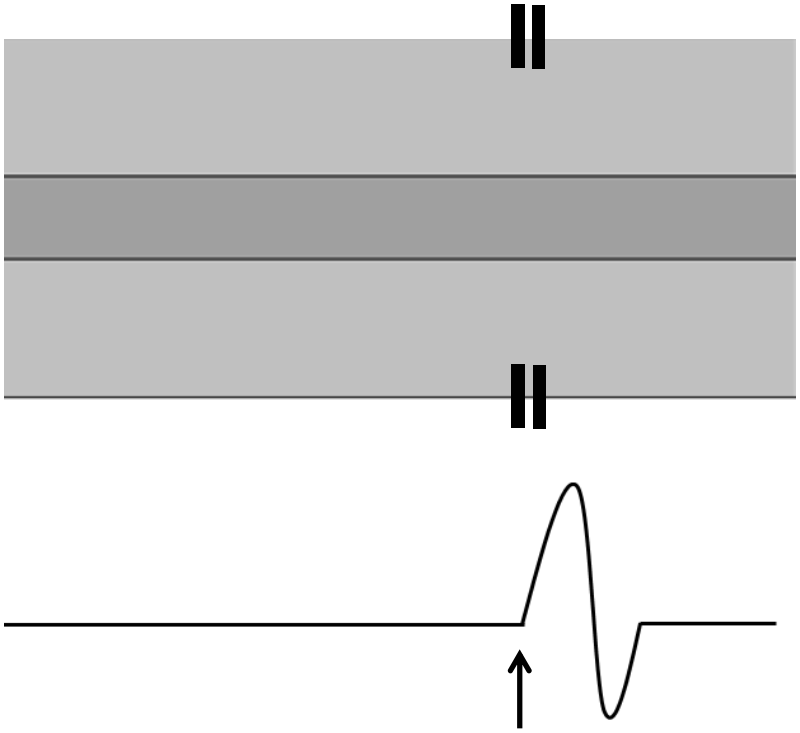
With Charger



Without Charger

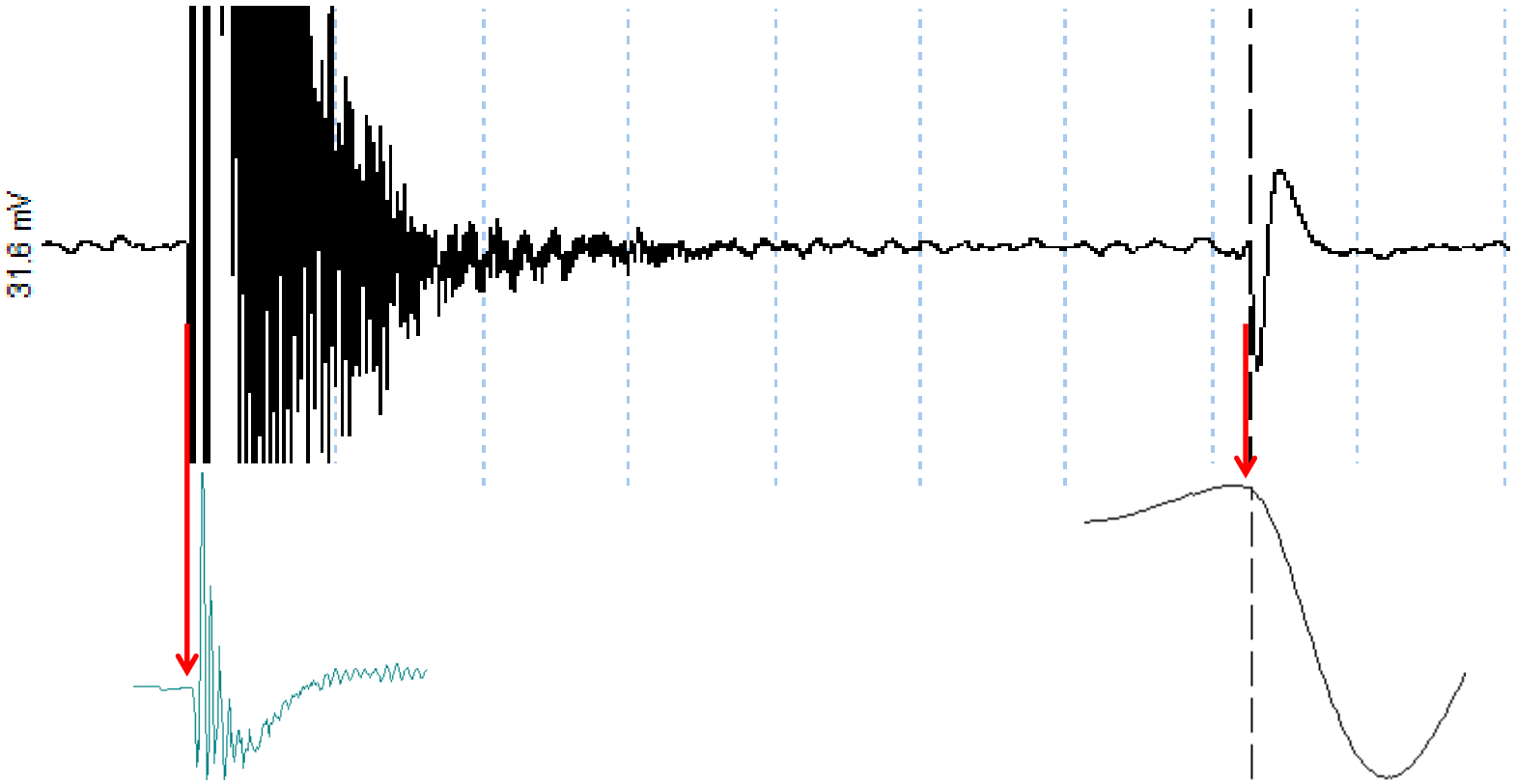
Direction of Kick





Normal Well – Liquid Level Echo

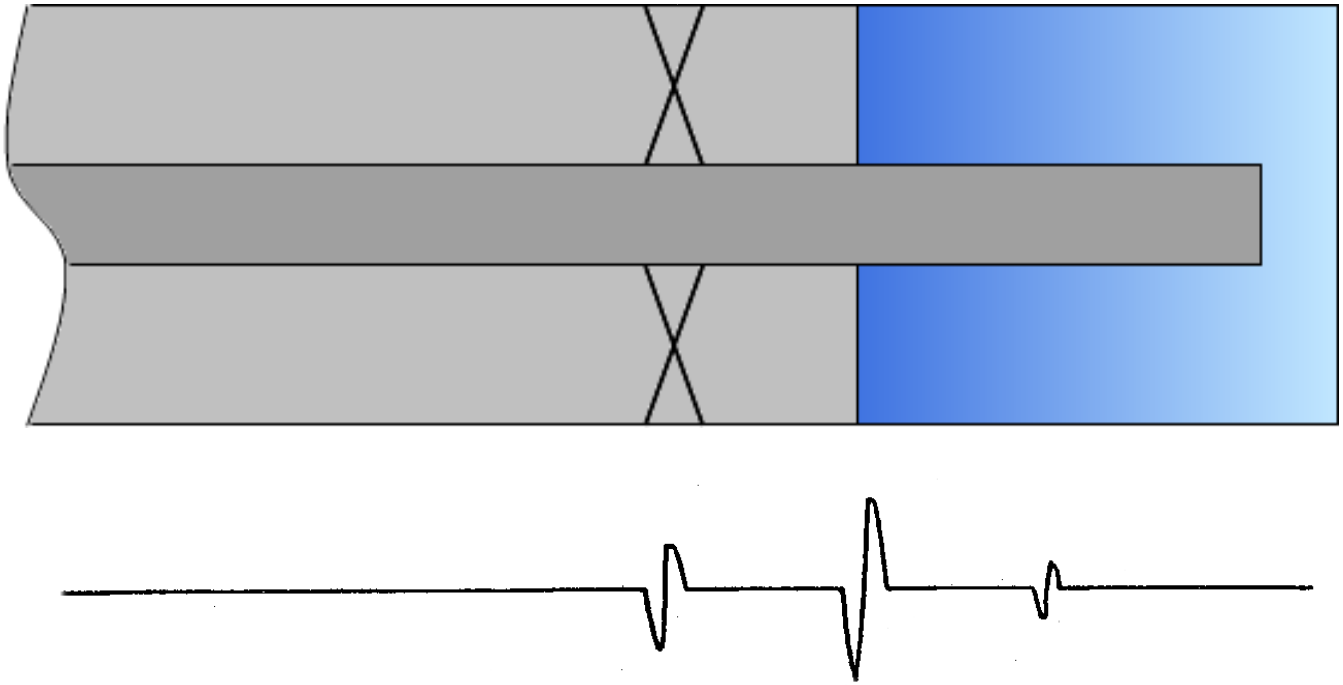
Polarity of echo same as polarity of pulse generated by gas gun



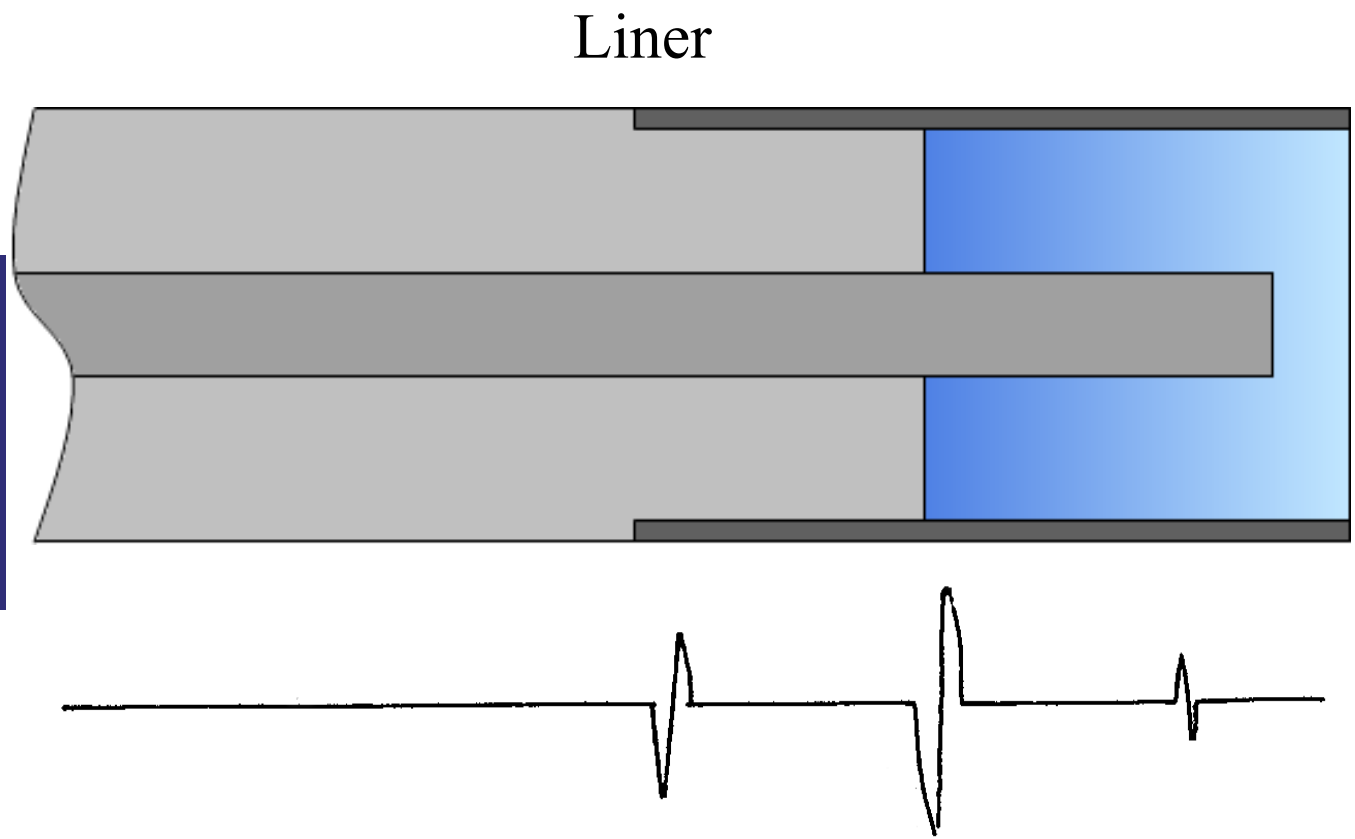
Downward kick when shot goes off = Downward kick at the Fluid Level

Tubing Anchor

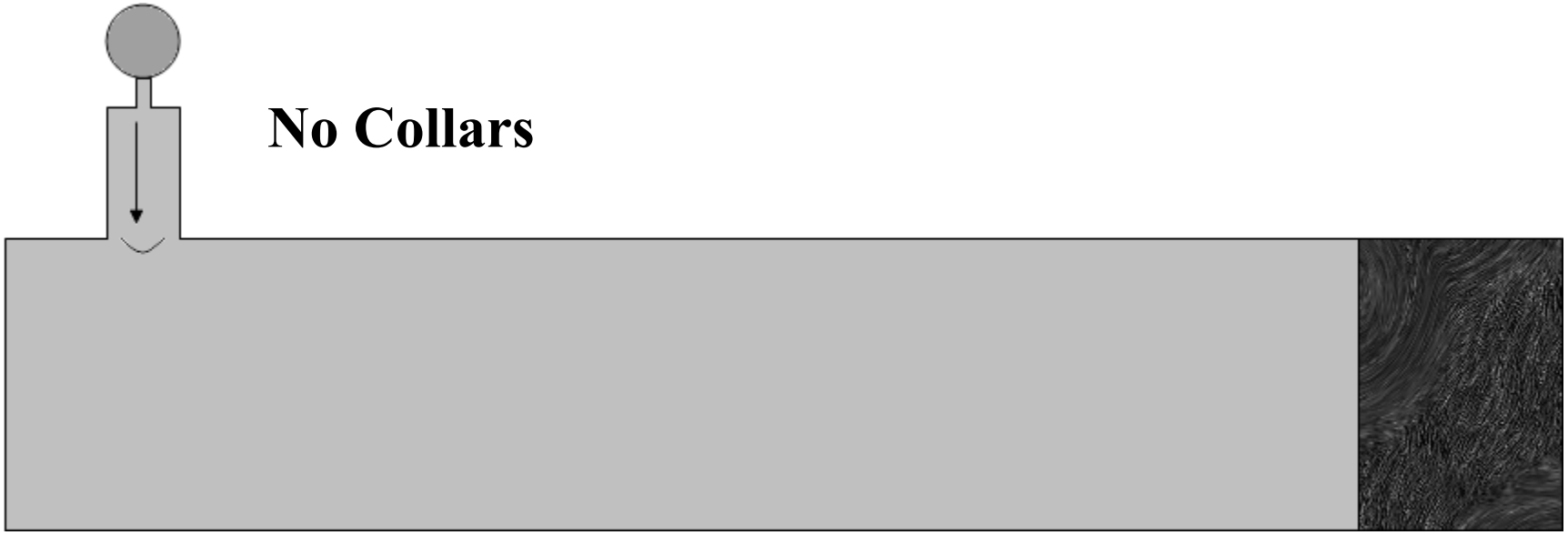
Direction of Kick



Direction of Kick



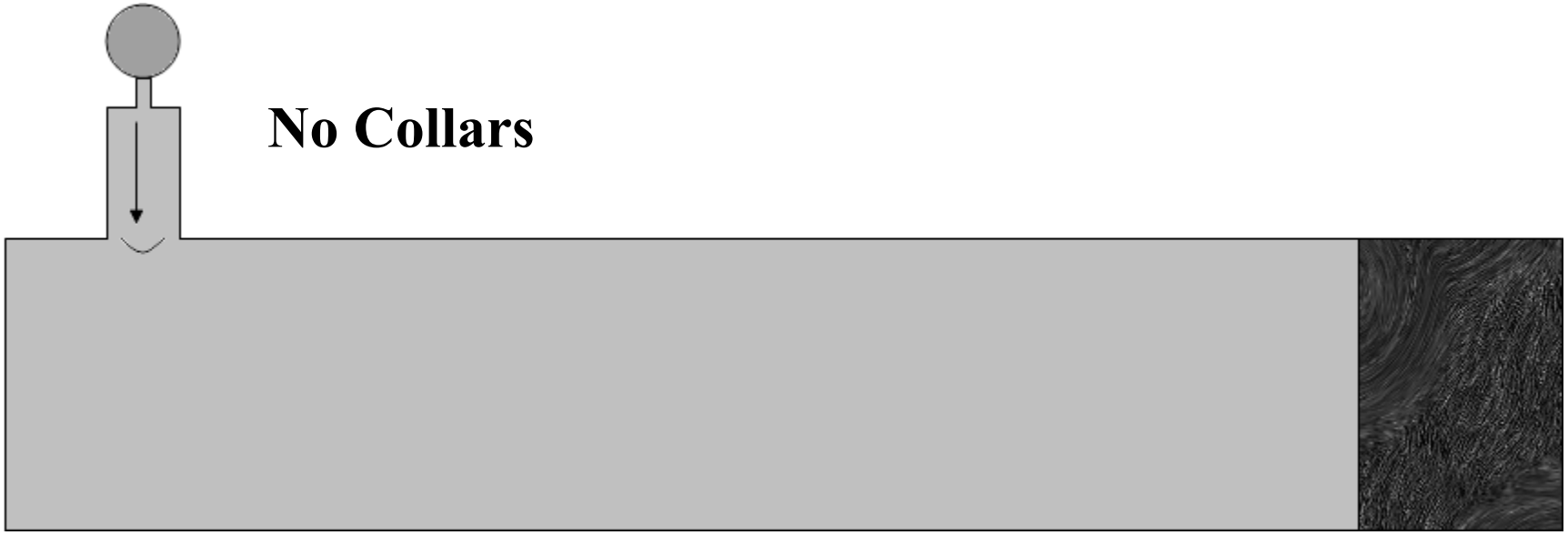
Fluid Level Shot Without Collars



$$D = \frac{T \times V}{2}$$

Where:
D = Distance to Liquid (Feet)
T = Time to Liquid Level (Seconds)
V = Velocity of Signal (Feet per Second)

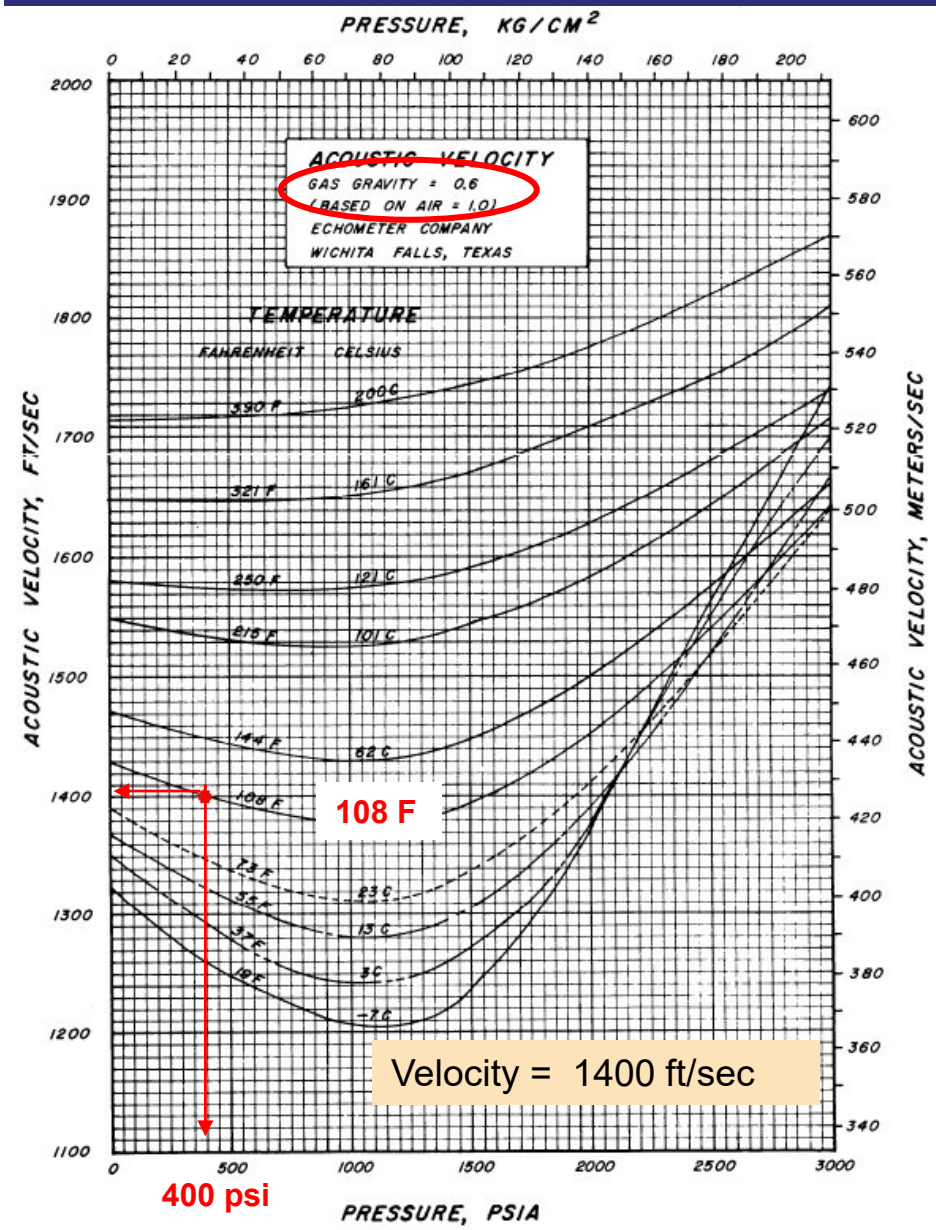
Fluid Level Shot Without Collars

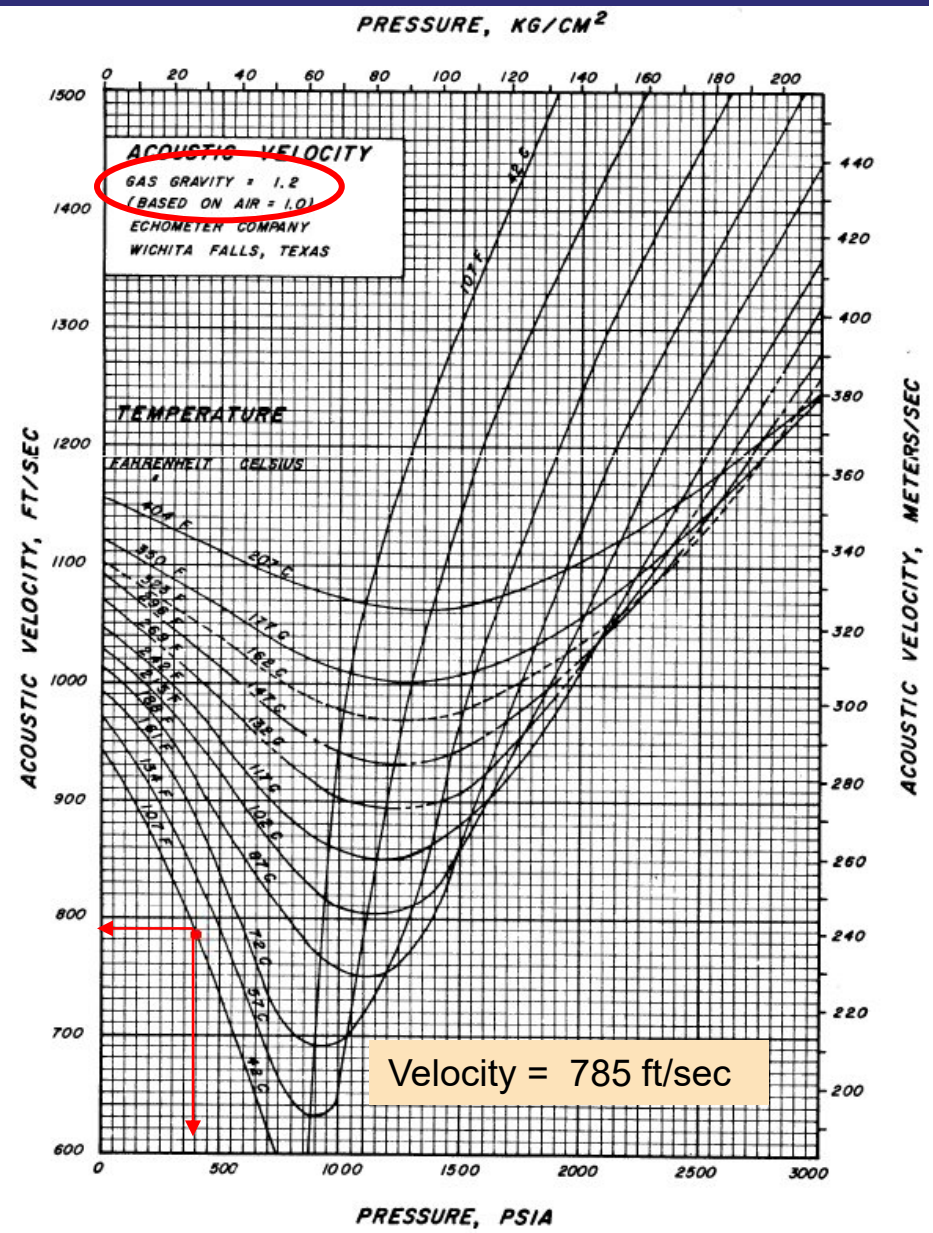


$$D = \frac{T \times V}{2} = \frac{19 \times 1120}{2} = 10{,}640 \text{ FT}$$

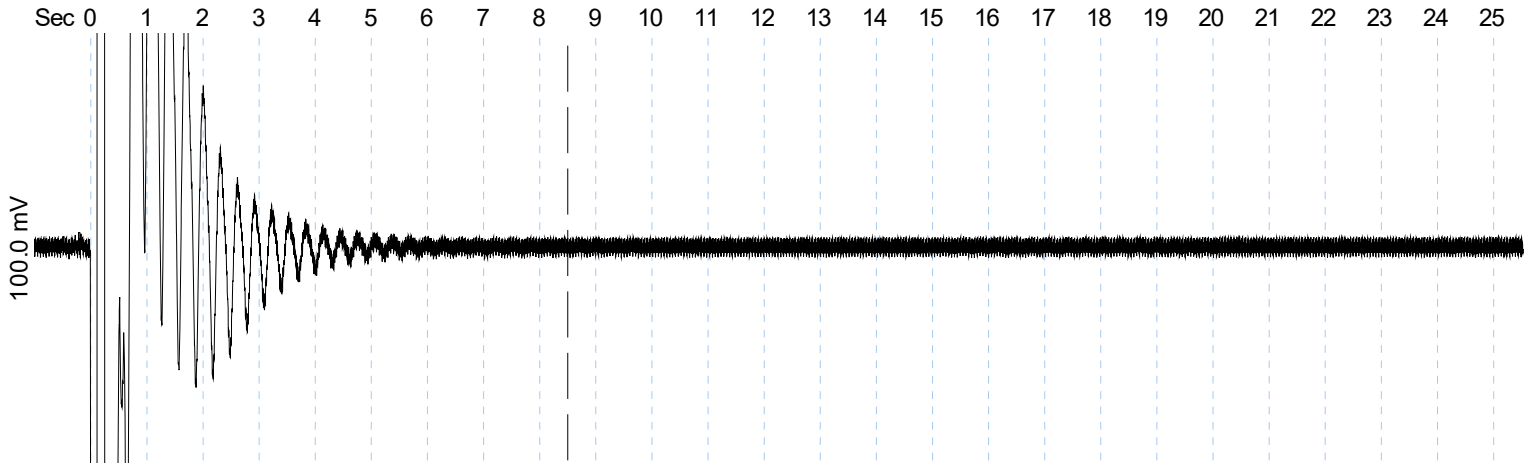
T = 19 sec
V = 1120 ft/sec

Acoustic Velocity of Gases Depends on P, T and Specific Gravity:



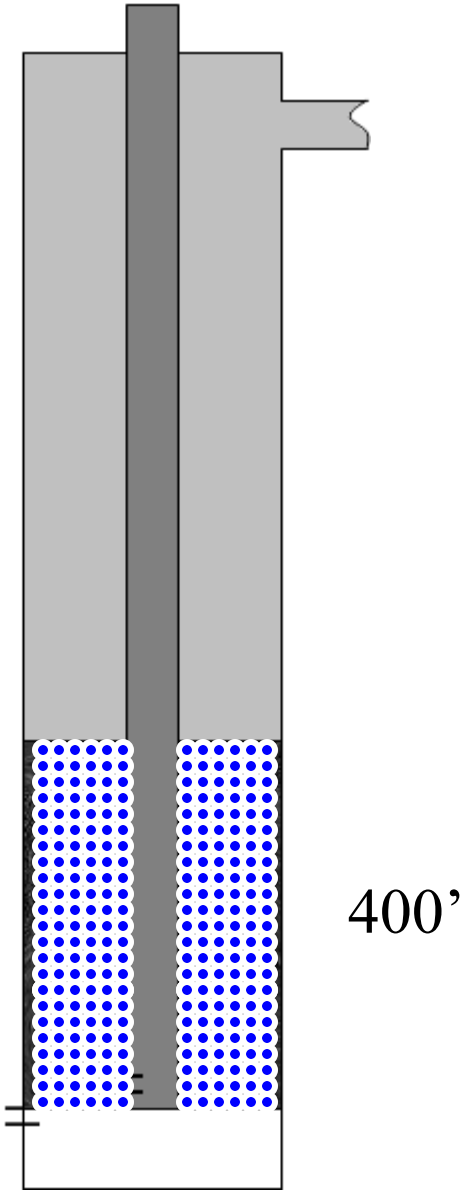


High Fluid Levels



Use a lower pressure differential in the volume chamber.

Foam



Foam Columns consist of stable small gas bubbles surrounded by oil. The gas bubbles are less than 0.1 inch in diameter and are not moving.

<u>Characteristics</u>

1. Negligible Downhole Noise
2. Weak Liquid Level Response
3. Foam Columns less than 400’ high
4. No Gas venting from Casing

<u>Shooting Technique</u>

- Use a large charge on the gas gun.
- Use a larger volume chamber if necessary.

Depth to Liquid Level NOT Obvious

- **Charts do not repeat**
- **Multiple Downhole Reflections**
- **Liquid Level Below Liquid Entry**
- **Liquid Level Below Partial Annulus Obstruction**

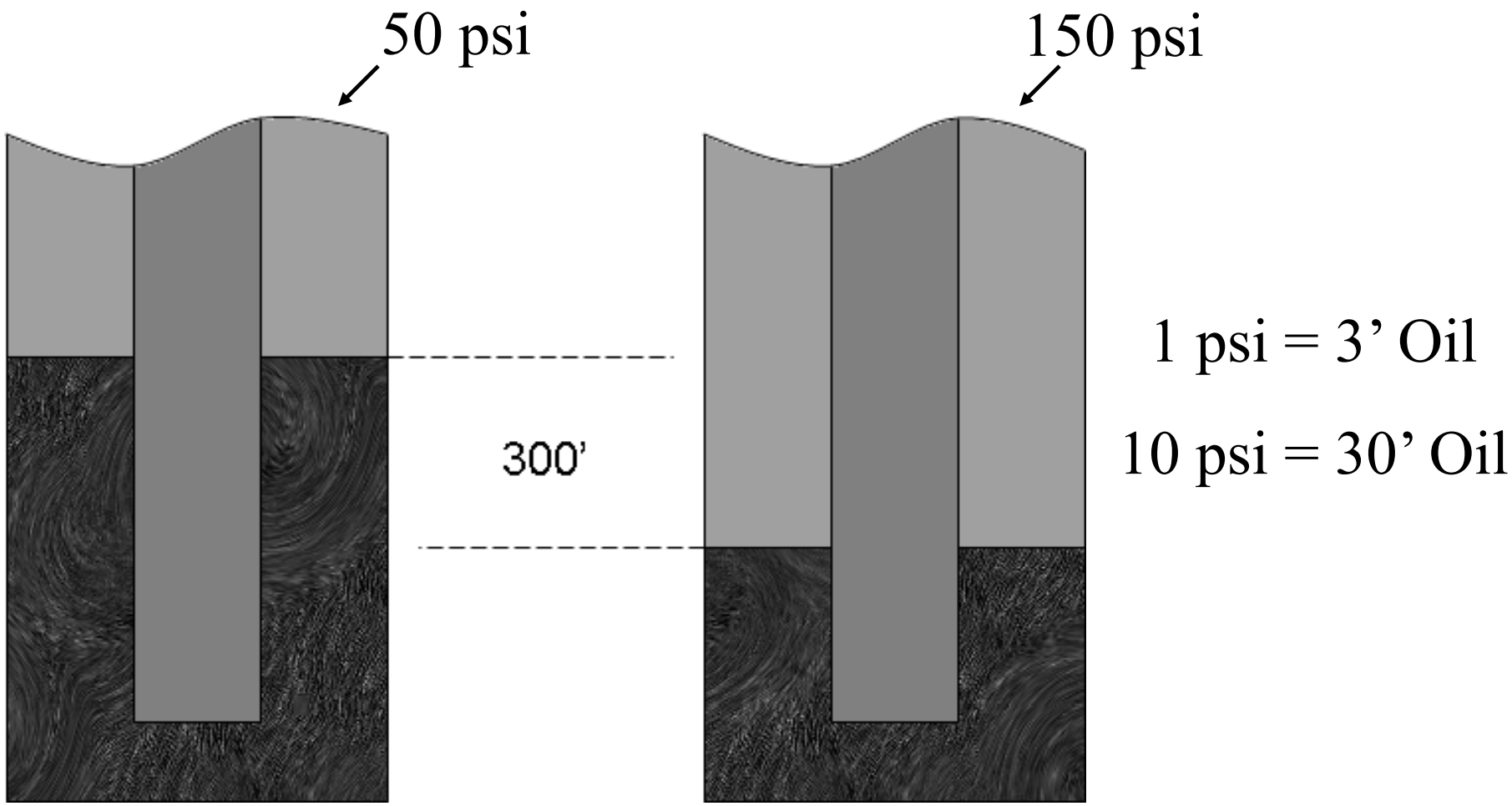
Then Move the Liquid Level

- **RAISED by shutting down Producing Well.**

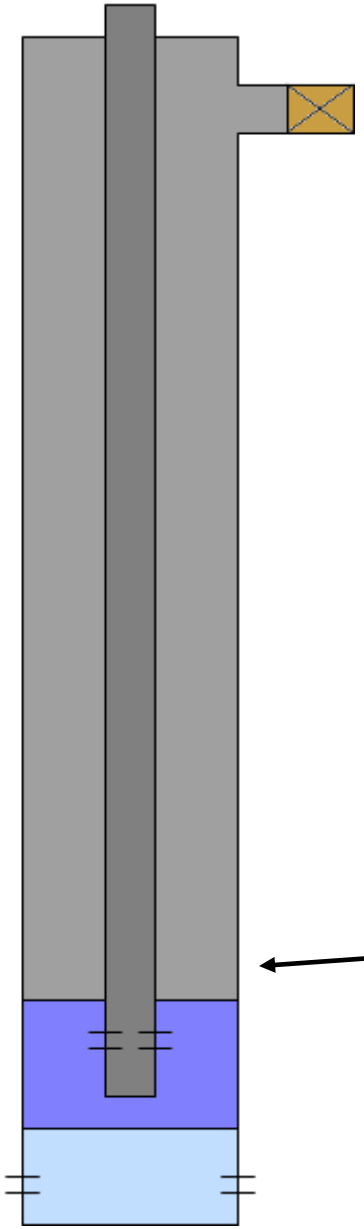
- **DEPRESSED by increasing casing pressure, if casing gas is produced.**

Proving Liquid Level

If the Liquid Level is high and Casing Gas is available, increase the Casing Pressure to depress the Liquid Level.



Liquid Level Depression Below Bottom of Tubing



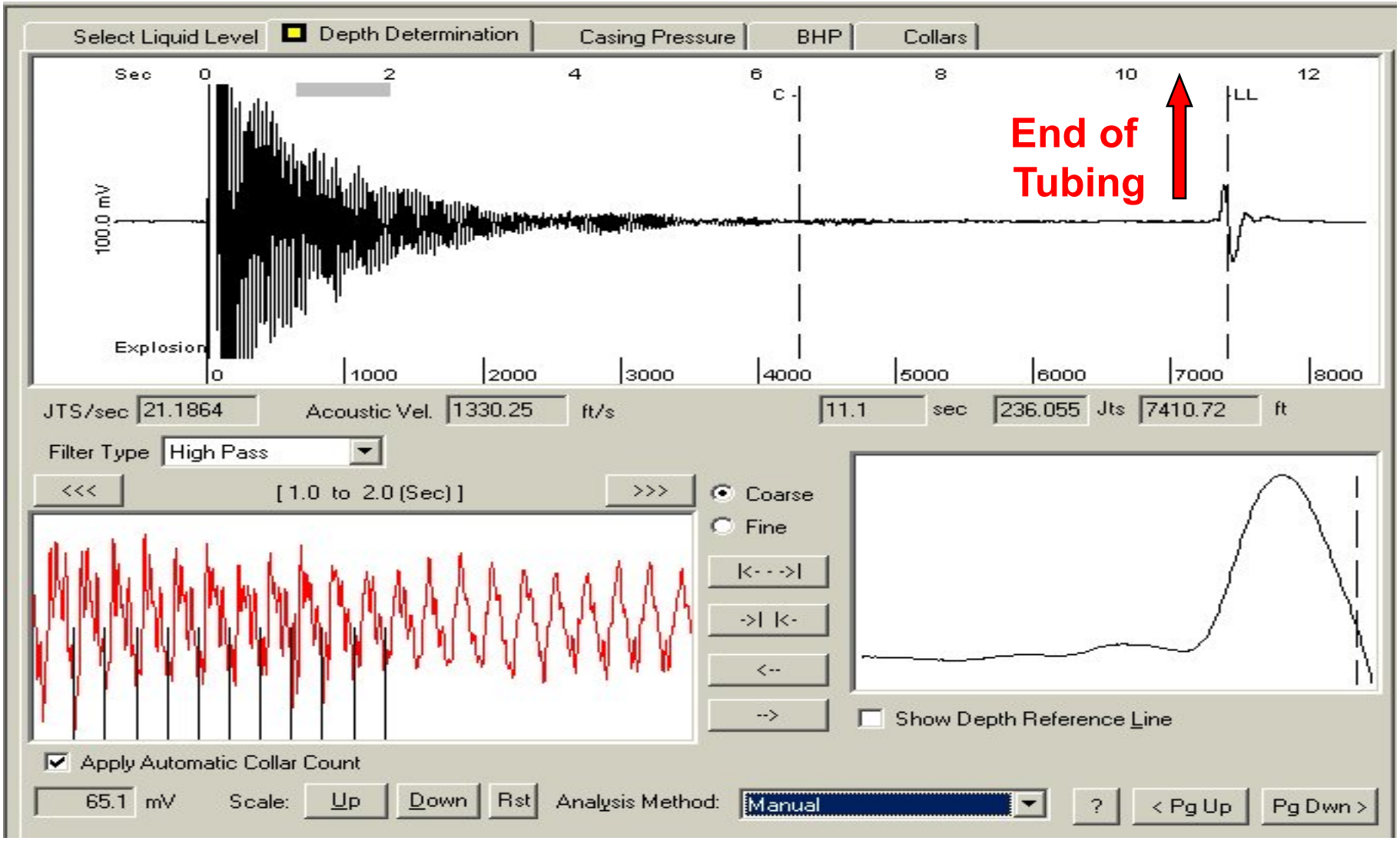
A rapid buildup in Casing Pressure when the Casing Valve is closed can depress the Liquid Level below the bottom of the Tubing and result in a Rarefaction (Reverse) Kick on the Echometer Chart.

This occurs when the Casing Pressure Buildup Rate exceeds the Liquid Level Pressure FillUp Rate.

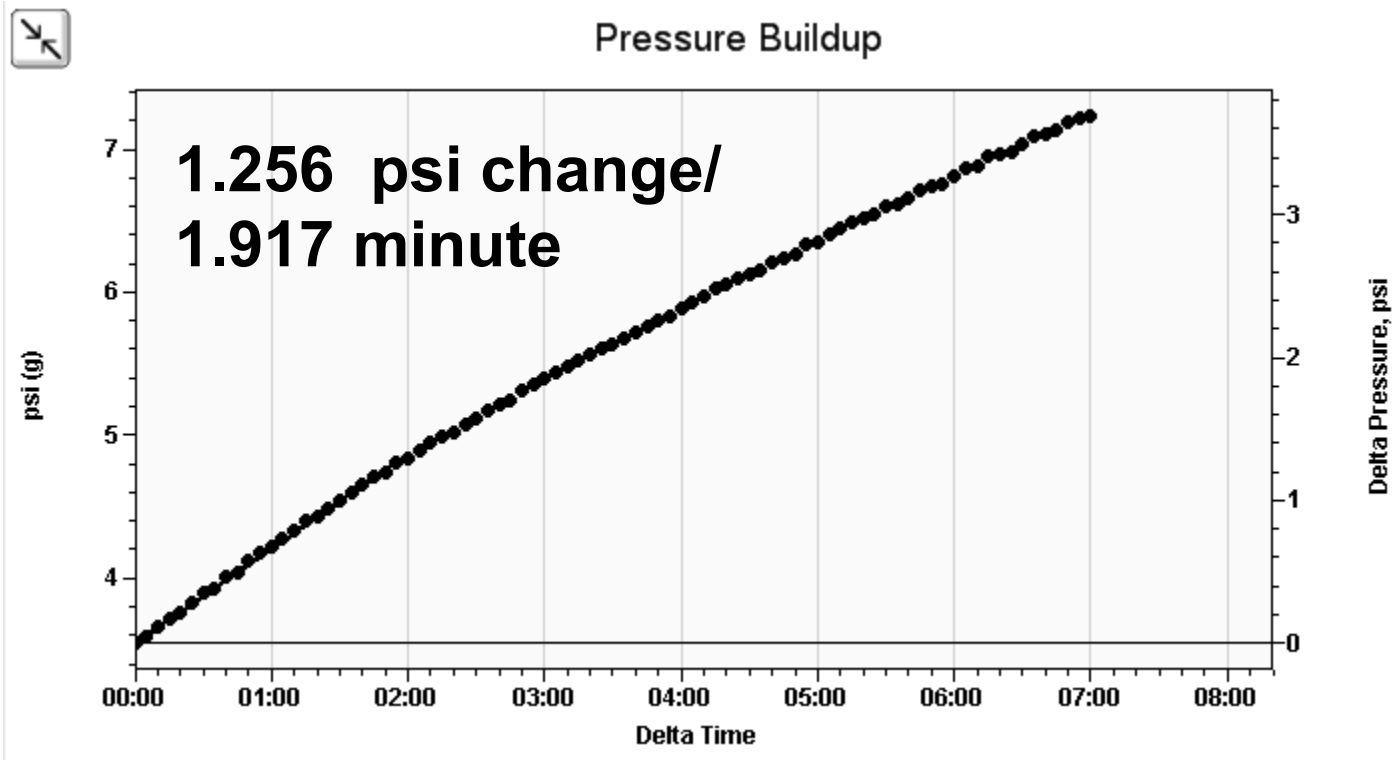
For example, if the initial Liquid Level FillUp Rate is 3 feet per minute, the resulting Pressure Buildup Rate is 1psi per minute. If the Casing Pressure Buildup Rate exceeds 1 psi per minute, the Liquid Level will be depressed.

Casing Pressure increased to
40 psi in 10 minutes

Shot Down Tubing or Casing
Verify LL Above/Below Tubing Inlet



Proved Liquid Level by Moving It with Increased Casing Pressure



Shot 1:
02:16:23 PM
Casing 3.5 Psi

Shot 2:
02:24:48 PM
Casing 7.9 Psi

change = 4.4 psi
change ~ 8.8 feet

Salt Water Gradient 0.50 psi/ft = 2 ft change / 1 psi change

Condensate Gradient 0.333 psi/ft = 3 ft change / 1 psi change

Gassy Loaded Gradient >0.1 psi/ft = 10-15 ft change / 1 psi change

Increasing Casing Pressure by 4.4 Psi Should Depress Gassy Fluid > 8.8 Feet

Shot 1: 02:16:23 PM

Distance To Liquid **392 ft**

Fluid Above Pump **52 ft**

Equivalent Gas Free Above Pump **48 ft**

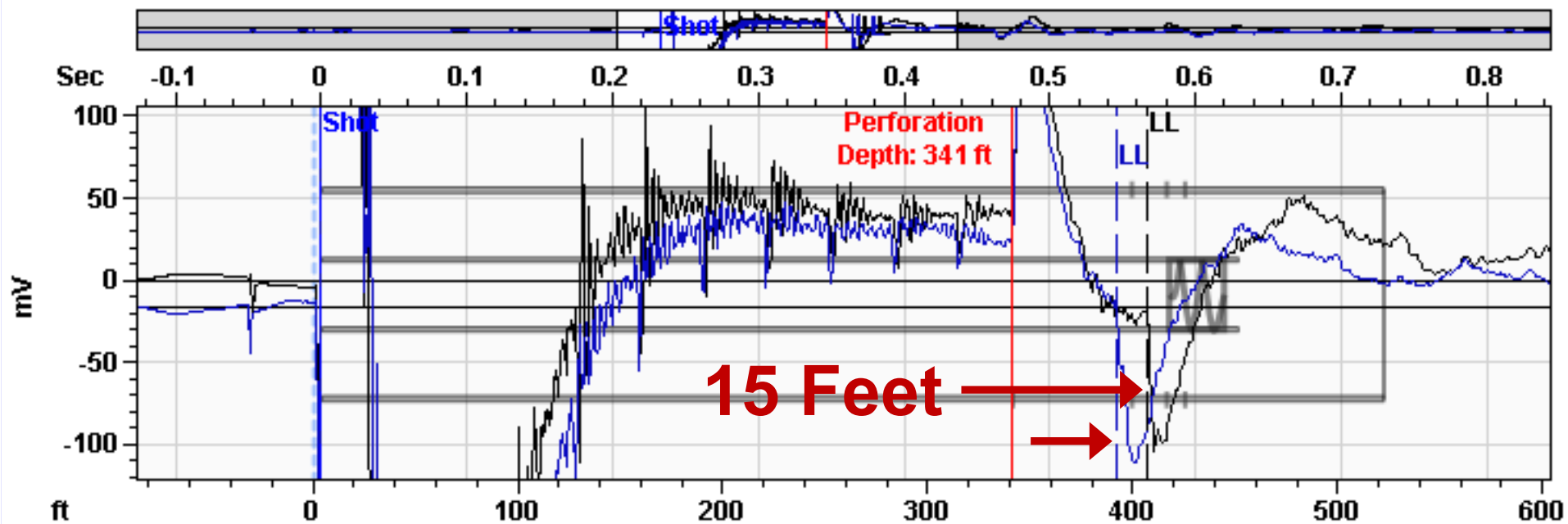
Shot 2 02:24:48 PM

Distance To Liquid **407 ft**

Fluid Above Pump **37 ft**

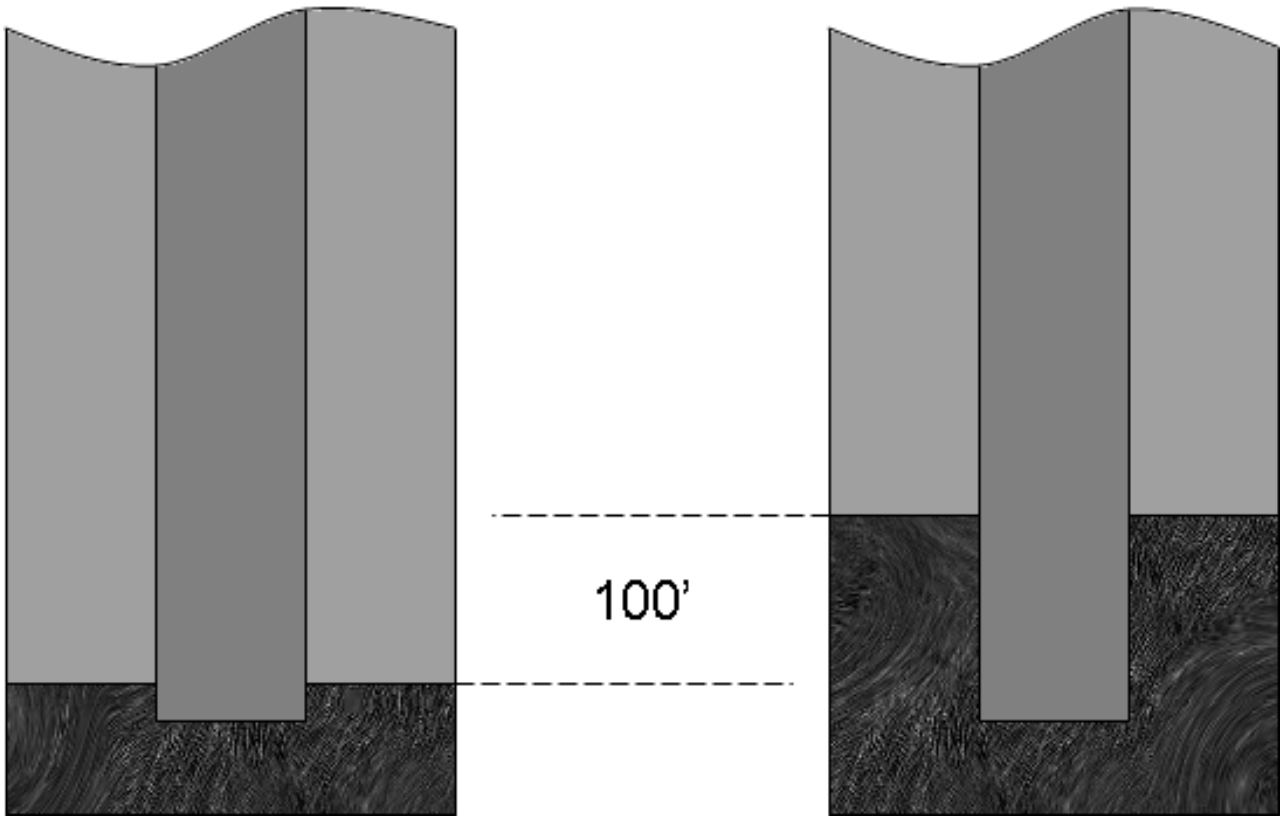
Equivalent Gas Free Above Pump **35 ft**

RTTT (sec) **0.567** #JTS **12.98** AV **1422 ft/s** Jts/sec **22.66**

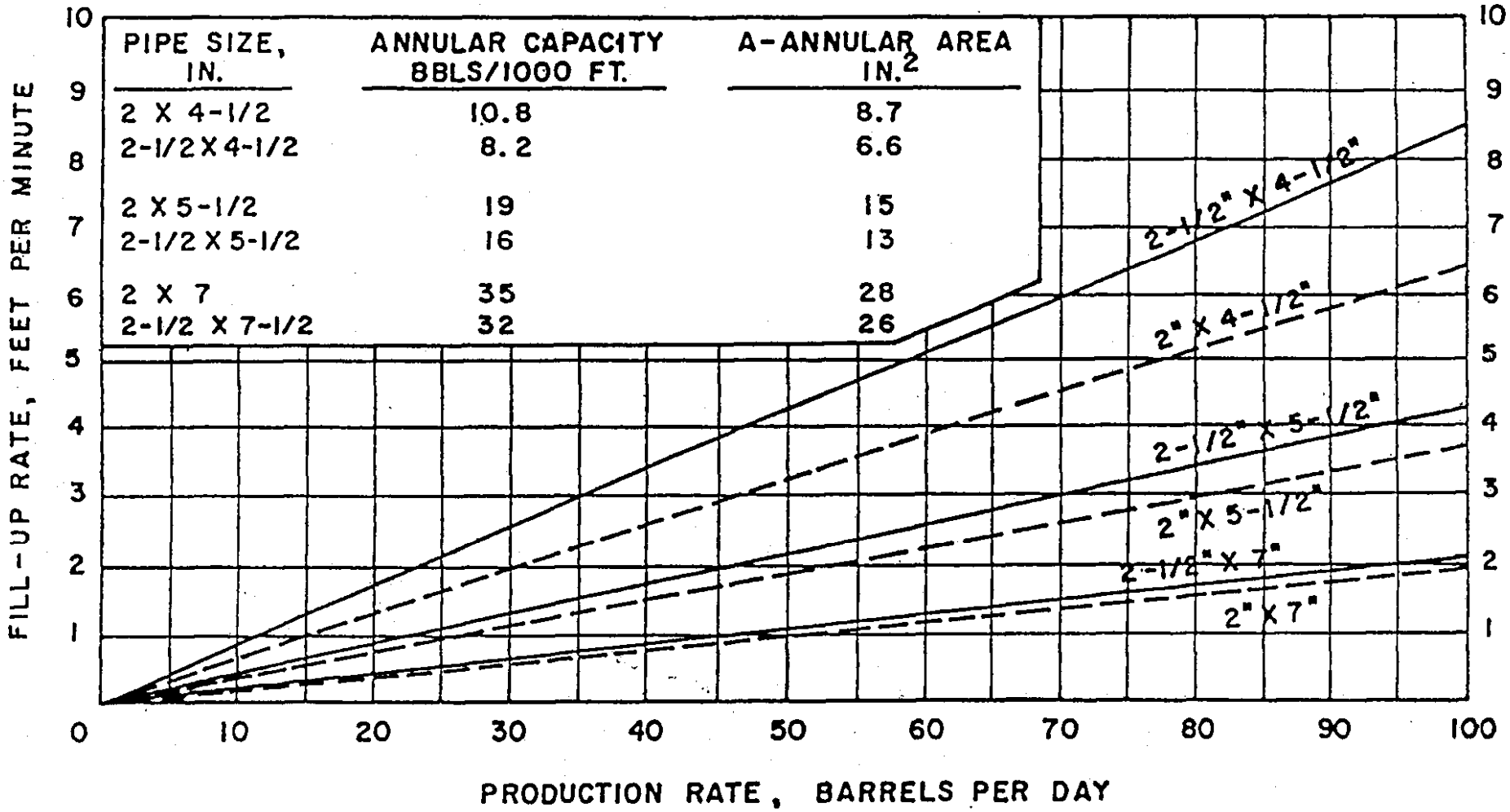


Proving Liquid Level

If the Liquid Level is at the Pump, or Casing Gas is not available, stop pumping the Well. The initial Fill-Up Rate shown on the chart should agree with the Fluid Level Data.

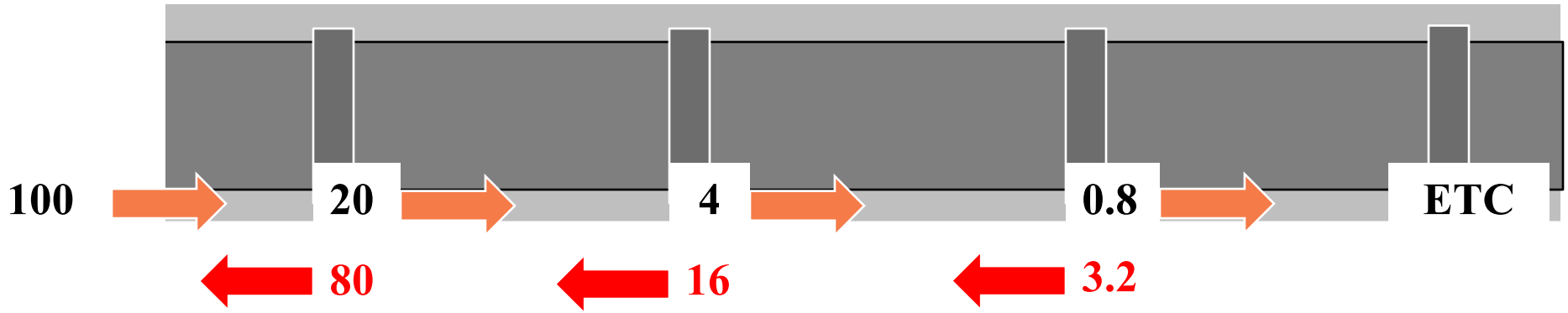


Fill Up Rate for Various Production Rates in Different Sizes of Pipes



Slim Hole, Low Pressure

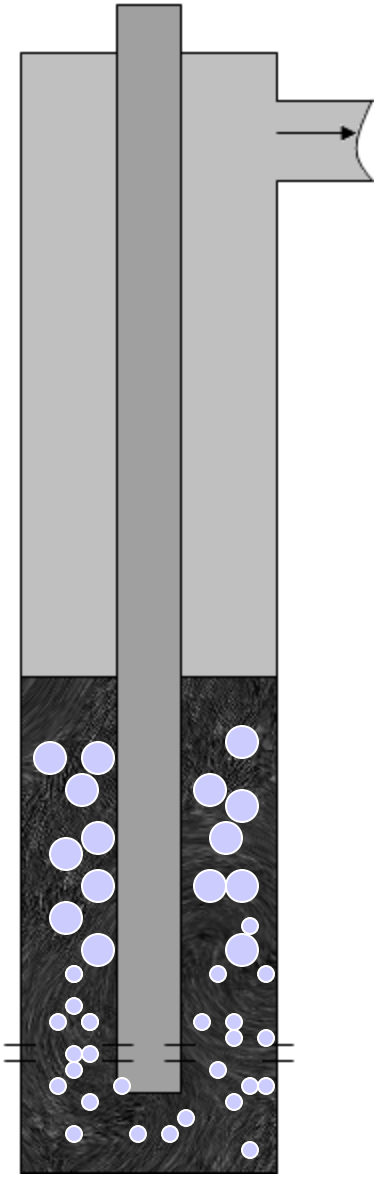
Problem: Each collar reflects a high percentage of the signal back to the surface. Only a very weak signal reaches the bottom of the well and reflects from the Liquid Level.



Shooting Technique:

1) Reduce well noise.
2) Increase casing pressure 5 psi helps carry pressure wave.
3) Use a larger pressure differential (blast) on the gas gun.

Annular Gaseous Columns



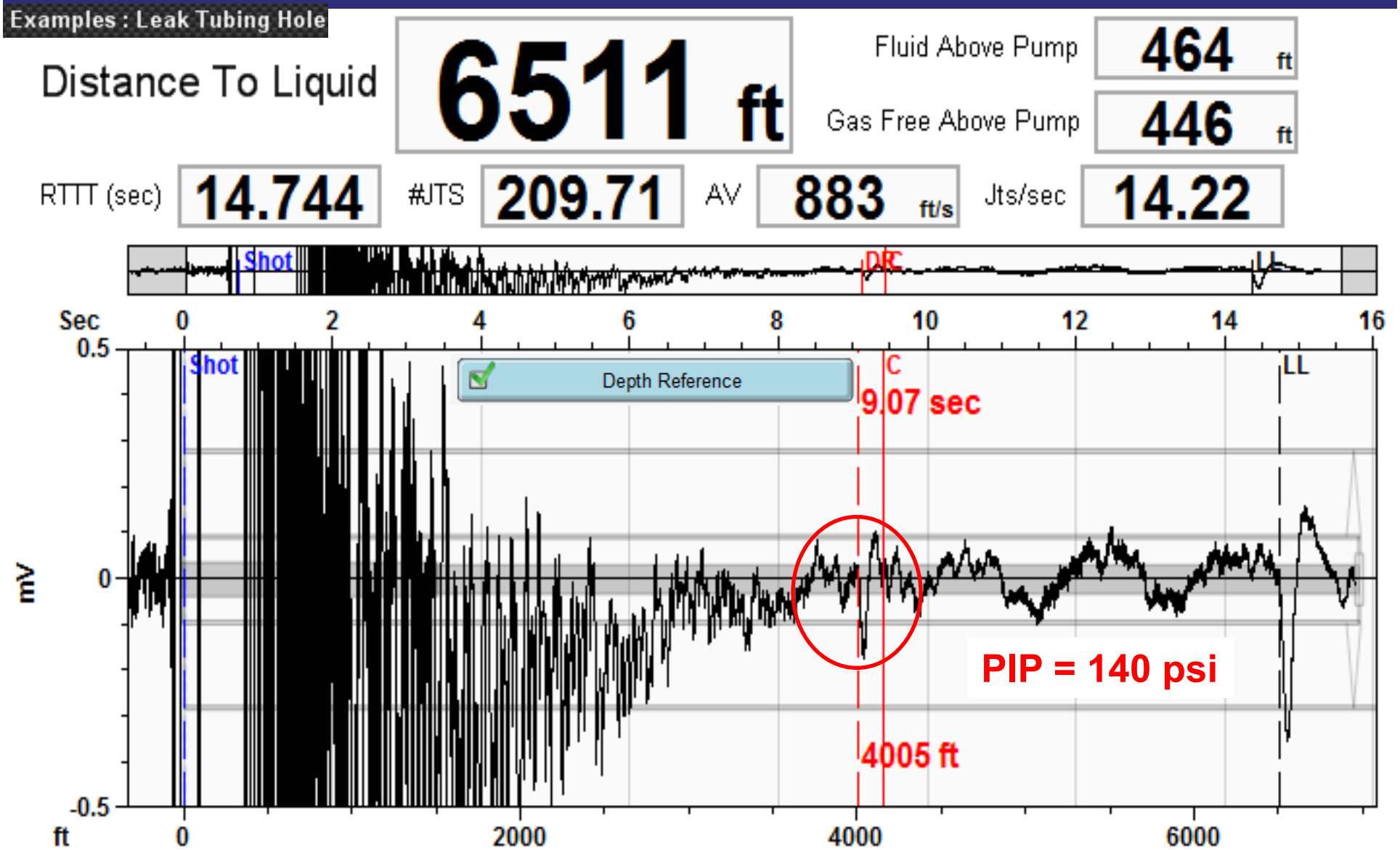
A Gaseous Column is defined as an Oil Column which is lighted by rising bubbles.

Problem: Rising gas bubbles in the Oil Column lighten the Oil Column and hence the producing well bore pressure cannot be easily determined.

<u>Gaseous Column Characteristics</u>

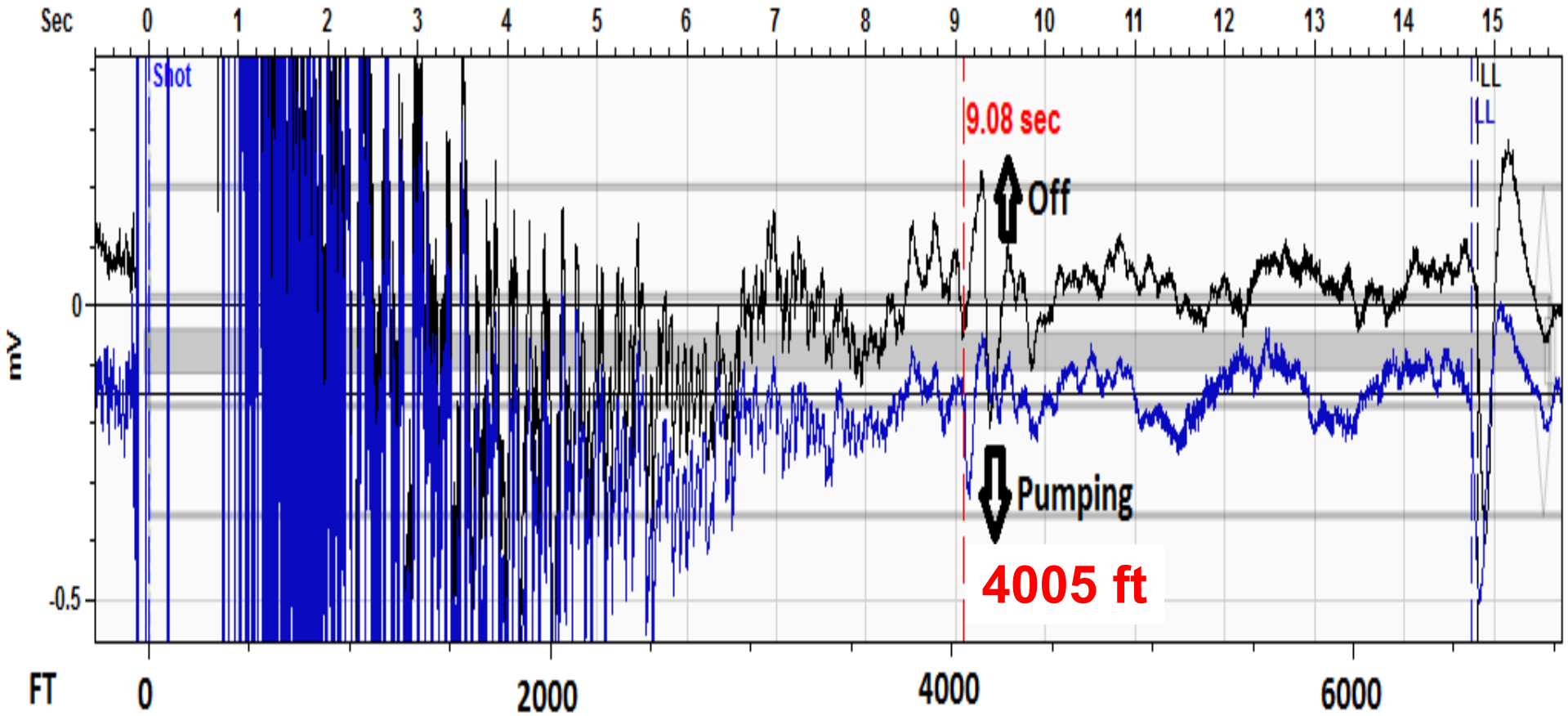
1. Gas must be venting from Casing Annulus
2. Erratic Liquid Levels
3. Considerable Downhole Noise
4. Increase in Casing Pressure when Casing Valves are closed in

Fluid Level 6511’ ~ HIT 4005’

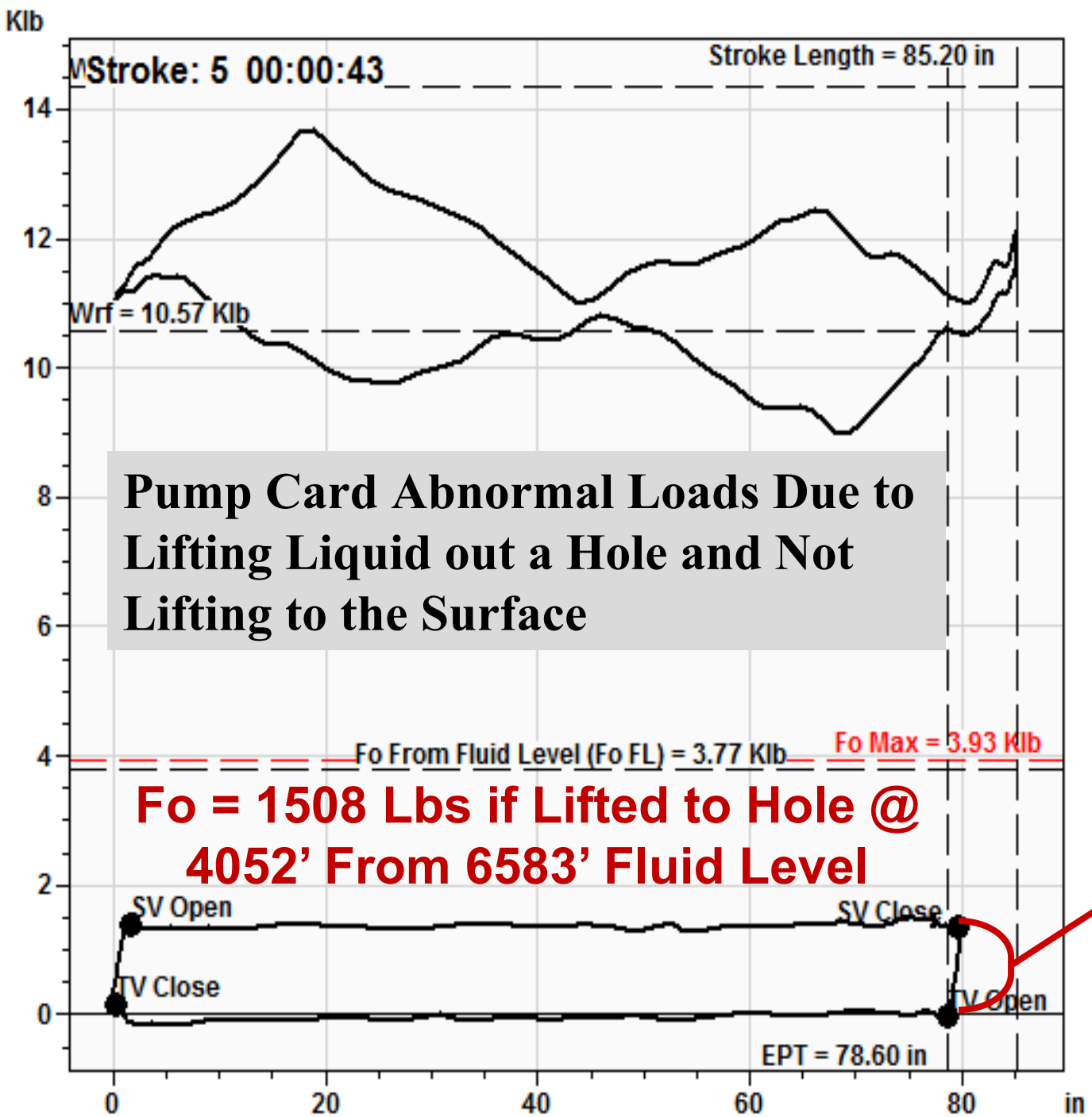


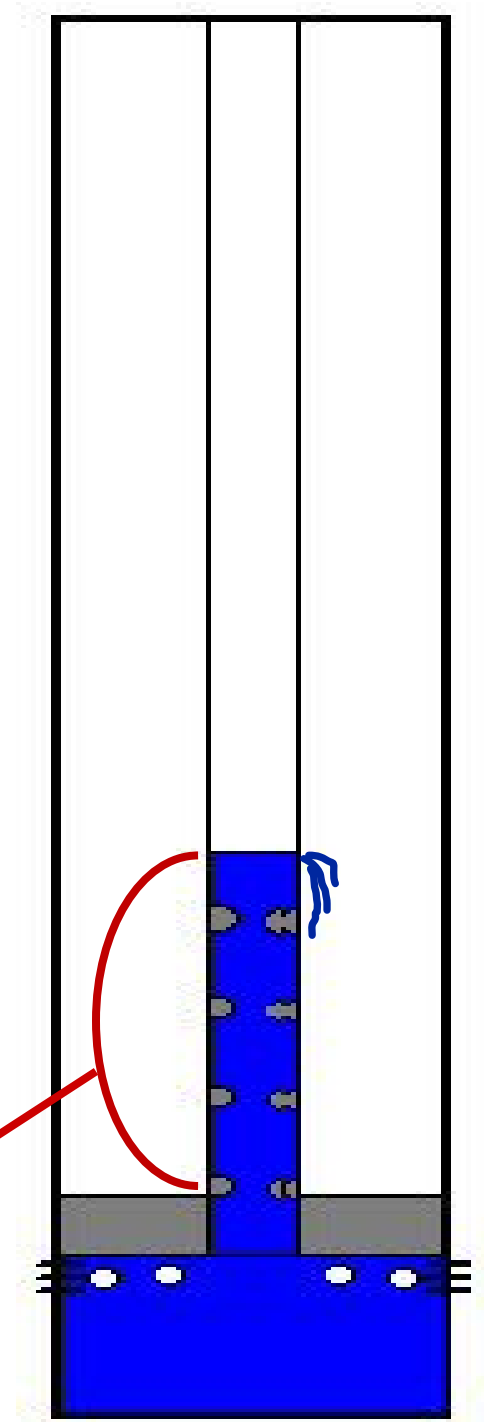
Down Kick from Well Pumping Liquid out Split Tubing Joint

Tubing Leak, No Fluid to Surface



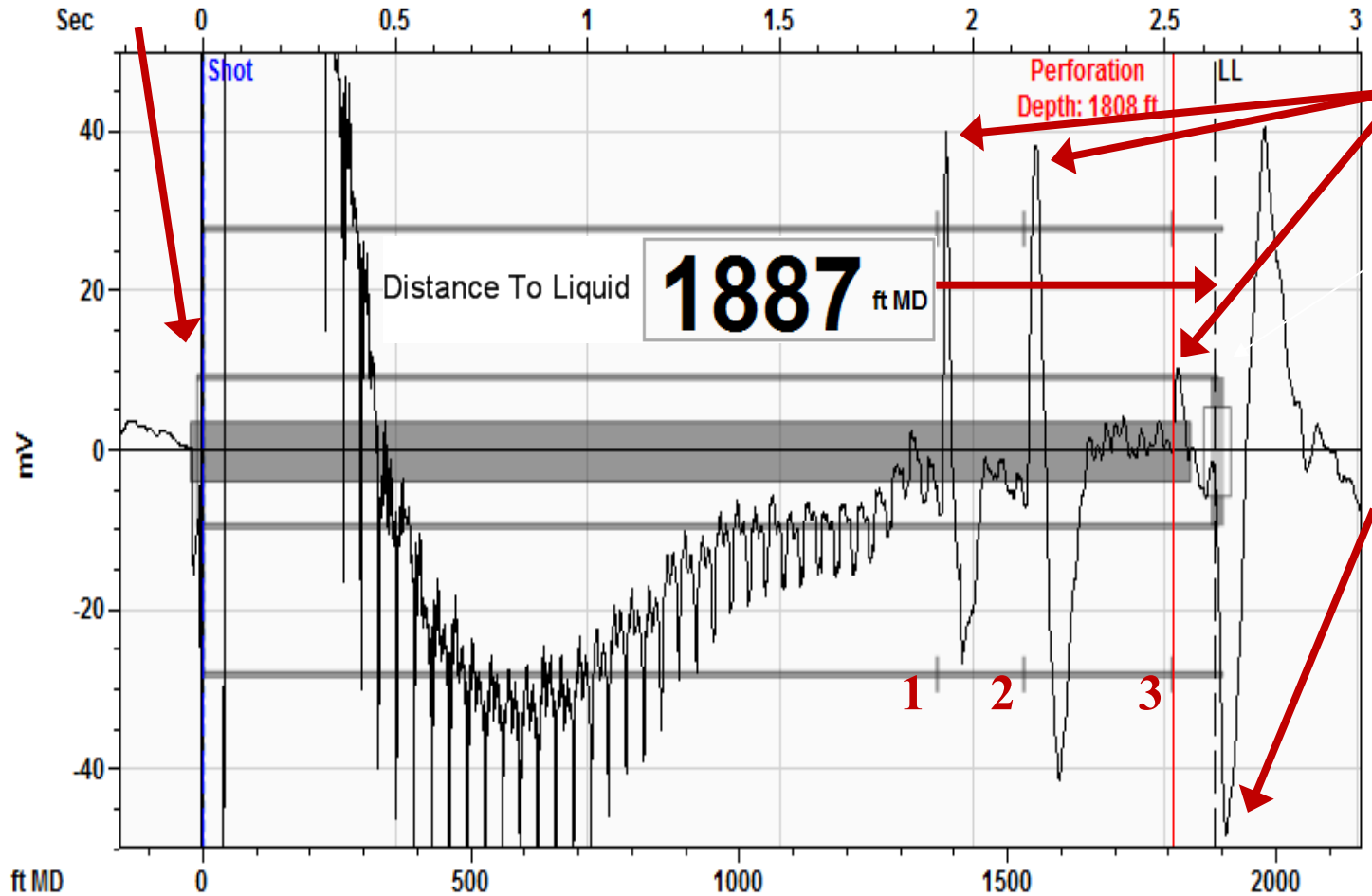
1. Hole in Tubing Shown as *Up Kick* when *Pump Off* and Time has Passed to Allow Liquid to Drain out of Tubing.
2. Hole in Tubing Shown as Down Kick when *Pumping* Liquid Out Tubing Hole into Casing Annulus


Klb
Stroke: 5 00:00:43
Stroke Length = 85.20 in
14
12
10
8
6
4
2
0
Wrf = 10.57 Klb
Pump Card Abnormal Loads Due to Lifting Liquid out a Hole and Not Lifting to the Surface
Fo From Fluid Level (Fo FL) = 3.77 Klb
Fo Max = 3.93 Klb
Fo = 1508 Lbs if Lifted to Hole @ 4052' From 6583' Fluid Level
SV Open
SV Close
TV Close
TV Open
EPT = 78.60 in
0
20
40
60
80
in



Direction of Kick Identifies Downhole Echo

Initial Acoustic Pulse – explosion of compressed gas into the casing annulus forms compression traveling wave.

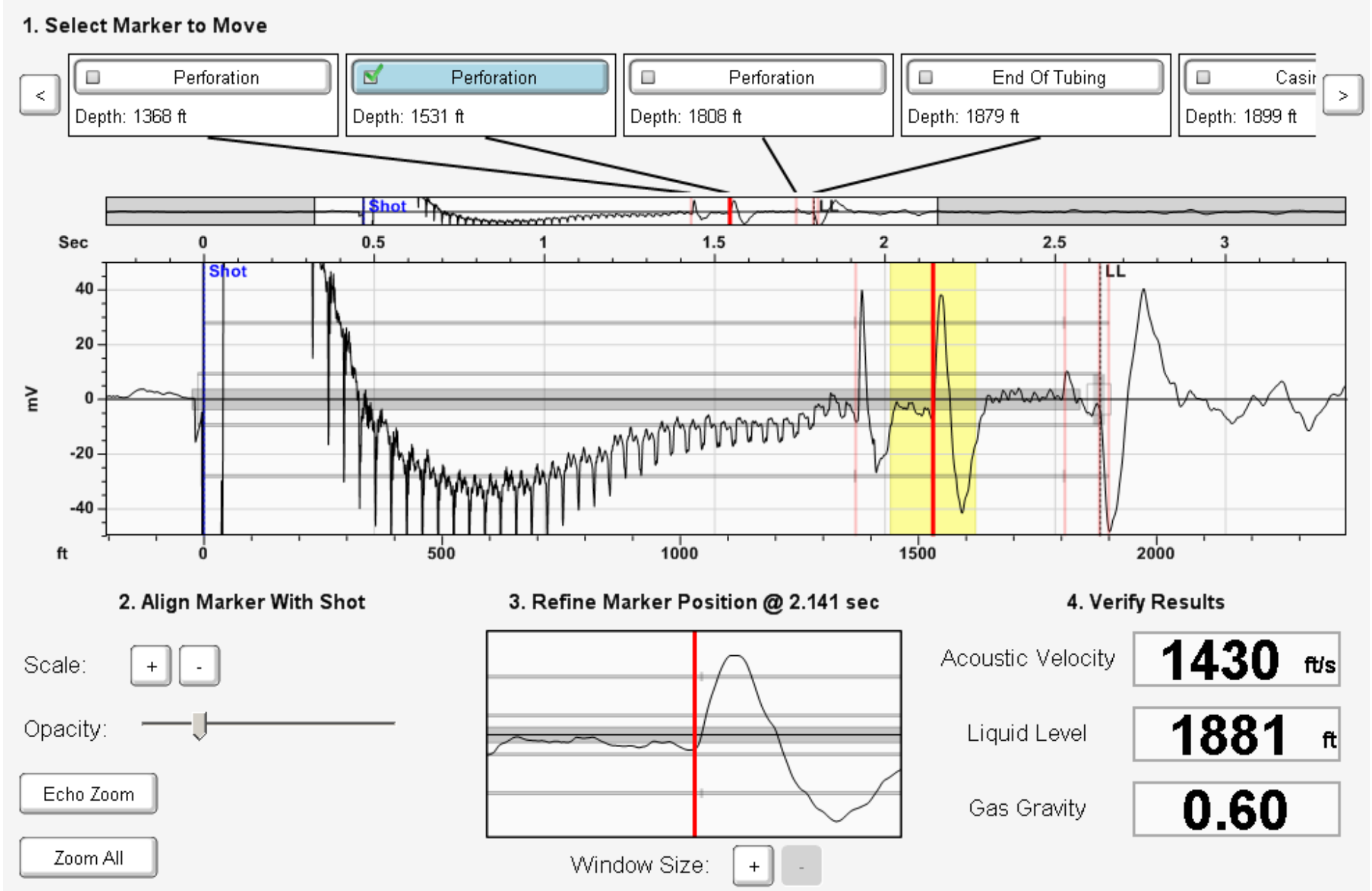


Up Kick– **INCREASE in the annular cross-sectional area displayed as an upward kick on the acoustic trace.**

Down Kick - **DECREASE in the annular cross-sectional area displayed as an downward kick on the acoustic trace.**

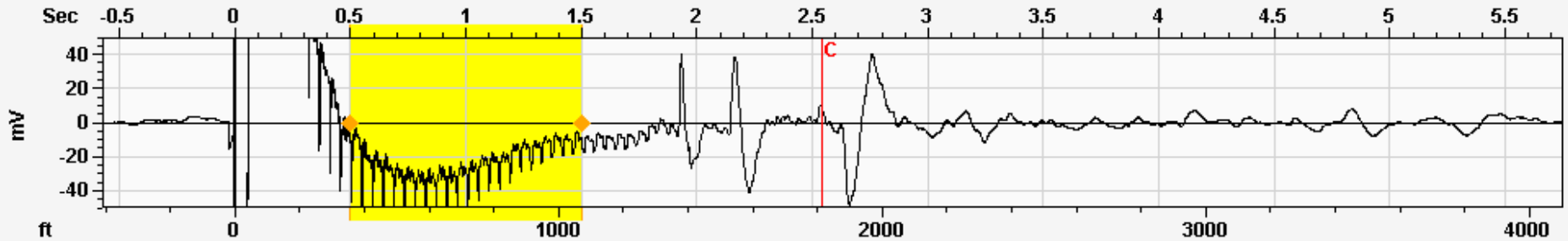
1 Perforation	2 Perforation	3 Perforation	End Of Tubing
Depth: 1369 ft	Depth: 1531 ft	Depth: 1808 ft	Depth: 1889 ft

Determine LL Depth with Known Markers



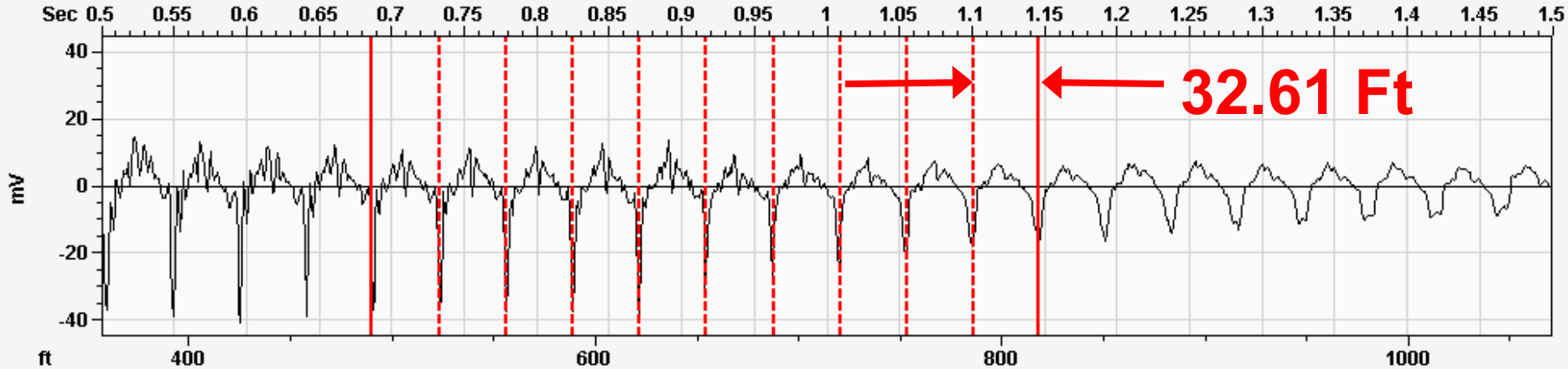
Determine LL Depth by Counting Collars

1. Choose collar region



2. Adjust collar markers

Auto Collar Selection | Manually Adjust Collars | Scale: + -



Raw | HP | BP | HBP

<< < > >>

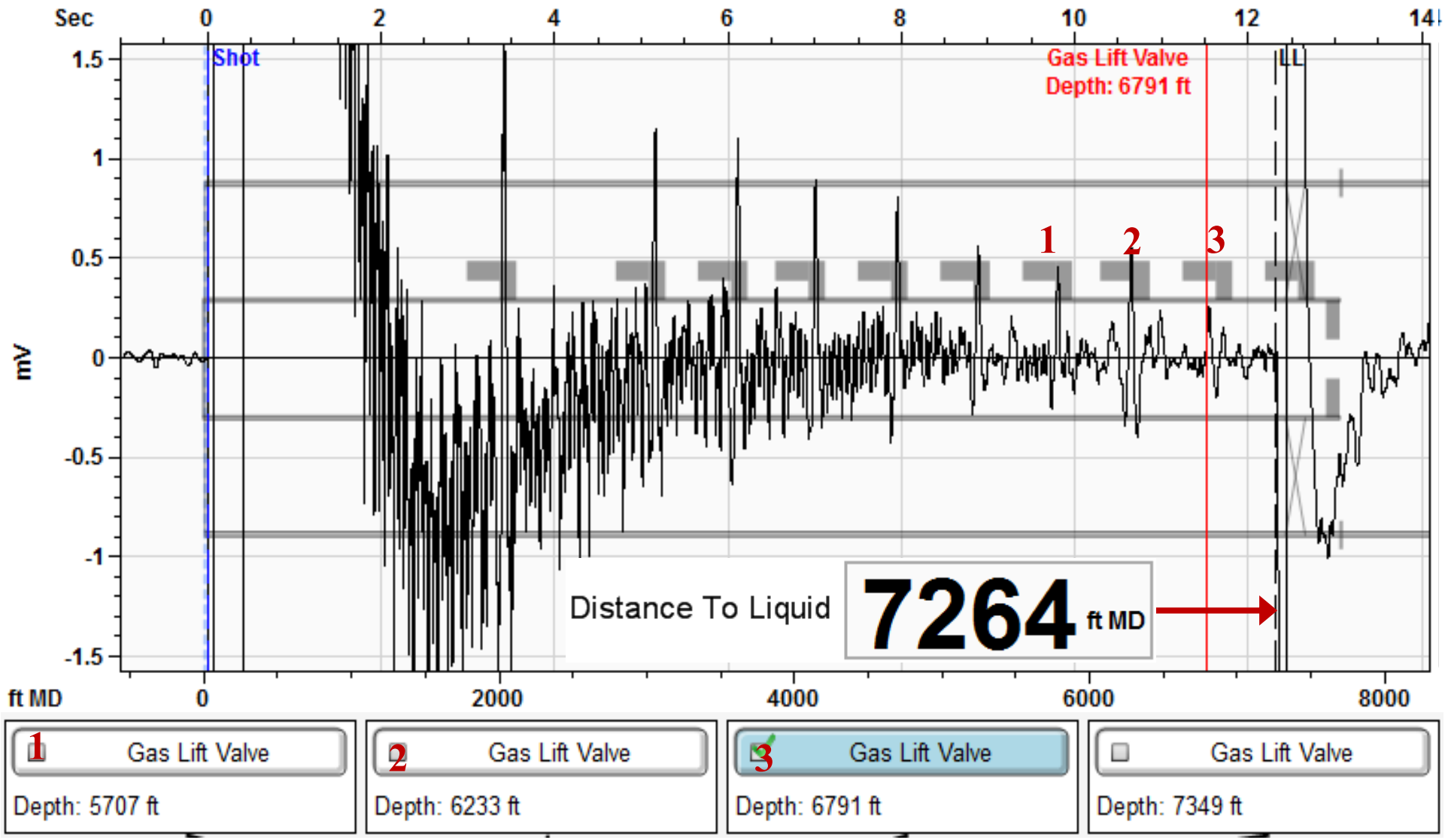
- - - + + +

All Collars | Scale: + -

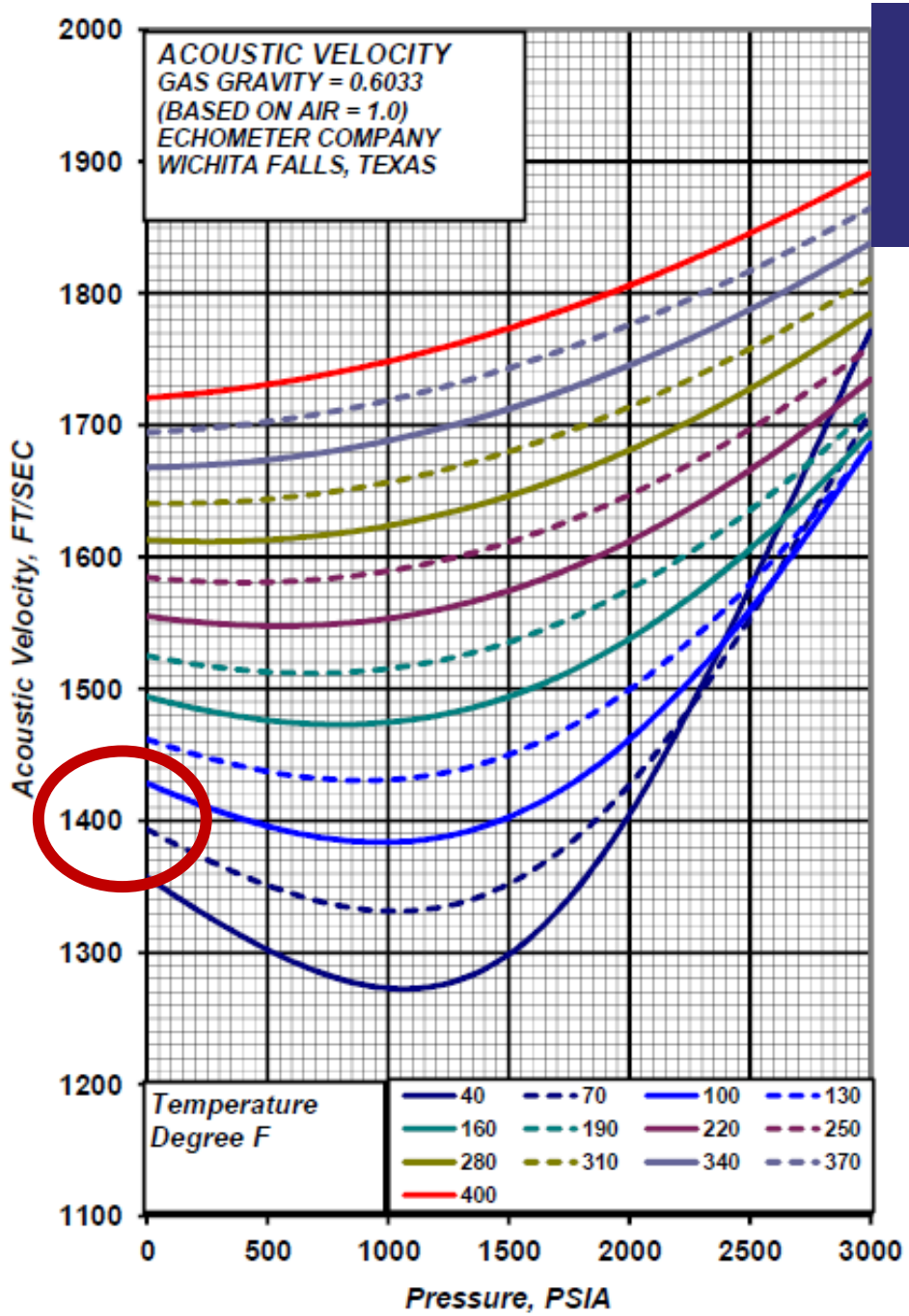
Apply Automatic Collar Count

Interval AV	1418 ft/s	Interval Jts/Sec	21.74	Liquid Level	1879 ft
Average AV	1428 ft/s	Average Jts/Sec	21.89	Gas Gravity	0.60

Wellbore Overlay for Gas-Lift Well: Downhole Marker Method Often Used on Gaslift Wells



Determine Acoustic Velocity in Range



Acoustic Velocity options:

- Manually entered
- Calculated based on SG of gas
- Calculated based on compositional analysis

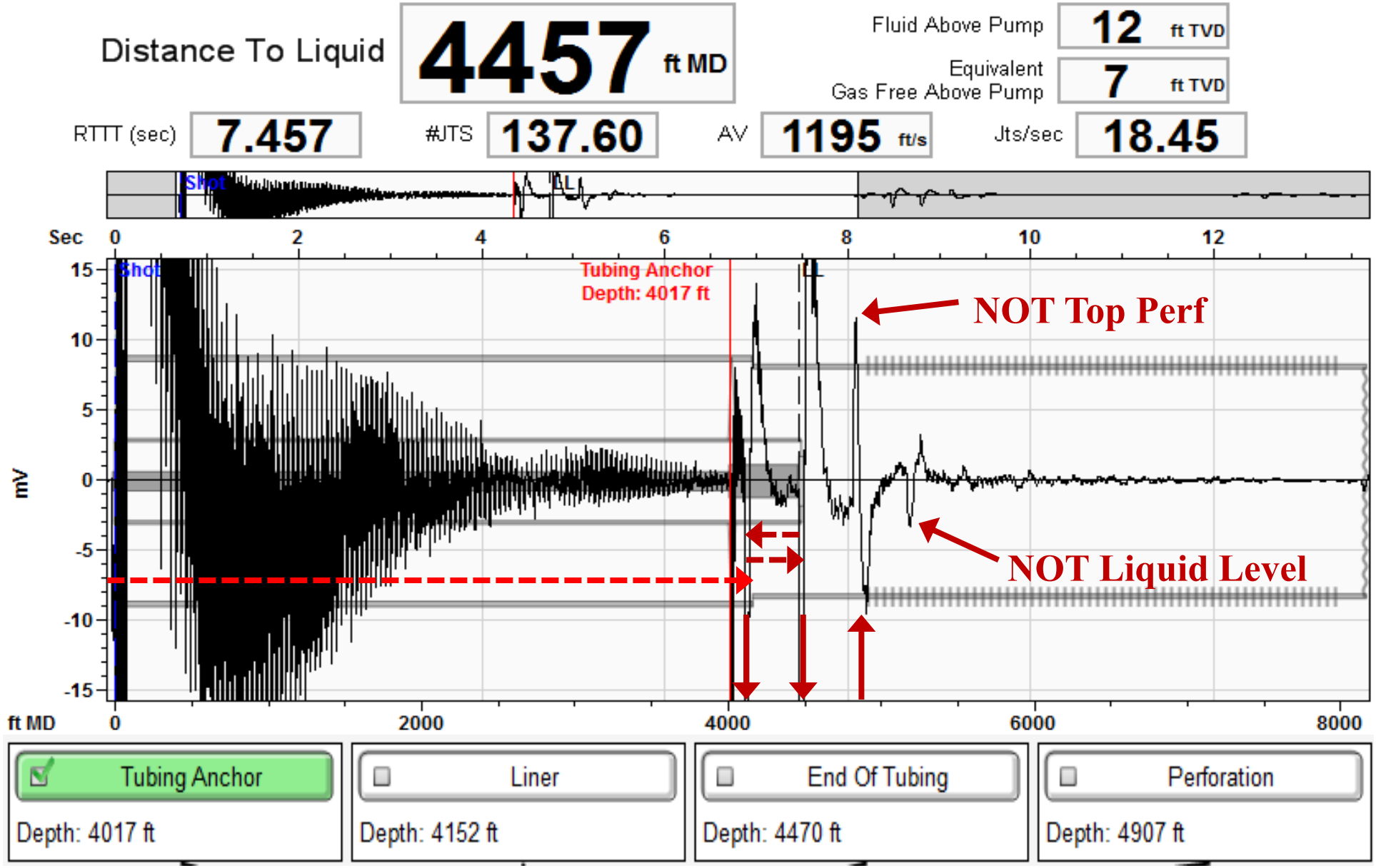
(Manual entry can be used for approximations or where <u>velocity already determined by collars or downhole marker in other shots</u>)

Depends on:

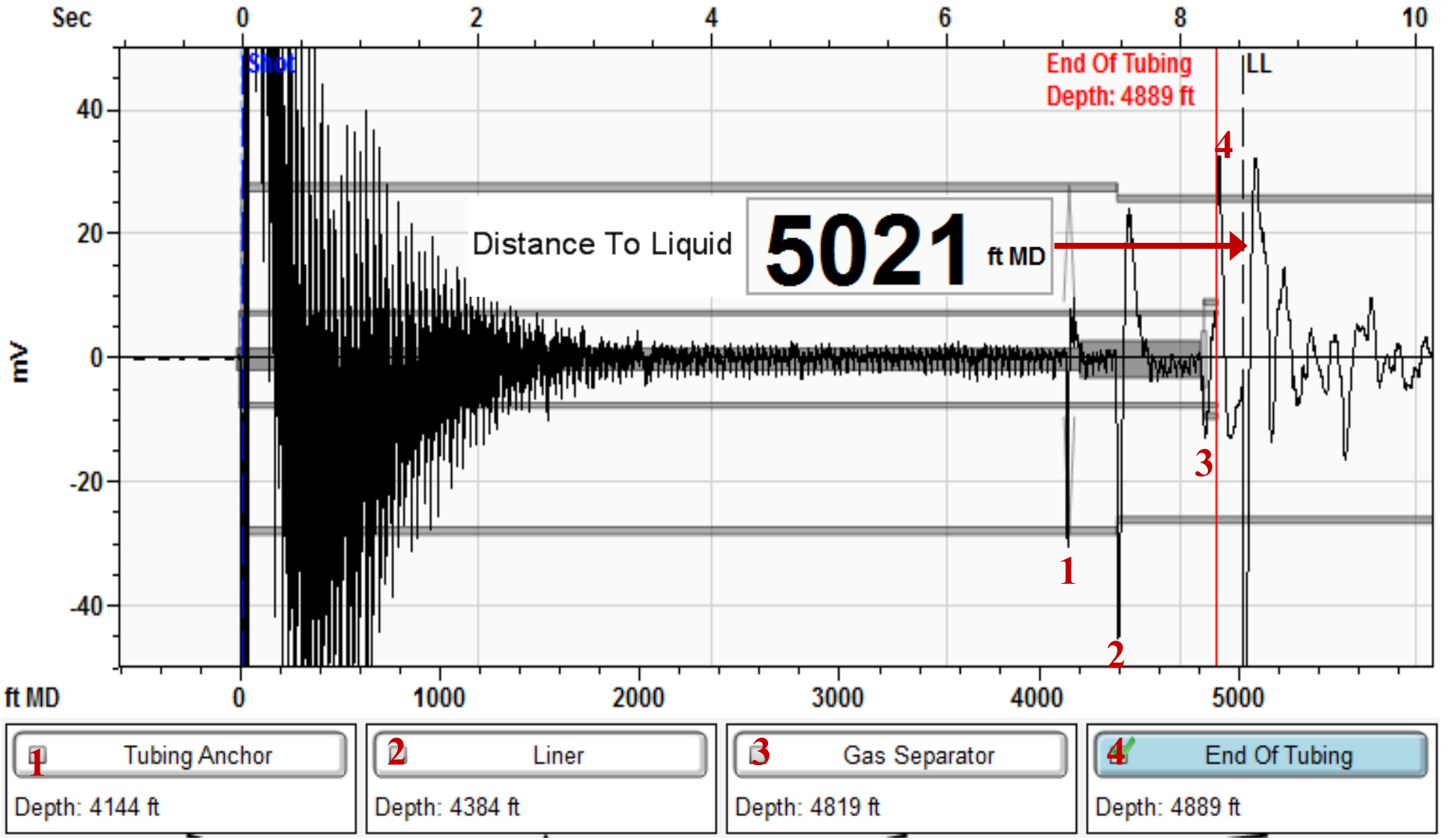
Gas gravity / composition

Average Temperature and Pressure (automatically calculated from acoustic velocity from a shot)

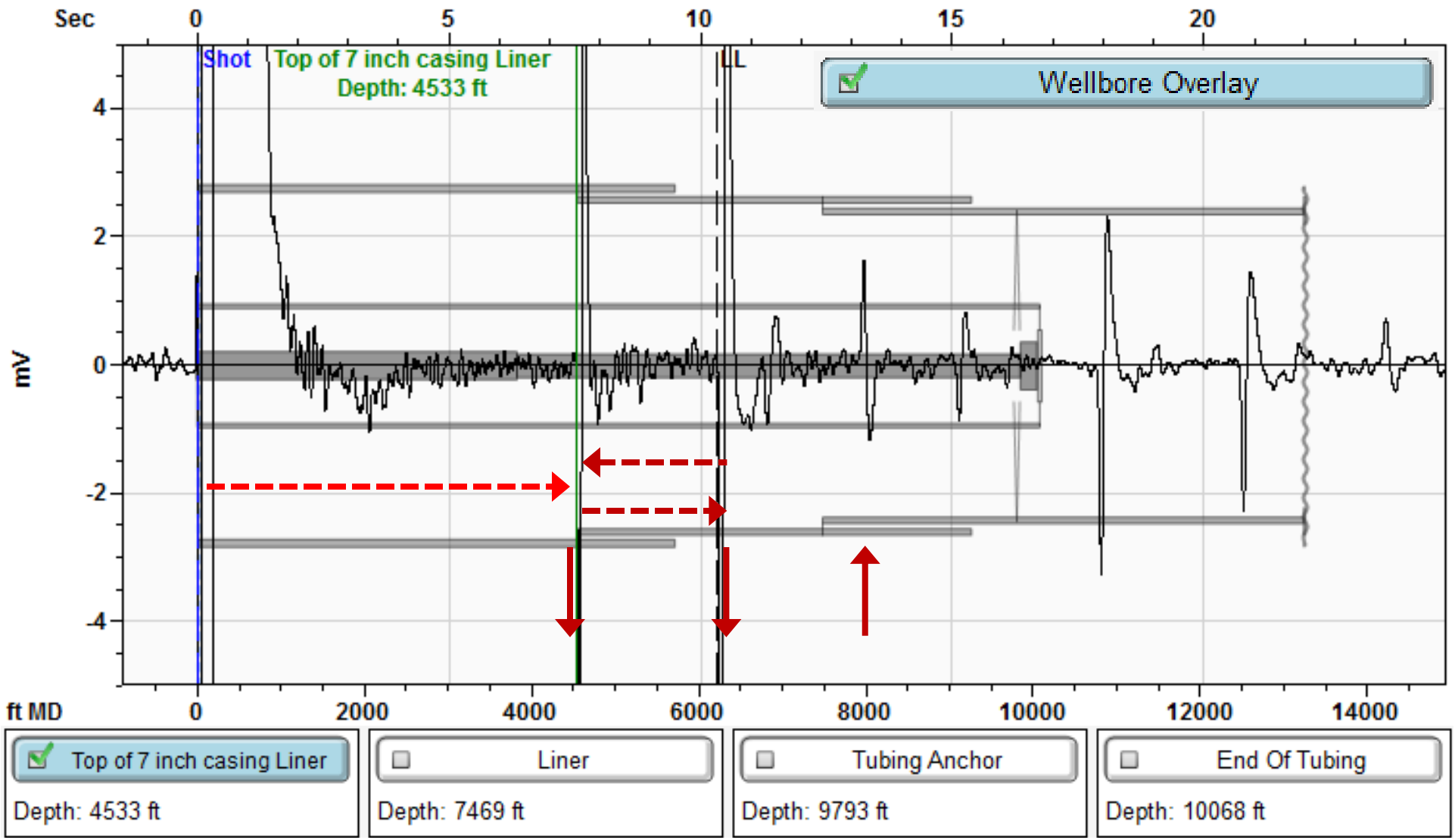
Multiple Echoes Due to Liner Makes LL Selection Difficult



Which Down Kick is the Liquid Level

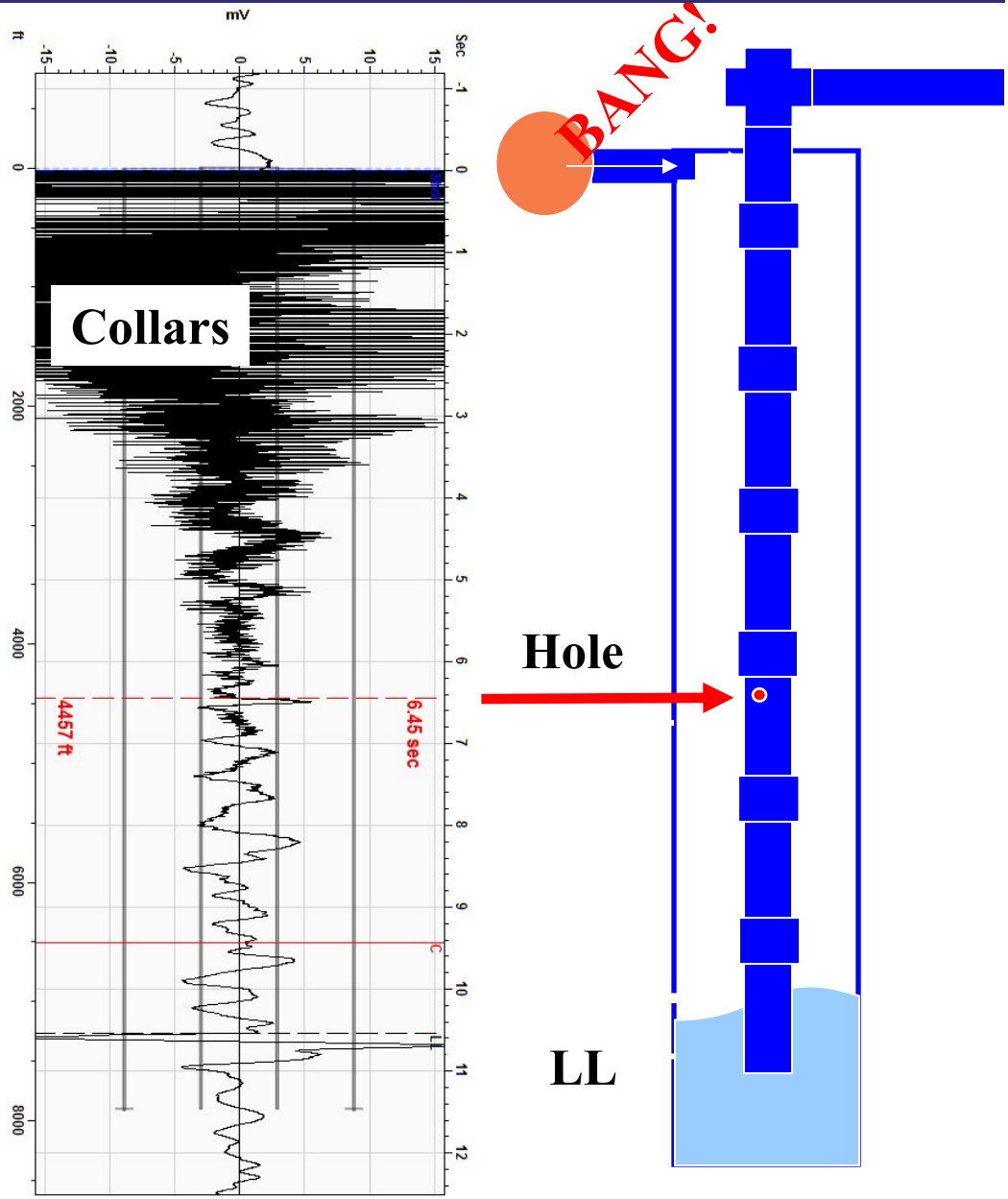


Look for Liner Down-Down-Up Kicks



Shoot a Fluid Level to Find a Hole

- Common to use acoustic liquid level instrument to shoot distance to the liquid level in the casing annulus
- Much-lesser-known is to shoot fluid levels inside the tubing (instead of just inside the casing annulus)
- Use Up Kick to Find Depth to the Hole



**Troubleshoot Rod Pumped Wells with Tubing Fluid Shots, SWPSC 2014. **

General Fluid Level Comments

1) Acoustic fluid level measurements are easily performed in producing or shut in wells
2) Recommended practice is to always acquire at least two (2) acoustic fluid level records when connected to a well
3) When shooting down the casing collar echoes can normally be detected
4) Using an echo from a known down hole marker near the fluid level is usually the most accurate method to determine depth.
5) Using gas composition is often the least accurate depth determination analysis method

For Accurate LL Depth Determination:

1. Use an accurate and representative wellbore schematic!
2. The deeper the Marker, the more accurate the liquid level depth
3. Verify correct reflection on the acoustic trace is selected to represent the perforation selected as the Downhole Marker.
4. At 1400 ft/sec acoustic velocity, a 1/10 second difference in marker selection will make a 70 ft difference
5. As a quality check, always verify the calculated acoustic velocity is within the known range.
6. If there is a question between using the Collar Count or DHM, use whichever is closest to the liquid level.
7. If using Collar Count, make sure the Average Joint Length is correct.
8. Do not shoot through a needle valve, always connect gun close to casing, and do not shoot through Chemical Pots.

Trouble Shoot Acoustic Survey Data

1. Don’t leave Casing to Flowline valve closed to long and push Liquid Level below pump.
2. Know downhole obstructions from accurate wellbore schematic - wellbore configuration is reflected in acoustic signal.
3. Inspect the well noise before shooting. If excessive noise exists:
   - Close Casing Valve and Determine if Noise from Downhole
   - Use a larger charge in the gas gun
   - Increase the casing pressure to attempt to reduce the noise level .
4. Inspect the acoustic trace. If an insufficient liquid level kick is obtained, data is otherwise unsatisfactory, or shot not detected:
   - Increase the pressure in the volume chamber
   - Additional casing pressure improves collar and liquid level response.
   - Inspect connections and Acoustic Cable
   - Shut down Noisy Pumping Unit (Surface Equipment) and Re-shoot

Conclusions

- Shallow wells can be difficult to determine accurate distances to liquid levels.
- Perforations, open hole, liner and quick echoes from the liquid level create many echoes on the acoustic trace.
- For accurate analysis the echo from the liquid level echo must be identified.
- Special filtering techniques can be applied to emphasize the liquid level echo.
- LL acquired on coal bed methane wells provide a low cost, direct method to observe the well; benefiting the operator through knowledge of the well's producing conditions.