Ask Echometer 23 Online Seminar – December 2, 2020

(((ECHOMETER)))

Identifying Holes in Tubing on Sucker Rod Lifted Wells

TOTAL ASSET MONITOR (TAM)

http://www.echometer.com/Software/Total-Asset-Monitor

"TROUBLESHOOT ROD PUMPED WELLS USING TUBING FLUID LEVEL SHOTS", Sparks, Rowlan, SWPSC 2014

"TUBING AND WELLHEAD INTEGRITY PRESSURE TEST", Norman, Rowlan, McCoy, Taylor, Podio, SWPSC 2015

"Direction of Kick on Acoustic Traces", Ask (((Echometer))) Online Seminar #1 – May 20, 2020 – www.echometer.com

"Acoustic Techniques for Gas-Lift Wells", Ask (((Echometer))) Online Seminar #5 – June 17, 2020 – www.echometer.com

"Use Acoustic Fluid Levels to Analyze & Troubleshoot Gas Wells", Ask (((Echometer))) Online #7 –July 1, 2020– www.echometer.com

Presenters: O. Lynn Rowlan and Carrie-Anne Taylor

Q & A: Gustavo Fernandez and Echometer Engineering and Support

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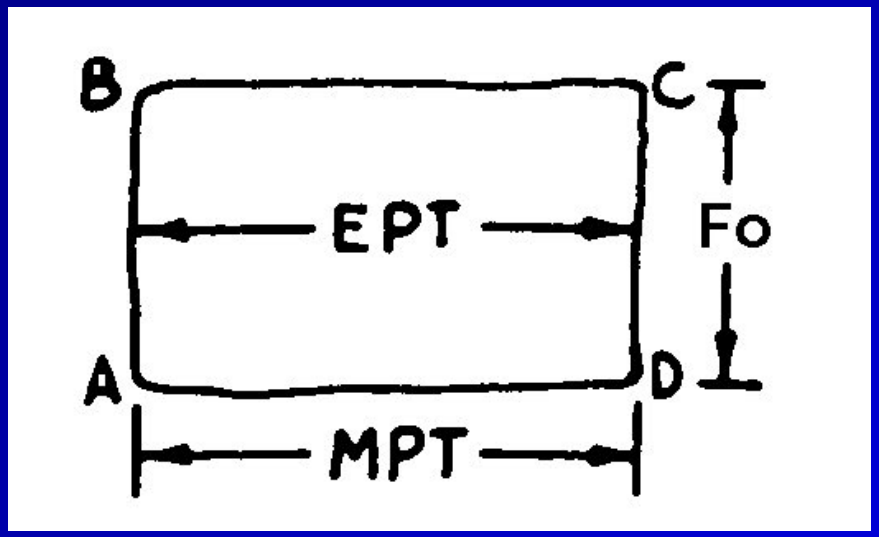
Download the Session 23 PDF Bundle and TAM Example Data from

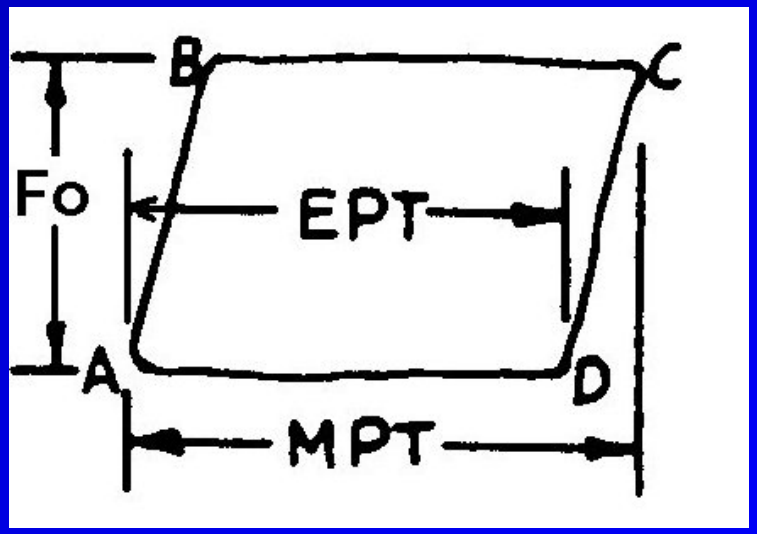
https://echometer.com/Support/AskEchometer

Has Production Rate Dropped Off?
Hole in Tubing Pump Card: Normally a Full Pump

Tubing anchored, EPT=MPT.



Unanchored tubing, EPT<MPT



1. **Pumping-Full of Liquid**
2. **No gas in Pump.**
3. **Valves Not Leaking**
4. **Pump functioning properly.**

Usually Hole in Tubing Pump Dynamometer Card Height is Less than Fluid Load from Fluid Level and Pump is Filled with Re-Circulated Liquid

Acoustically Find the Tubing Hole

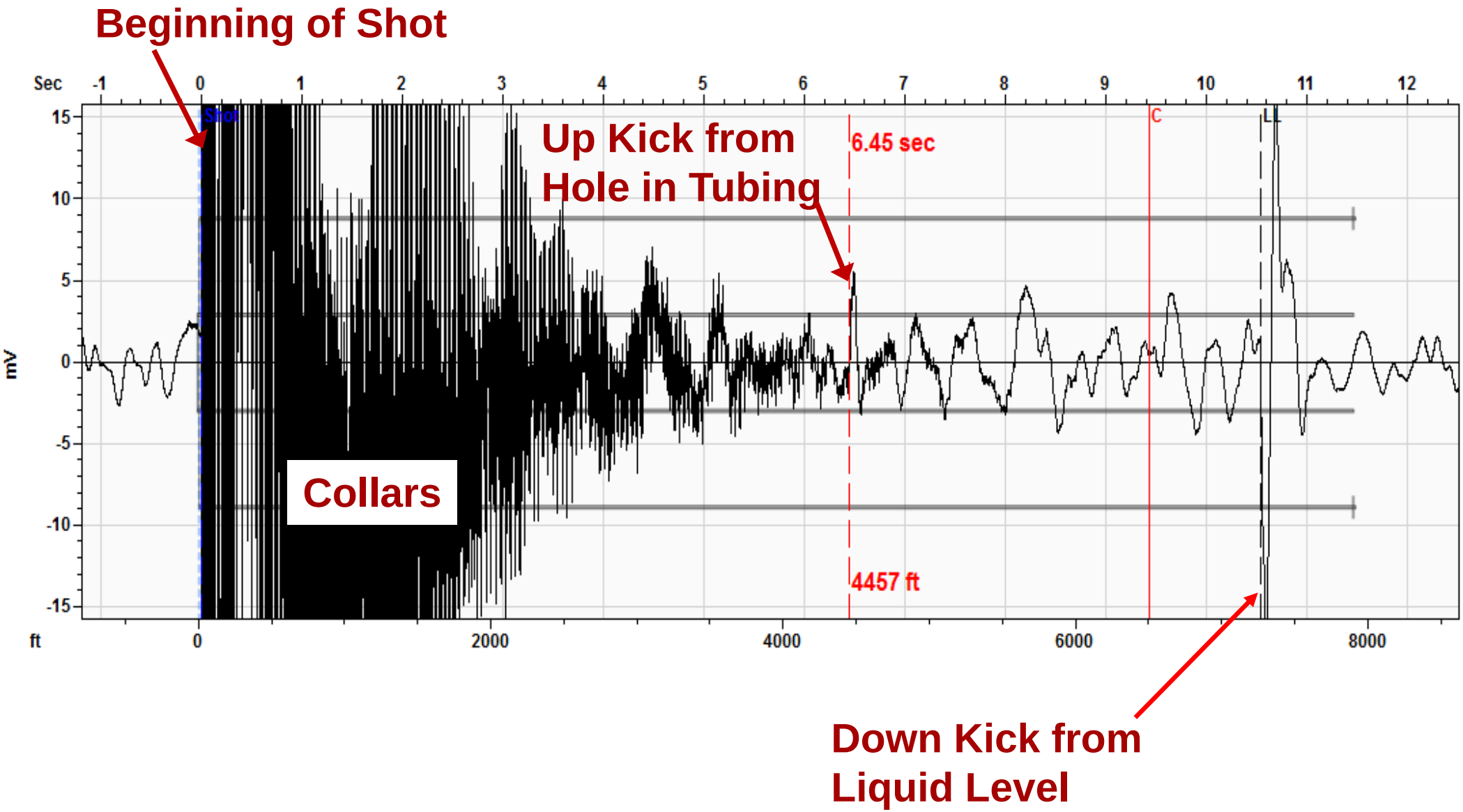
- Most basic use of shooting fluid levels down the tubing can show if a well has developed a hole in the tubing.
- Begin by shooting a fluid level down the casing.
- Connected to the tubing valve and use the same procedure as shooting a fluid level inside the casing.
- Shooting the inside the tubing usually requires 50 to 65% less charge pressure into the gas gun than is normal for the casing shot.
- Using the acoustic velocity determined from analyzing the casing shot generally is the easiest and most accurate method for determining distance down the tubing.
- Rod on tubing wear often creates a hole in the lower portion on the tubing string and the tubing leak is usually deep, but the presence of a deep hole in the tubing allows equalization of the two fluid levels.
- Re-shoot the tubing to verify the hole after operating the pumping unit for 30-60 minutes, a hole in the tubing is likely if the fluid level inside the tubing has not risen

Gas Gun Physical Set-up on Well

Acquire High Quality Fluid Level

- Requires stabilized conditions for accurate BHP.
- Determination of Liquid Level Depth: obtain a clear indication fluid level echo.
- Correct average tubing joint length: required to calculate distance to fluid level and accurate acoustic velocity.
- Wellbore deviation survey: required to compute pressure in wellbore and at pump intake
- Measurement of casing pressure: required for correct calculation of pump intake pressure
- Measurement of casing pressure change vs. time: required to calculate annular gas flow rate and annulus liquid fraction.
- Tubing, Casing diameters: required for calculation of annular gas rate.
- Oil, water and annular gas densities: required for calculation of pressure gradients
- Measurements should be repeated whenever excessive acoustic noise is present and fluid level echo is not clearly identifiable (always acquire 2 shots).

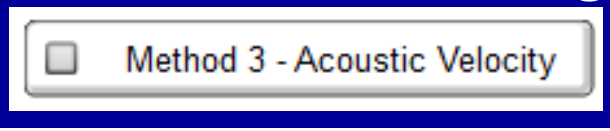
Acoustic Trace Show Shot's Echoes



Direction of Kick of the Acoustic Signal

1. On the acoustic trace the direction of the reflected echo kick indicates wellbore enlargements and reductions
2. For an Explosion shot reduction in the cross sectional area are displayed as downward kicks.
3. Wellbore decreases displayed as a down kick:
   - Liners tops, tubing anchors, paraffin/scale deposits, blockages, the liquid level
4. Wellbore increase displayed as upward kick:
   - Hole in tubing, perforations, open hole, sliding sleeves, parted casing, parted tubing, end of tubing.
5. Acoustic traces created by Implosion Pulse Type are reversed, when compared to Explosion Pulse Type
6. ***BUT***, Select Details Option to identify Explosion or Implosion Pulse Type; then implos
   acoustic traces appear identical o

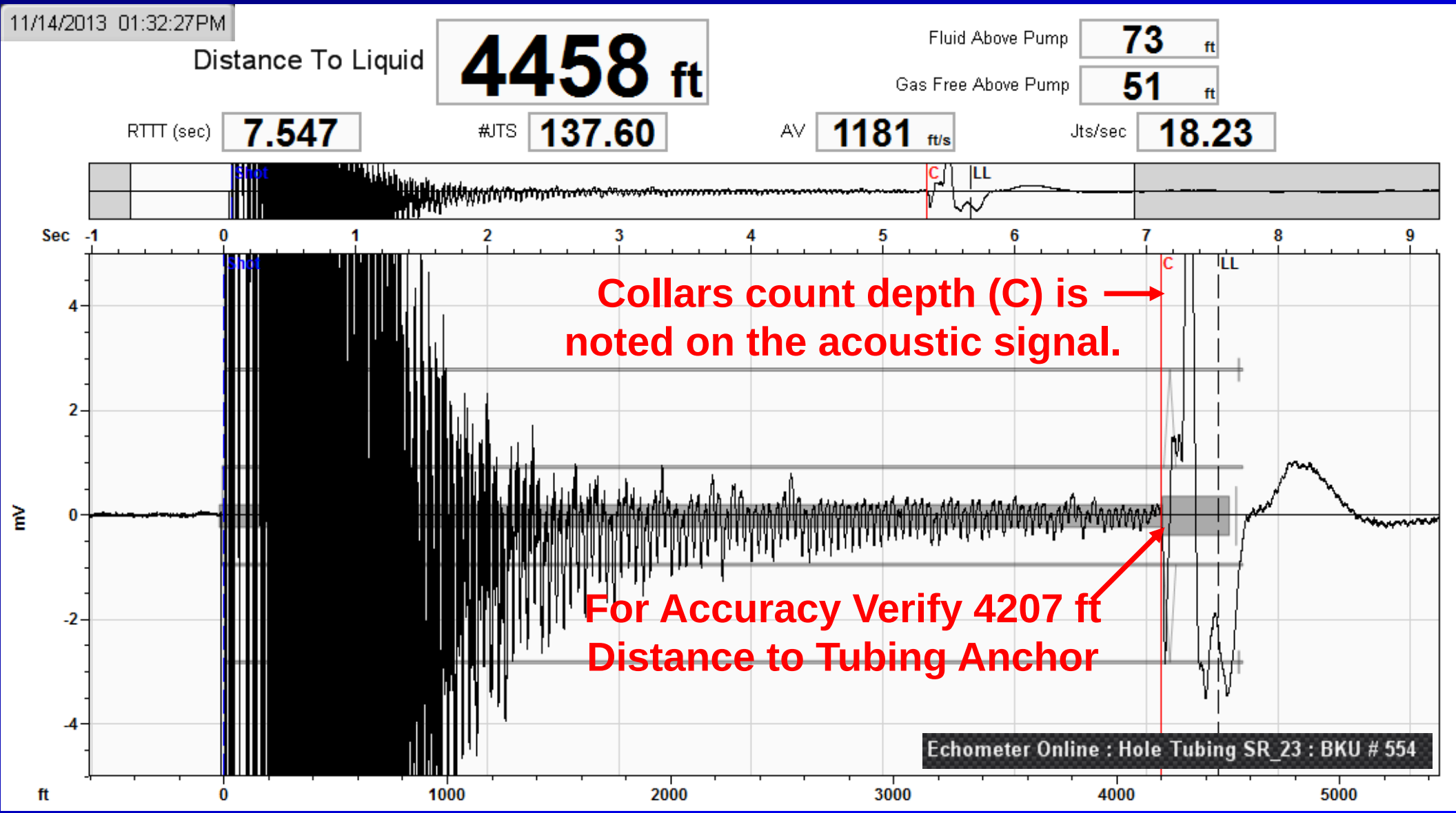
Troubleshooting Procedures - General

1. Upon arrival a well is normally turned off, if the well is suspected of no pump action or <u>no production</u>.
2. Acquire two (2) fluid level shots down the casing and verify the acoustic traces appear the same on both shots and determine the casing acoustic velocity.
3. Acquire two (2) fluid level shots down the tubing and verify the acoustic traces appear the same on both shots and use Casing Acoustic Velocity for distance.
4. Since the shut-in well is normally quiet the casing tubing collar echoes are normally very clear.
5. Collar Count Depth Determination method skews the depth by counting 25’ spaced rod couplings echoes inside the tubing, that’s why the acoustic velocity obtained from the Casing Collar Count is used for the tubing: 

Potential Results from Analysis

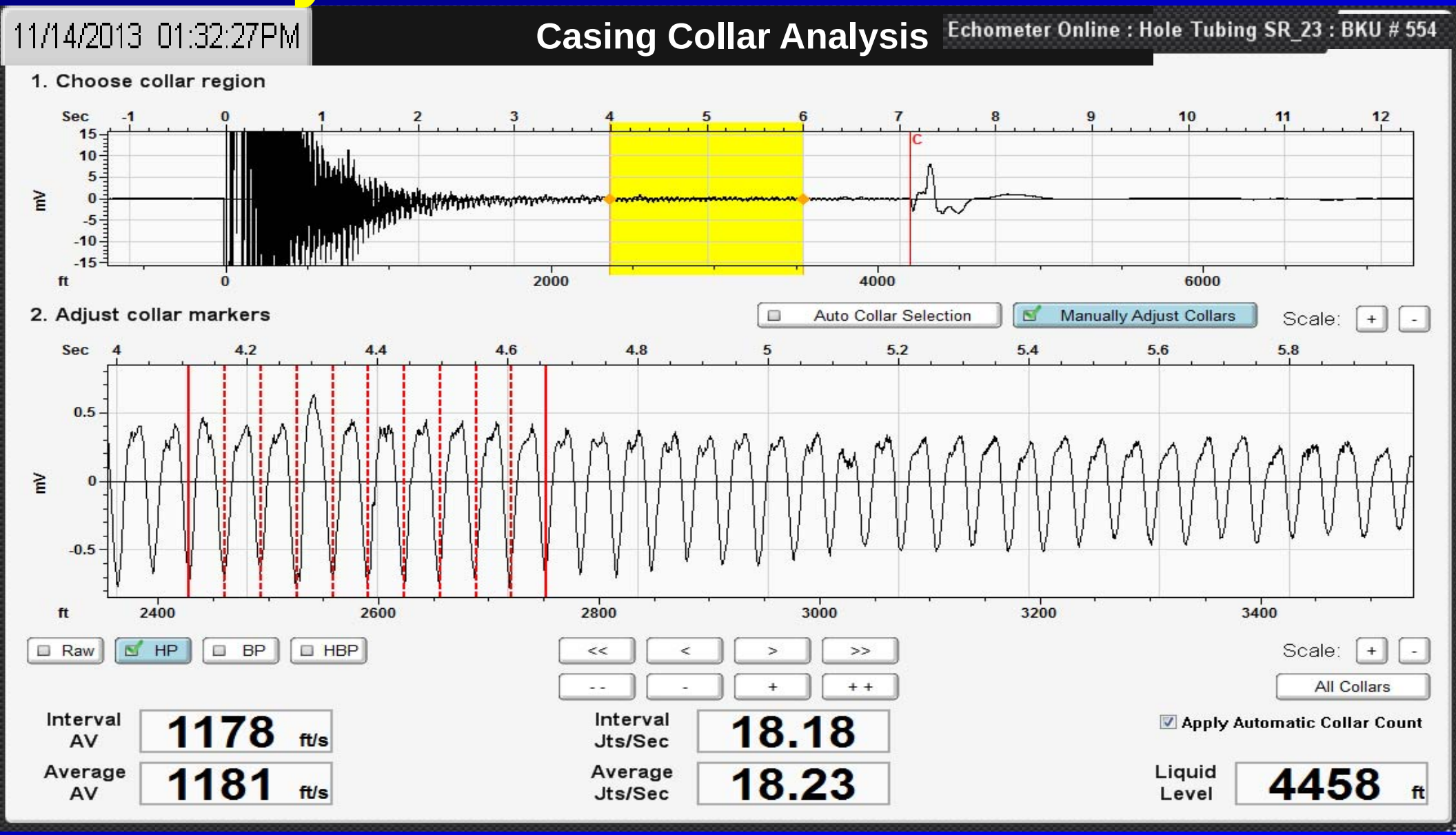
1. Whether or not the well has a hole in the tubing.
2. If the well has kicked; stopping production up tubing
   a. Excessive gas flow has unloaded the tubing liquids
   b. Backpressure adjustment is required to apply more tubing pressure.
3. Is gas flowing up the tubing? Determined by dP/dT greater than 0 from the pressure buildup test.
4. % liquid in the tubing, determines the effectiveness of the downhole gas separation equipment.
5. Tubing fluid level shots at regular intervals can show the operator if a well is truly “pumping up.”
6. Too much paraffin in the tubing makes it difficult to shoot – so beware.

Liquid Level Normally Located at Pump



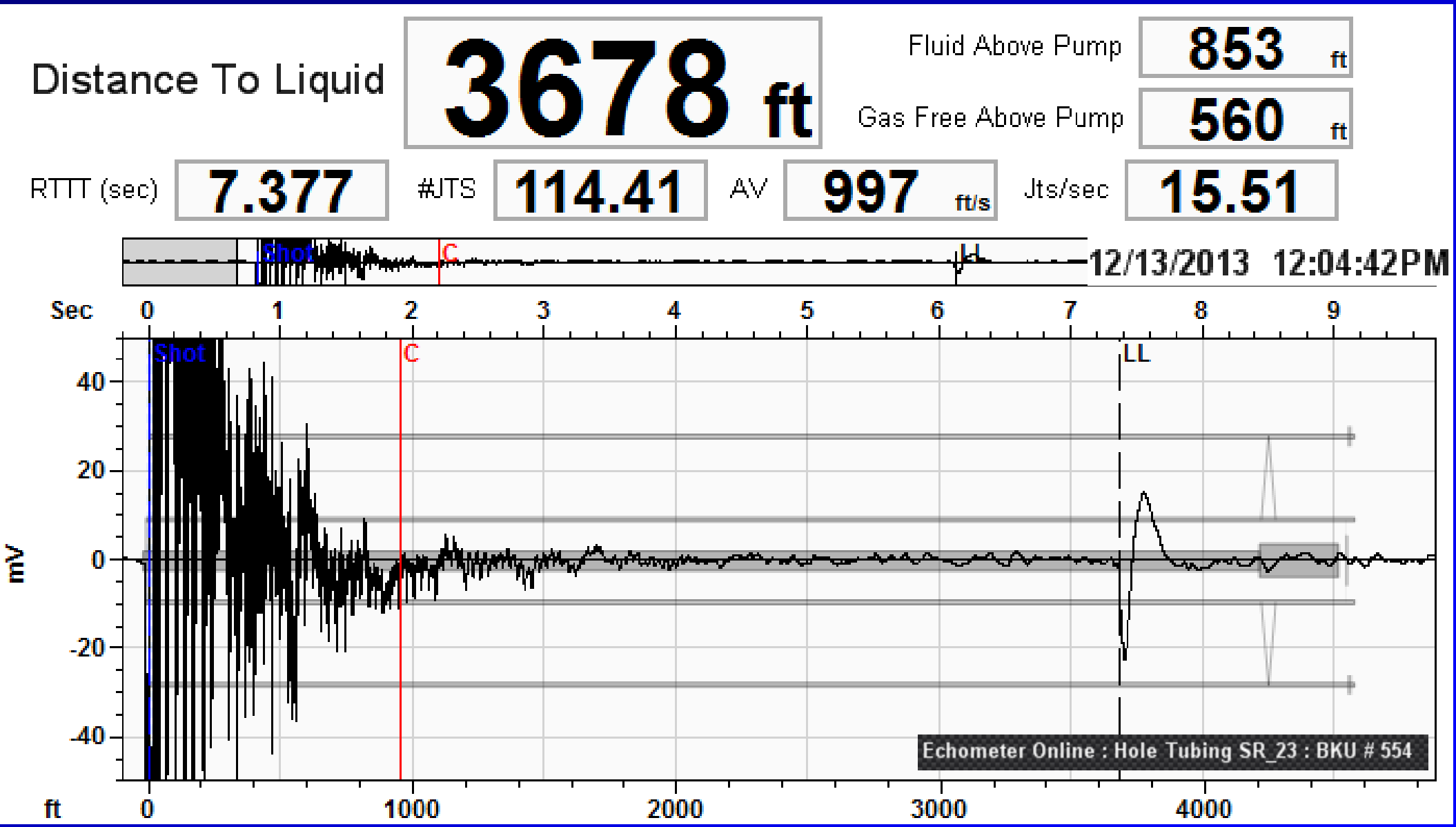
Liquid Level Depth (LL) of 4458 feet is determined by counting as many collars as possible and using the average acoustic velocity of the collars counted to determine the distance to the liquid level.

Analysis Method: Count Collars



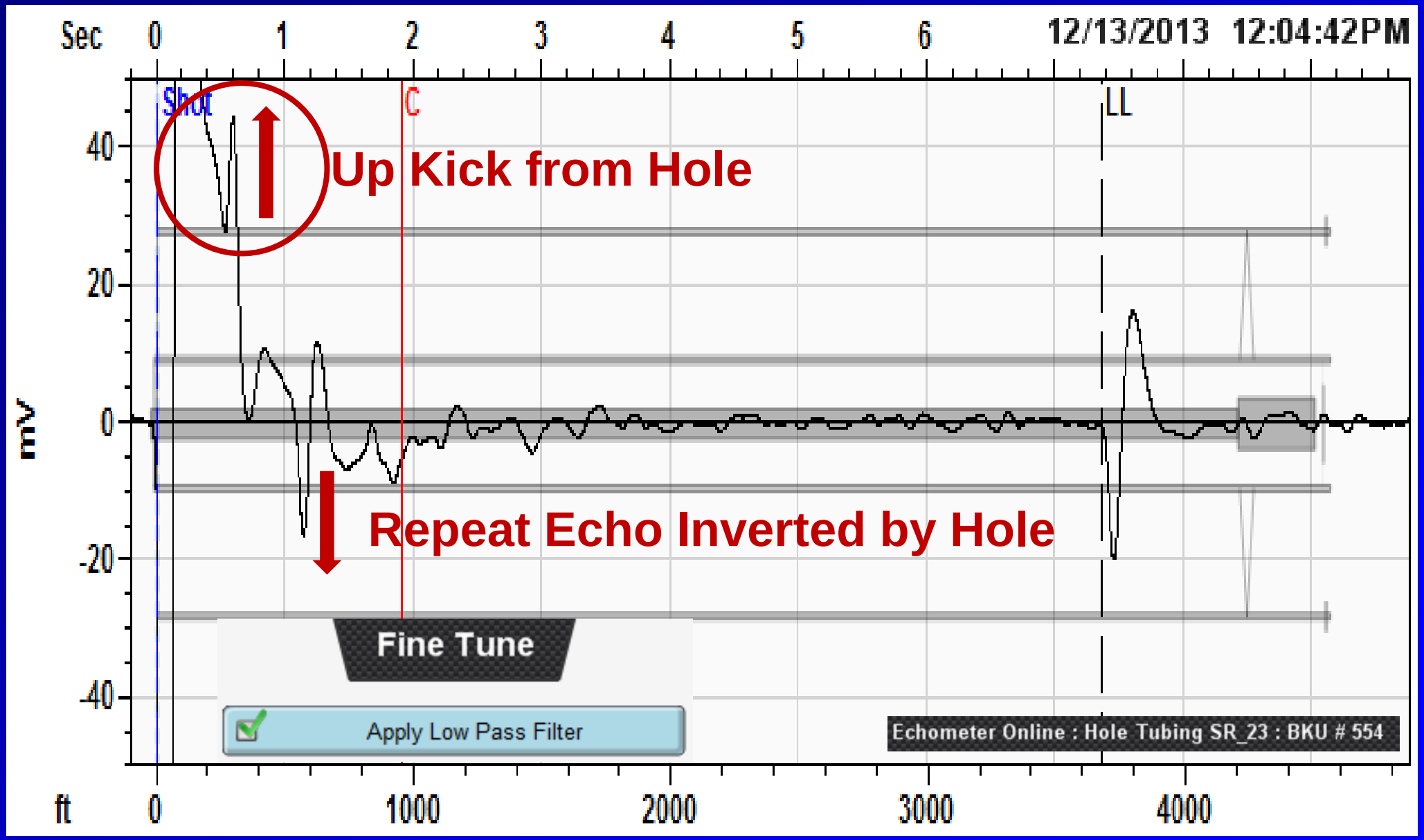
Distance down tubing is determined by using the average acoustic velocity obtained from the casing shot, because inside the tubing the echoes from couplings are spaced at the length of the sucker rods.

Well Shut-down No Production to Surface



Liquid Level Depth (LL) at 3678 feet is above tubing anchor and perfs. High hole in tubing is suspected, but no obvious up kick seen on trace.

Remove Collar Noise Collars to See HIT

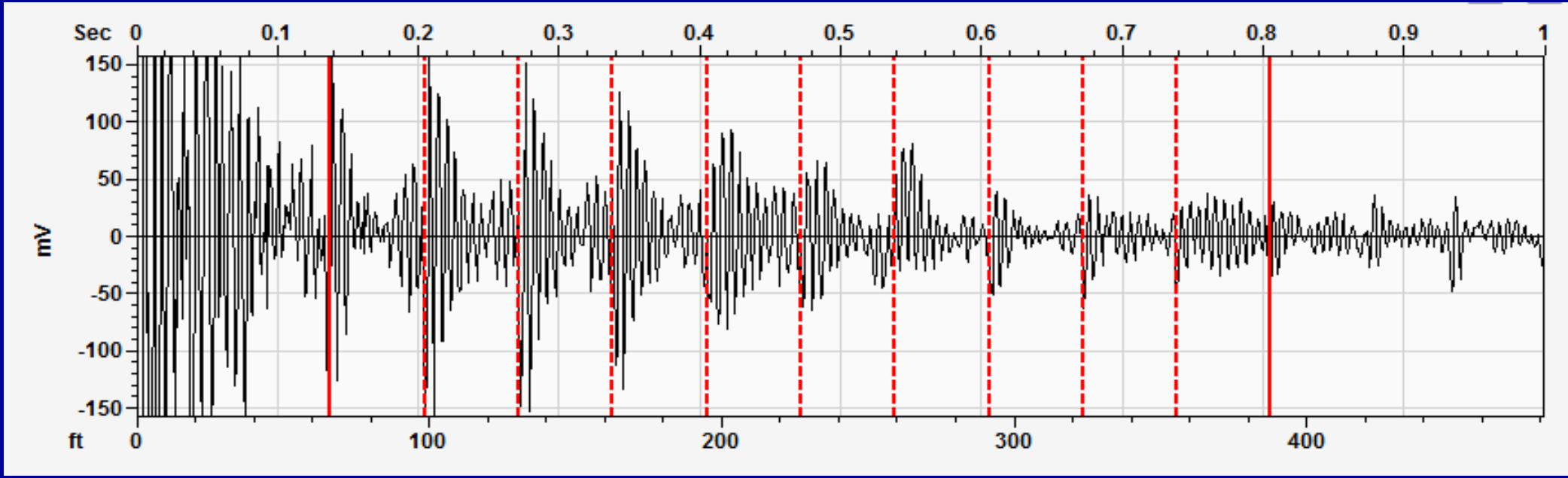


Use less pressure differential in gas gun to shoot the liquid level and see echoes near the surface OR *apply low pass filter to remove noise*.

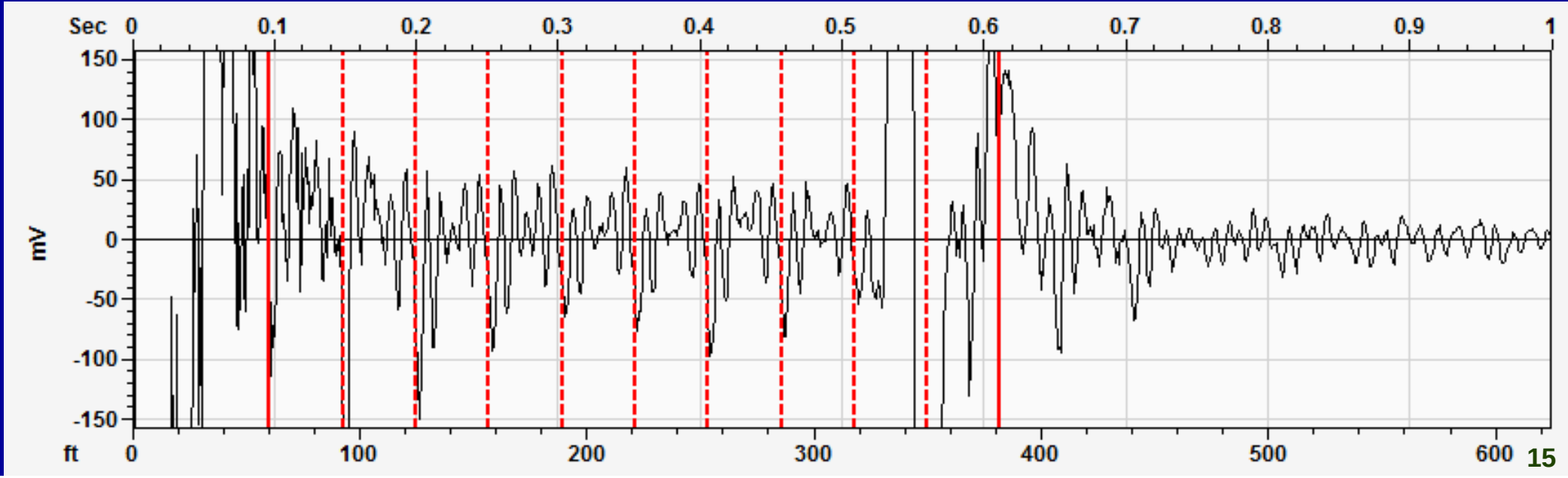
Casing Acoustic Velocity Determined to be 973 ft/sec by Counting Tubing Collars Near Surface

Casing acoustic velocity determined to be 973 ft/sec

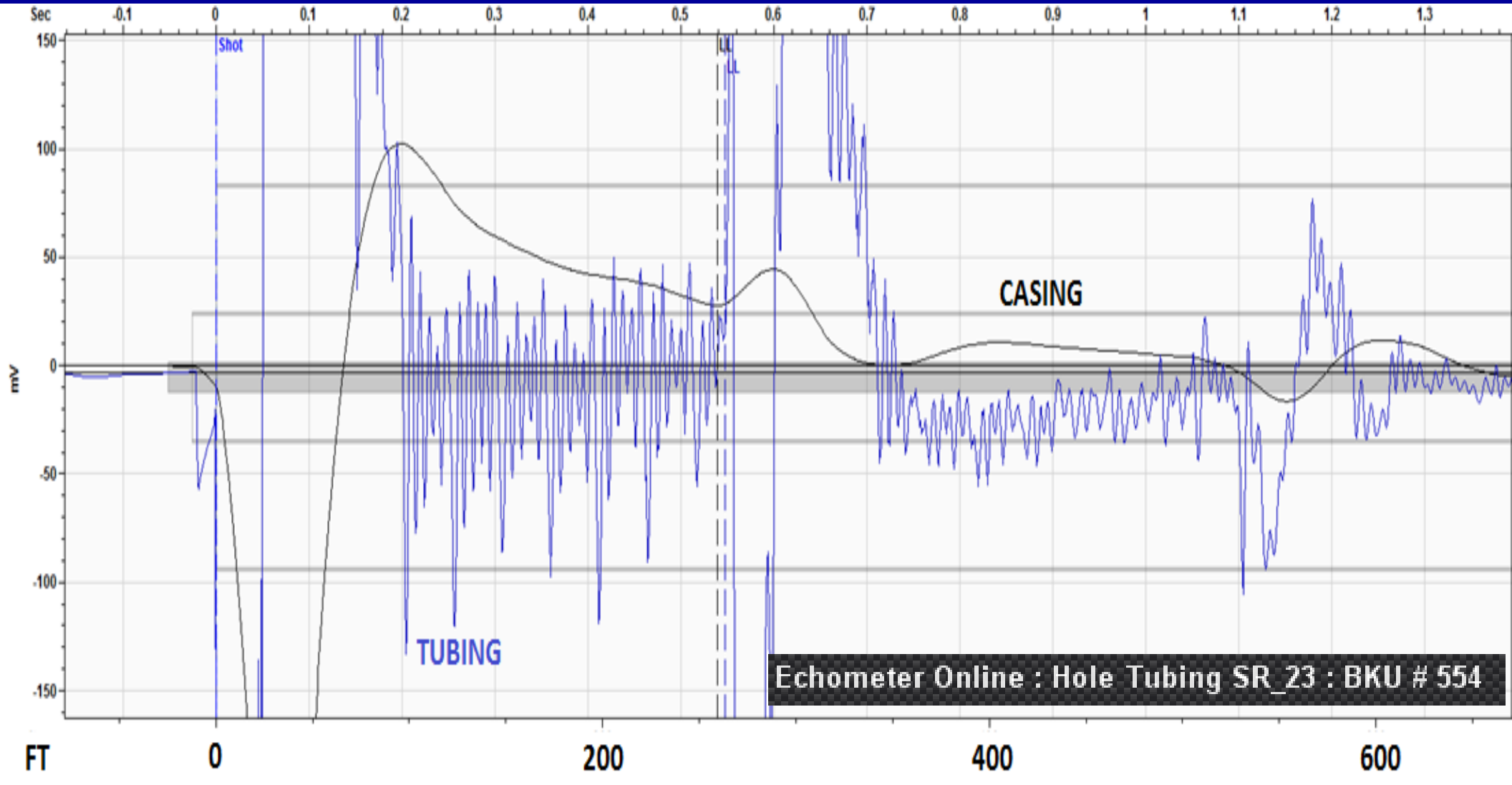
Tubing Collars Frequency in Casing of 15.13 Jts/second at 32.15 ft/joint



Rod Couplings Frequency in Tubing of 19.46 Jts/second at 25.0 ft/joint



Comparing Tubing Hole Up Kick Echo by Overlay of Low Pass Filtered Casing Shot to Raw Tubing Shot



Distance to the Tubing Hole is 263 feet

Fluid Level 6511’ ~ HIT 4005’

Echometer Online : Hole Tubing SR_23 : Hole Tubing - PRT

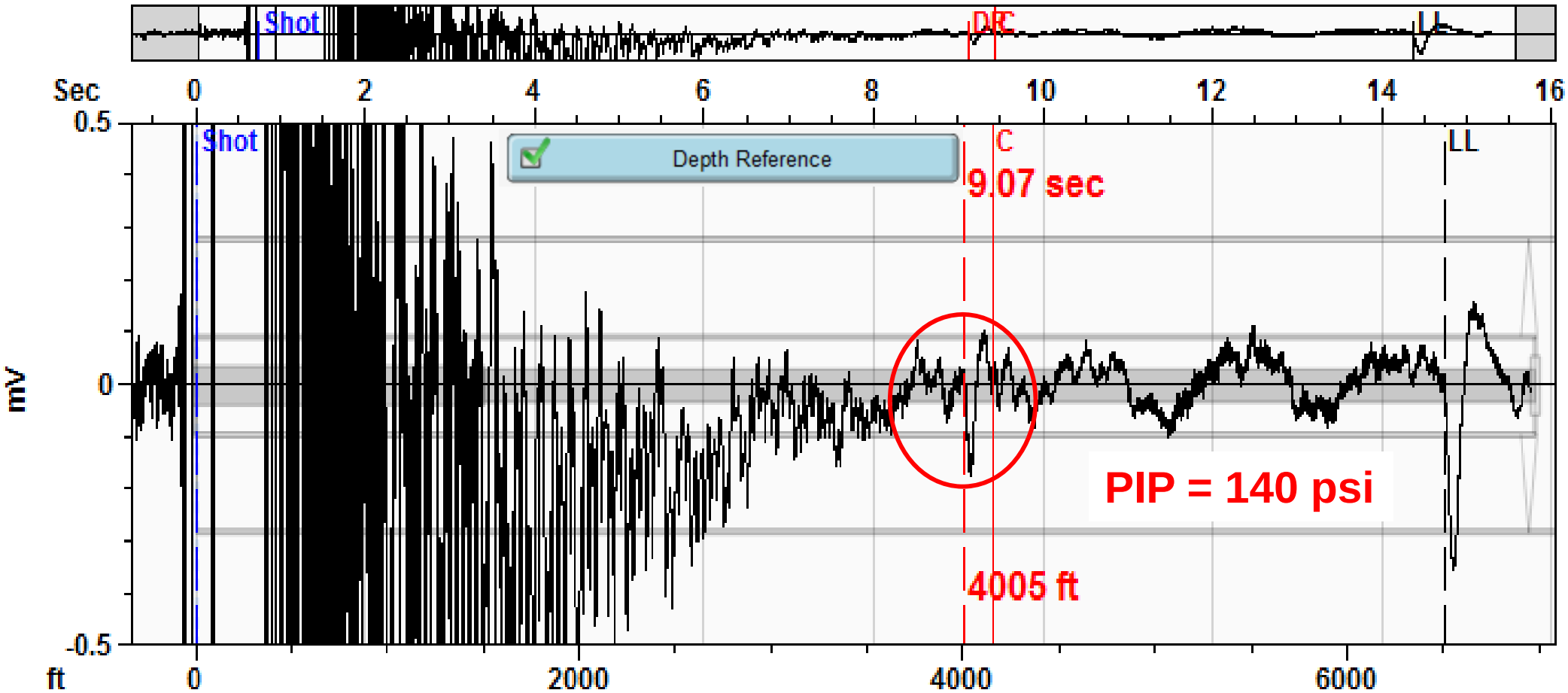
Distance To Liquid **6511 ft**

Casing Shots

Fluid Above Pump **464 ft**

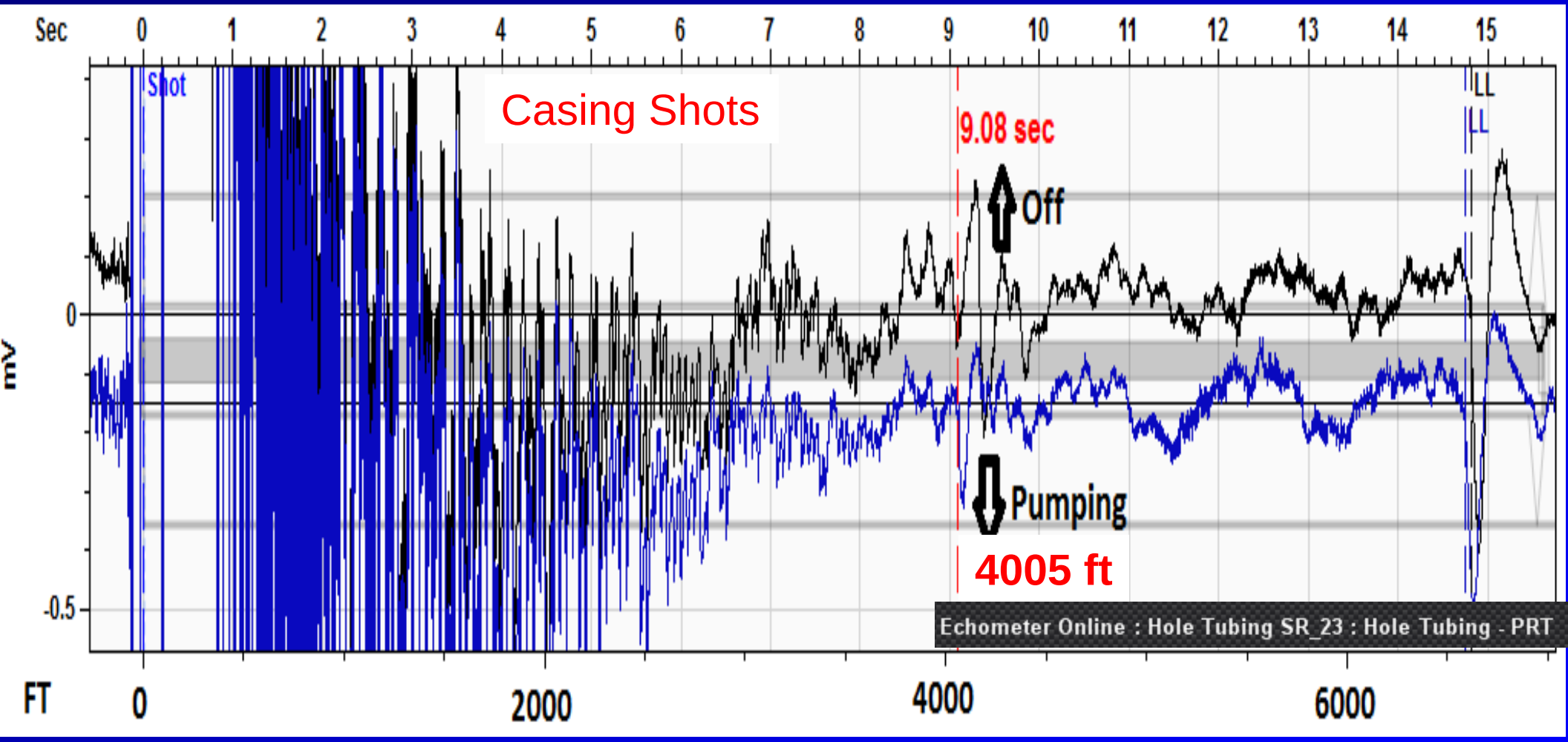
Gas Free Above Pump **446 ft**

RTTT (sec) **14.744** #JTS **209.71** AV **883 ft/s** Jts/sec **14.22**

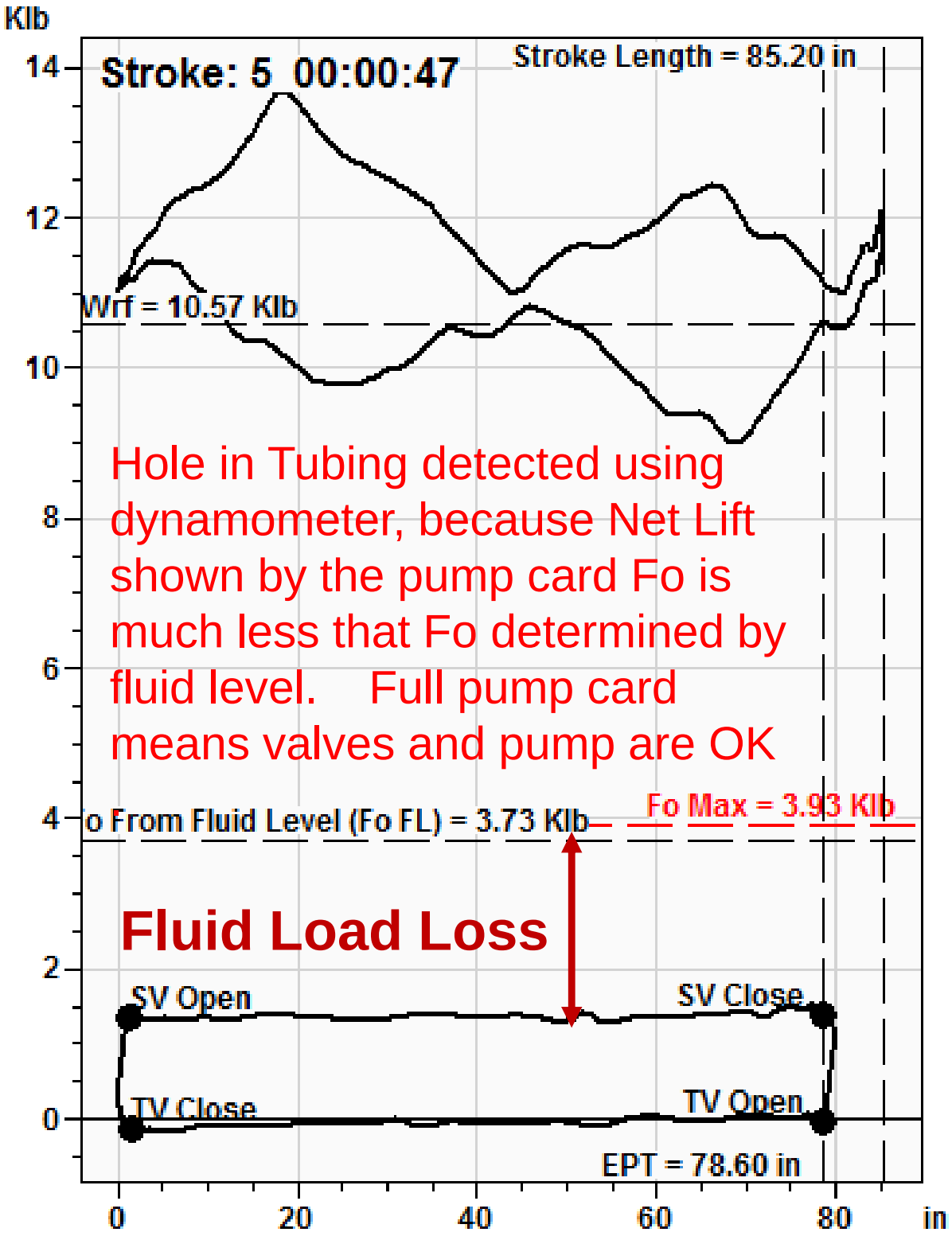


Down Kick from Well Pumping Liquid out Split Tubing Joint

Tubing Leak, No Fluid to Surface



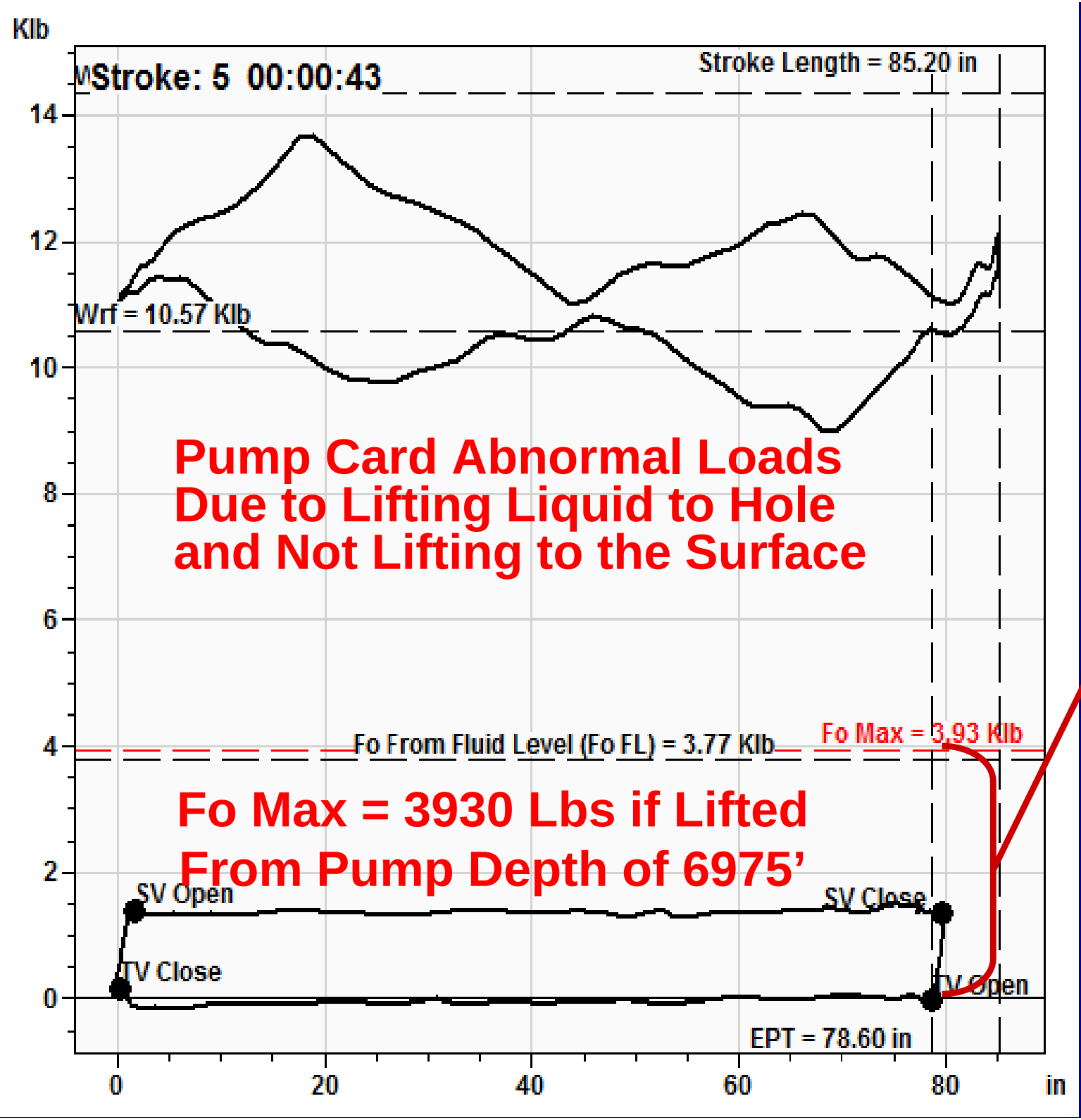
1. Hole in Tubing Shown as ***Up Kick*** when ***Pump Off*** and Time has Passed to Allow Liquid to Drain out of Tubing.
2. Hole in Tubing Shown as Down Kick when ***Pumping*** Liquid Out Tubing Hole into Casing Annulus

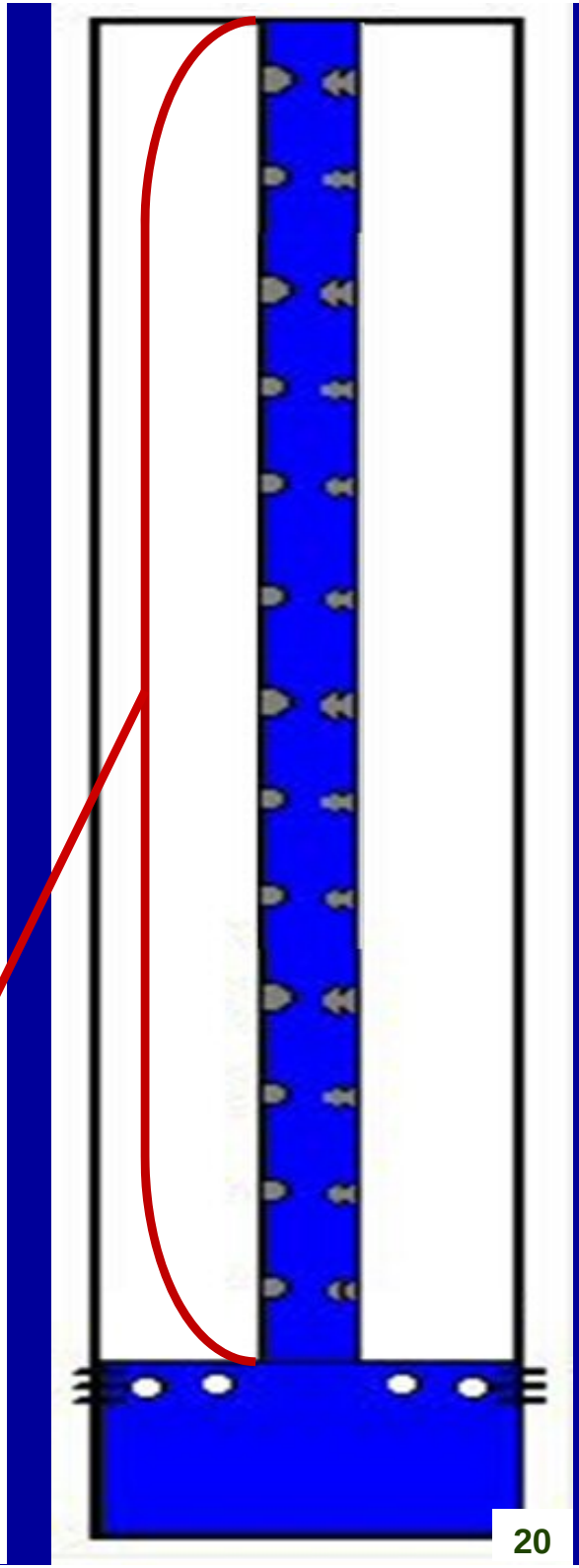


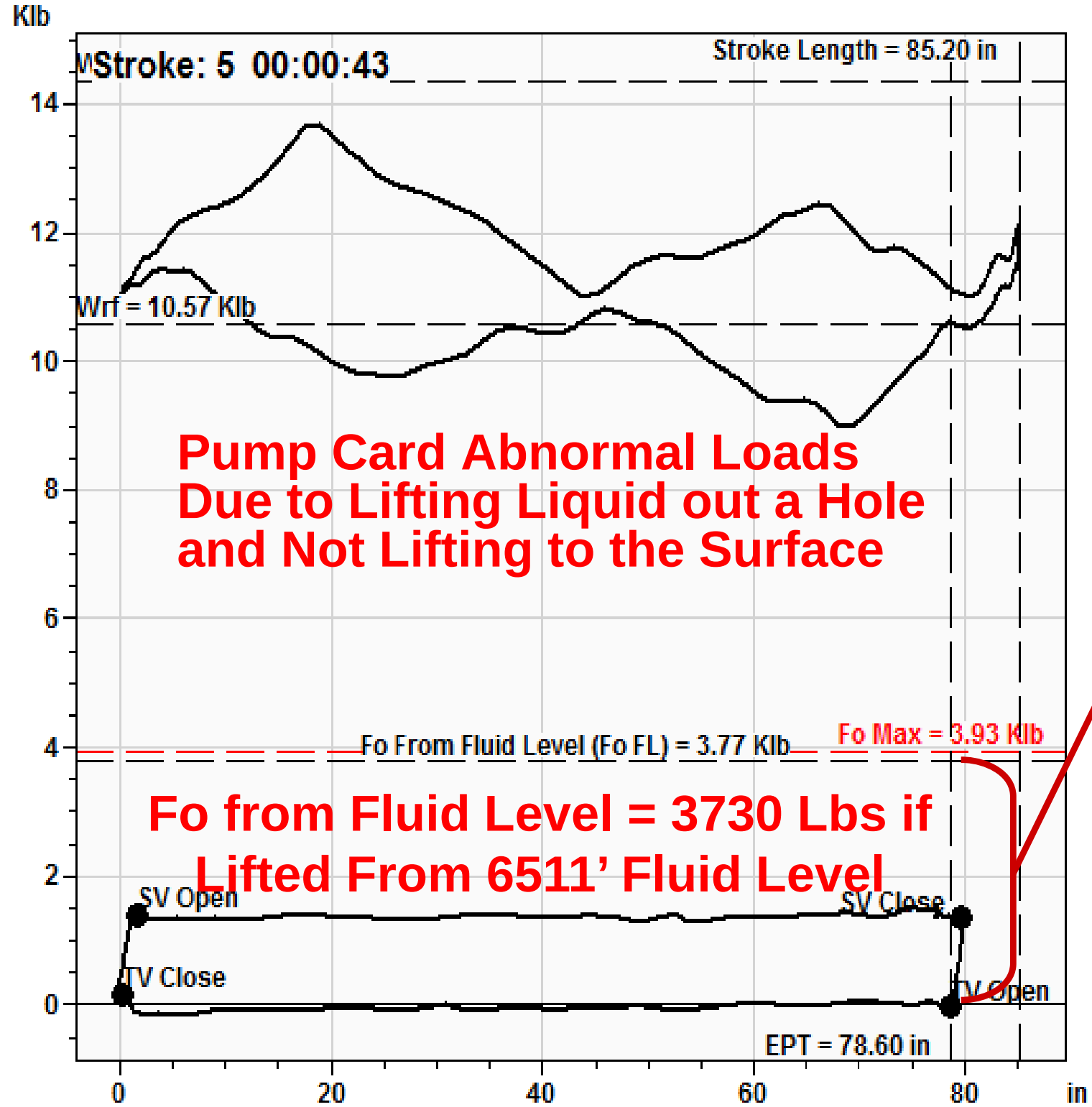
Fluid Load Loss when actual pump card fluid load is less than the pre-calculated fluid load using PIP from fluid level. Can be caused by a HIT, tubing or pump leak, or a high tubing-casing annulus fluid level.

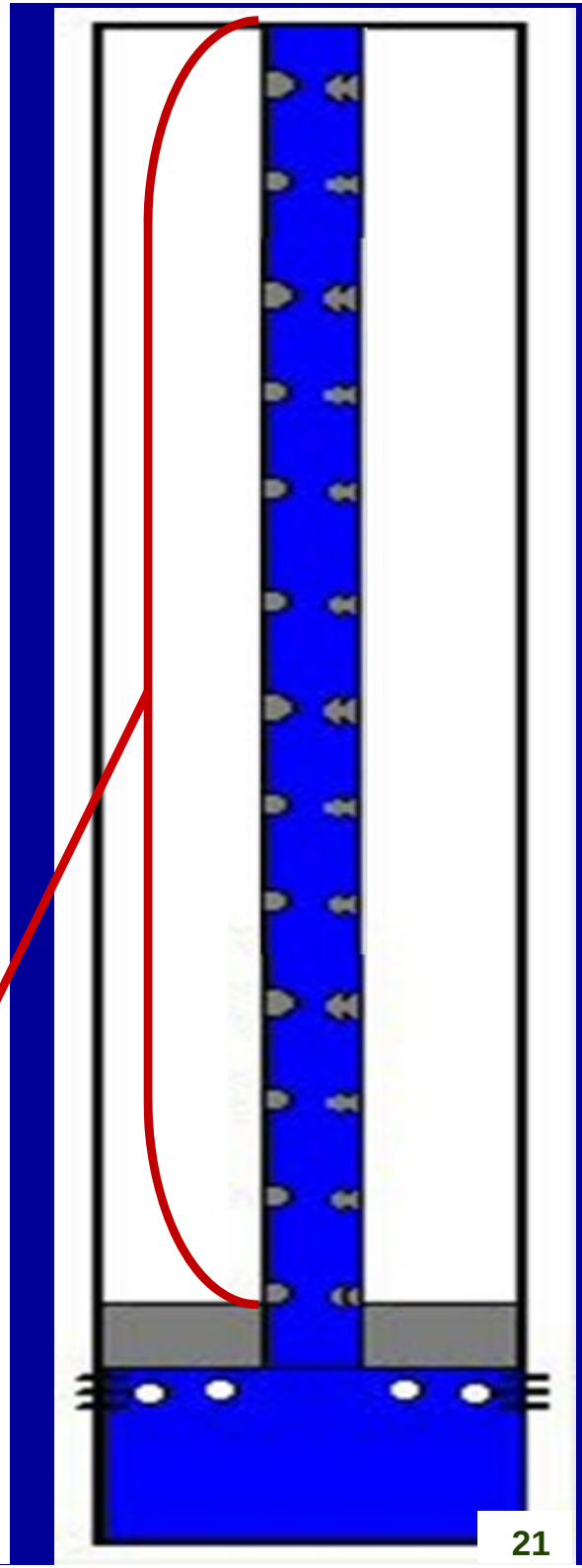
Fo FL assumed net lift from pump intake pressure at pump depth.

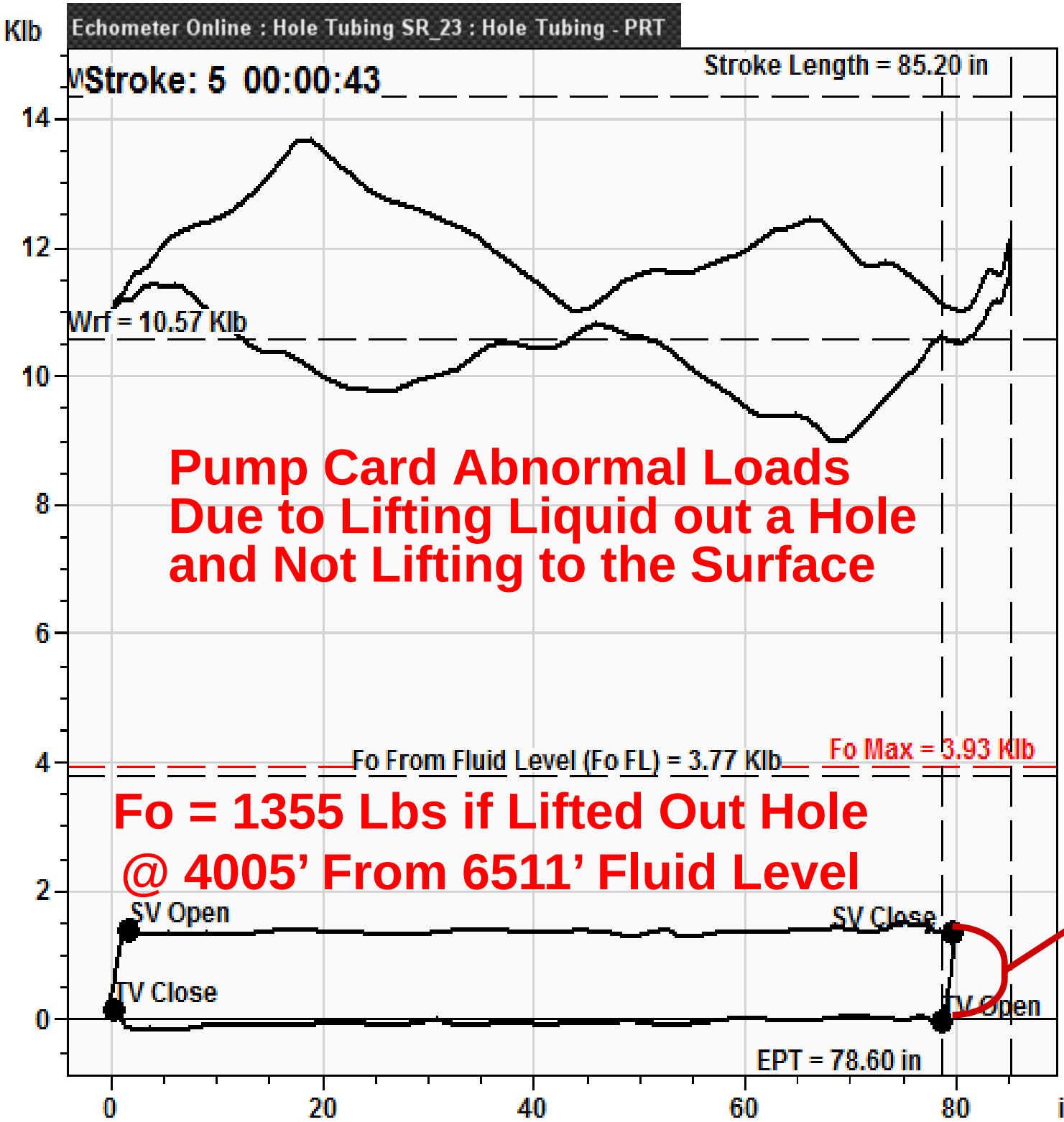
Split Tubing Joint	4005’
Fluid Level	6511’
Pump Depth	6975’
Net Lift	**2506’**

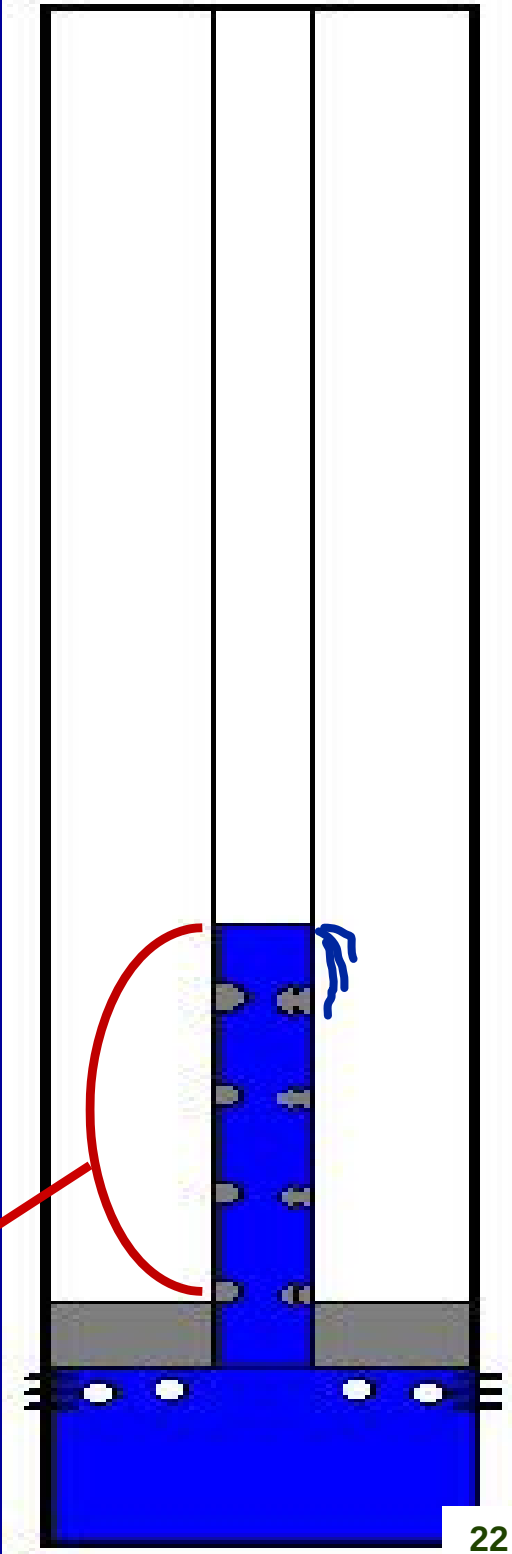

Klb
Stroke: 5 00:00:43
Stroke Length = 85.20 in
14
12
10
8
6
4
2
0
Wrf = 10.57 Klb
Pump Card Abnormal Loads
Due to Lifting Liquid to Hole
and Not Lifting to the Surface
Fo From Fluid Level (Fo FL) = 3.77 Klb
Fo Max = 3.93 Klb
Fo Max = 3930 Lbs if Lifted
From Pump Depth of 6975'
SV Open
SV Close
TV Close
TV Open
EPT = 78.60 in
0
20
40
60
80
in



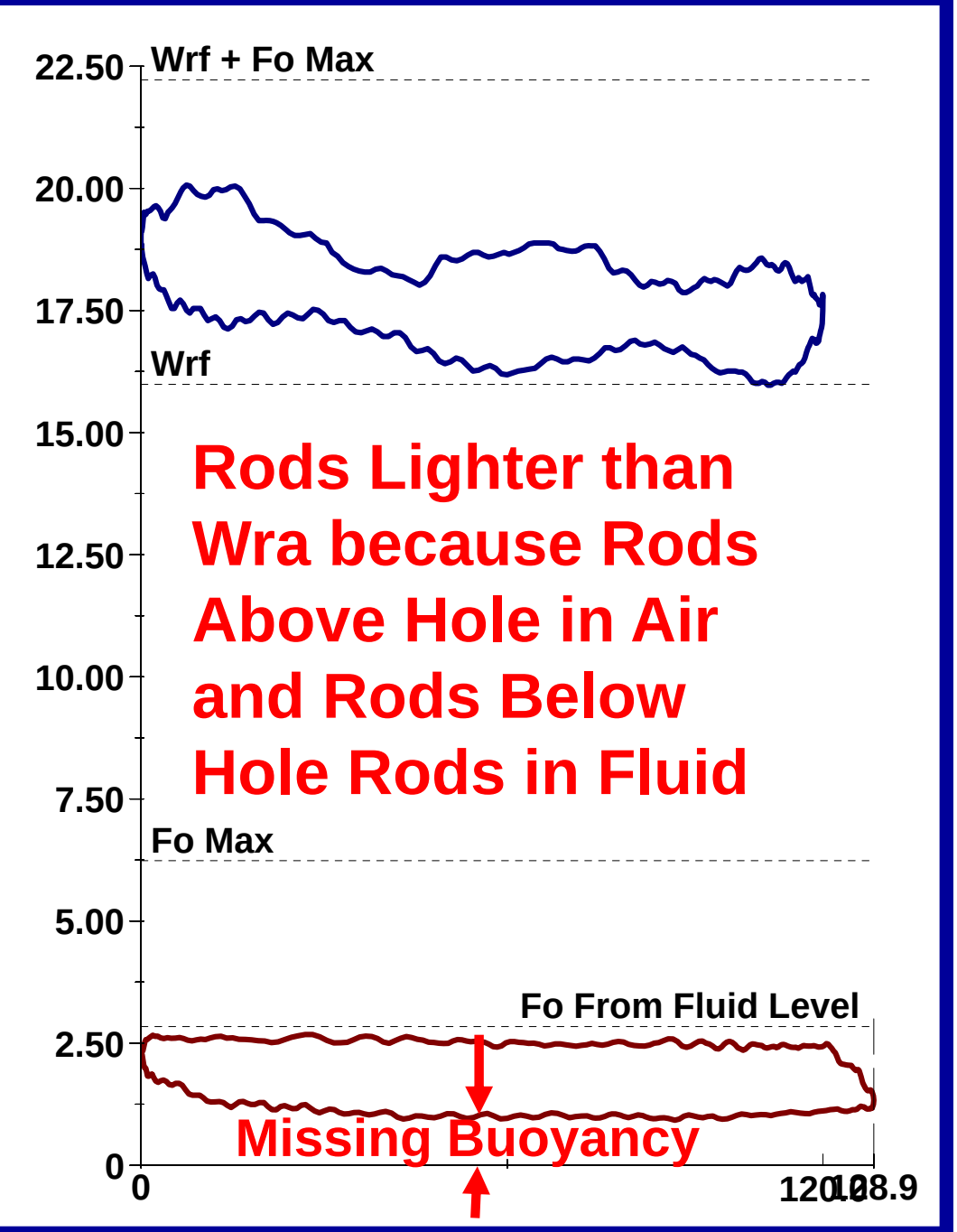

Klb
Stroke: 5 00:00:43
Stroke Length = 85.20 in
14
12
10
8
6
4
2
0
Wrf = 10.57 Klb
Pump Card Abnormal Loads
Due to Lifting Liquid out a Hole
and Not Lifting to the Surface
Fo From Fluid Level (Fo FL) = 3.77 Klb
Fo Max = 3.93 Klb
Fo from Fluid Level = 3730 Lbs if
Lifted From 6511' Fluid Level
SV Open
SV Close
TV Close
TV Open
EPT = 78.60 in
0
20
40
60
80
in

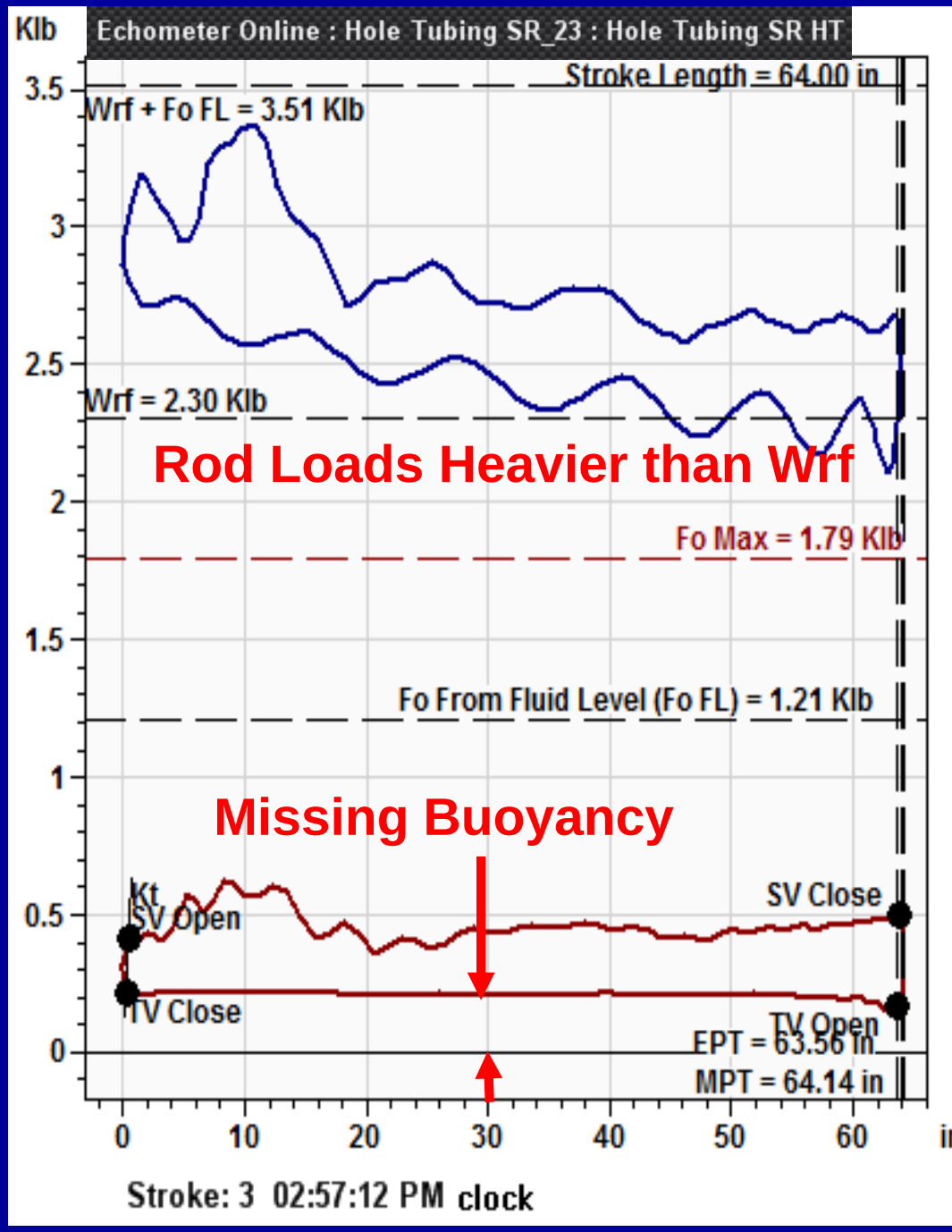



Klb
Echometer Online : Hole Tubing SR_23 : Hole Tubing - PRT
Stroke: 5 00:00:43
Stroke Length = 85.20 in
14
12
10
8
6
4
2
0
Wrf = 10.57 Klb
Pump Card Abnormal Loads
Due to Lifting Liquid out a Hole
and Not Lifting to the Surface
Fo From Fluid Level (Fo FL) = 3.77 Klb
Fo Max = 3.93 Klb
Fo = 1355 Lbs if Lifted Out Hole
@ 4005' From 6511' Fluid Level
SV Open
SV Close
TV Close
TV Open
EPT = 78.60 in
0
20
40
60
80
in



Missing Buoyancy – Hole in Tubing - HT

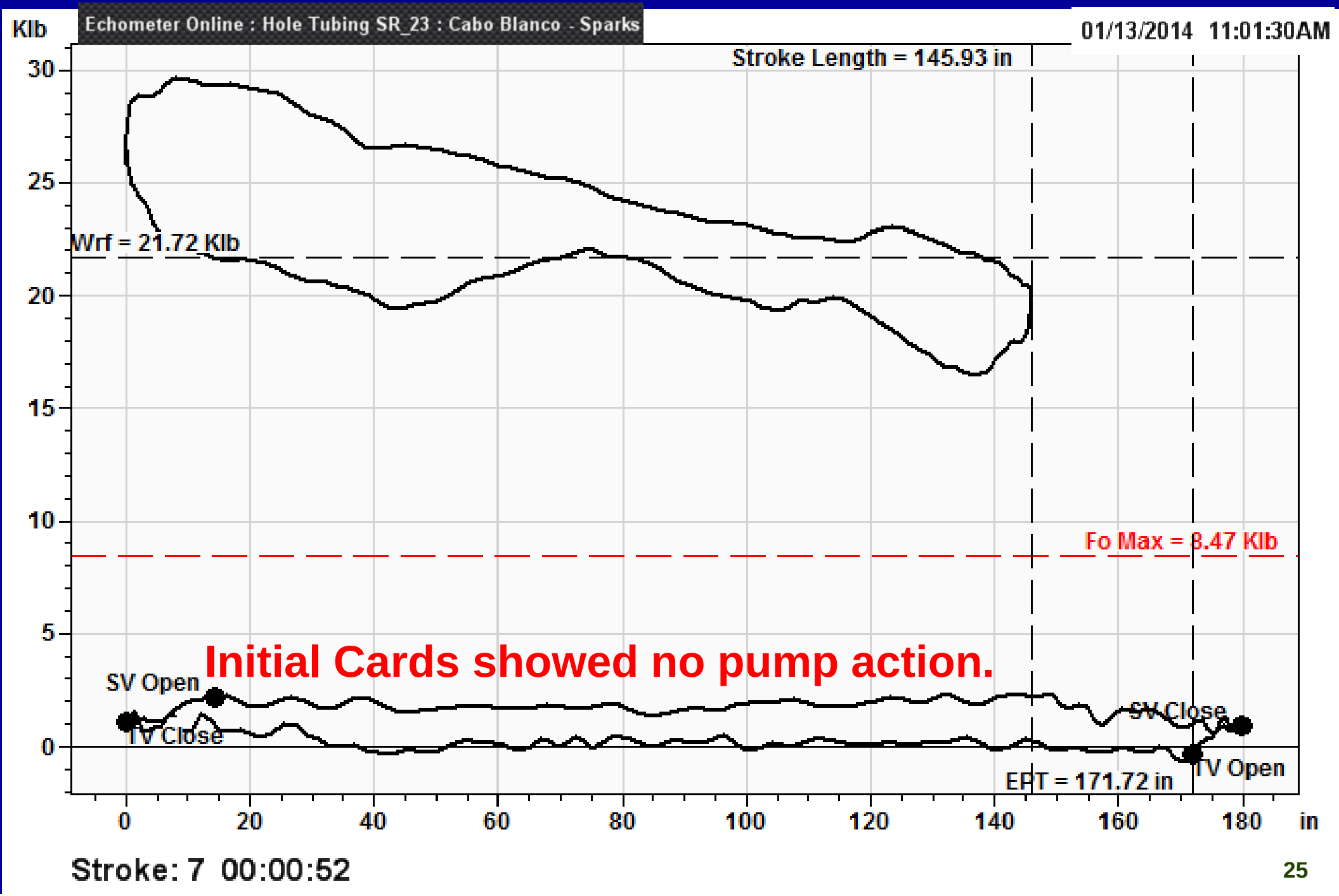


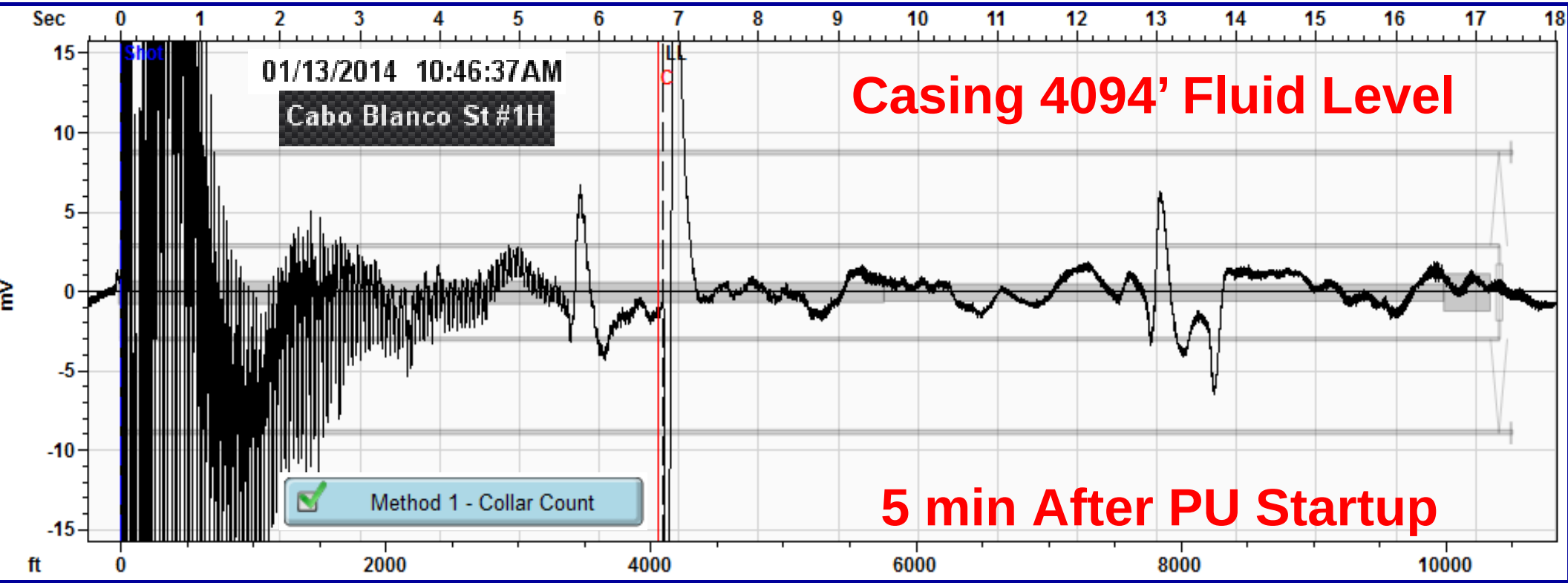


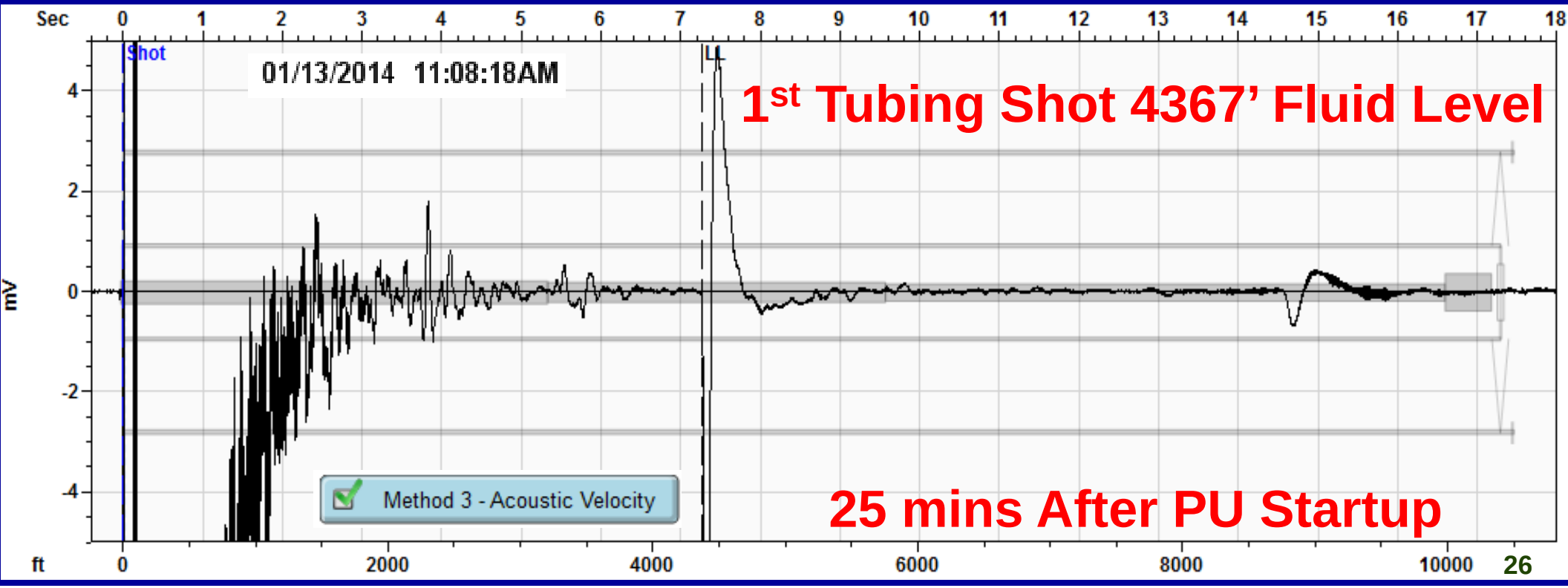
Wells that “Kick”

- Excessive amounts of gas produced up the tubing can “unload the tubing”
- Horizontal leg can “kick” large quantities of gas
- After “unload the tubing” occurs
  1. Operator discover the well not producing to the tank
  2. May suspect the well has a hole in the tubing
  3. Foreign material may stick open a valve in the pump
  4. Surface back-pressure may be insufficient.
- Restart Pump action by loading the tubing with water
- Frequent operator intervention required on wells that “unload the tubing”
- Usually additional back-pressure on the tubing is required to prevent unloading of the tubing

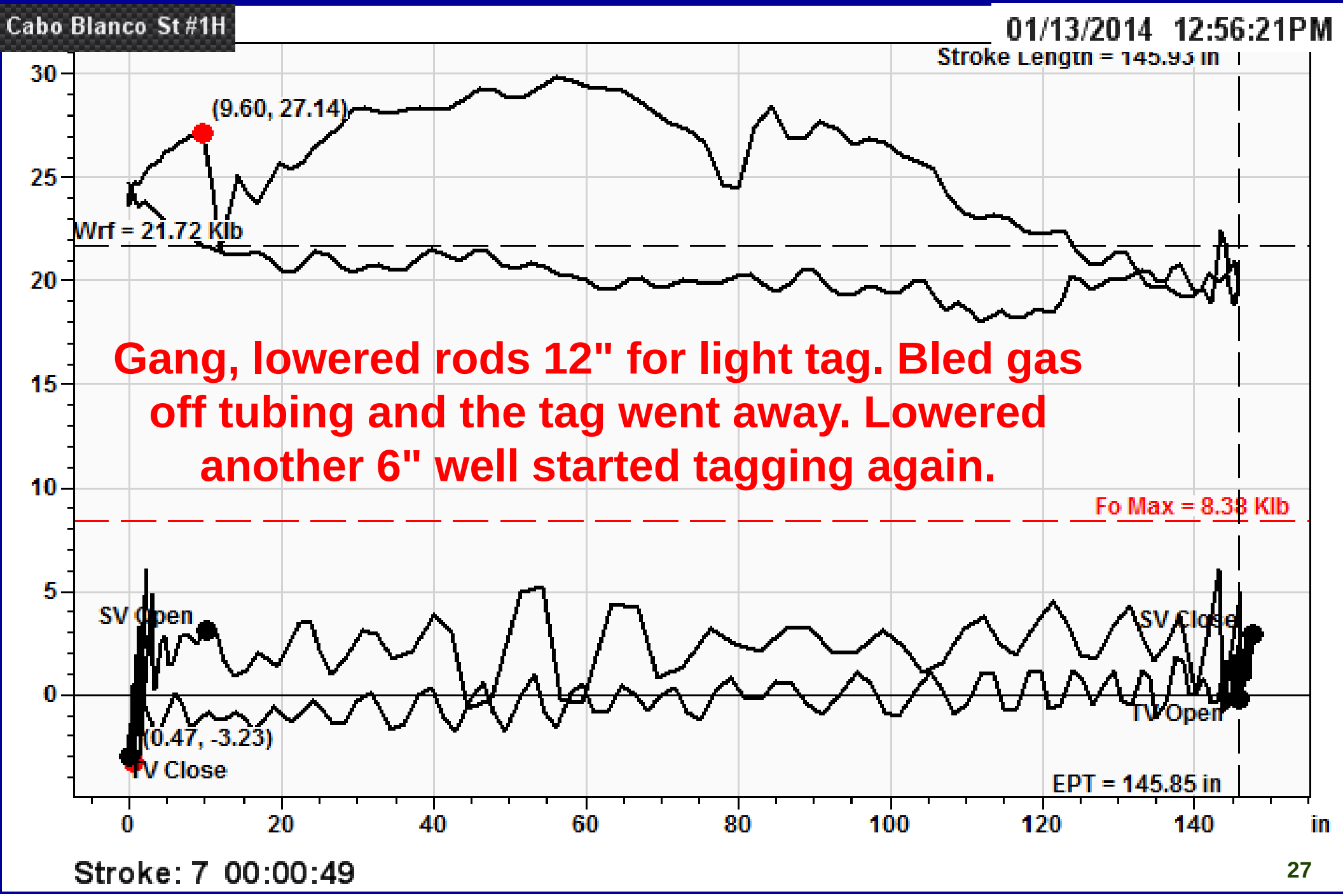
Pumper Reported Well Not Pumping ~ No Fluid to Surface. Arrived on location the well shut-down (HOA on OFF).

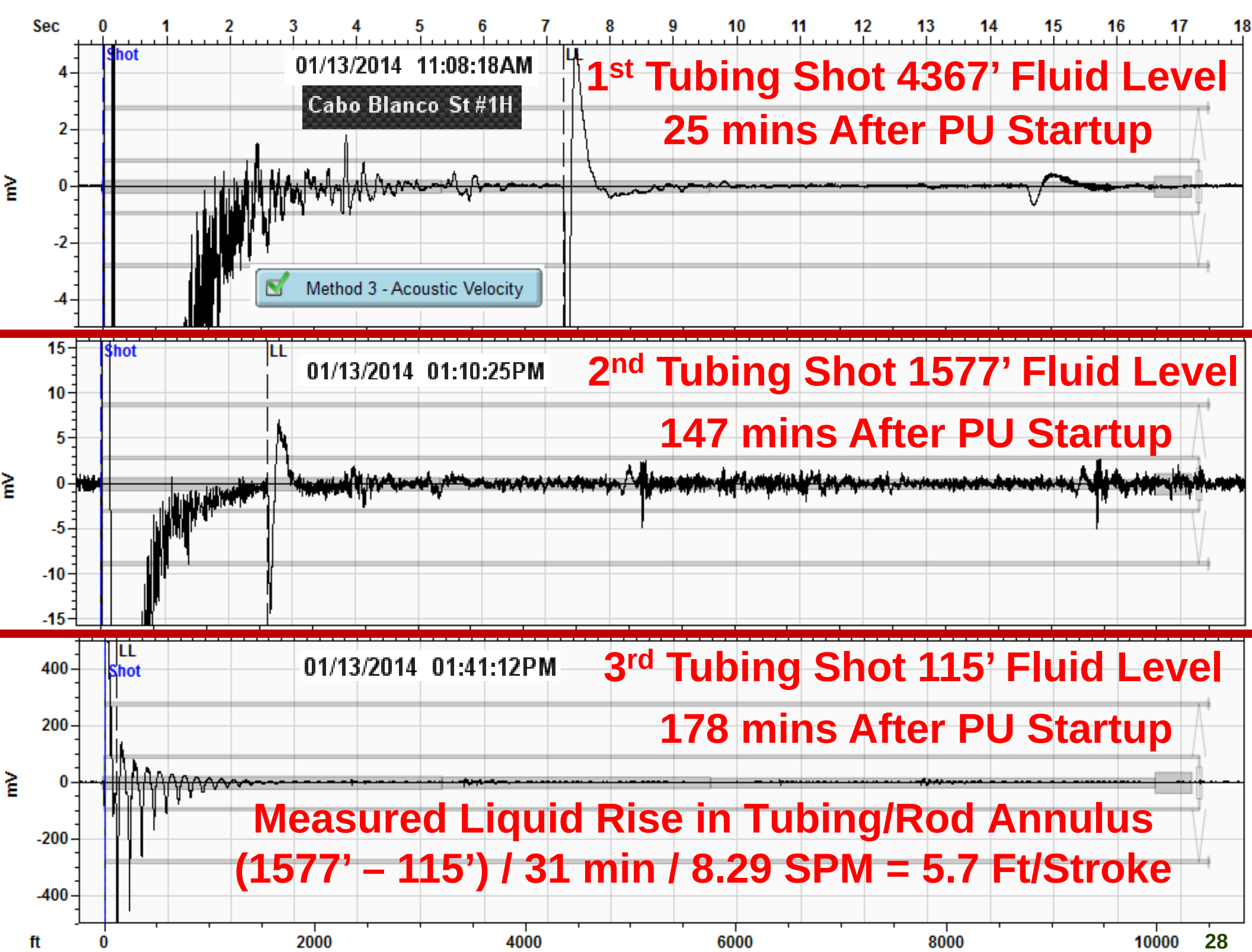



Sec
Shot
01/13/2014 10:46:37AM
Cabo Blanco St #1H
LL
Casing 4094' Fluid Level
Method 1 - Collar Count
5 min After PU Startup
mV
ft

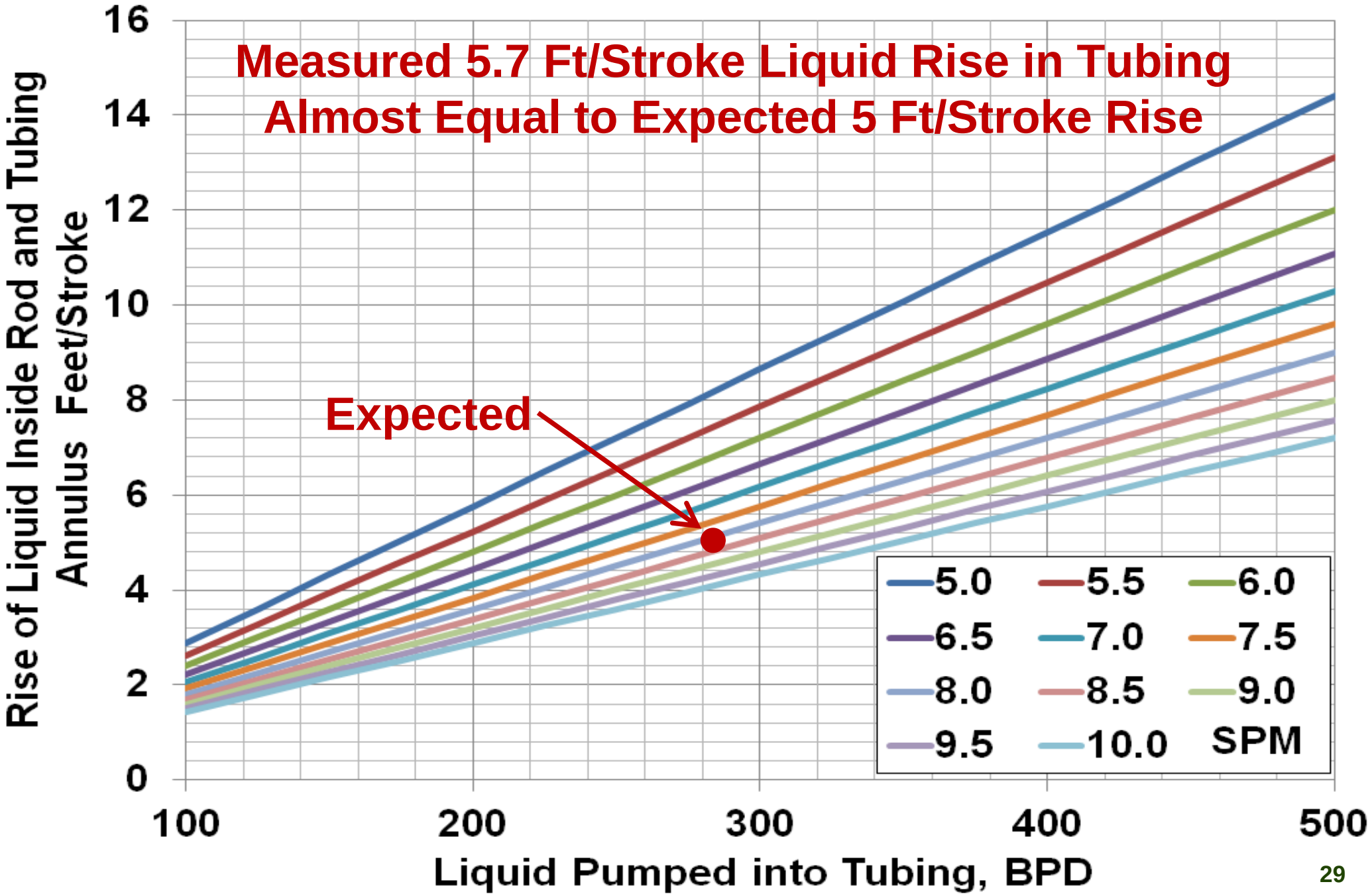

Sec
Shot
01/13/2014 11:08:18AM
LL
1st Tubing Shot 4367' Fluid Level
Method 3 - Acoustic Velocity
25 mins After PU Startup
mV
ft

Lower Rods to Increase Compression Ratio and Pump any Gas interference and Prevent Gas Locking Pump

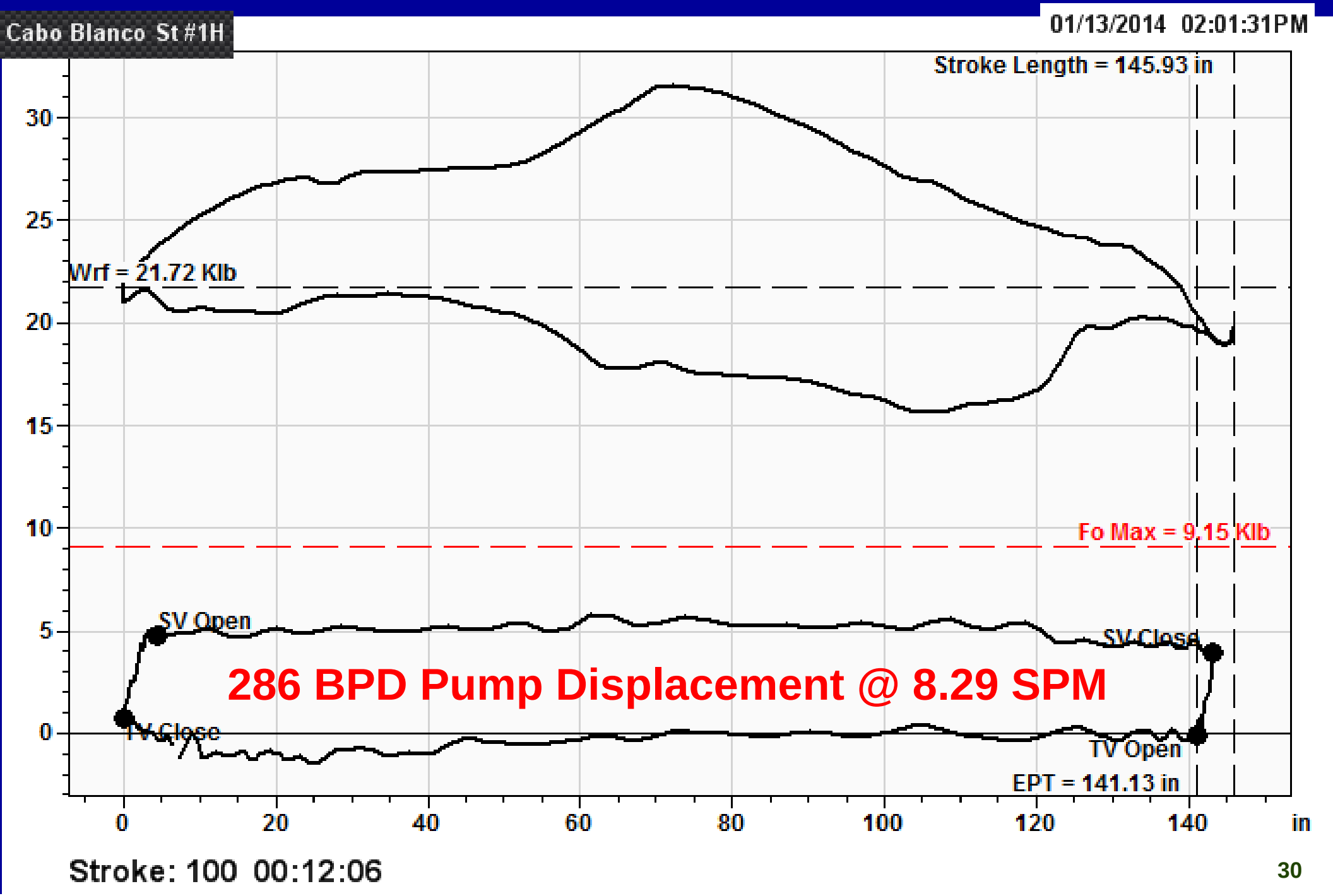



Sec
Shot
01/13/2014 11:08:18AM
Cabo Blanco St #1H
LL
1st Tubing Shot 4367' Fluid Level
25 mins After PU Startup
Method 3 - Acoustic Velocity
mV
Shot
LL
01/13/2014 01:10:25PM
2nd Tubing Shot 1577' Fluid Level
147 mins After PU Startup
LL
Shot
01/13/2014 01:41:12PM
3rd Tubing Shot 115' Fluid Level
178 mins After PU Startup
Measured Liquid Rise in Tubing/Rod Annulus
(1577' – 115') / 31 min / 8.29 SPM = 5.7 Ft/Stroke
ft

Feet/Stroke Liquid Level Rise Between 1” Rod and 2.875” Tubing Annulus



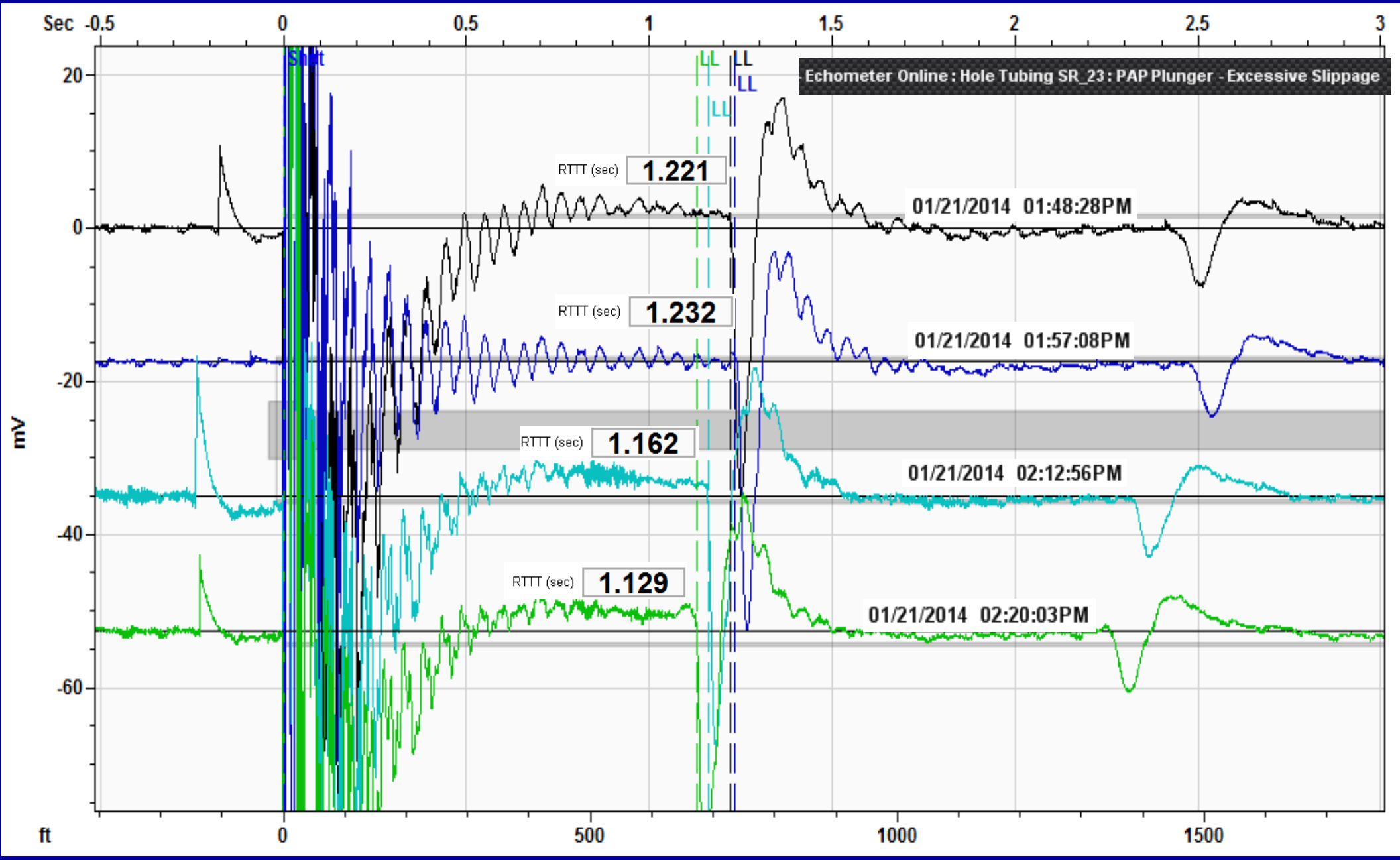
Left Well Pumping with 450 psi Back-pressure



Documenting Fluid Movement

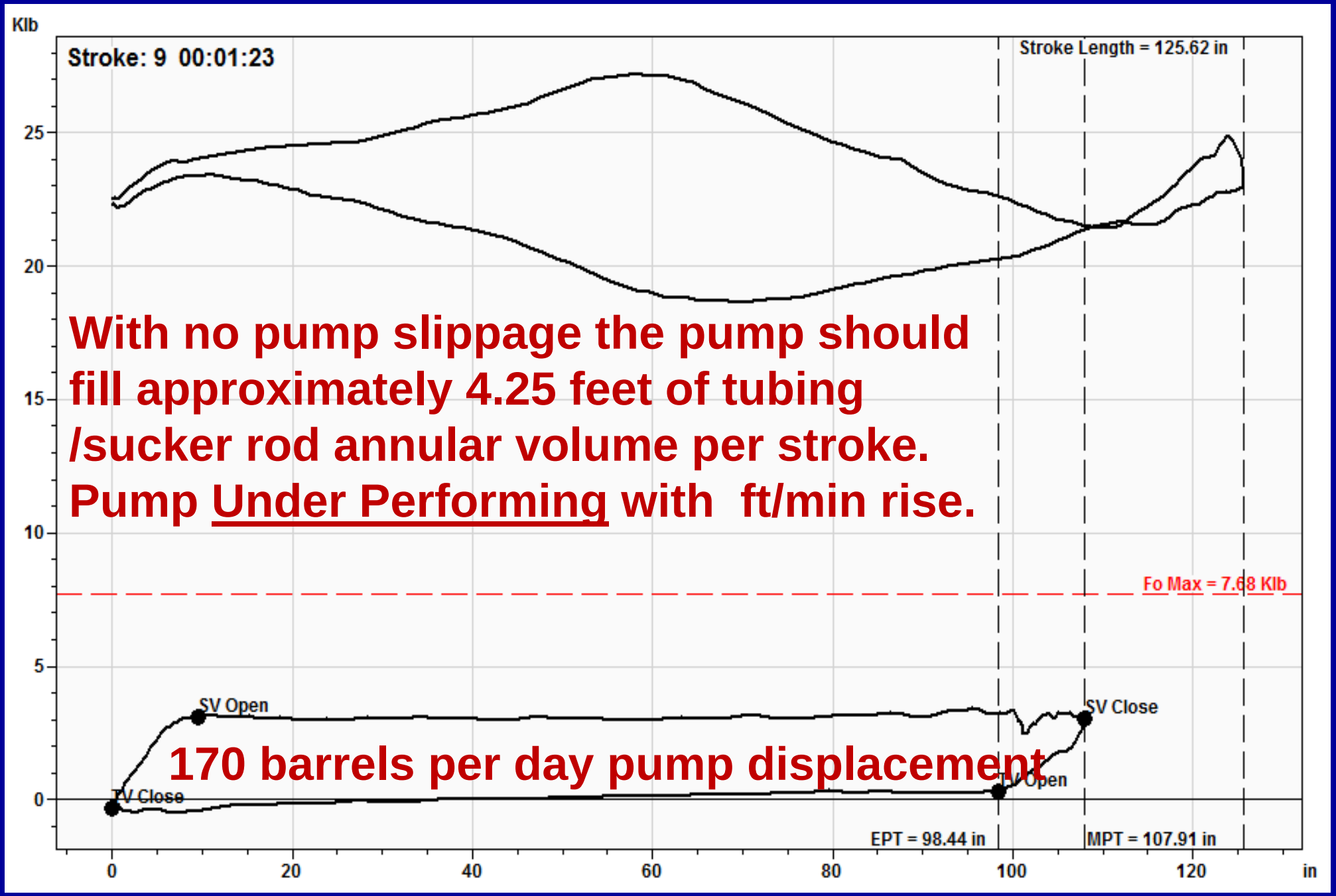
- Pump installed in the well was under-performing and not pumping sufficient liquid per stroke into the tubing
- Dynamometer pump card shows good pump action
- As the well was produced, the lowered fluid level increased the pressure acting across the plunger and pump slippage increased.
- High differential pressure acting across the PAP plunger, lost pump displacement due to slippage
- Fluid level shots down the tubing determined whether or not the pump in this well is truly pumping
- No matter what the “cards” look like, the fluid level shot down the tubing shows the pump is not bringing fluid to the surface

Fluid Level Rise Inside Tubing



Successive tubing fluid shots show PAP pump was under-performing by not pumping sufficient liquid per stroke

Measured 1.0 ft/min Fluid Level Rise Too Slow



With no pump slippage the pump should fill approximately 4.25 feet of tubing /sucker rod annular volume per stroke. Pump <u>Under Performing</u> with ft/min rise.

170 barrels per day pump displacement

When to Run a Pressure Test

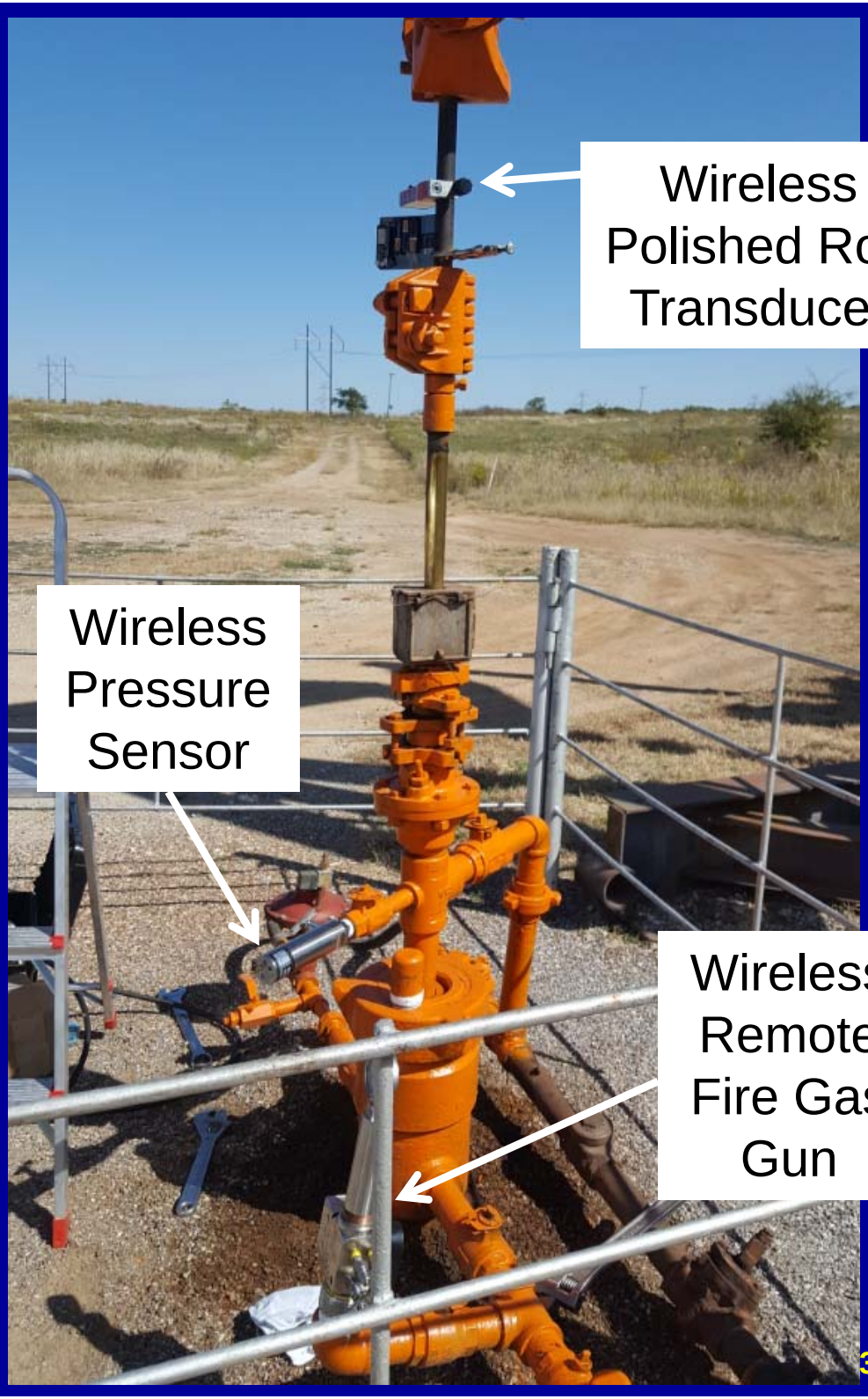
1. Troubleshooting Sucker Rod Lifted Well because Production Rate has Dropped Off OR Less Than Expected.
2. Verify Tubing Holds Pressure and Casing Check Valve Operates Properly After a Work-Over on a Well
3. Standard Practice to Perform Test During a Scheduled Dynamometer Test Acquisition.
4. As an additional Test Following a Traveling/Standing Valve Test
5. TV Test Indicates a Leaky Pump, Verify Tubing is Holding Pressure

Pressure Test Tubing

1. When a Hole-In-Tubing, HIT, is suspected then a recommended practice is to confirm the HIT by pressure testing the tubing with a water truck.
2. If no fluid is produced to the surface, then the tubing pressure test is done by shutting down the well (usually on the downstroke) and pumping clean treated water into the tubing.
3. Tubing is usually pressured up to 500 psi(g) and the pressure is held for a period of time.
4. If hole is present the tubing pressure will quickly leak off ..
5. Collar leak can take 10 minutes or longer to leak off
6. If fluid is produced to surface, then the typical procedure to pressure test the tubing is performed by using the sucker rod pump to increase surface pressure by pumping against a closed surface flow line valve.

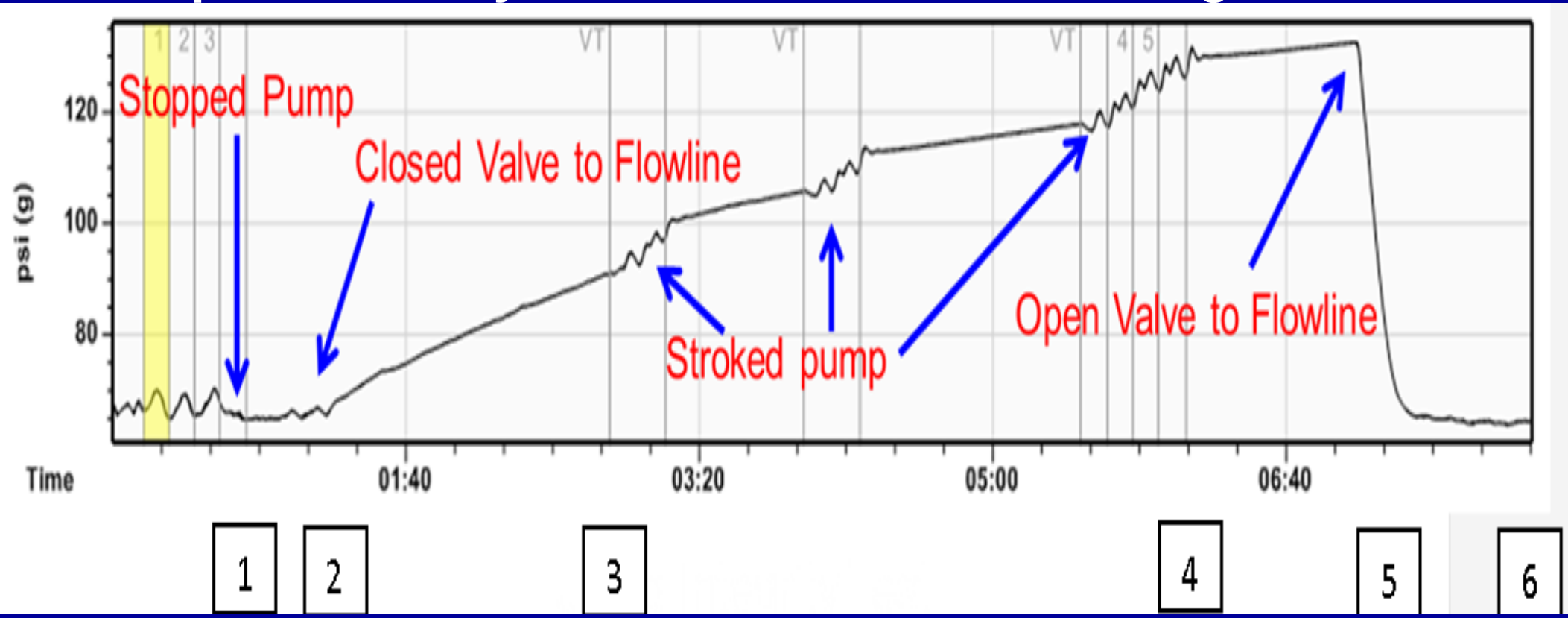
How Pressure Test Data Acquired

1. Test is primarily performed during wireless acquisition of dynamometer (WPRT or WHT)
2. Simultaneously pressure is acquired with wireless pressure sensor (WPT) connected to the tubing at the pumping-tee or at the flowline fluid sampling valve



Example Tubing Integrity Pressure Test Data

Sequence of key events that occurred during this test.



(5) to (6) Valve to flow line is opened and the pressure monitored at the surface quickly decreases to original flow line pressure.

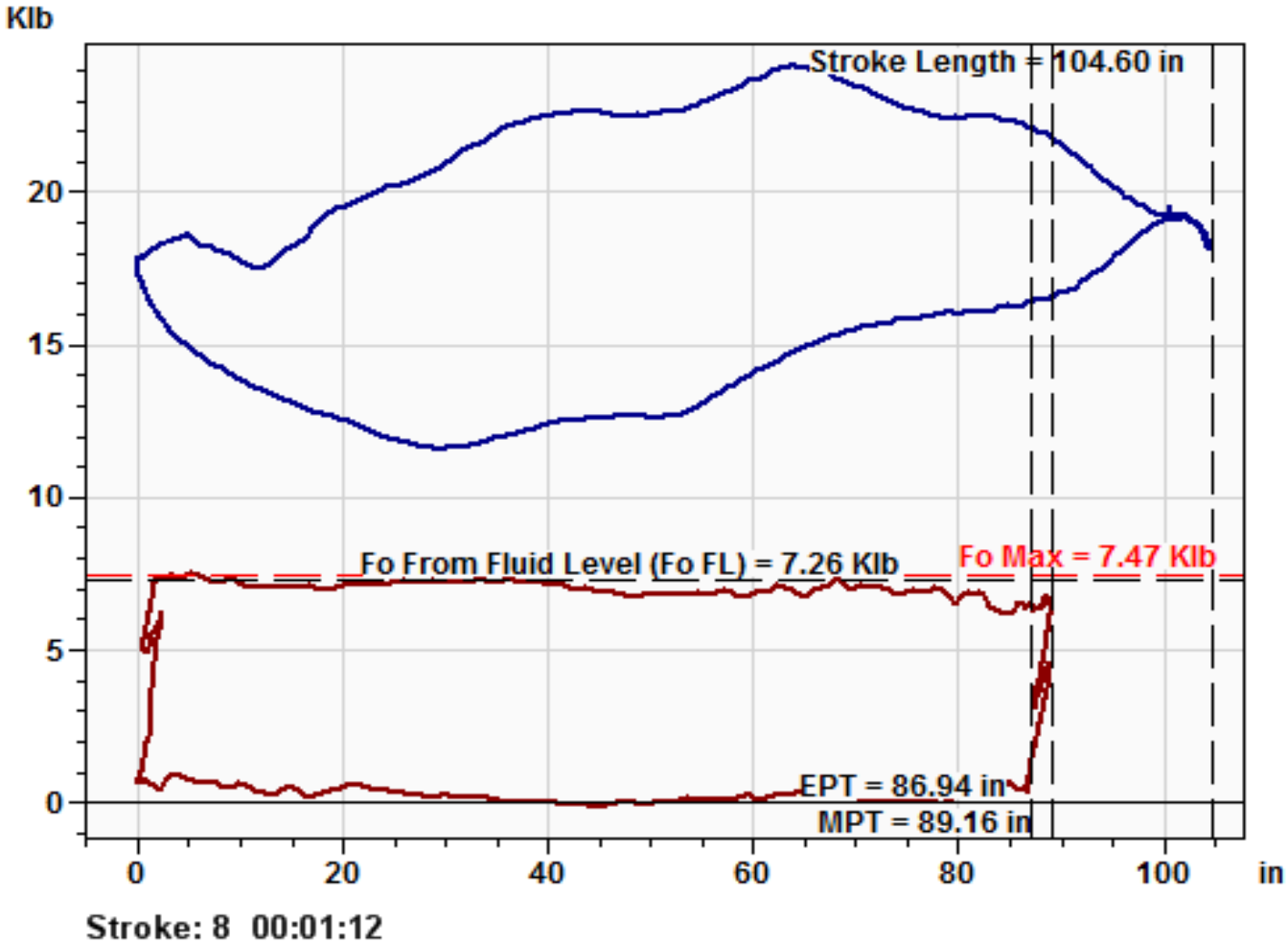
Note: One reason the pump was stroked in several periods, rather than continuously, was to prevent the surface pressure from building up too high. If/when the tubing is completely filled with incompressible liquid, then the surface pressure can quickly increase to over pressure the stuffing box.

Dynamometer Data Shows Liquid Filled Pump Displacement Matches Production Rate

	Peak Load	Min Load	Power
Polished Rod	24.14 Klb	11.60 Klb	11.6 HP
Pump	7.54 Klb	-0.11 Klb	9.7 HP

Replay | Events

< Stroke 8 of 14 >



Adj Pump Displacement	128 BBL/D
Calculated Fluid Load Max	7.47 Klb
Surface Efficiency	---- %
Pumping Speed	6.510 spm
Motor to Pump Efficiency	---- %
Pump Intake Pressure	267 psi (g)
Damp Up	0.141
Damp Down	0.141
Adj Fillage	83.94 %
Adj EPT	74.8 in
WPT Tubing Pressure	133.0 psi (g)

Unanchored Kt 490 lb/in Kr 117 lb/in

Annotations

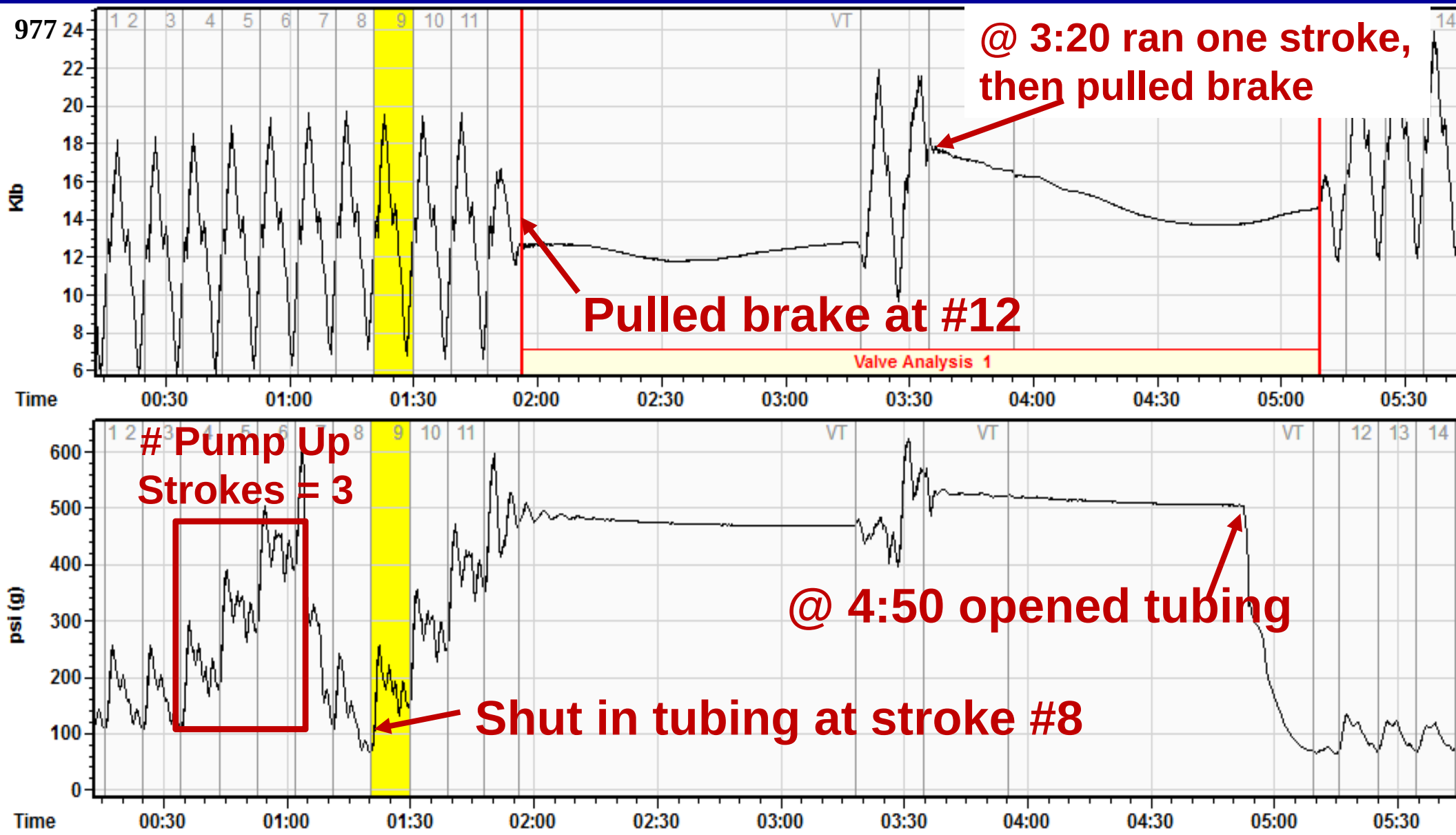
Pump Card Analysis

Determine Number of Pump Up Strokes

1. On wells producing primarily liquid number of pump up stroke must be determined before a pressure testing well.
2. When one person performs pressure test
   - At front he must close the flow valve
   - At back of unit STOP when desired pressure is reached.
3. Operator can not know when the desired pressure is reached, when at the back of unit without knowing pressure
4. Operator could easily overpressure the stuffing box while he is at the back of the pumping unit deciding when to stop for the pressure test
5. Perform a short test to determine the number of strokes required to reach 500 psi by closing the flow valve
6. Lower left corner of following plot shows the tubing pressure built up to 500 psi in just 3 pump up strokes (166 psi/stroke).

Pressure Test as Part of SV/TV Test

Tubing Appears to be Holding Pressure

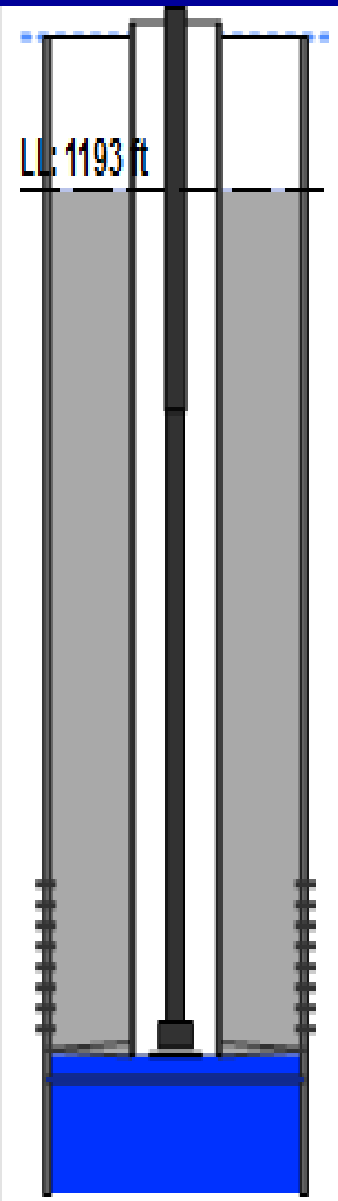


Echometer Online : Hole Tubing SR_23 : PT OK Pump_Full_Liquid

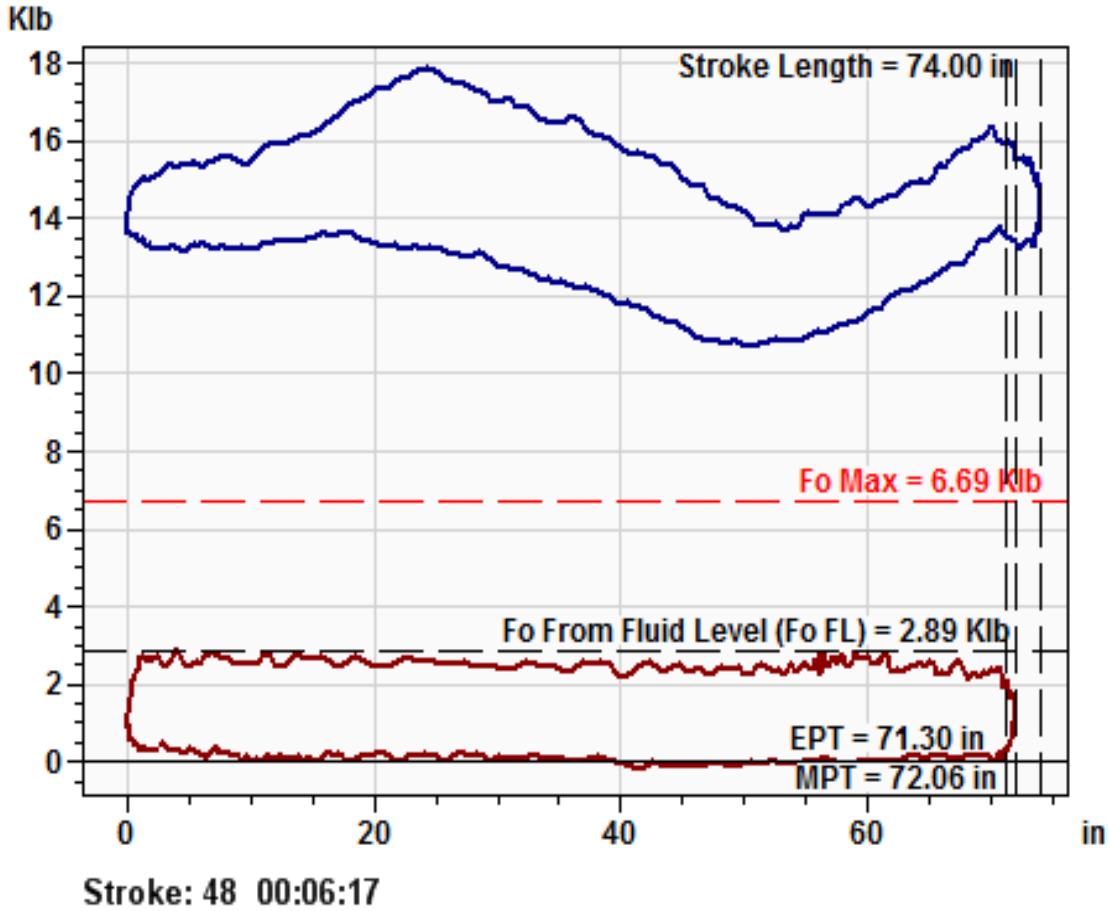
Suspect a Hole in the Tubing when Low Pump Card Height

1. Low pump card height for next example often would cause the operator to suspect a hole in the tubing.
2. Pressure test shows the tubing pressure held fairly constant over a 10 minute time interval, there does not appear to be a hole in the tubing.
3. The tubing quickly pressured up from stroke 51 to 53, because only liquid was being discharged from the pump into the tubing.
4. Tubing pressure test indicates that there is no hole in the tubing
5. Problem identified on this well is the run time is set at 50 % and the well is not being drawn down.
6. Fo from the Fluid Level matches to the height of the downhole pump card, since this well has a very high fluid level.
7. ***<u>Recommendation to increase the run time should result in a significant increase in the production from this well.</u>***

Run Time is 50% and Fluid Level is High and Pump is Full of Liquid



	Peak Load	Min Load	Power
Polished Rod	17.89 Klb	10.71 Klb	4.5 HP
Pump	2.90 Klb	-0.15 Klb	3.3 HP



Stroke: 48 00:06:17

Unanchored Kt 407 lb/in Kr 162 lb/in

Replay | Events

< Stroke 48 of 53 >

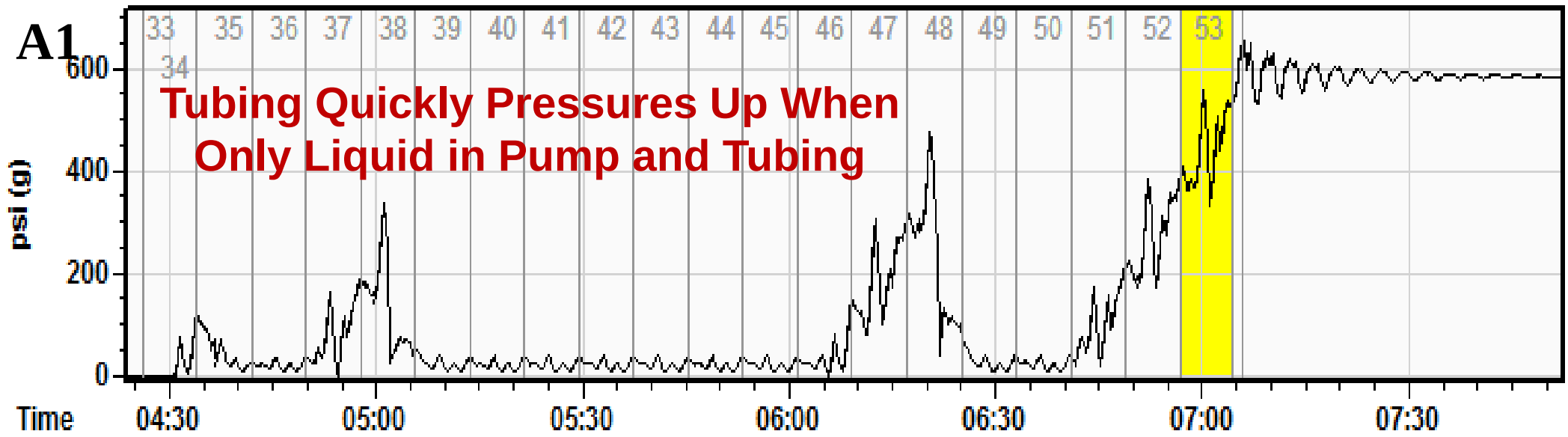
Adj Pump Displacement	124 BBL/D
Calculated Fluid Load Max	6.69 Klb
Surface Efficiency	---- %
Pumping Speed	7.531 spm
Motor to Pump Efficiency	---- %
Pump Intake Pressure	2372 psi (g)
Damp Up	0.129
Damp Down	0.129
Adj Fillage	87.23 %
Adj EPT	62.9 in
WPT Tubing Pressure	235.9 psi (g)

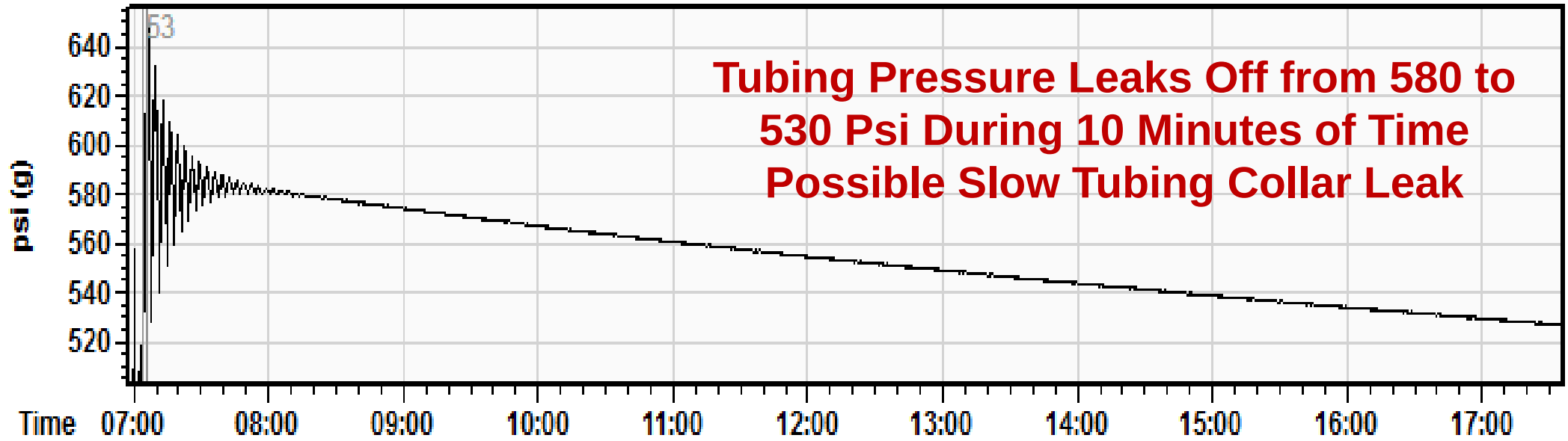
Annotations

Pump Card Analysis

Echometer Online : Hole Tubing SR_23 : PT OK_Pull_Pump_IncreaseRunTime

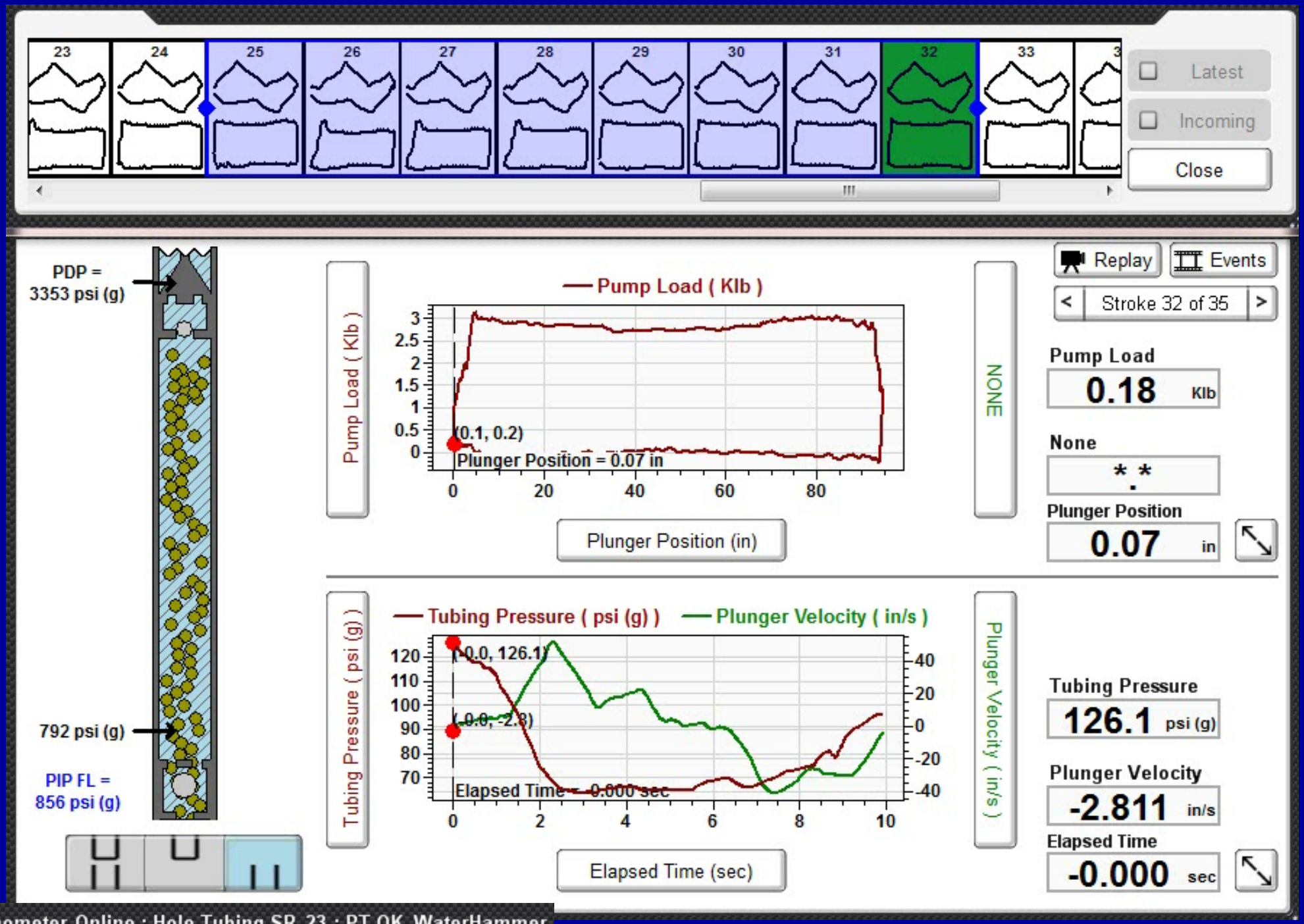
Tubing Pressure Leaks Off from 580 to 530 Psi in 10 Min. of Elapsed Time – NO Hole in Tubing





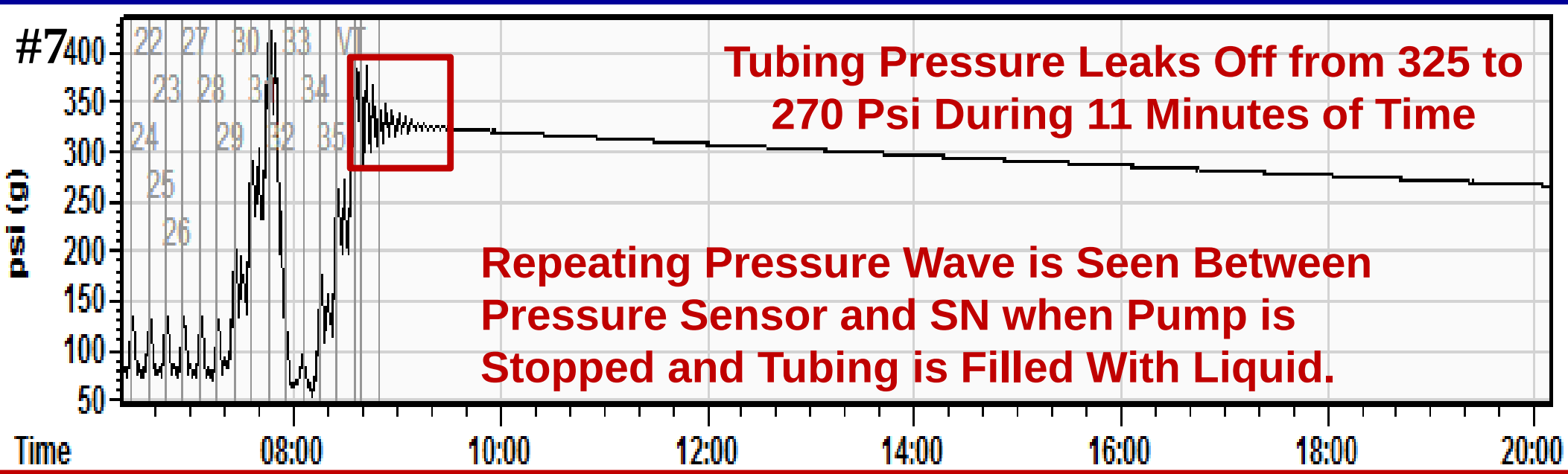
Echometer Online : Hole Tubing SR_23 : PT OK_Pull_Pump_IncreaseRunTime

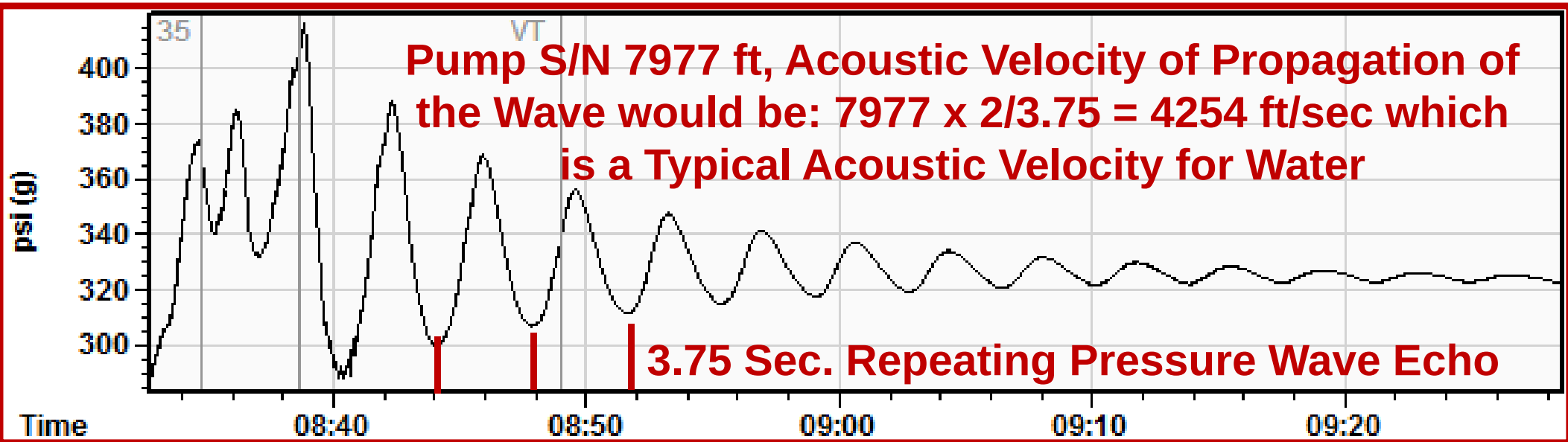
Strokes 25-32 ~ Pump is Full of Liquid



Echometer Online : Hole Tubing SR_23 : PT OK_WaterHammer

Tubing Pressures Up Quickly and Very Slow Leak Off May Indicate a Minor Tubing Collar Leak



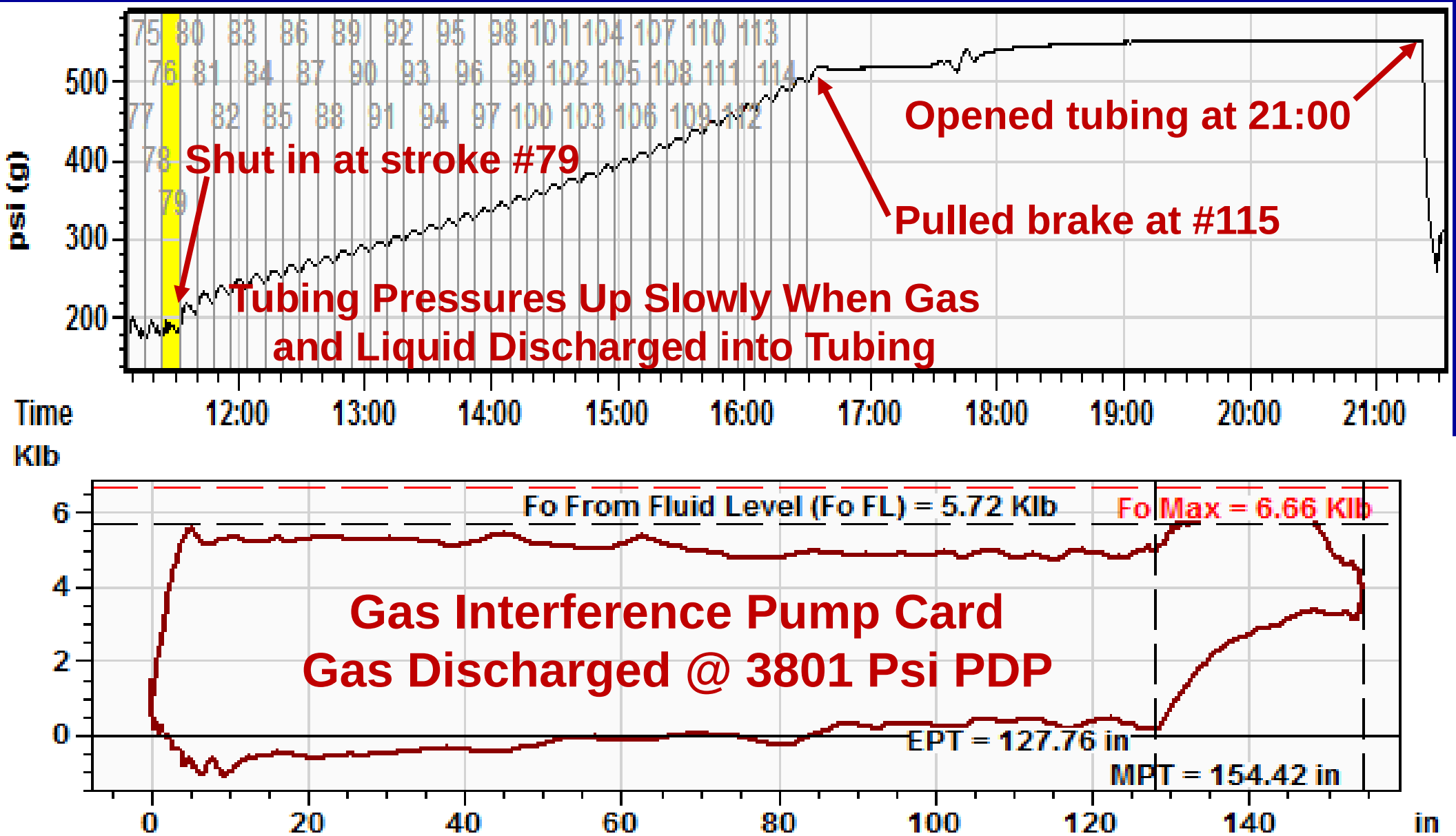


Echometer Online : Hole Tubing SR_23 : PT OK_WaterHammer

Water Hammer Wave Echo Created by Closing Valve with Pump & Tubing Full of Liquid

1. Pump card shape displays gas in the pump and the gas in the pump is compressed and discharged from the pump.
2. This compressed high pressure gas is discharged into the tubing at a 3801 psig pressure.
3. Since there was gas inside the pump a pretest was not required because the tubing pressure slowly increased at 8.6 psi per stroke.
4. The gas in the tubing tends to slip through the liquid in the tubing upward toward the surface.
5. Once the pumping unit is stopped to determine if the tubing pressure will hold, then the higher pressure gas at the near the pump discharge will continue to float through the liquid and accumulate near the top of the tubing string.
6. As the higher pressure gas mixes with the lower pressure gas near the surface, then the tubing pressure at 500 psig increased to 560 psig until the point in time when the surface valve was opened at 21:00

Surface Pressure Increases as High Pressure Gas Rises up Tubing After Pumping Stops



Echometer Online : Hole Tubing SR_23 : PT OK-GasInterference

Pump Filled with Liquid But NO Production to Tank

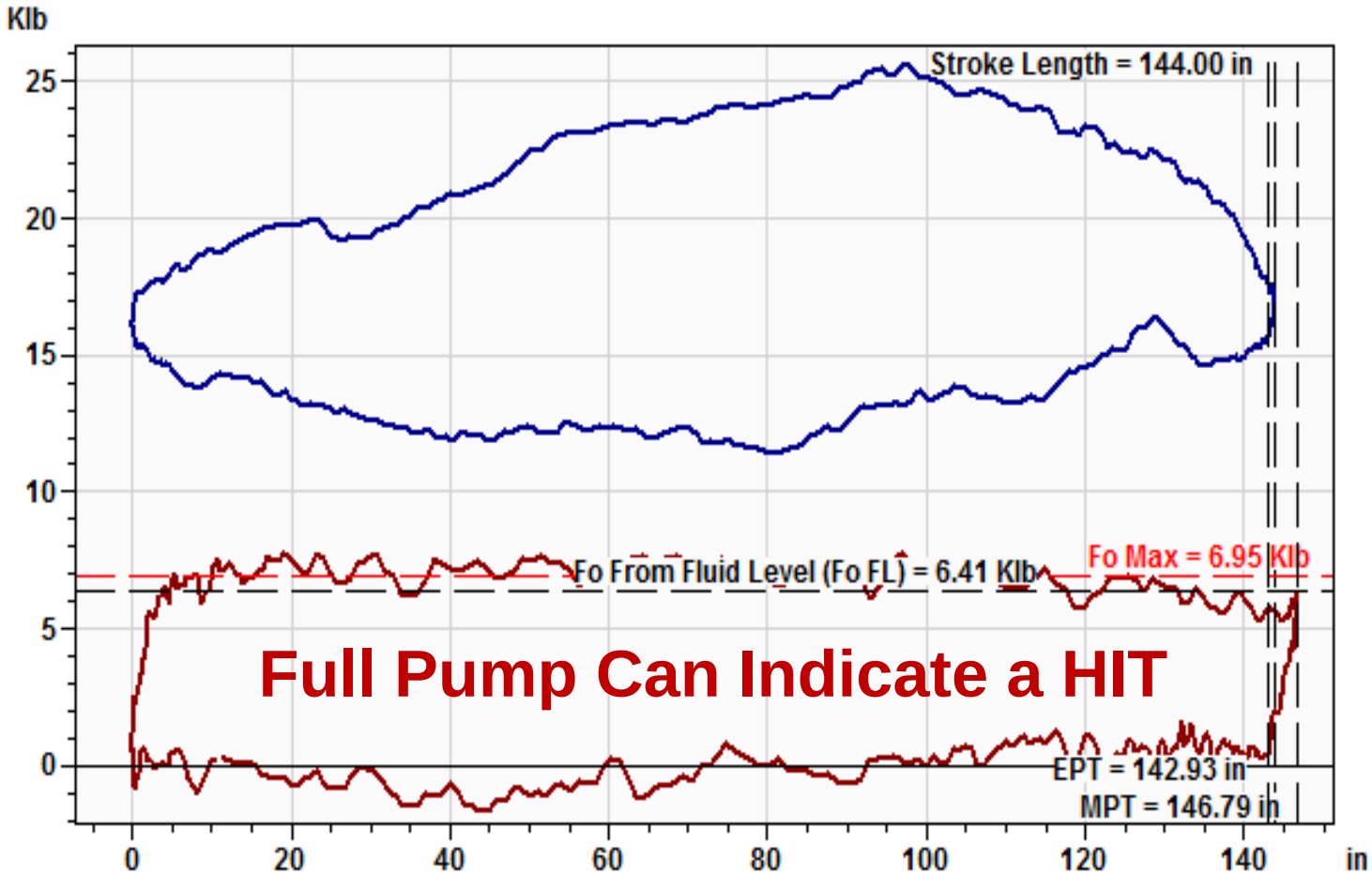
1. Example of a pump filled with liquid, but there is no production to surface even though the pump card displacement is 268 BPD.
2. Fo from the fluid level and Fo Max are approximately equal to the pump card height, so producing bottom hole pressure is low.
3. Tubing pressure near 0 and not changing with the surface flow line is closed.
4. Tubing is filled with liquid based on the pump card height.
5. Liquid is being discharged from the pump, none of the liquid can exit the tubing since the flow line valve is closed.
6. Since the leak rate is high and the pump card loads are high, it is likely that the hole near the surface.
7. ***There is a hole in the tubing since the closed flow line valve isolates the casing check valve from the tubing.***

268 BPD Pump Displacement Shut-in @ Stroke #10 - NO Pressure Increase NO Production

	Peak Load	Min Load	Power
Polished Rod	25.55 Klb	11.37 Klb	24.6 HP
Pump	7.79 Klb	-1.69 Klb	19.6 HP

Replay | Events

< Stroke 11 of 103 >



Stroke: 11 00:01:26

Unanchored Kt 508 lb/in Kr 115 lb/in

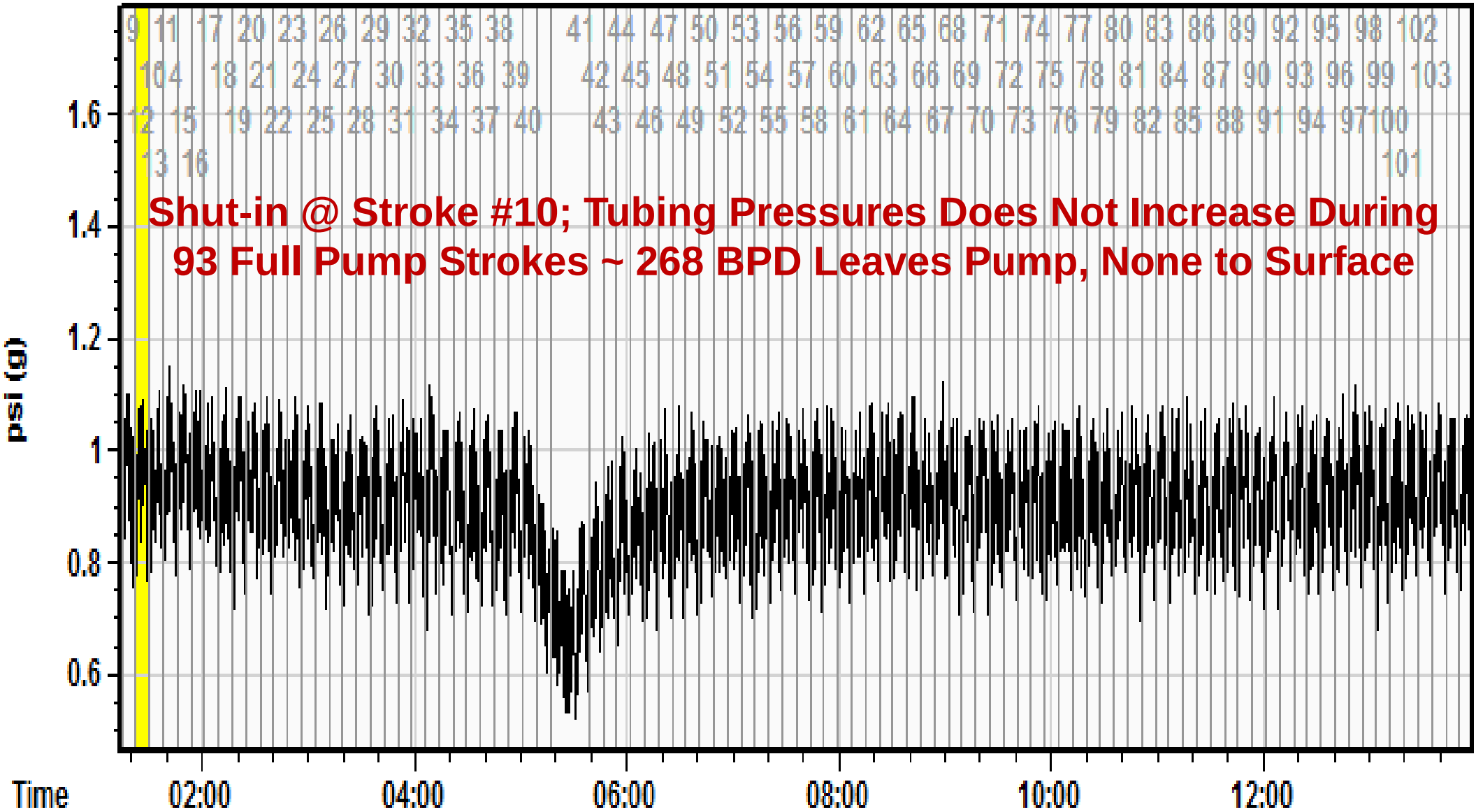
Adj Pump Displacement	268 BBL/D
Calculated Fluid Load Max	6.95 Klb
Surface Efficiency	---- %
Pumping Speed	7.709 spm
Motor to Pump Efficiency	---- %
Pump Intake Pressure	297 psi (g)
Damp Up	0.110
Damp Down	0.166
Adj Fillage	90.42 %
Adj EPT	132.7 in
WPT Tubing Pressure	0.9 psi (g)

Annotations

Pump Card Analysis

Echometer Online : Hole Tubing SR_23 : PT Fail - HIT Near Surface

Likely Hole in Tubing Near Surface, Lifting Liquid to Surface Since Pump Card Height near FoMax

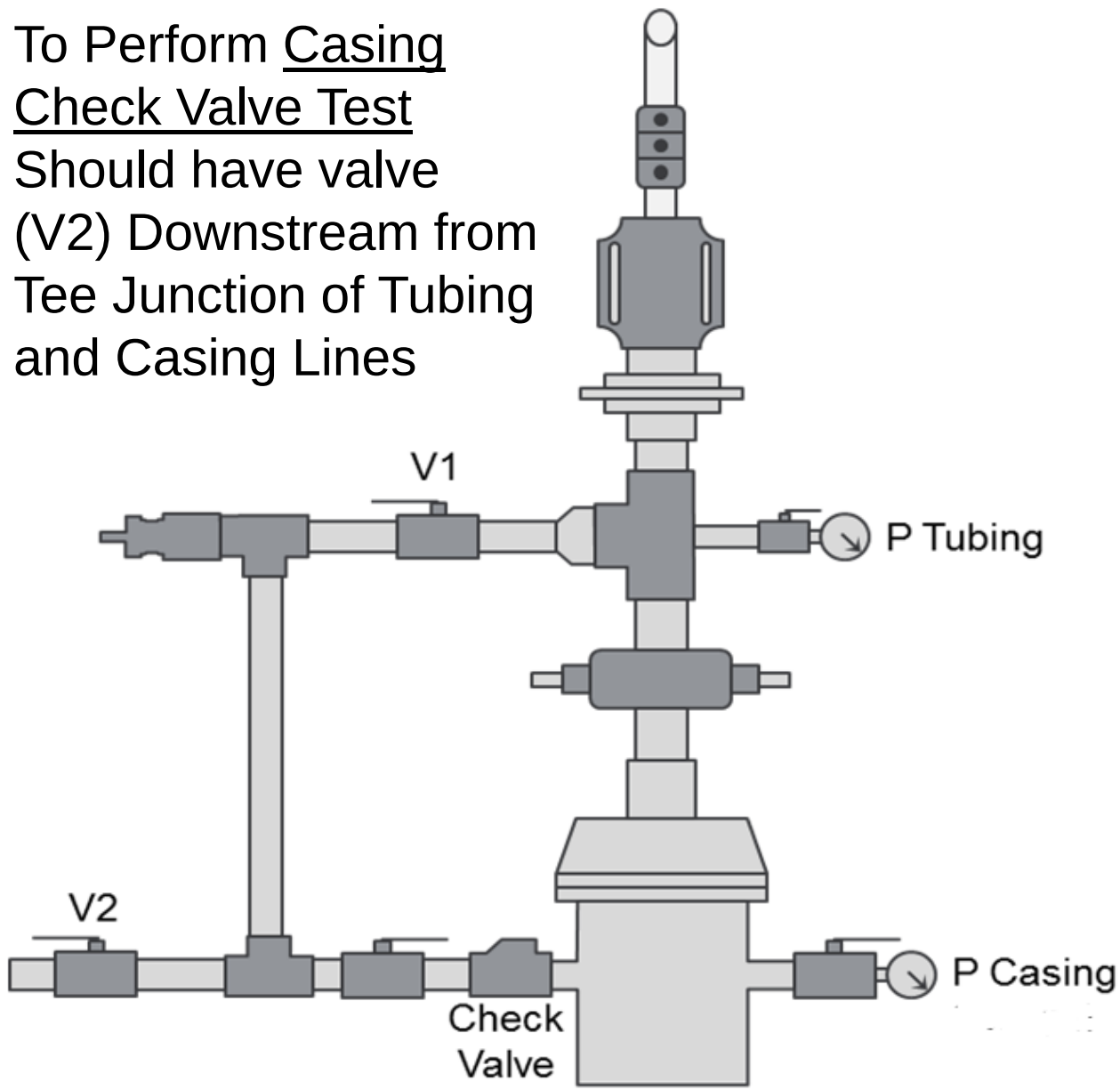


Echometer Online : Hole Tubing SR_23 : PT Fail - HIT Near Surface

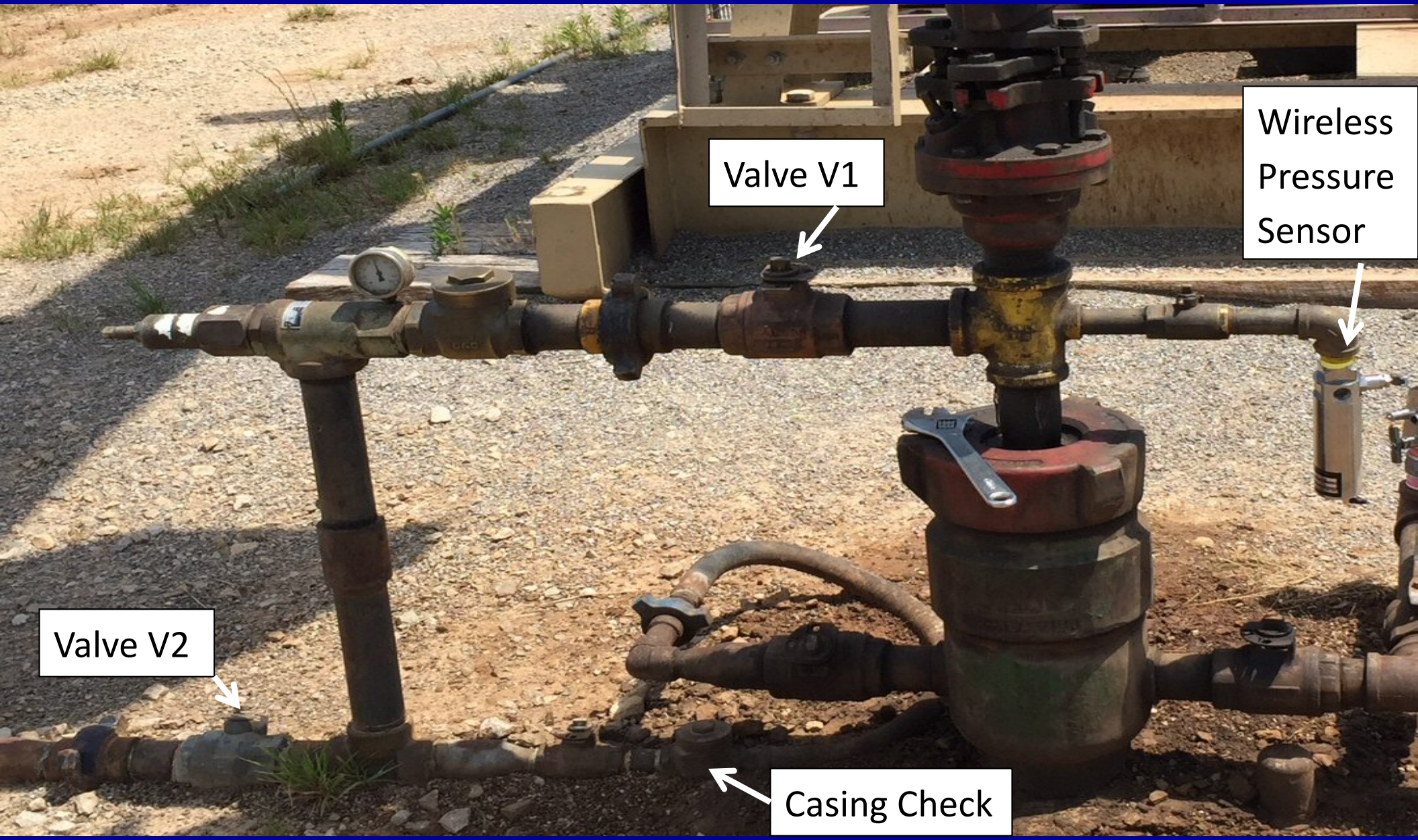
Check Valve Between Flowline and Casing Holding to Prevent Liquid Recirculating Out the Tubing Back Down the Casing

1. Perform at the end of the Tubing Pressure Test
2. Tubing pressure increased above flow line pressure by shutting valve V1 until desired test pressure reached.
3. Tubing is not leaking or leak not very significant.
4. Closing the valve to the flow line (V2) and opening Valve V1
5. Monitor pressure:
   a. If pressure holds then check valve is OK
   b. If pressure drops significantly, then the Casing Check Valve has a problem

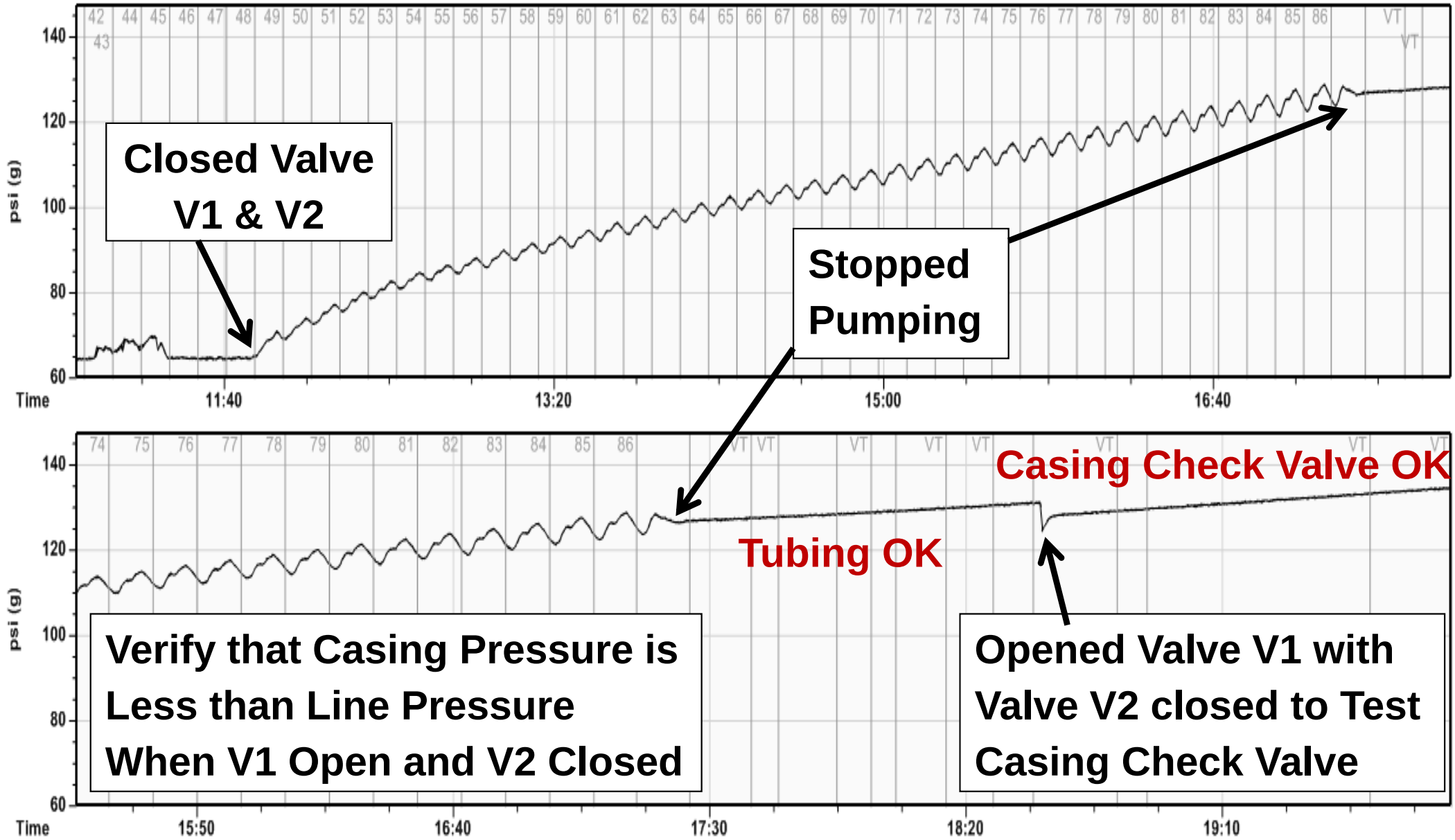
To Perform <u>Casing Check Valve Test</u> Should have valve (V2) Downstream from Tee Junction of Tubing and Casing Lines



Specific Well Setup to Pressure Test Tubing and Then Pressure Test Casing Check Valve



Verified Casing Check Valve is OK and Holding Pressure



Can Pressure Up Tubing

1. Tubing Pressure Test can be used to Identify a HIT.
2. Pressure Data Acquired in Conjunction with a Dynamometer Card Provides Enhanced Troubleshooting Capability.
3. When the Pump is Liquid Filled, then Tubing Pressure can increase in a Few Strokes (Determine # of Pump up Strokes)
4. If hole is present the tubing pressure will quickly leak off or NOT build-up.
5. If Gas is in the Pump, then Tubing Pressure will Slowly Increase and will Continue to Increase After Pumping Stops
6. Important to Pressure Test Tubing, Casing Check Valve, and Tubing Back Pressure Valves.
7. Tubing Pressure vs. Time During Static Traveling and Standing Valve Tests Confirm Valves and Tubing are Holding Pressure
8. Tubing Pressure Increase During Stroke Related to the Plunger Velocity, Well Depth, and Liquid Acoustic Velocity.

No Production to Surface

1. For Rod Pumped Wells, If no pump action or no production to surface, then shoot a fluid level down the tubing.
2. Distance down the tubing typically determined by using the average acoustic velocity obtained from the casing shot.
3. Checked for an upkick from the tubing hole appearing on both traces at or near the same depth.
4. Dynamometer Pump Card height is less than fluid load from fluid level (Fo FL) load required to lift liquid to the surface.
5. Monitoring the fluid level in the tubing over time can be used to determine if the pump action is filling the tubing with liquid.
6. When the data collected on the well is properly interpreted and acted upon, gassy wells can be economic to operate if production can be maintained without continuous intervention.
7. Shooting a fluid level inside the tubing is a valuable troubleshooting technique used on wells that have either stopped producing altogether, or production rate has drastically decreased.