Ask (((ECHOMETER))) Online Seminar – July 22, 2020

Liquid Level Workshop

(((ECHOMETER)))

How to Shoot a Liquid Level

TOTAL ASSET MONITOR (TAM)

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

"Advanced Techniques for Acoustic Liquid Level Determination", McCoy, Podio, Rowlan, Becker, SWPSC 2003

"Acoustic Velocity for Natural Gas", McCoy, J. N.,
https://www.echometer.com/Portals/0/Technical%20Papers/Acoustic%20Velocity%20of%20Natural%20Gas.pdf?ver=2018-12-18-102749-200

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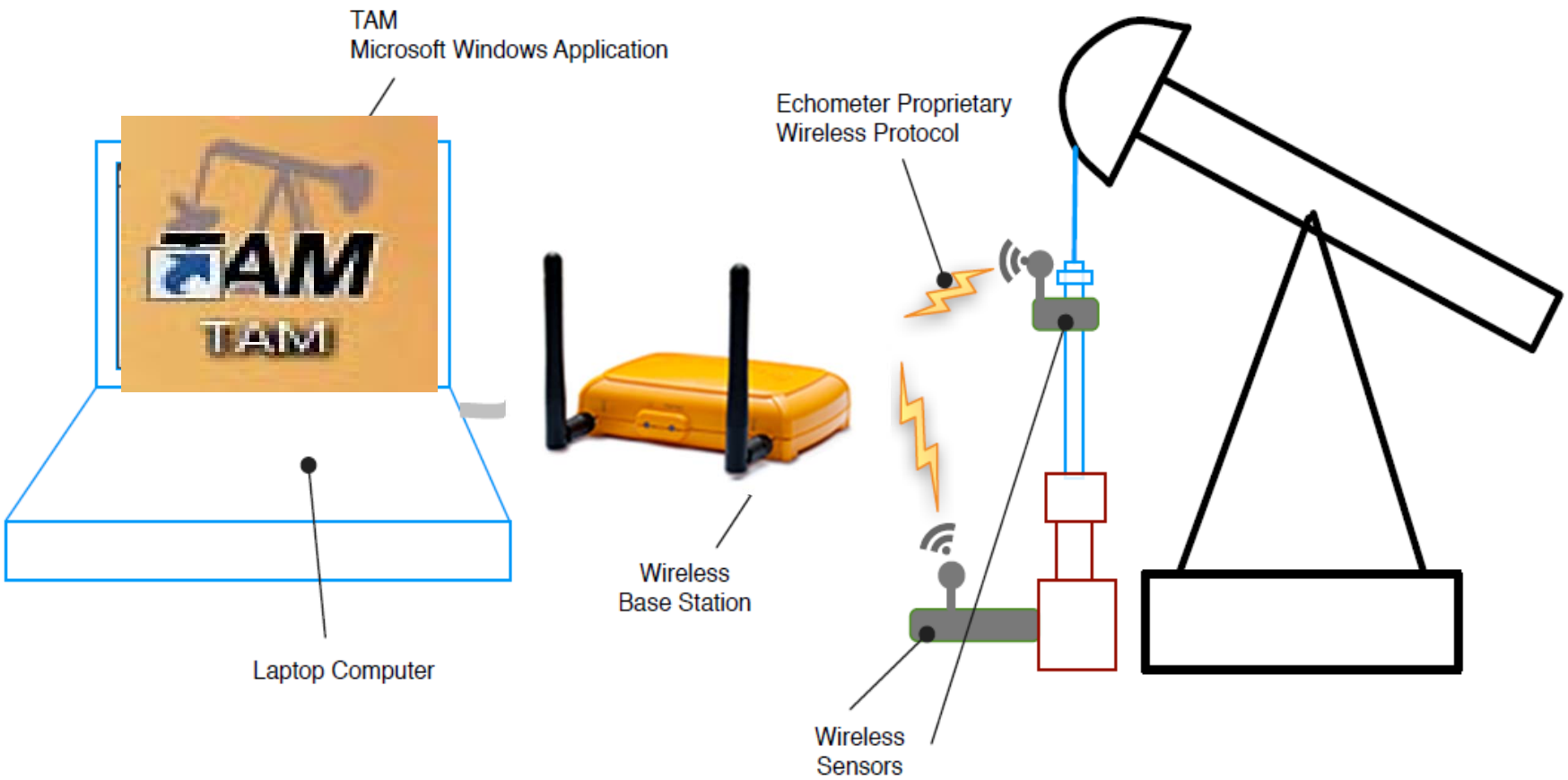
Connect the Wireless Well Analyzer to the Laptop



1. Plug in USB cable.
2. Turn on the Laptop
3. Logon to Windows
4. Start TAM software

Acoustic Pulse Generators

Modern Acoustic Gas Guns:

1. Compact gas gun
2. Remote-fired gas guns

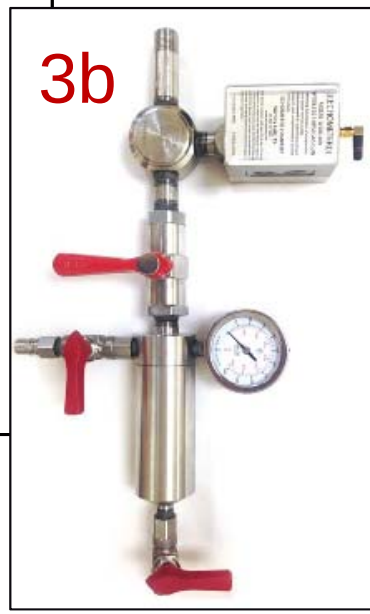
   2a –Wired, 2b-Wireless
3. 5000 psi gas gun

   3a-Wired , 3b Wireless

4 15,000 psi gas gun

Obsolete Acoustic Pulse Generators Include:

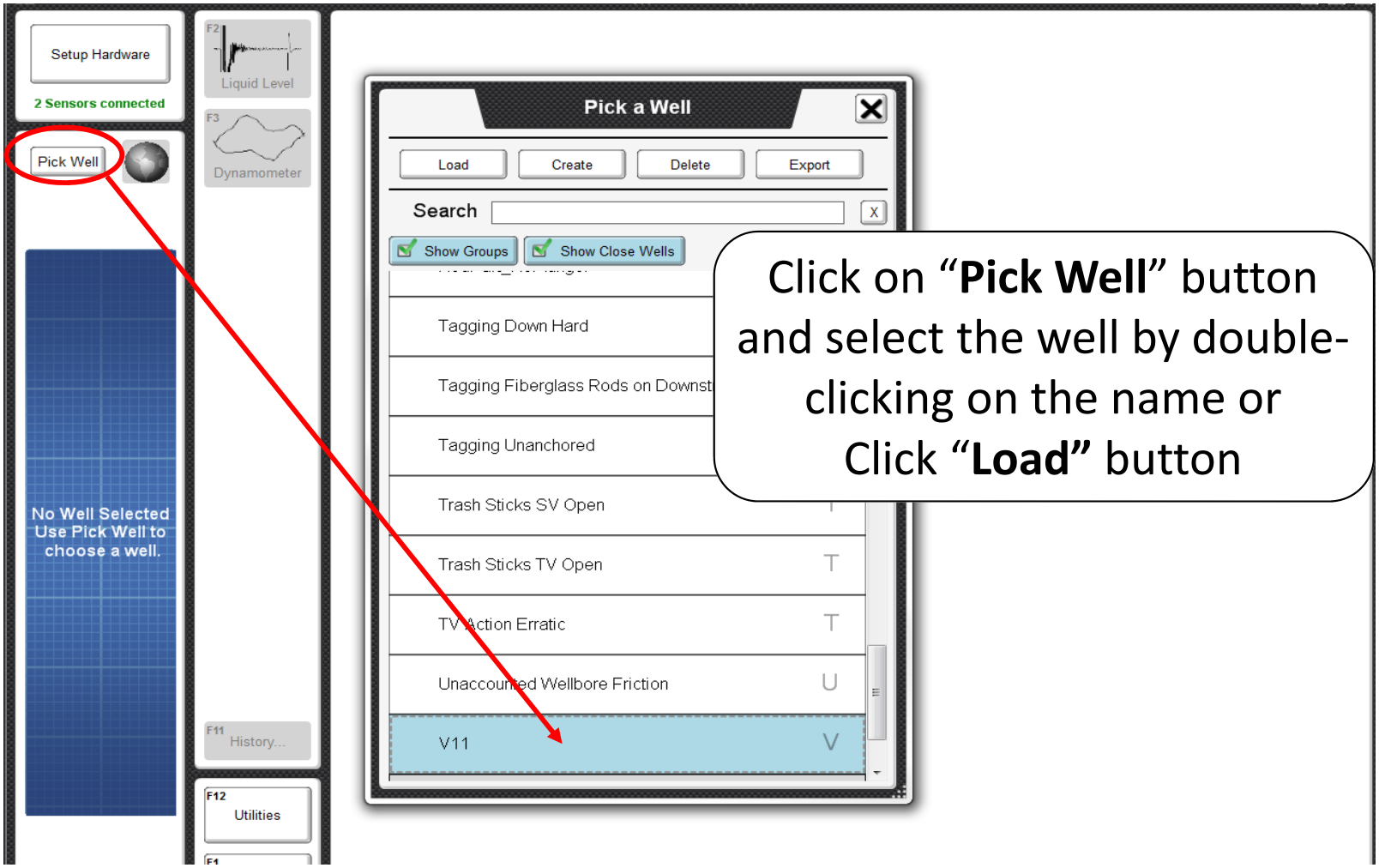
- dynamite cap
- 45 caliber blank
- 10 gauge black powder blank



Comparison of Energy from Gas Gun:

1. 45 caliber = 150 psi
2. 10 gauge = 300 psi

1 Connect Wireless Well Analyzer



If one does not exist, Create a Well and be sure to enter at least avg. joint length, pump and formation depth.

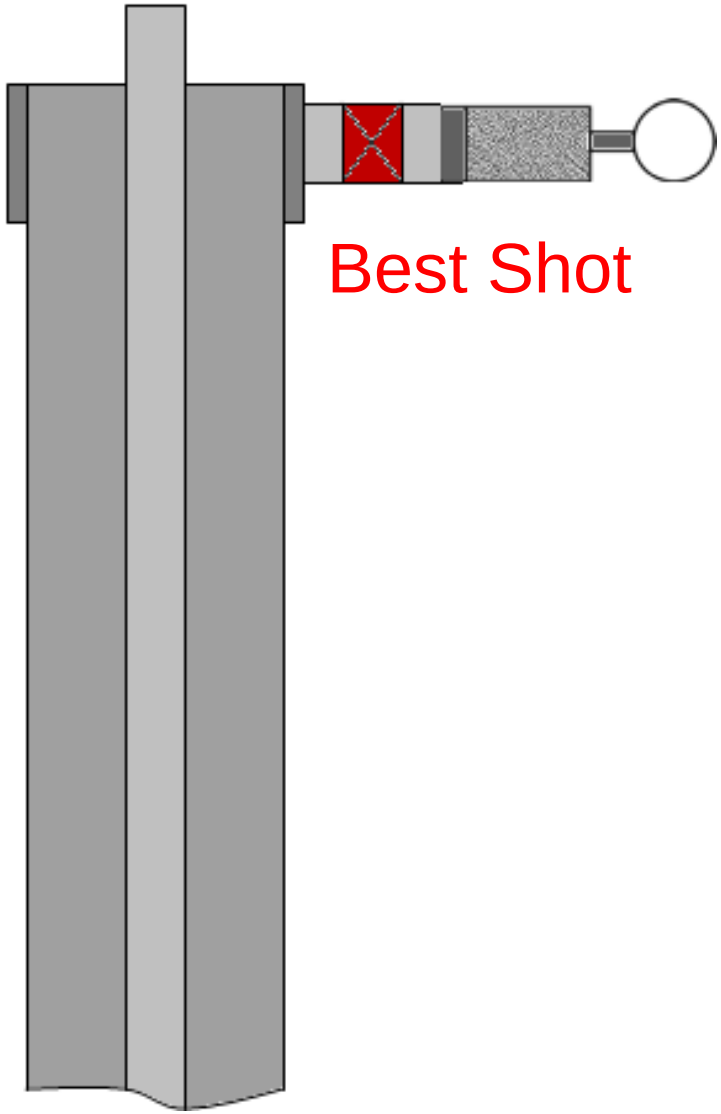
Attach Echometer gas gun to well

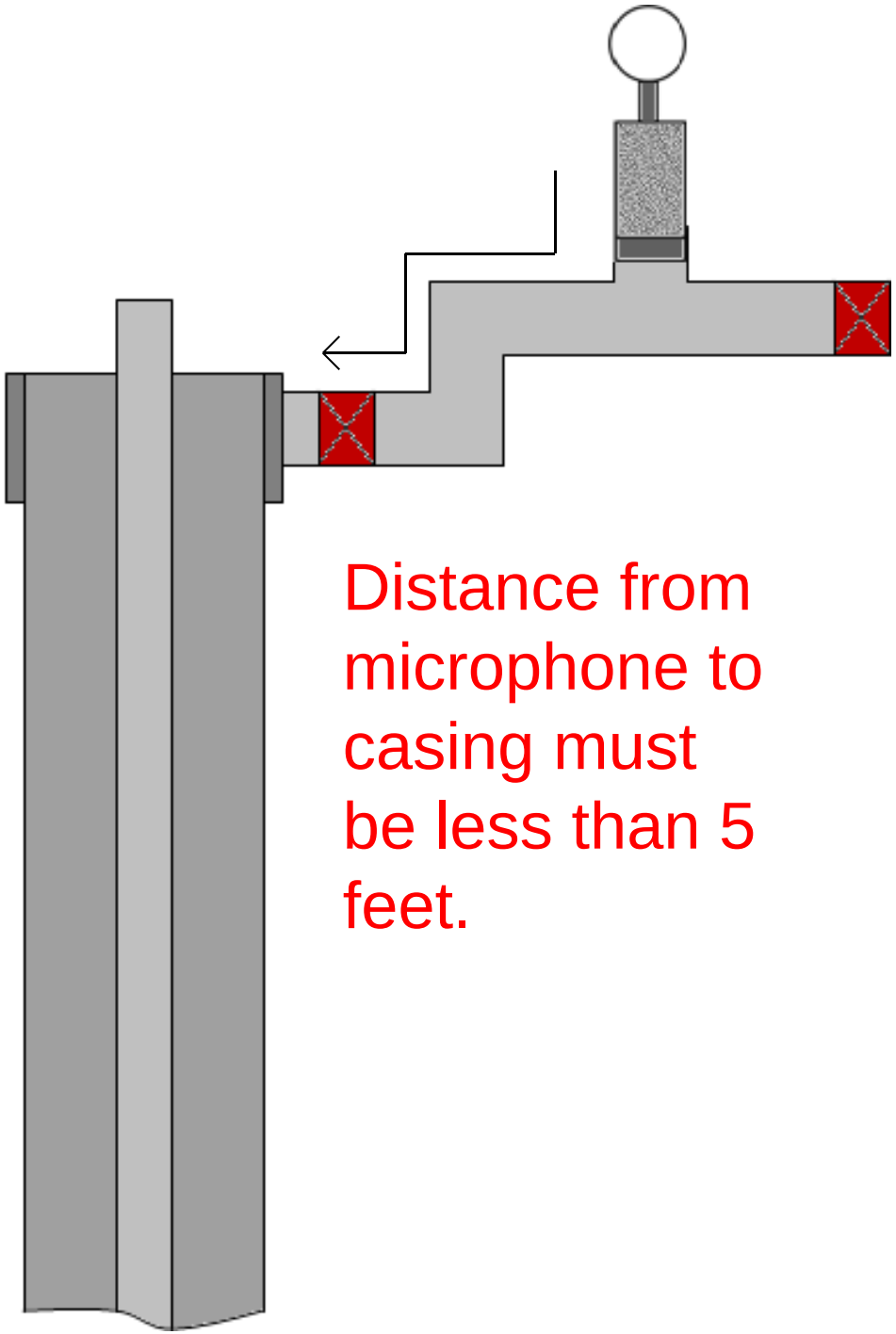
- Check the threads on the wellhead valve for corrosion, wear, or damage.
- For 2” NPT make 4 1/2 turns for SAFE connection to Wellhead when attaching the Echometer gun.
- Less turns may mean threads are damaged.
- Apply Teflon tape to Mic Protector collar to prevent galling of threads.

Attach gas gun to well

1. Know the pressure in the well at the surface.
2. Be alert that equipment ratings exceed well pressure.
3. Do not attach any equipment to the gas gun having a lower rated working pressure, such as a quick connect, its use can result in personal injury plus damage to your equipment.
4. Close off other connections to casing annulus.
5. CHARGE gas gun volume chamber ABOVE the estimated casing pressure.
6. Make Sure Casing Valve between Gas Gun and Casing annulus is Open before shot is fired.

Connecting to Well



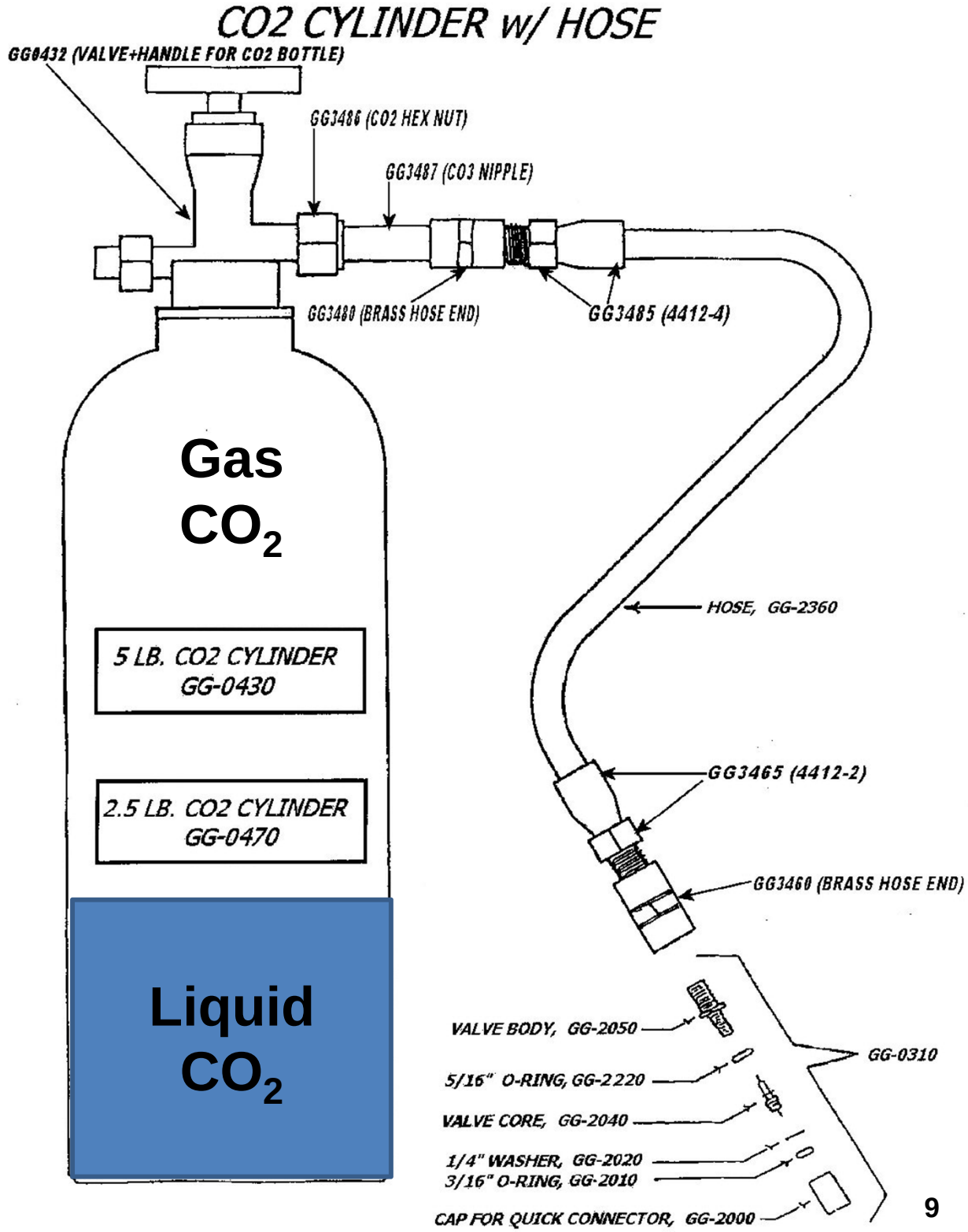


CO_2 Gas & N_2 Gas Advantages

1. Approximately 100 shots from 16 ounces of CO_2
2. 5 pound bottle will provide a lot of shots.
3. Fill CO_2 from siphon-type bottle.
4. Large amount of CO_2 gas contained in small cylinders.
5. CO_2 critical temperature is 88 Deg F & 1070 PSIA.
6. 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.
7. As long as the temperature of the CO_2 gas is high enough that the vapor pressure exceeds the well pressure, carbon dioxide gas is the most convenient gas to use for acoustic testing.
8. If the well pressure exceeds the vapor pressure of carbon dioxide, nitrogen gas is the most common gas to use for acoustic testing.
9. Nitrogen gas supplied at pressure in excess of the rating of gas gun. (May need Pressure Regulator)

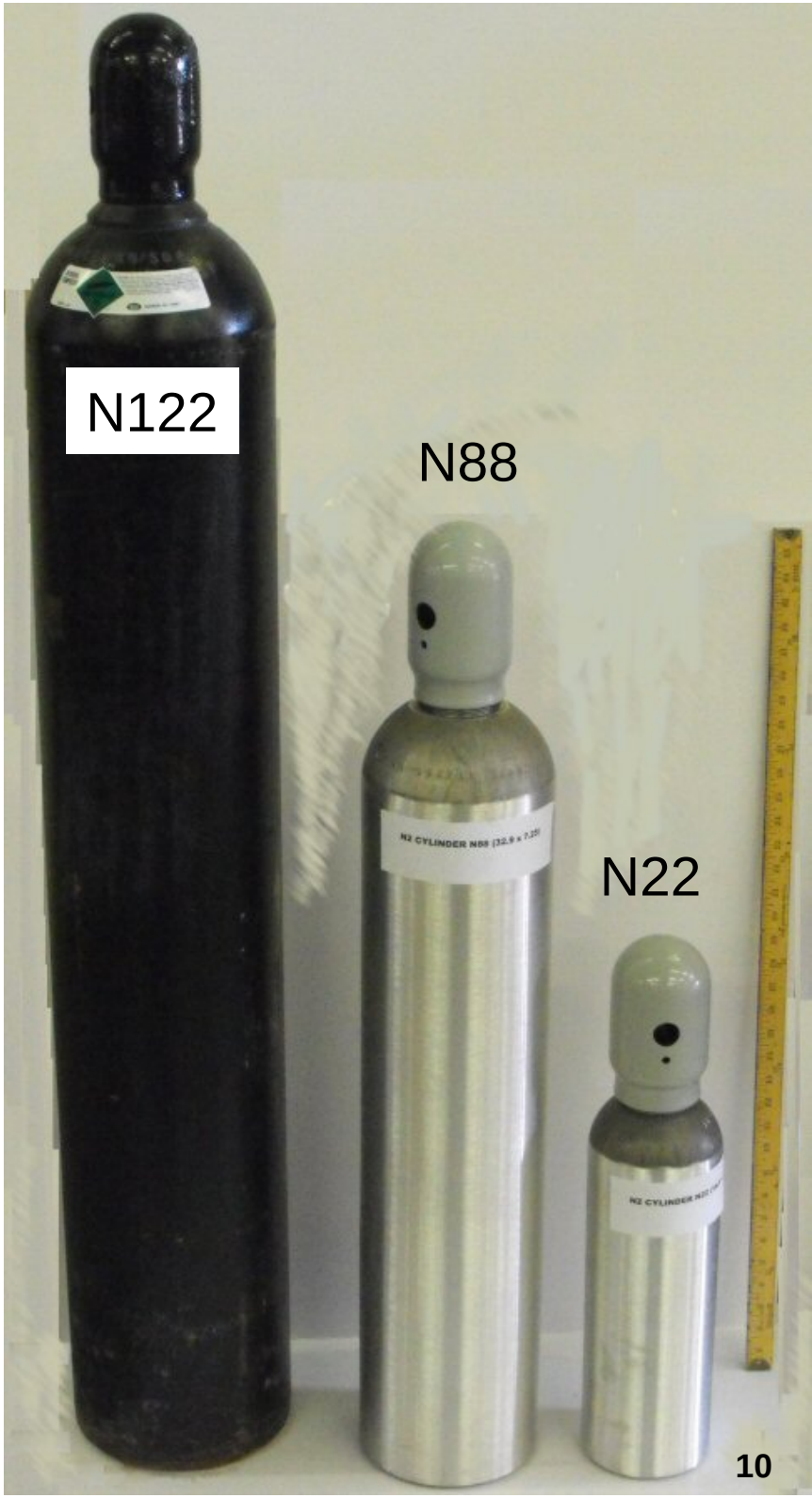
5 Lb. CO_2 Container

1. Constructed of aluminum
2. Test pressure of 3000 PSI and a service pressure of 1800PSI.
3. Dimensions are 20" long by 5.25" O.D.
4. Weight is 10 lbs.
5. Capacity is 5 lb. of liquid CO2, which is sufficient for ~500 tests.
6. Gas valve has 0.965-14 NGO R.H. external thread.



Hardware Configuration: <u>N2 Gas</u>

1. Typical Cylinders:
   - N22 aluminum cylinder, 20.8 cubic ft, service pressure rating of 2216 PSI. The cylinder length is 17" and the O.D. is 5.25". The cylinder weighs 9 lbs. or 4.1 Kg.
   - N88 aluminum cylinder, weighs 30 lbs. with a length of 33" and an O.D. of 7.25". The N88 cylinder holds 83.3 cubic feet, service pressure of 2216 PSI.
   - Both cylinders have a service pressure rating of 2216 PSI and a test pressure of 3694 PSI. Both cylinders are equipped with a USA industry standard CGA-580 valve that has 0.965-14 NGO R.H. internal threads.
2. Larger cylinders are usually used to supply gas for pressure build-up testing



Fill Volume Chamber with Compressed N2 or CO2 Gas

1. Gas gun volume chamber is filled with compressed gas.
2. Pressure gage used to determine when chamber is filled approximately 150-300 psi above the casing pressure.
3. Quick release of gas into casing annulus delivers an acoustic pulse to the casing annulus gas.

Equivalent Energy: 300 psi = 10 gage shot

Prior to determining Zero Offset - Valve between gas gun and wellhead should still be closed.

- When the wireless remote fire gas gun is placed onto the well, charge the gas gun volume chamber to a pressure in excess of well pressure before opening the casing valve
- Charge > well pressure prevents debris from entering the gas gun volume chamber and valve assembly. Debris could cause corrosion/wear to the gun.
- Charge volume chamber to 150-300 psi above estimated casing pressure.
- Open bleed valve to bleed pressure between the casing valve and the gun before obtaining the ZERO OFFSET for the pressure transducer.

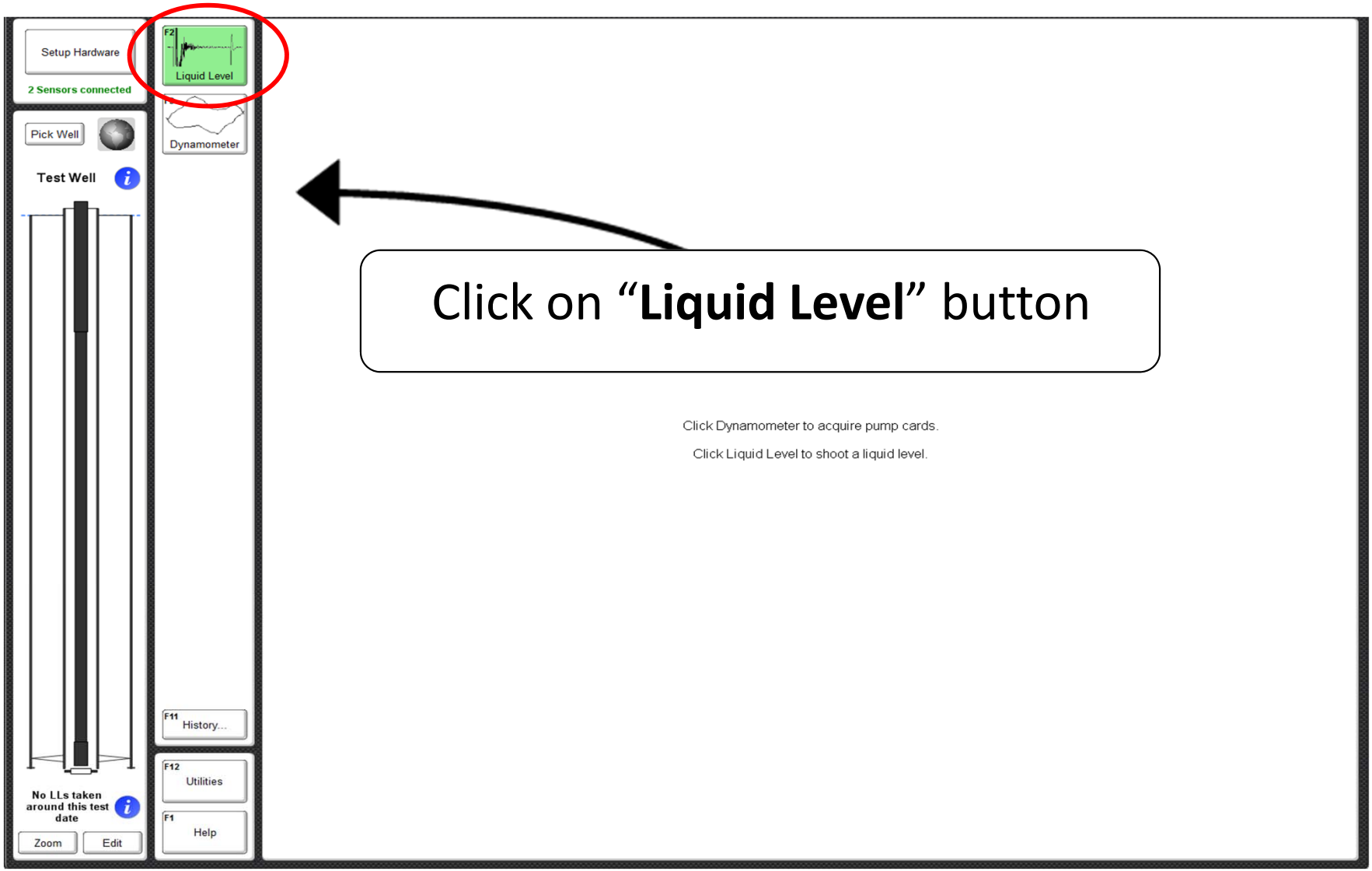
2 Turn on the Gas Gun

NOTE: counting the rapid flashing LEDs will provide the percentage of battery life remaining.

(Example:
2 flashes=20%,
6 flashes=60%.
10% per flash)

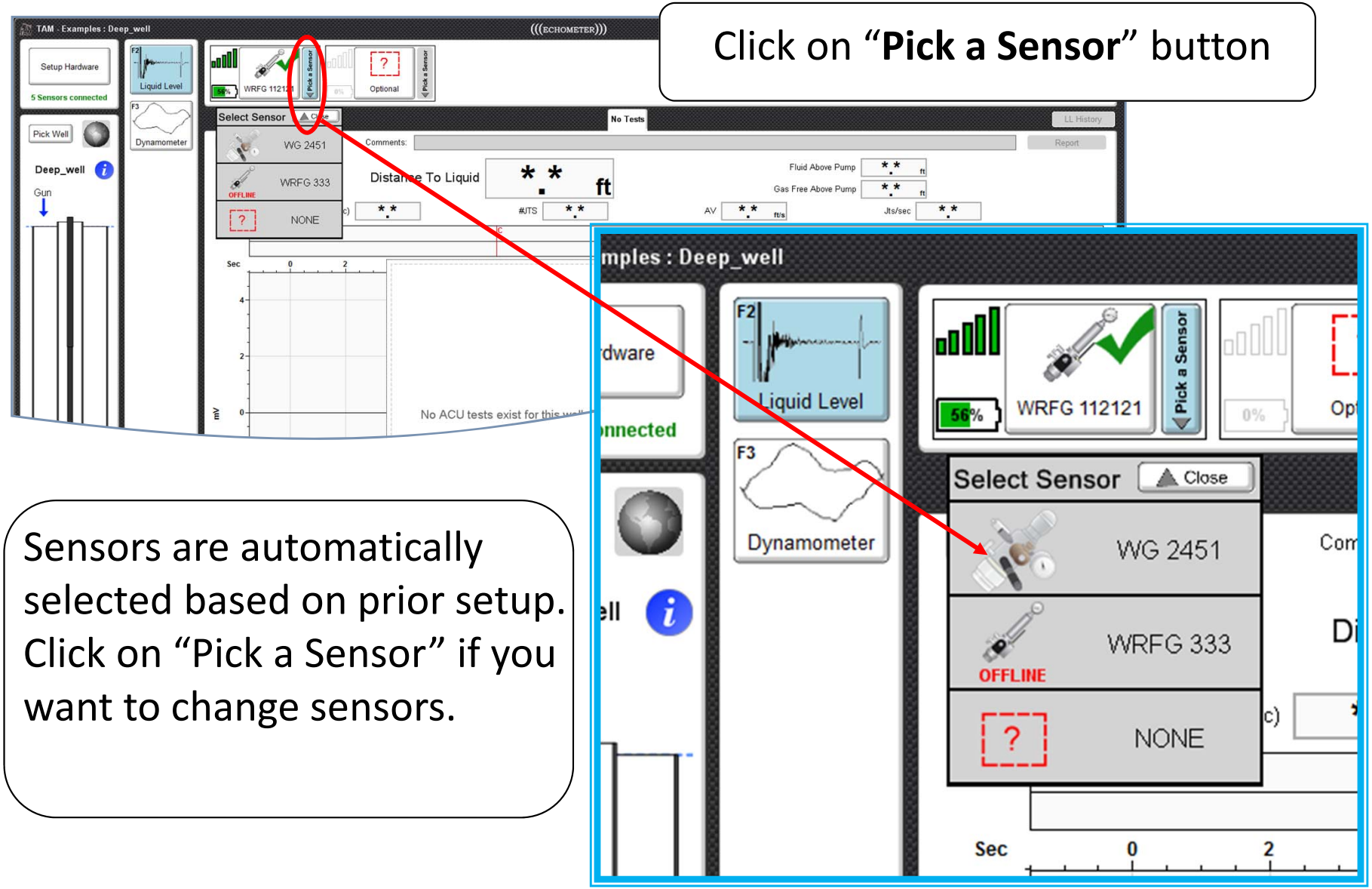
Press Power button to turn on the gas gun and pressure transducer.

2 Select Liquid Level



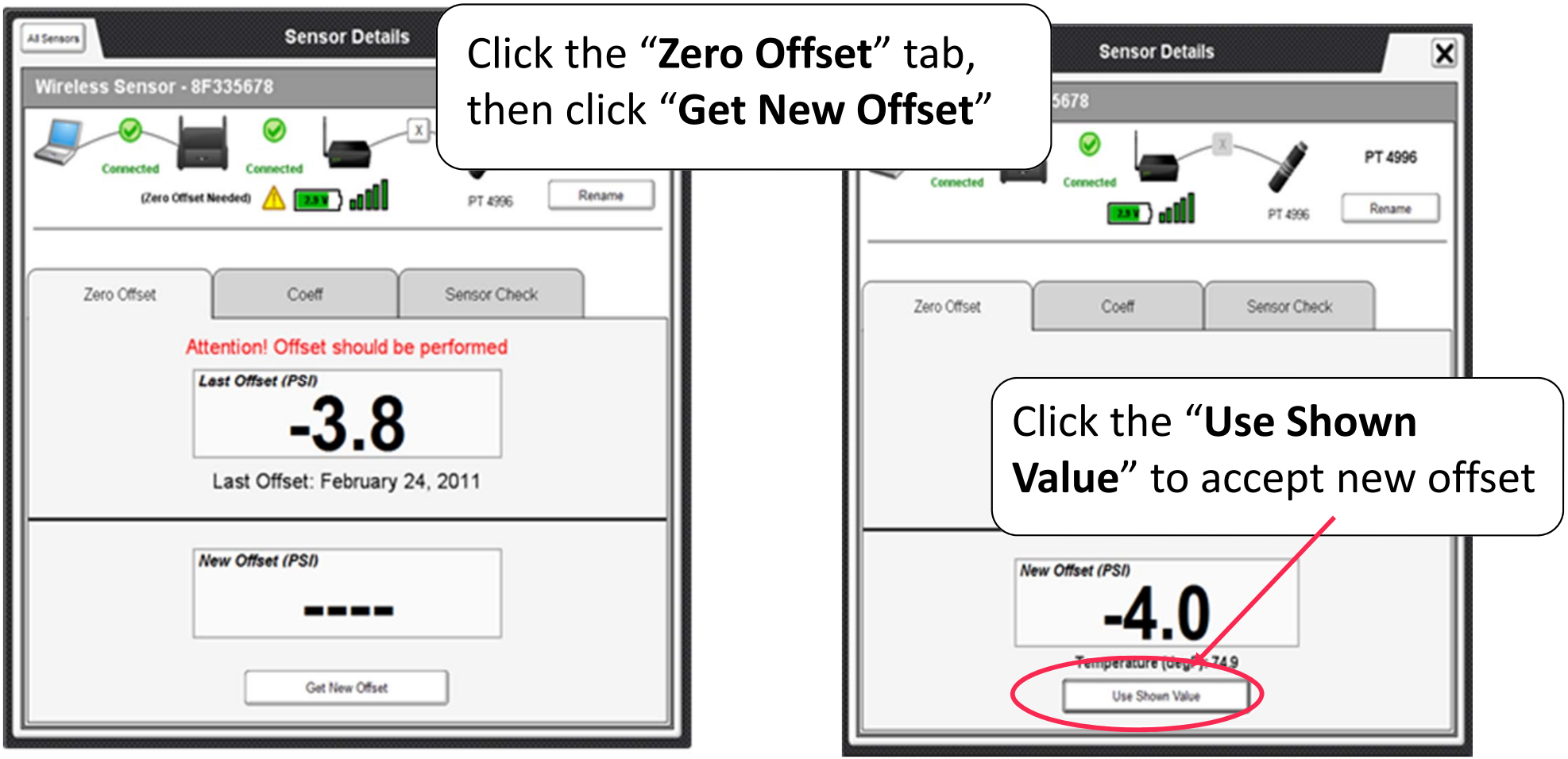
3 Pick Sensor

Click on “**Pick a Sensor**” button



Sensors are automatically selected based on prior setup. Click on “Pick a Sensor” if you want to change sensors.

4 Zero the Pressure Sensor



When finished, close popup window to proceed with testing.
Changes save automatically.

5 Prepare to shoot the Well

1. Charge the gas gun 150-300 psi above surface pressure on the well.
2. Close the gun bleed valve.
3. Open casing valve between gun and wellhead.
4. Close casing valve to the flowline.

Prepare to shoot the Well

1. Open the casing head valve between the gas gun and the well
2. Before opening the casing valve, the operator should know the well surface pressure and be alert that equipment ratings exceed well pressure.
3. Close other valves connecting casing to flowlines
4. Isolated from any surface piping the casing annulus acts like a giant gas storage bottle
5. Pressure increases due to free gas flowing past pump intake into annulus.

6 Start Acquisition from Sensor

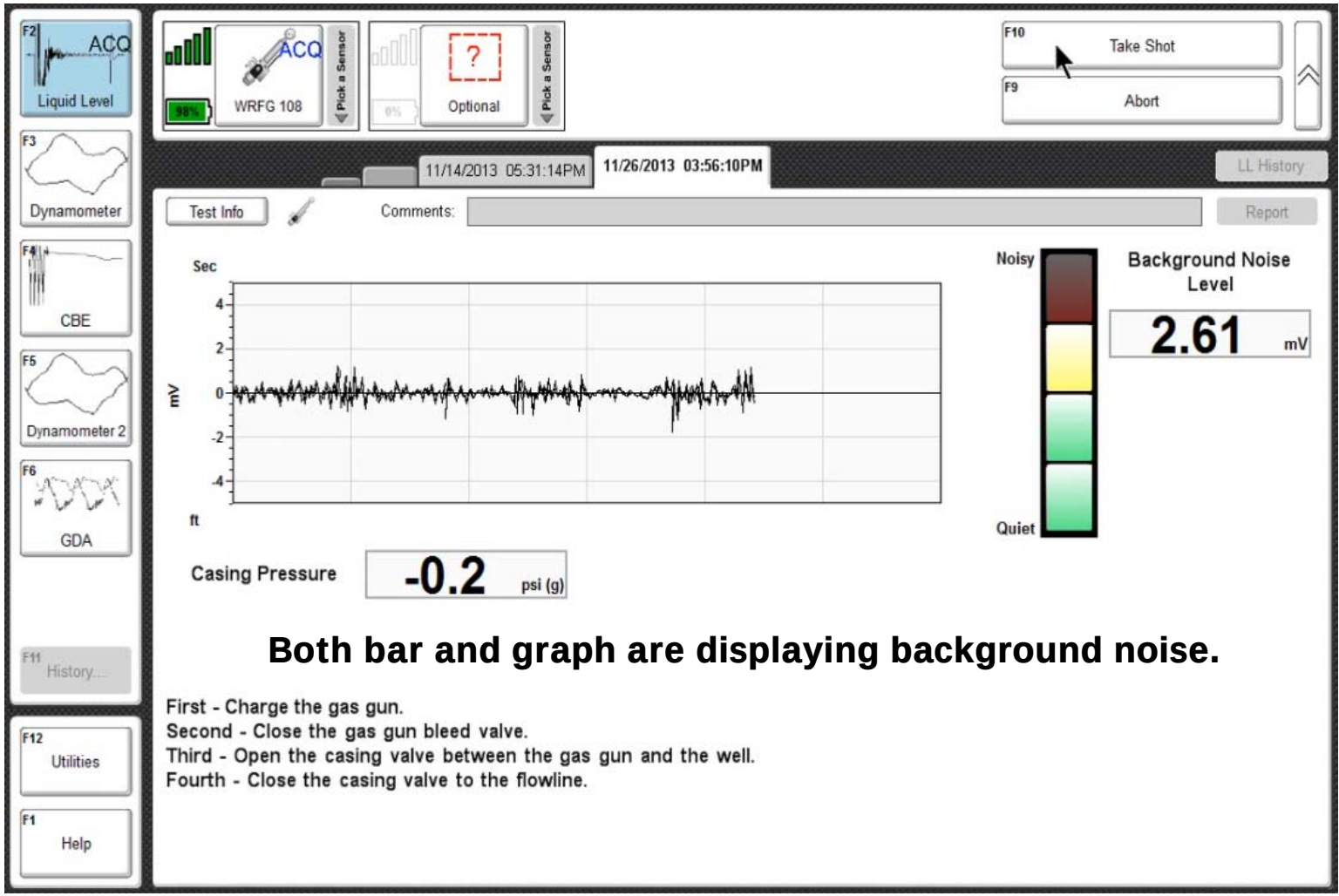
Press "**Acquire**" switch on gun and wait for the "Fire" light to stop blinking, then press "**Fire**" button when ready to shoot. Make sure the chamber pressure is greater than the well pressure.

Press Acquire to automatically activate the gas gun and pressure transducer.

Or TAM Software: Take Shot Button

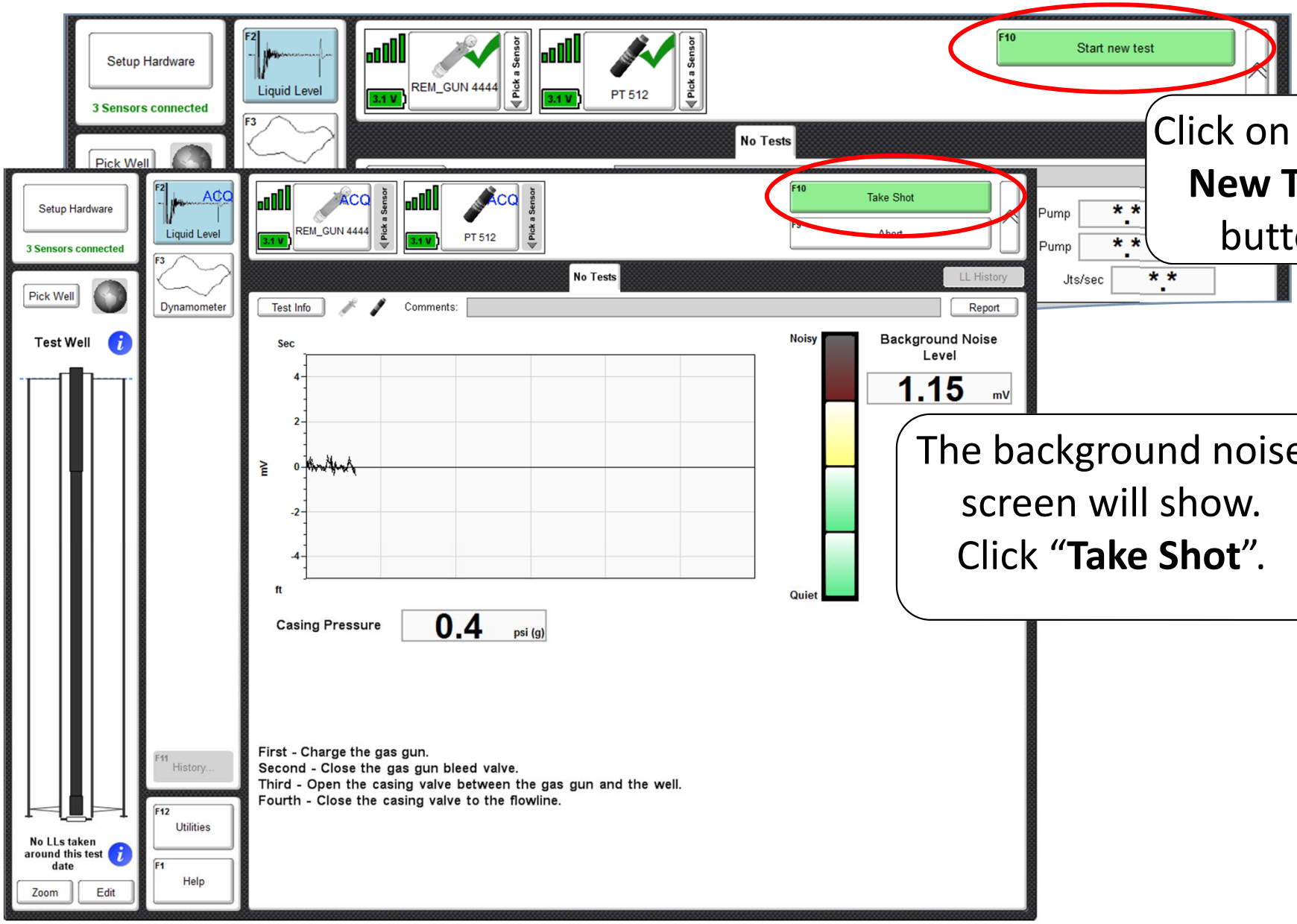
Prepare to acquire shot by following steps on INSTRUCTIONS panel.

1st: Charge Gas Gun
2nd: Close the gas gun bleed valve
3rd: Open the casing valve between gas gun and well.
4th: Close the casing valve to flowline.



Inspect the well noise displayed on the screen before shooting to verify proper instrument operation and well conditions. If excessive noise exists, use a larger charge in the gas gun or increase the casing pressure to attempt to reduce the noise level .

6b Start Acquisition from Laptop



Click on "**Start New Test**" button

The background noise screen will show. Click "**Take Shot**".

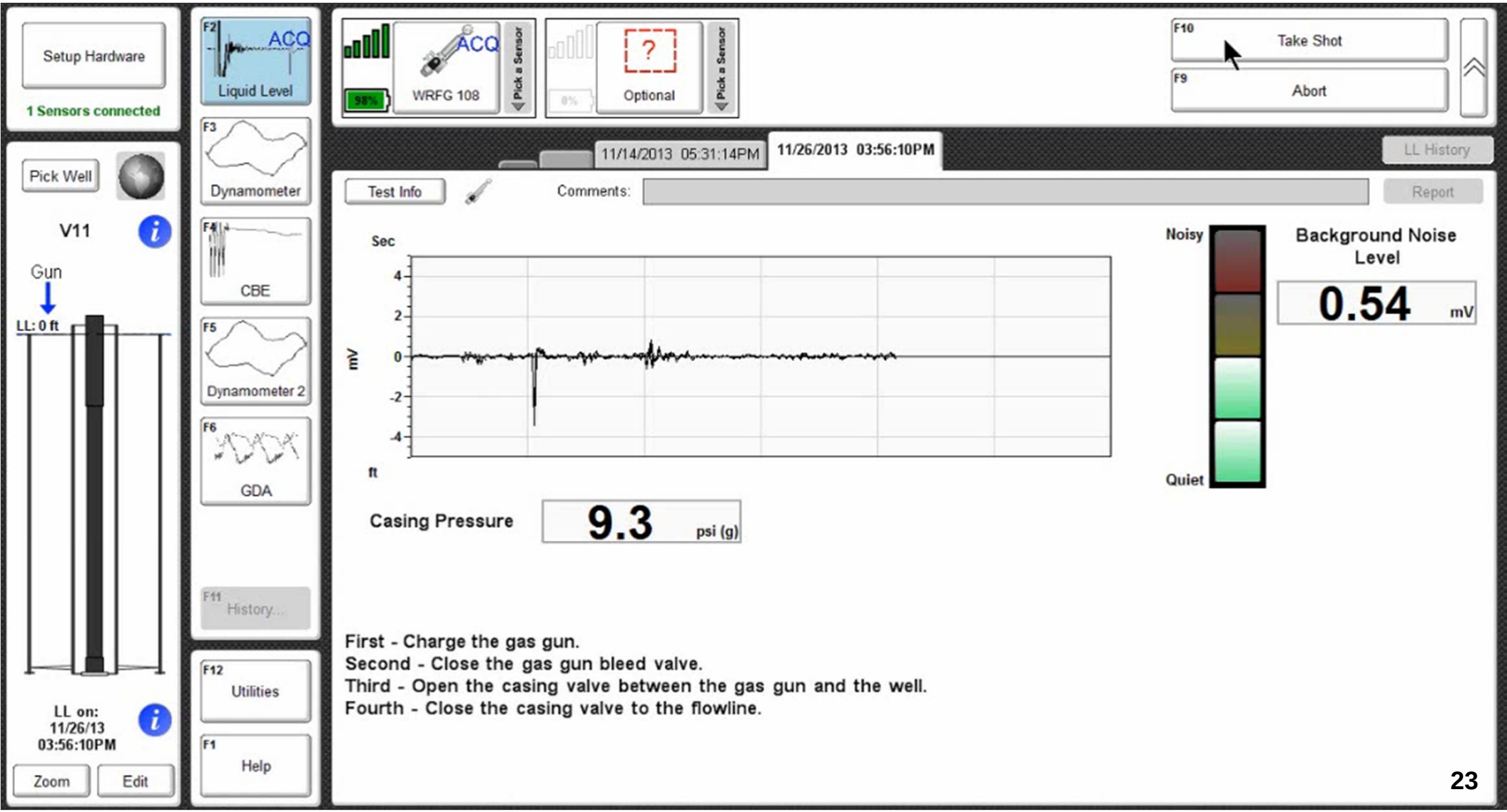
Wireless Remote Fire Gas Gun

1. Volume chamber manually or automatically filled with compressed gas.
2. Charge in the volume chamber filled to desired pressure above the casing pressure.
3. Solenoid gas valve quickly opened by software control from the laptop computer.
4. Acoustic pulse generated by sudden release of high pressure gas from volume chamber.
5. Noise-canceling dual-disk microphone detects the shot and the reflected pulses.
6. Accurate strain gage pressure transducer electronically indicate temperature and casing pressure.

TAM: Fire Shot

1. **Message "Acquiring shot" is displayed once the gun is fired.**
2. **Shot is acquired for predetermined numbers of seconds based on depth.**

Note: If shot pulse was not detected after firing gun, then press Abort button (Stop acquisition of shot data), recharge at a higher pressure, go to step 6.



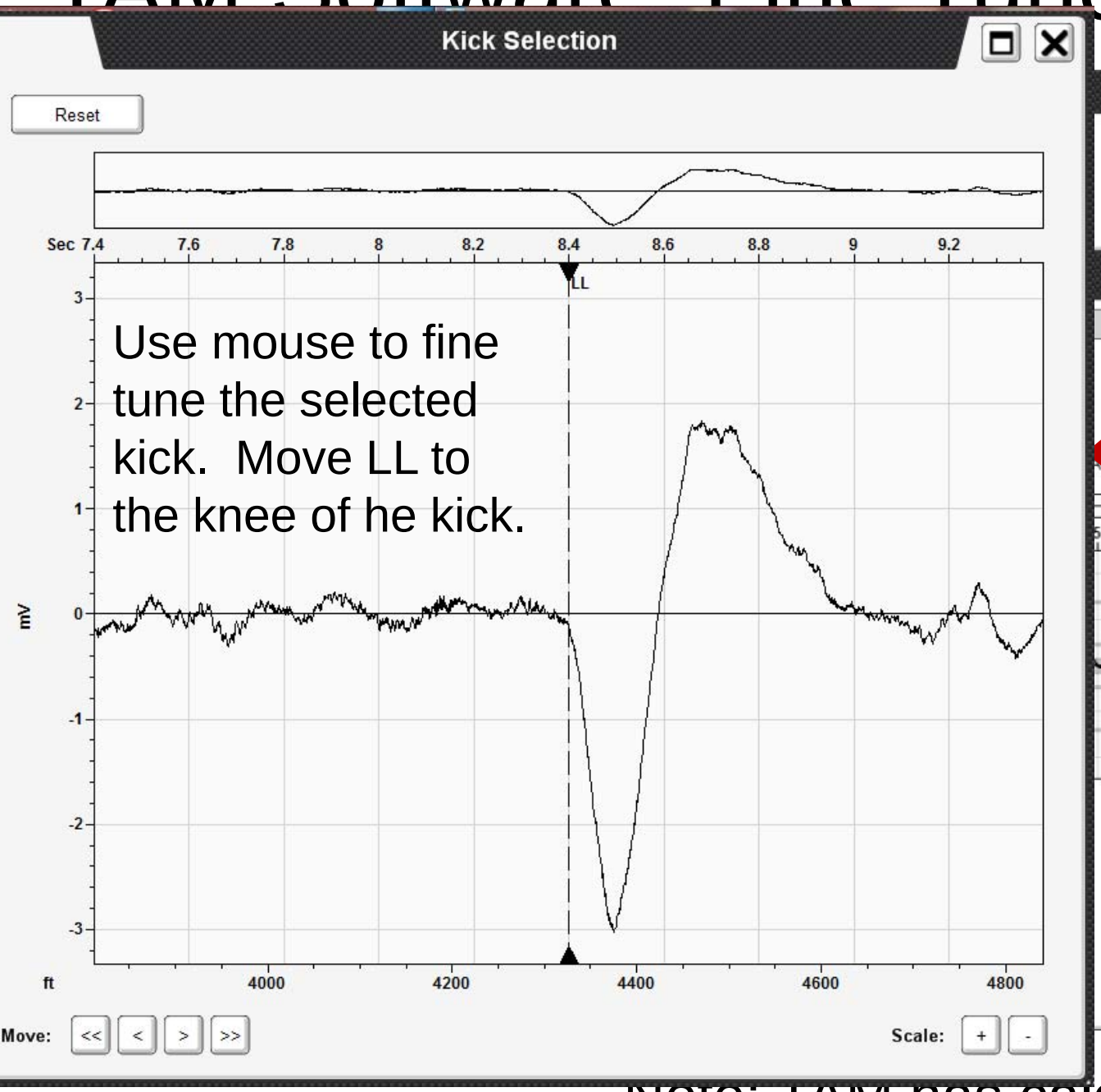
TAM Software: Shot Acquired

Note: Acoustic Shot Trace is automatically saved. TAM continues to acquire casing pressure every 5 seconds for a maximum of 15 minutes or until manually stopped.

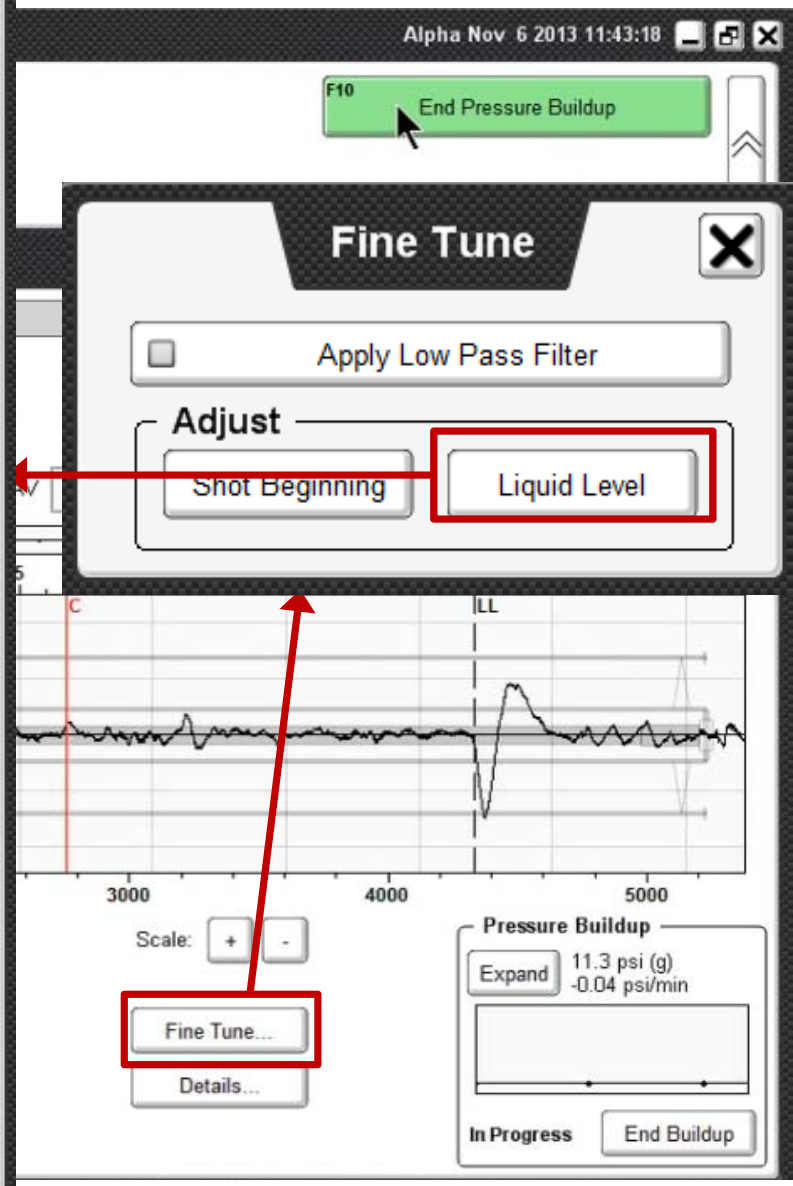
TAM Software: Verify Shot Details

Note: If an insufficient liquid level kick is obtained or the data is otherwise unsatisfactory, increase the pressure in the volume chamber and repeat from step 6.

TAM Software: Fine Tune LL Selection

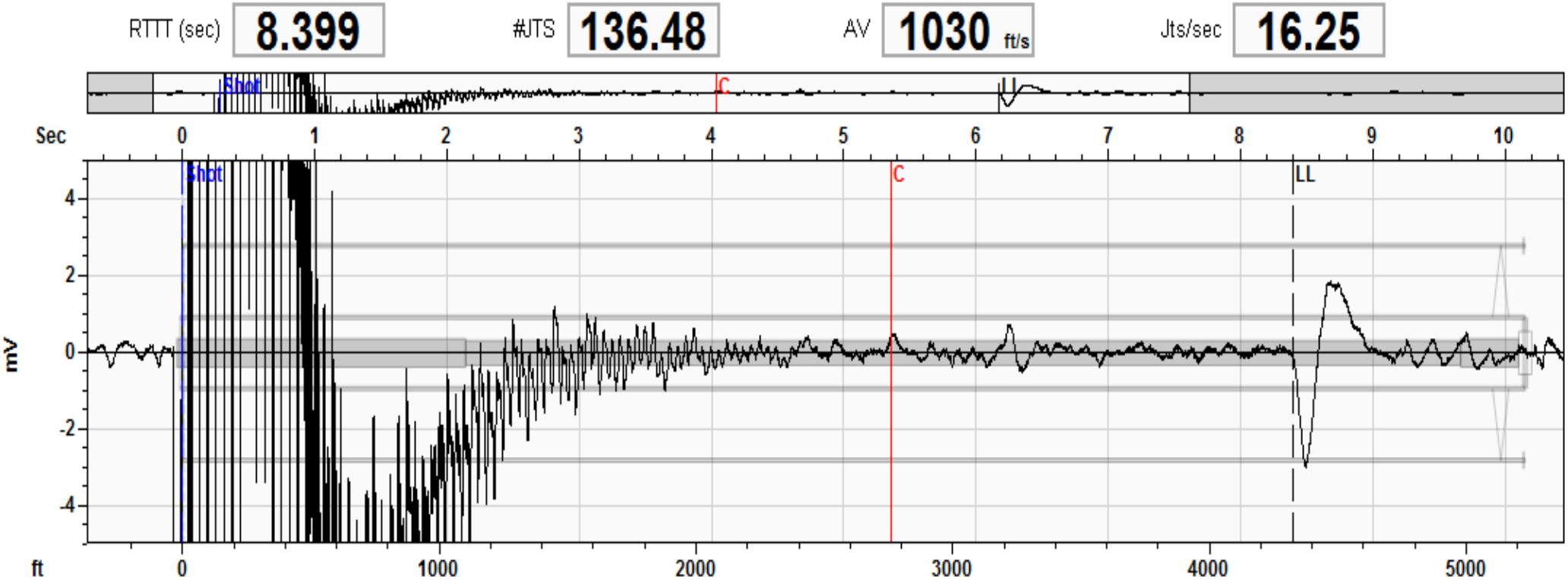


Use mouse to fine tune the selected kick. Move LL to the knee of he kick.



Note: TAM has calculated and selected a candidate for the best Liquid Level kick.

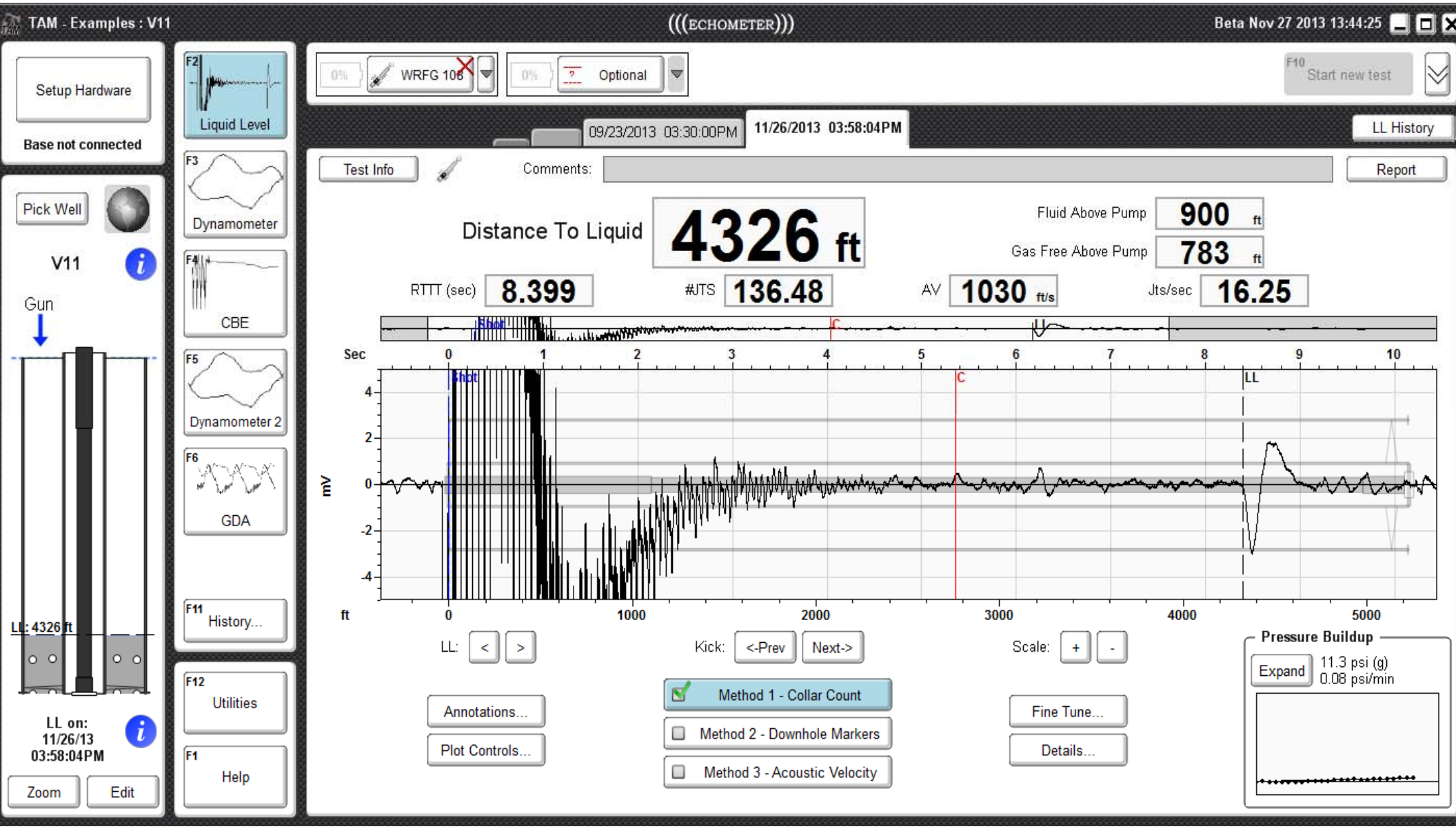
Acoustic Trace - RTTT



1. The Liquid level is automatically determined by the computer from reflected acoustic signals digitally processed, filtered, and displayed versus time.

2. TAM measures the time for the acoustic pulse to travel from the surface through the casing annulus gas to the liquid level and reflect back to the surface (round trip travel time, RTTT).

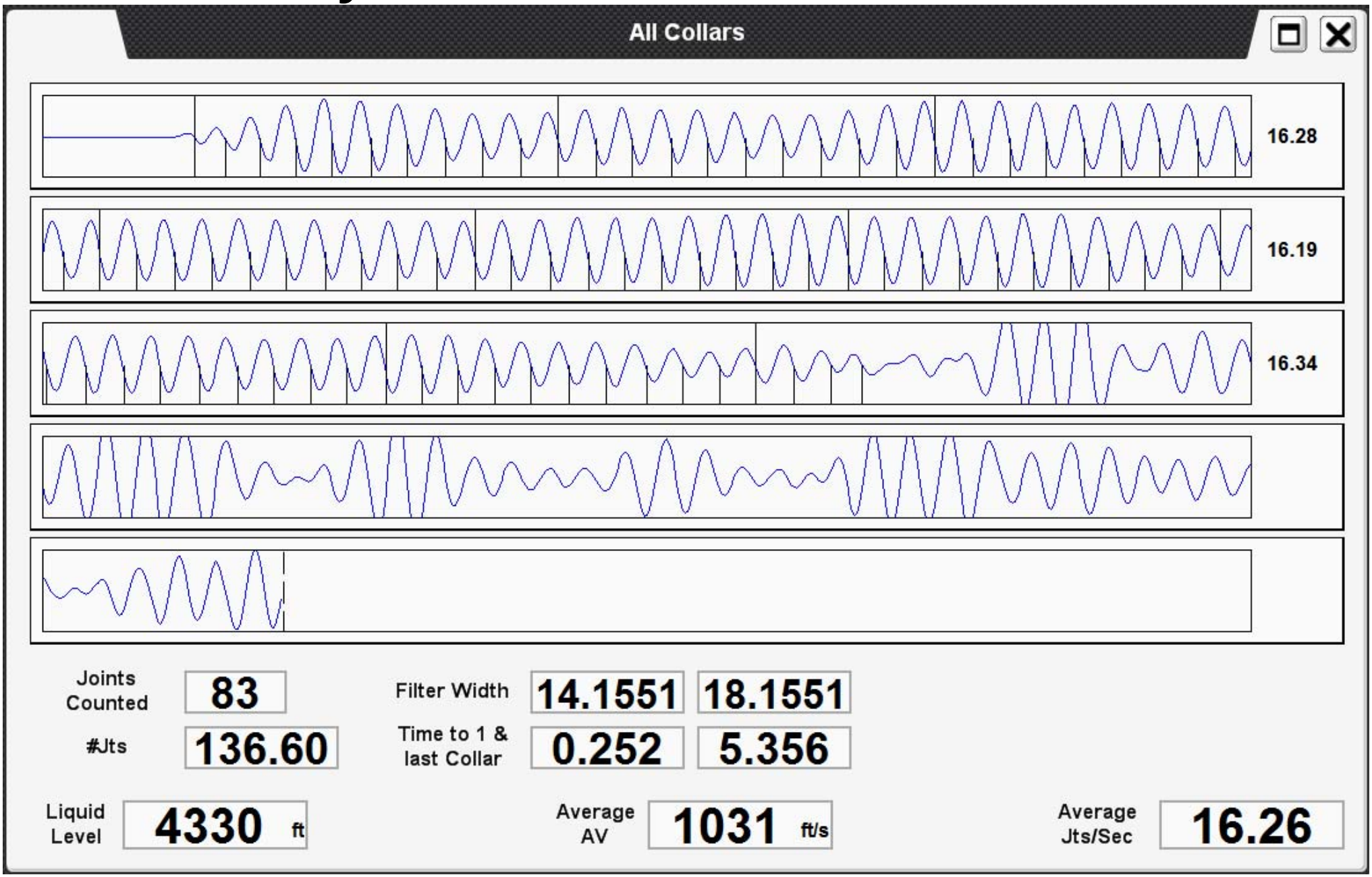
TAM: Determine Depth



The depth is calculated using an acoustic velocity determined by the automatic spreader analysis, click “Method -1” to manually adjustment collars.

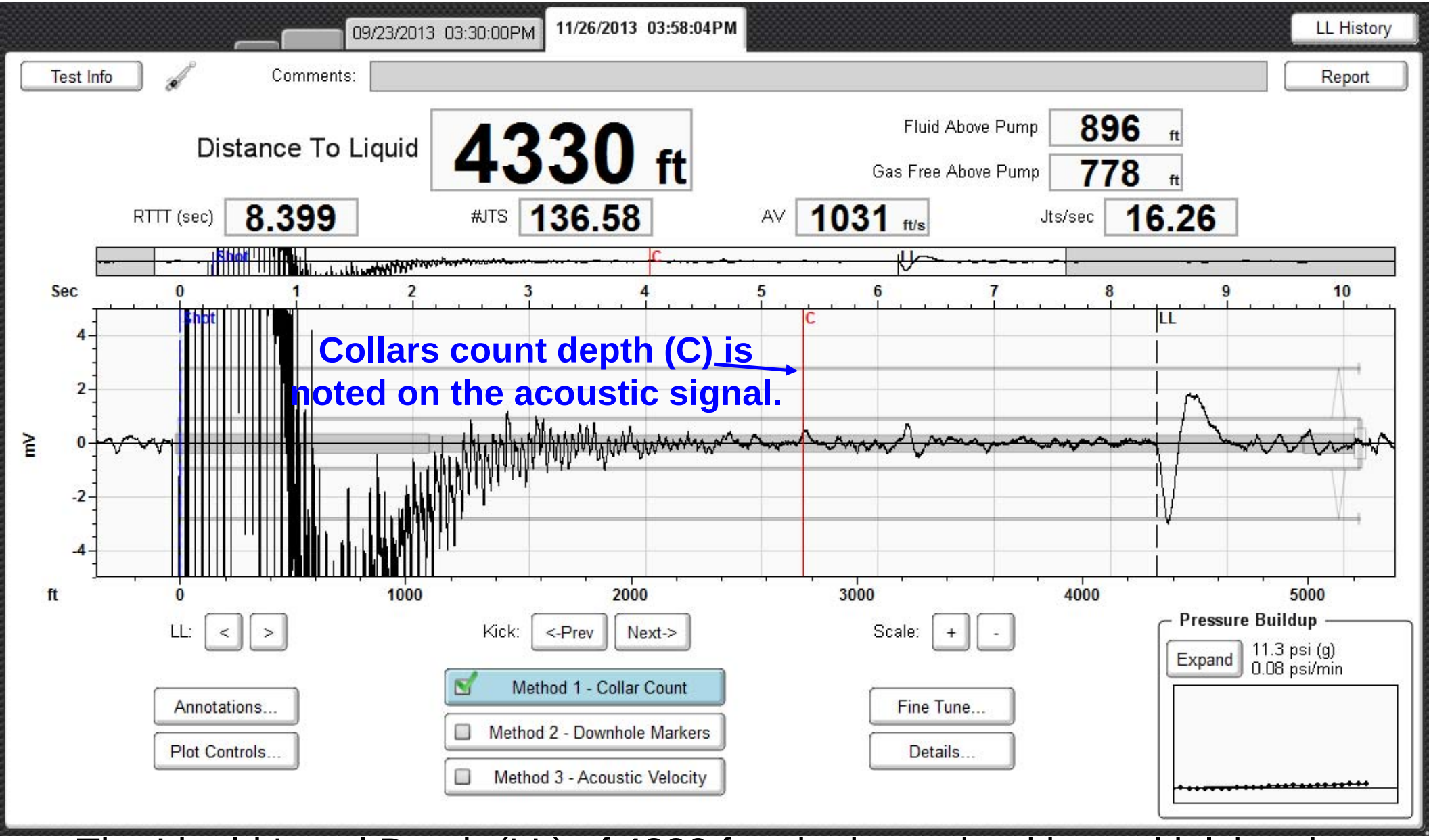
Collar Analysis
1. Choose collar region
Sec
mV
ft
C
2. Adjust collar markers
Auto Collar Selection
Manually Adjust Collars
Scale:
Raw
HP
BP
HBP
All Collars
Apply Automatic Collar Count
Interval AV 1024 ft/s
Average AV 1031 ft/s
Interval Jts/Sec 16.16
Average Jts/Sec 16.26
Liquid Level 4330 ft
Liquid Level 4326 ft

Analysis Method: Count Collars



Automatic Collar Count analysis method will determine the depth to the liquid level for 95% of the wells

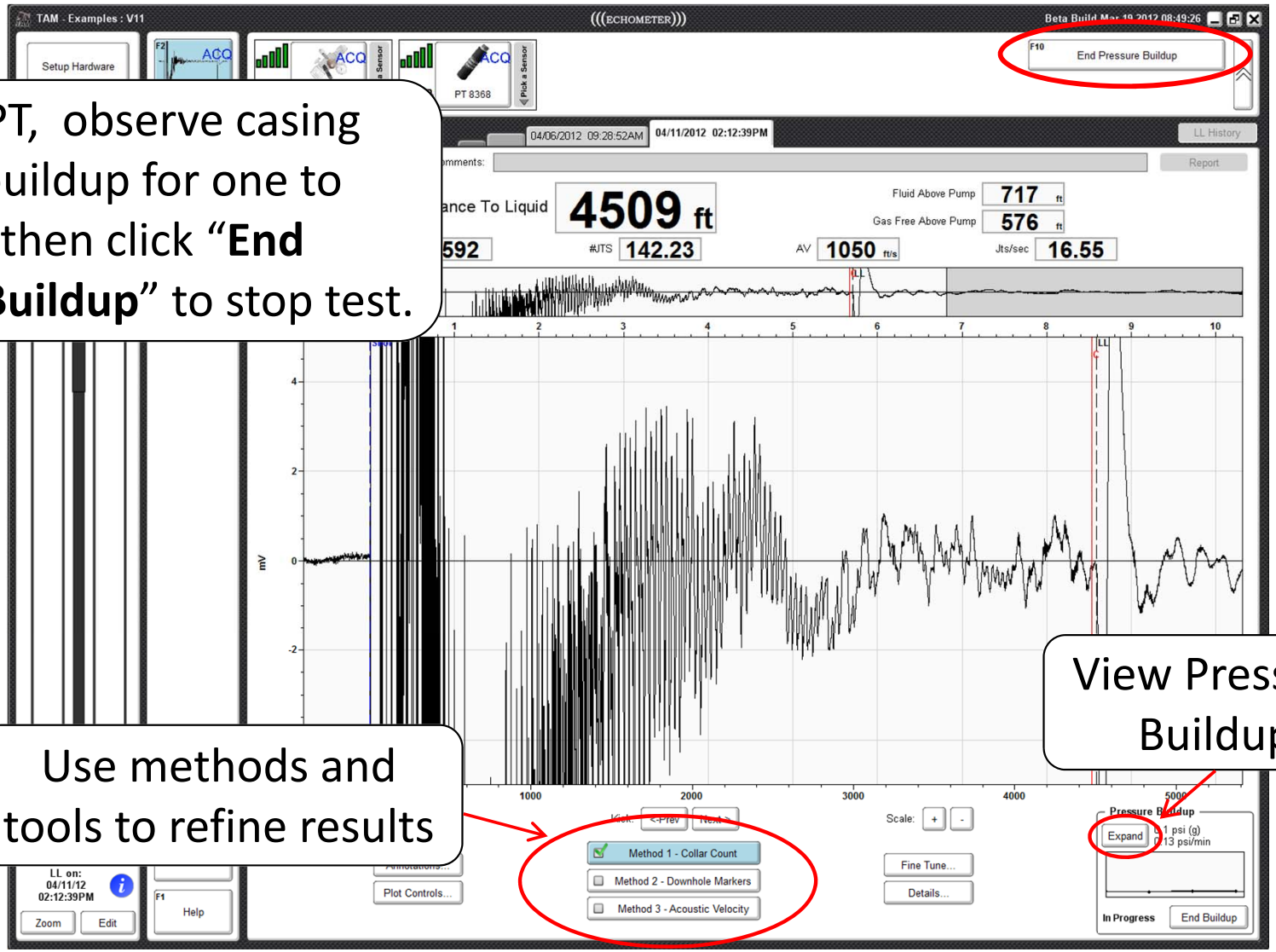
Acoustic Trace with Depth Determination



The Liquid Level Depth (LL) of 4330 feet is determined by multiplying the RTTT (Seconds) by 1/2 times the average joint length (Feet).
(8.399*1031/2 =4330 feet)

7 Results: Finish Pressure Buildup

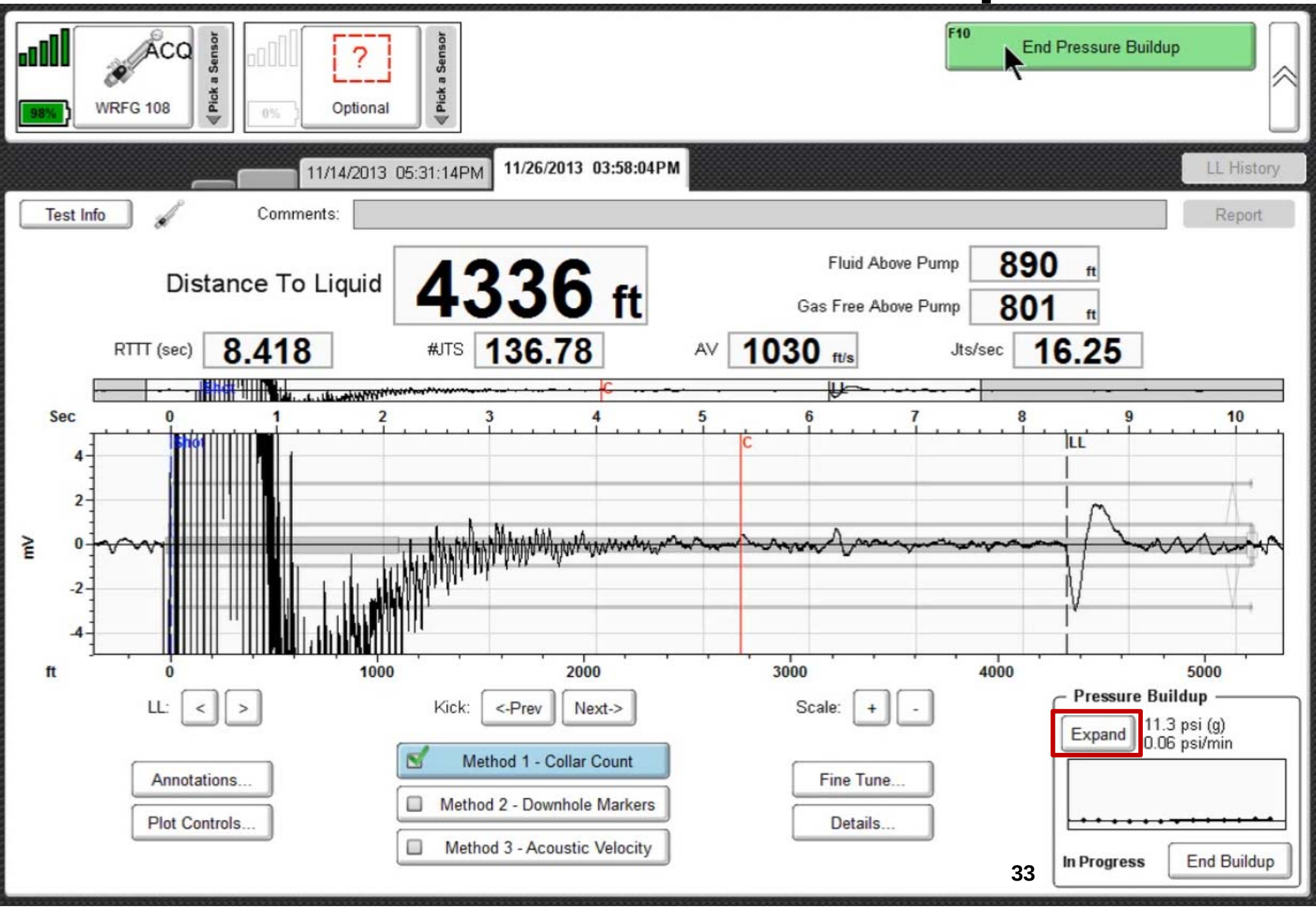
If using a PT, observe casing pressure buildup for one to two mins, then click "**End Pressure Buildup**" to stop test.



View Pressure Buildup

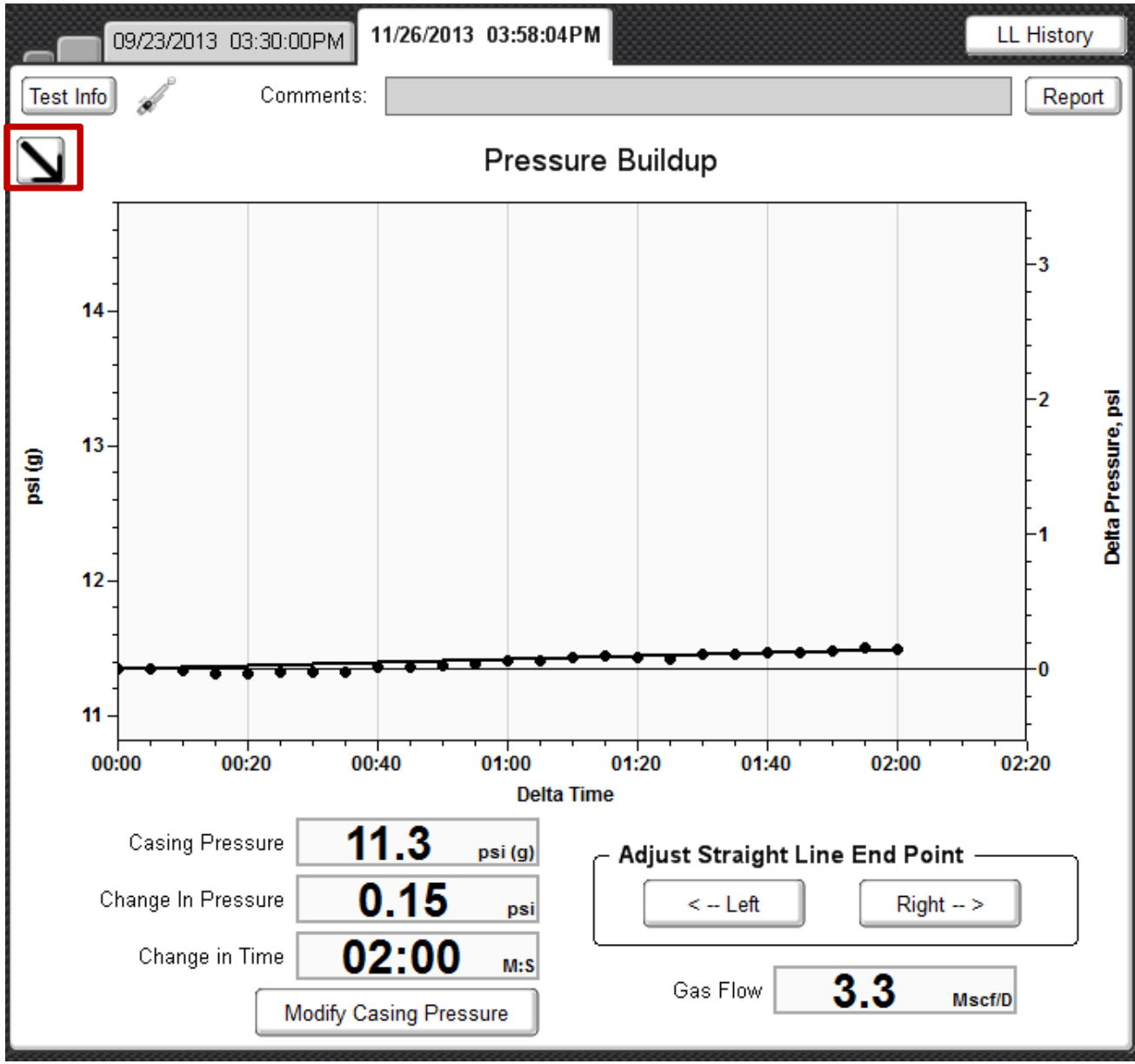
Use methods and tools to refine results

TAM: Pressure Build up



Casing Pressure Buildup Test – dP/dT

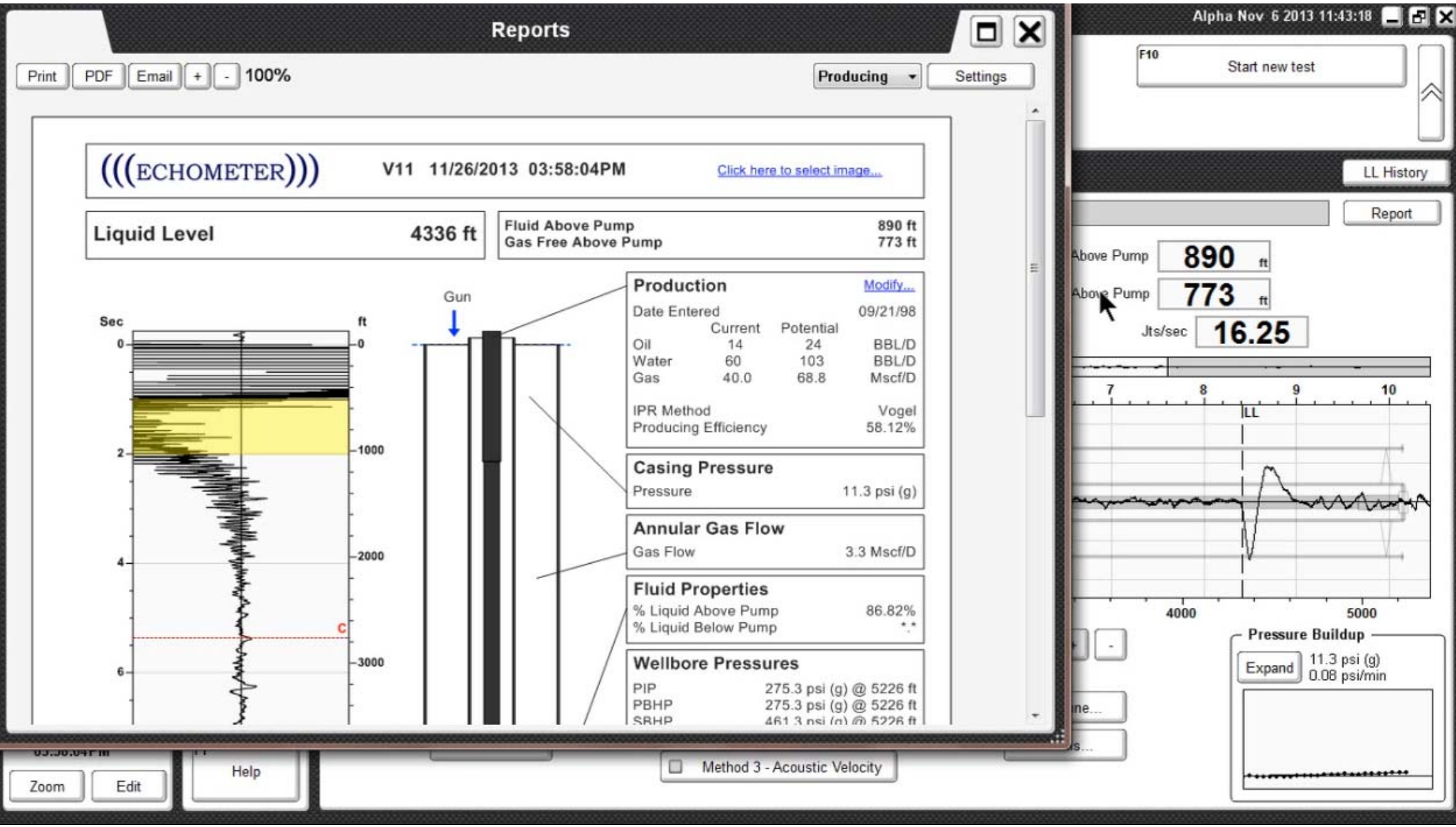
1. At the well the TAM will display End Build Up Message after 2 minutes elapse.
2. Pressure measured at 5 second intervals is being recorded and the pressure buildup rate is being determined.
3. The buildup line is selected by drawing a line from the origin of the plot to the last point recorded.
4. If the buildup line does not fit through most of the data, wait for the next point to be plotted and stop the buildup when the curve best-fits through the all of the points.



Acoustic Surveys Answer the Following Well Performance Questions:

1. What is the depth to the top of the liquid?
2. Does liquid exist above the pump?
3. What is the percentage of liquid in the annular fluid column?
4. Is gas flowing up the annulus? At what rate?
5. How efficiently is the well being produced?
6. Does the liquid in the casing annulus restrict production?
7. Does the casing-head pressure restrict production?
8. What is the maximum production rate available from the well?

TAM Final Results

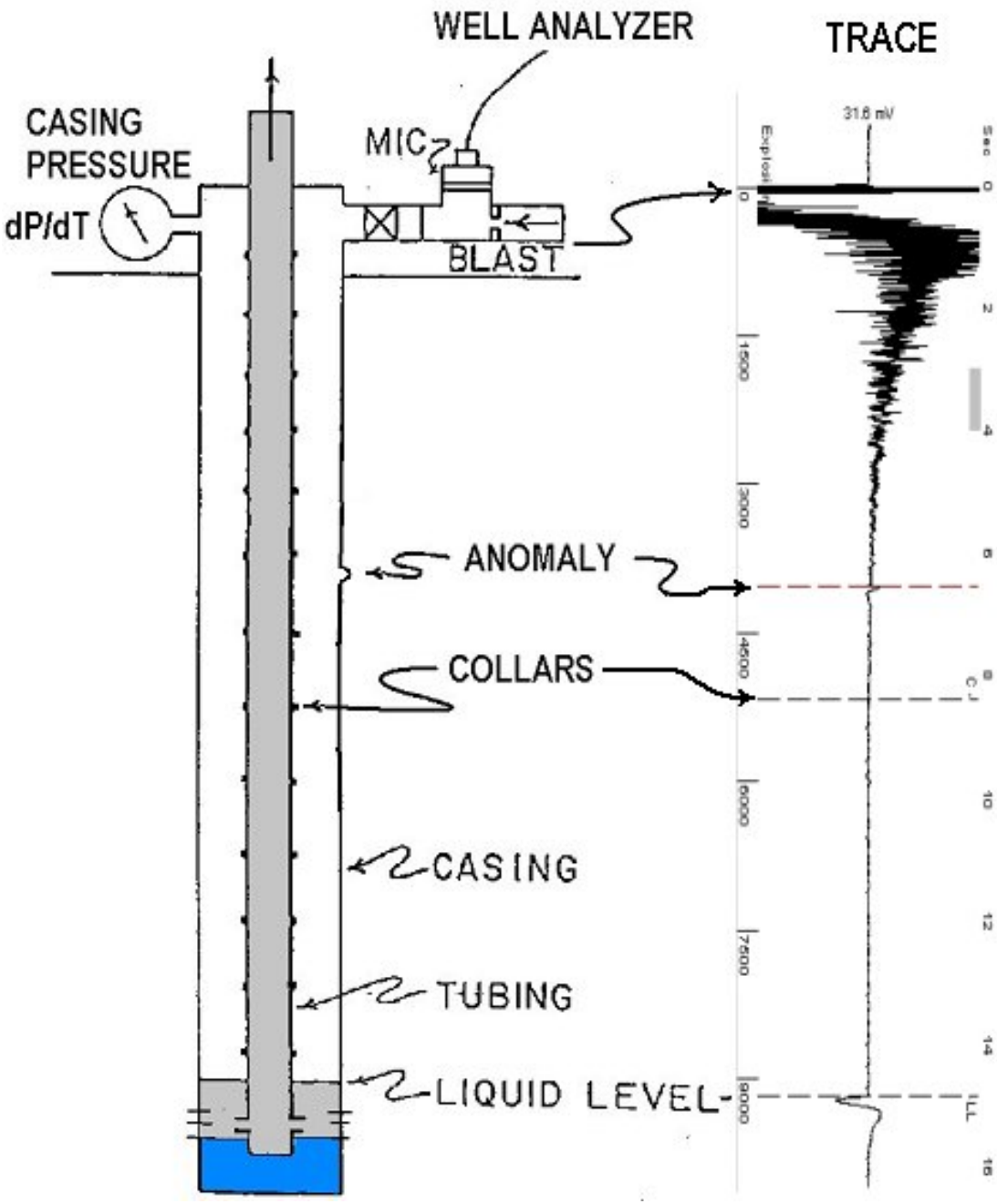


For the Final Results, click Report button. Here TAM displays the results based on the determined liquid level, acquired casing pressure, and well data.

Remove Echometer gas gun from well.

Use bleed valve on gun to release confined pressure between well valve and gun. Be sure to release pressure before removing pressure transducer.

Time to Depth Relationship

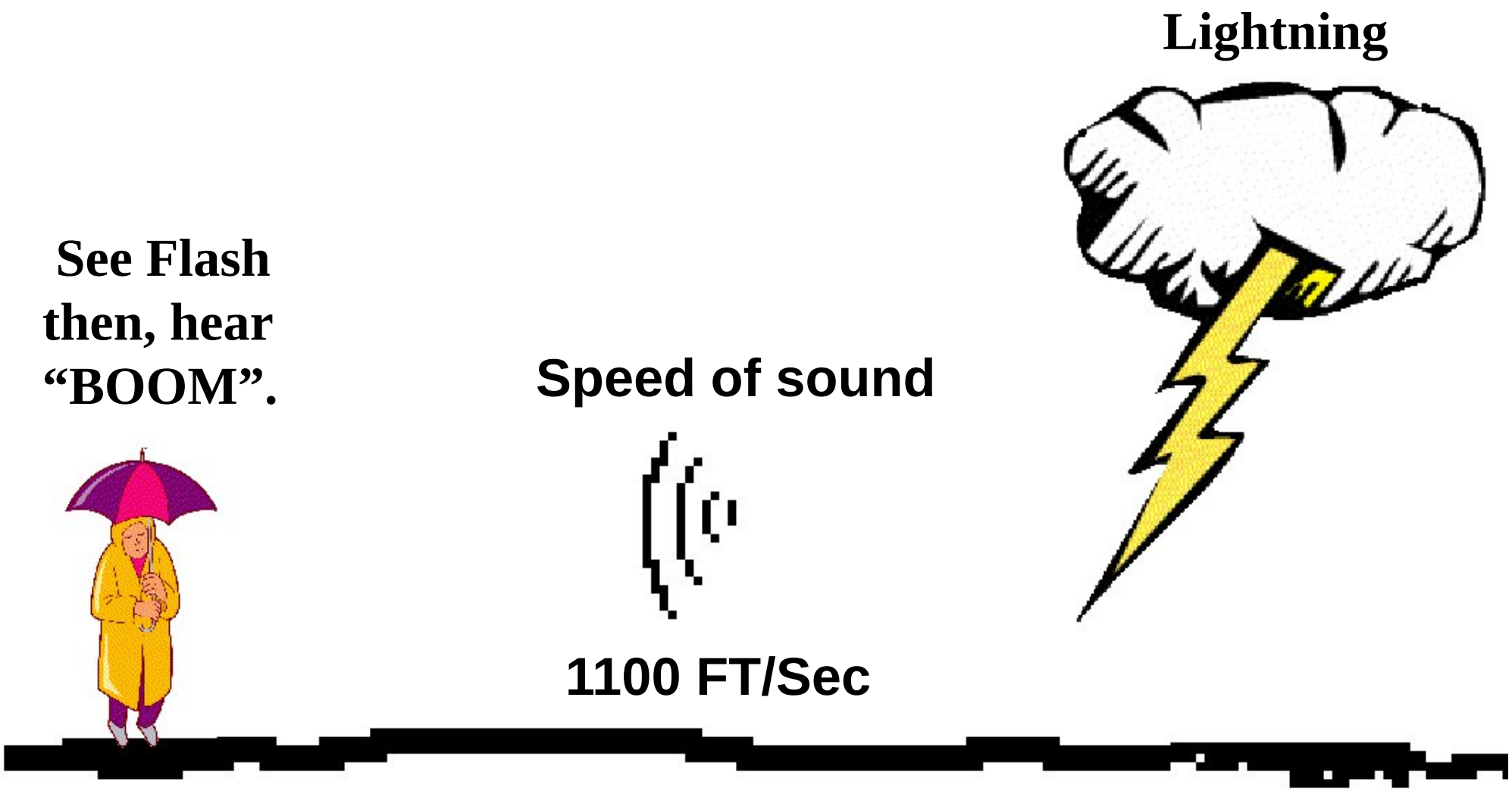


1. The Depth from the gun to an anomaly in the casing annulus is directly proportional to the time, RTTT, for the acoustic pulse to travel from the gun down the casing gas to the anomaly and reflect back to the microphone at the surface.

2. Microphone housed in the gas gun detects the blast from the shot and reflected sound from collars, liners, perforations, liquid level, plus other obstructions in the annulus.

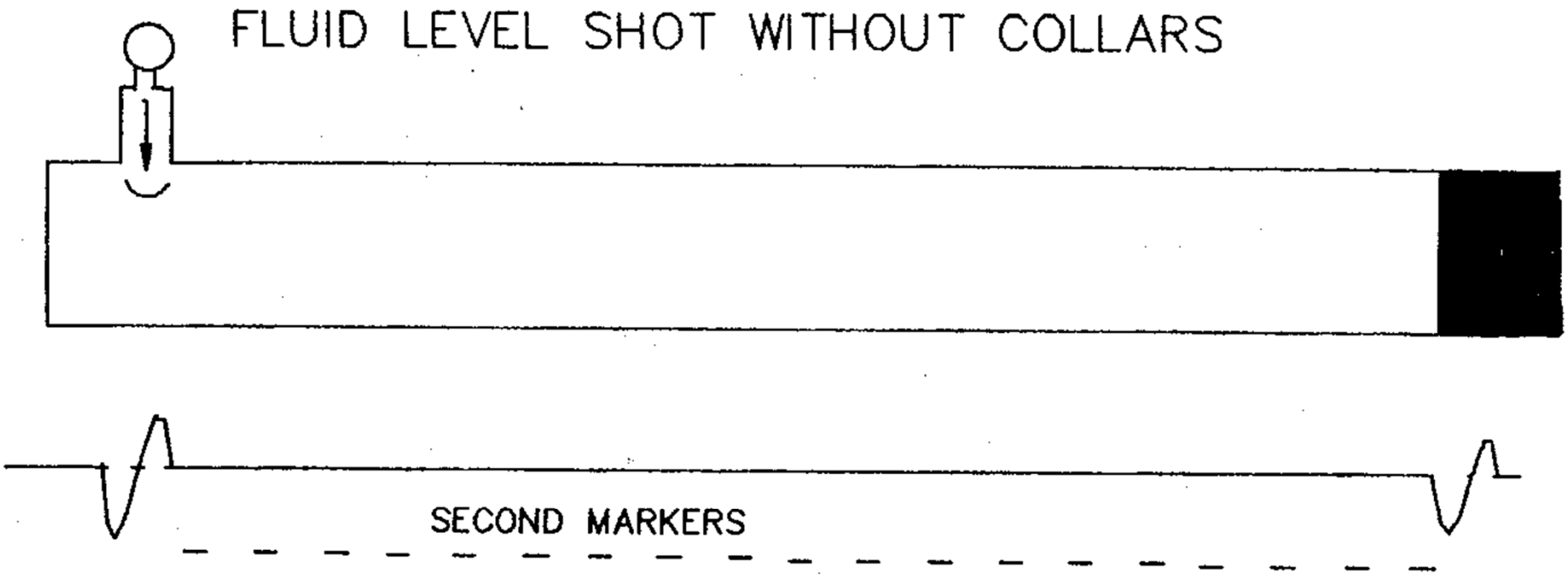
3. Based on formation depth TAM acquires acoustic data for a predetermined numbers of seconds.

Acoustic Velocity in Air



Sound in air travels 1100 feet per second. If a person "sees" the flash and hears the "BOOM" 5 seconds later, then the lightning struck 5500 feet away.

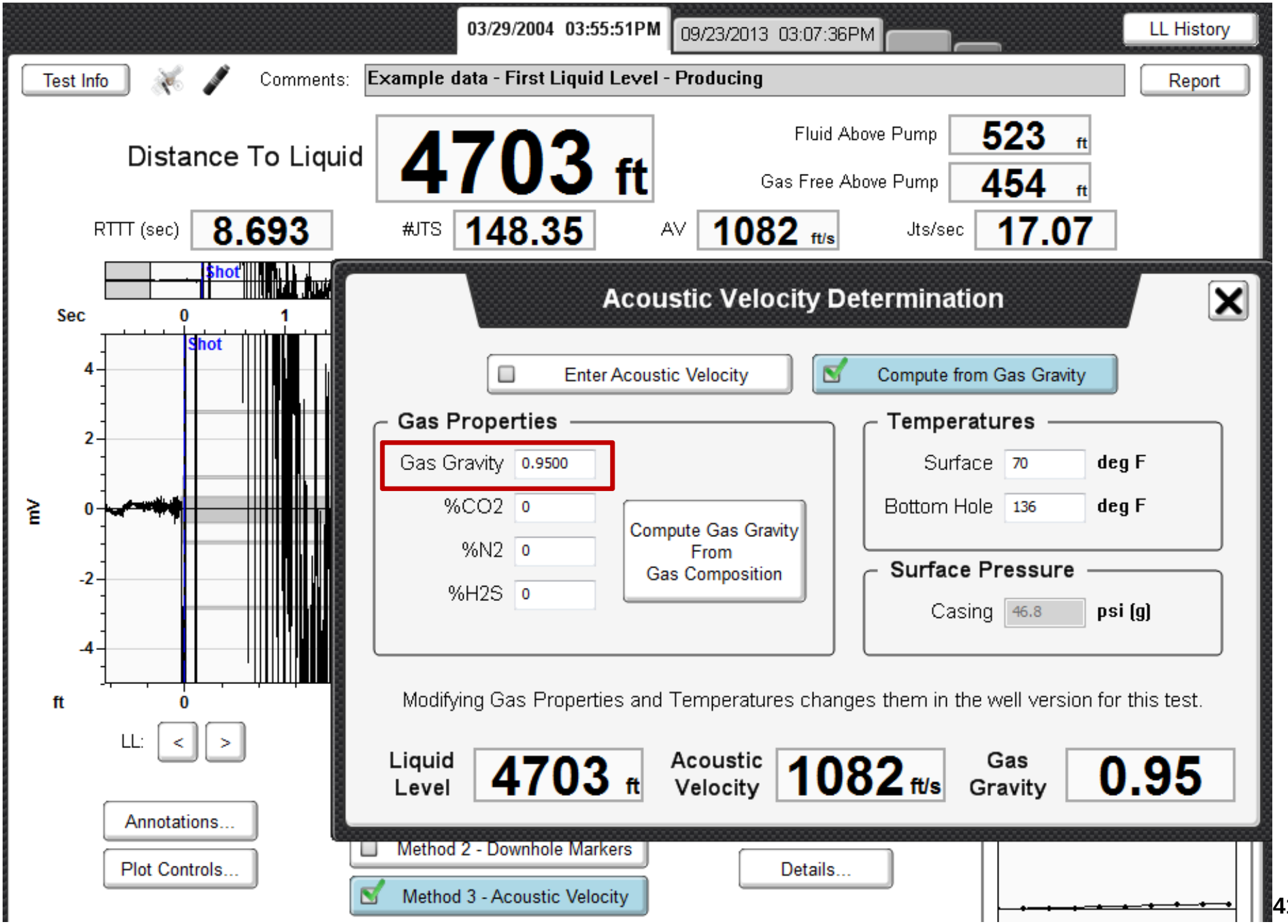
No Collars or Coiled Tubing



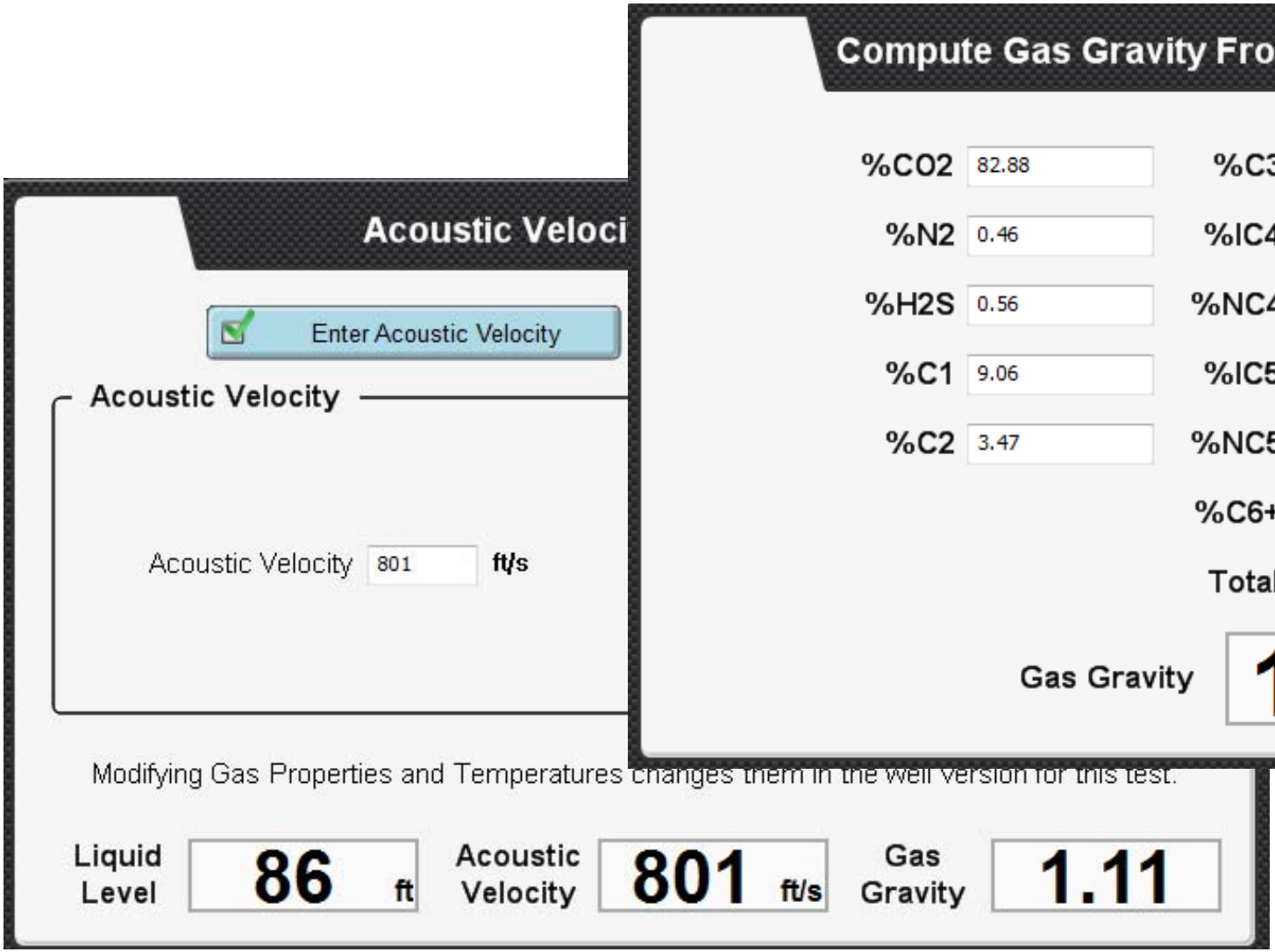
$$D = \frac{T \times V}{2}$$

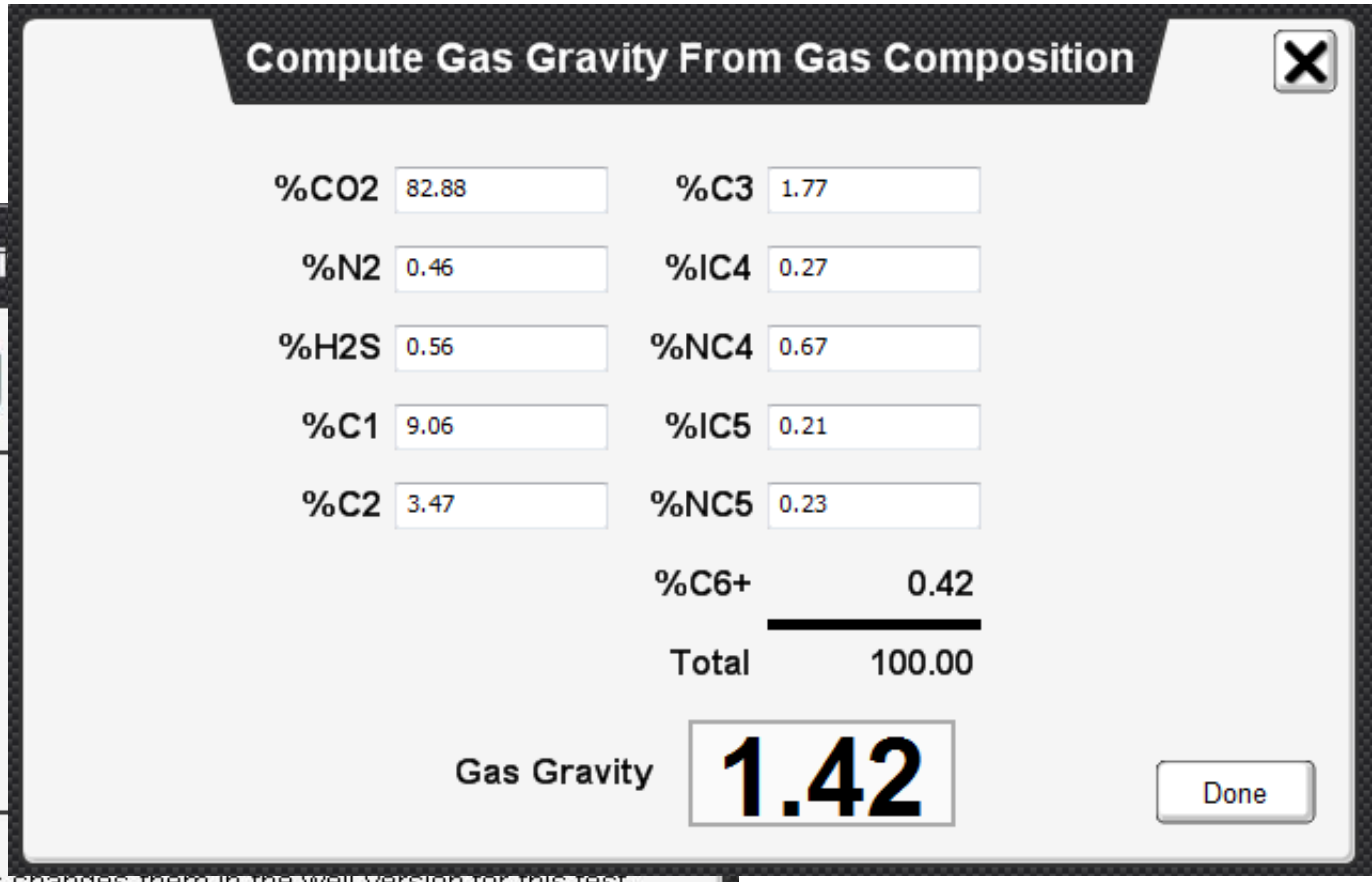
D=DISTANCE TO LIQUID (FEET)
T=TIME TO LIQUID LEVEL (SECONDS)
V=VELOCITY OF SIGNAL (FEET PER SECOND)

Estimate Acoustic Velocity



Analysis Method: Acoustic Velocity





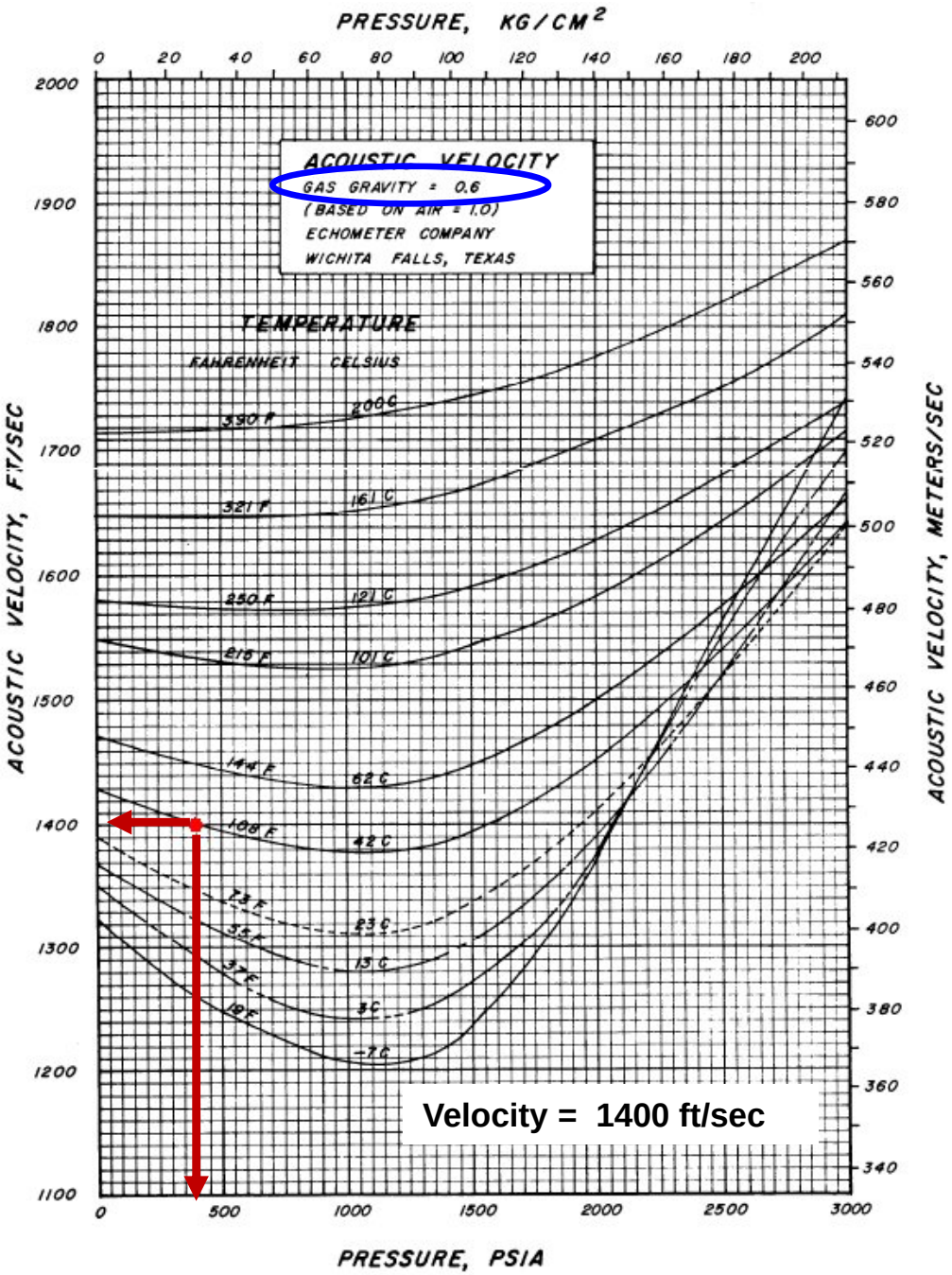
Enter Velocity

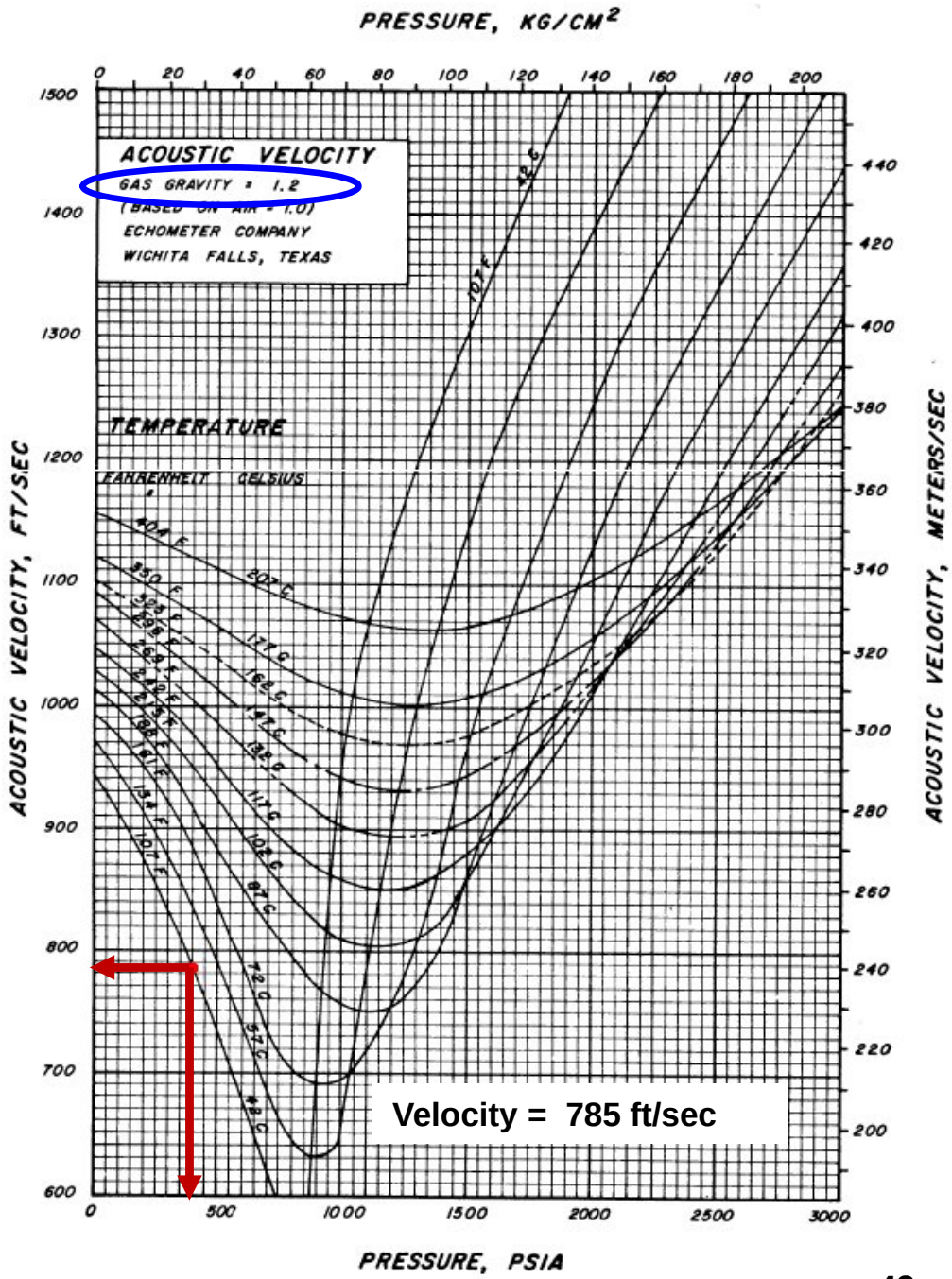
Enter Gas Composition

Reference: Acoustic Velocity for Natural Gas, Echometer Company

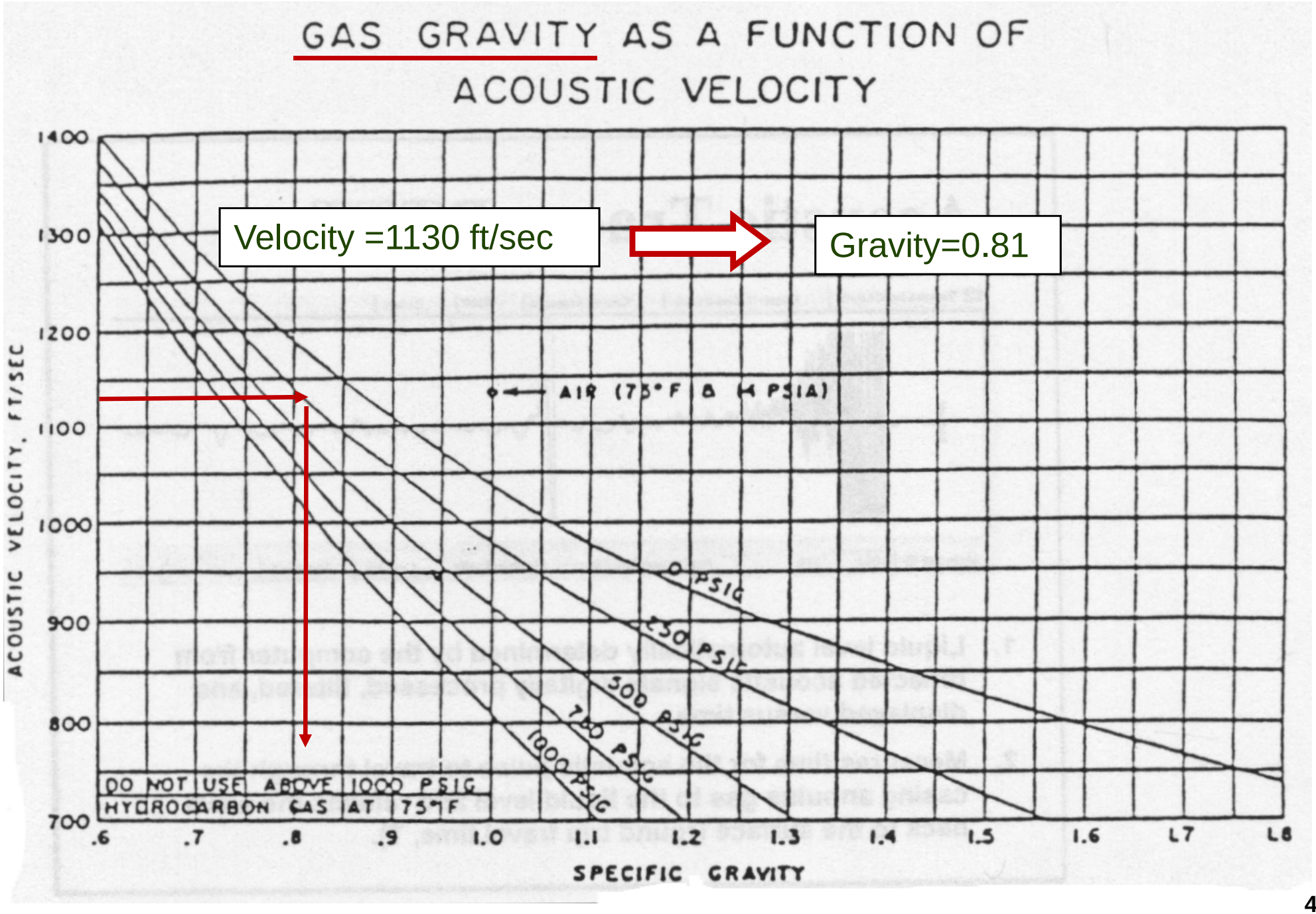
Acoustic Velocity of Gases

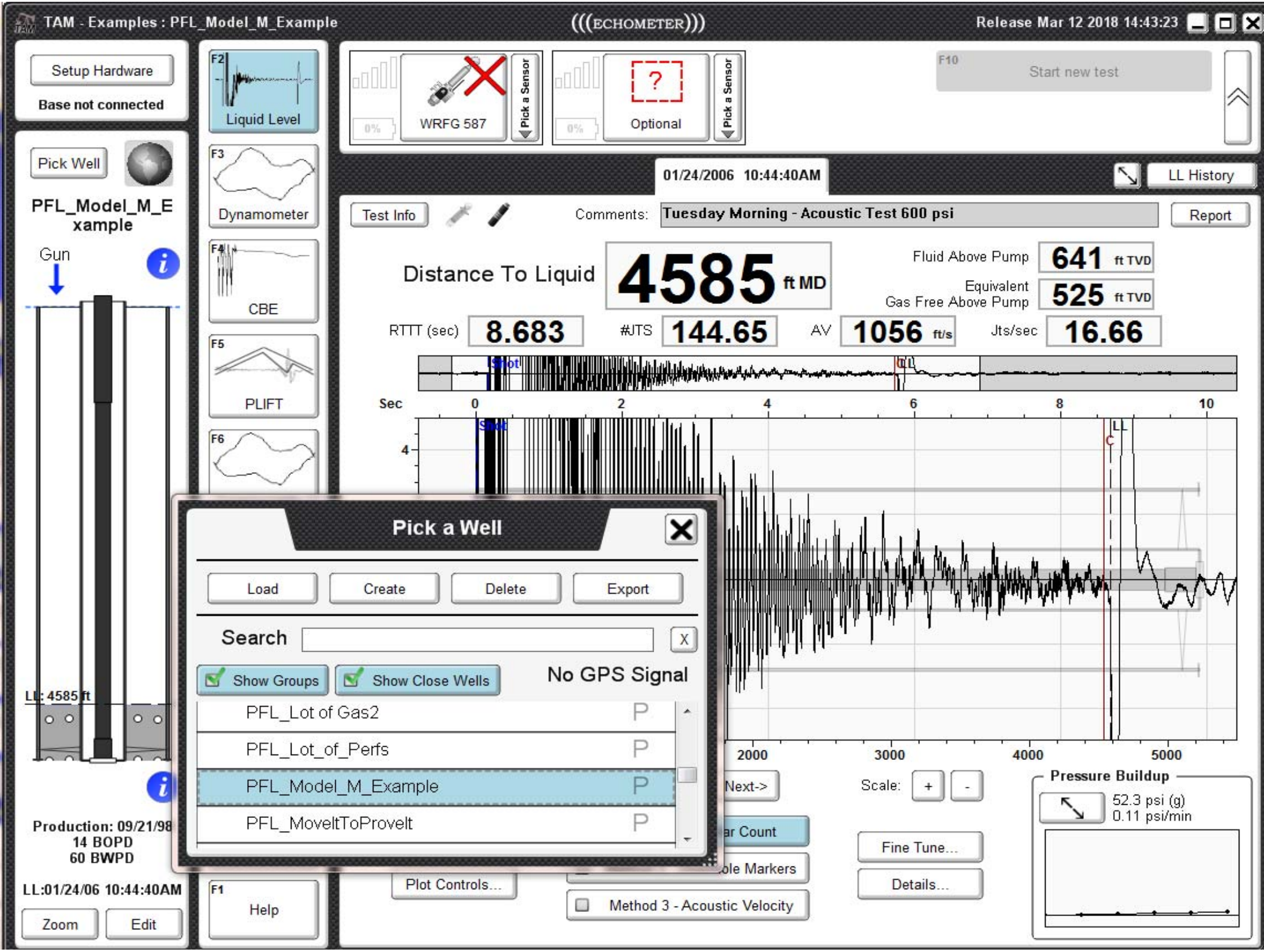
Depends on P, T and Specific Gravity/Composition:





Low Pressure Hydrocarbon Gas




TAM - Examples : PFL_Model_M_Example
(((ECHOMETER)))
Release Mar 12 2018 14:43:23
Setup Hardware
Base not connected
Pick Well
PFL_Model_M_Example
Gun
LL: 4585 ft
Production: 09/21/98
14 BOPD
60 BWPD
LL:01/24/06 10:44:40AM
Zoom
Edit
F2
Liquid Level
F3
Dynamometer
F4
CBE
F5
PLIFT
F6
F1
Help
WRFG 587
Pick a Sensor
Optional
F10
Start new test
01/24/2006 10:44:40AM
LL History
Test Info
Comments:
Tuesday Morning - Acoustic Test 600 psi
Report
Distance To Liquid
4585 ft MD
Fluid Above Pump
641 ft TVD
Equivalent Gas Free Above Pump
525 ft TVD
RTTT (sec)
8.683
#JTS
144.65
AV
1056 ft/s
Jts/sec
16.66
Sec
0
2
4
6
8
10
Shot
LL
2000
3000
4000
5000
Next->
Scale:
+
-
Pressure Buildup
52.3 psi (g)
0.11 psi/min
Fine Tune...
Details...
Plot Controls...
Method 3 - Acoustic Velocity
Pick a Well
Load
Create
Delete
Export
Search
X
Show Groups
Show Close Wells
No GPS Signal
PFL_Lot of Gas2
PFL_Lot_of_Perfs
PFL_Model_M_Example
PFL_MoveItToProveIt

TWM Recall Previous Data

TWM - Examples : PFL_Model_M_Example <Surface Card> acq-[01/24/06 11:02:56] Dynamometer Test

File Mode Option Tools Help

Acquire Mod

Recall Mode

F2 Data Files

F3 P/C DYN ACU Select Test

F4 Analyze

Open Data Set File

[Alt 1] Base Well File

PFL_Anchor_ButNotSet
PFL_Anomaly
PFL_DHM_CasingWtChange
PFL_DHM_CoalBedPerfs
PFL_ESP
PFL_Gaseous_noisy
PFL_Gaslift
PFL_High
PFL_High_liquid_low_gas
PFL_Imp_Exp
PFL_Liner
PFL_Lot of Gas2
PFL_Model_M_Example
PFL_SBHP
PFL_SSSV
PFL_Tubing_anchor
PFL_VeryHighFluidLevel
PFL_VSD_ESP_noise
PFL_VSD_ESP_noise_2
Plunger_Normal Cycle
PRT Bending Polished Rod
PumpingBelowPacker
RodPart_3000
RodPart_5365
RodPart_NoPlunger
RodStretch
Sand Springs #277
Sandia

Open | Cancel | File Transfer...

[Alt 2] Data Sets for Given Base Well File

Date/Time	*	Test Data	Description
01/24/2006 10:30:57		A--DVCp--	Tuesday Morning

C:\TWM\Examples\PFL_Model_M_Example.011

Show Individual Transient Acoustic Hard Shot Files

Well Description Data Tab

Define Base Well Information with Selected Production Method

Quick View | Detailed View

01/24/06
10:30:57AM

New
Delete
Insert Version
Change Version Date

Well Conditions
Mechanical Wellbore
Lift System
Survey
Producing Interval
Tubular Markers
Well Description

Well Name	PFL_Model_M_Example
Well ID	
Company Name	ECHOMETER
Operator Name	BILLY
Lease Name	EASTEND
Comments	This is an example of a well with un-anchored tubing with the Pump Intake set below perforations. 4 3CRO Master Weights 40" from end of Crank 8495B Master weights weigh 5308 Lbs. 71sec/10 strokes = 8.45 spm
Group	Examples
Subgroup	
GPS	0 0

Current Location
No GPS Signal

Change Template... | Summary | Undo | Save | Close

Zoom | Edit | Help | Method 3 - Acoustic Velocity

Lift System Tab

Data not used in Fluid Level

Quick View | Detailed View

01/24/06
10:30:57AM

New
Delete
Insert Version
Change Version Date

Well Conditions
Mechanical Wellbore
Lift System
Survey
Producing Interval
Tubular Markers
Well Description

Lift System Type

Select Lift System: **Rod Pump**

Surface Unit and Torque | Prime Mover | Rod String and Pump

Surface Unit

Manufacturer: **Lufkin Conventional**
Class: **Conventional**
API: **C-320D-256-100**
Model:
Stroke Length: **100.00** in
Rotation: CW / CCW
Select Pumping Unit
Automatically Detect Valve Tests

Counterweights Database

Counter Balance Moment (Existing)
500.9 Kin-lb
Counter Weights...
Weight of Counter Weights: **5308.0** lb

For Net Torque Calculations Use

CBM From Counterweights Database
CBM: **500.9** Kin-lb CBE: **10.47 Klb**

CBE Manually entered
CBE: **10.92** Klb CBM: **523.3 Kin-lb**

Use	Date/Time	CBE	CBM
	01/24/2006 11:16:46AM	10.92	523.3

Change Template... | Summary | Undo | Save | Close

Wellbore Tab

Required: Tubing OD, Tubing ID, Deviation Survey, Avg Joint Length, Pump Depth

Quick View | Detailed View

01/24/06
10:30:57AM

New
Delete
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Well Conditions
Mechanical Wellbore
Lift System
Survey
Producing Interval
Tubular Markers
Well Description

Tubing

#	Top	bottom	OD	Weight	ID	Avg. Jt Length
	ft	ft	in	lb/ft	in	ft
top	0	5226	2.375	4.60	1.995	31.700
Total				24039.6		

Insert Tubing Row | Delete Tubing Row

Casing(s)

Production | Intermediate | Surface

#	Top	bottom	OD	Weight	ID	Avg. Jt Le...
	ft	ft	in	lb/ft	in	ft
top	0	5226	5.500	15.50	4.950	31.700
Total				81003.0		

Add Liner at End | Insert Casing Row | Delete Casing Row

*** All Depth are Measured Depths ***

Hardware

Present in Well?		@ Measured Depth RKB (ft)
	KB Offset	0.0
☐	Sub-Surface Valve	
☐	Landing Nipple(s)	
☐	Packer	
☐	Bridge Plug	
☑	Tubing Anchor	5100.0
☑	Seating Nipple	5226.0
☐	Plugback	
☐	Other	

Change Template... | Summary | Undo | Save | Close

Conditions Tab

Required: Oil & Water Rates, Gravities, BHT. Formation Depth, Static BHP

Quick View | Detailed View

01/24/06
10:30:57AM

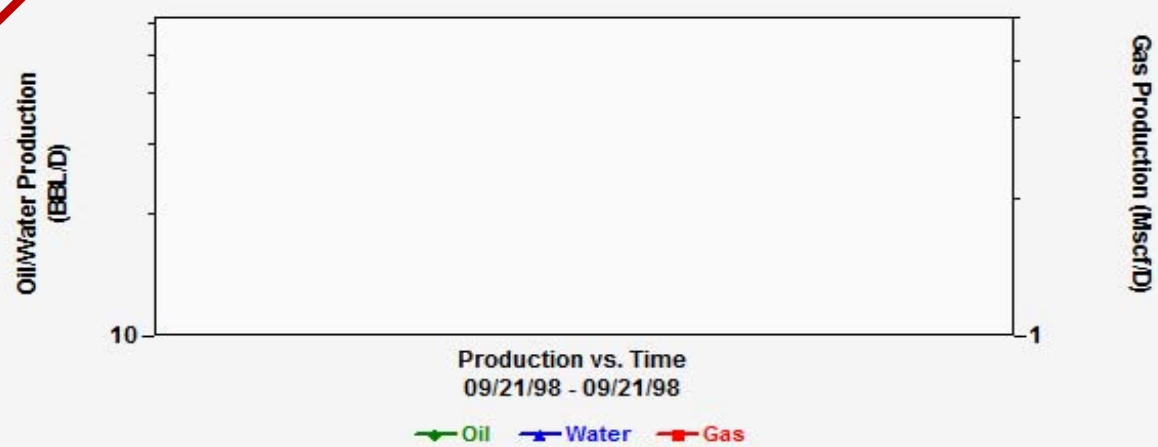
New
Delete
Insert Version
Change Version Date

Well Conditions
Mechanical Wellbore
Lift System
Survey
Producing Interval
Tubular Markers
Well Description

Well Production

#	Date	Oil Production	Water Production	Gas Production	Tubing Gradient
	MM/DD/YY	BBL/D	BBL/D	Mscf/D	psi/ft
1	09/21/98	14.00	60.00	4.00	0.435
2					
3					
4					
5					

Insert Entry | Delete Entry



Fluid Properties

Oil	42.0	deg.API
Water	1.050	Sp.Gr.H2O
Fluid Visc	0.76	cp
Gas Gr.	0.92	
%CO2	0.00	
%N2	0.00	
%H2S	0.00	

☐ Always use the above gas properties for pressure profile calculations

Compute Gas Gravity

Temperatures

Surface	70	deg F
Bottom Hole	136	deg F

Standard Conditions

Temperature	60	deg F
Pressure	14.7	psi (g)

Change Template... | Summary | Undo | Save | Close

Quality Control of Acoustic Survey Data

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

SINGLE and MULTI- SHOT ACOUSTIC TESTS

- Single shot acoustic tests determine the conditions in the well <u>at the time</u> of the test:
  - Liquid level depth
  - BOTTOM hole pressures
  - Well inflow performance

- Multi-shot acoustic tests determine how liquid level and bottom hole pressures <u>change as a function of time.</u> Well Analyzer is programmed for automatic shooting:
  - Pressure transient tests
  - Liquid level tracking tests