Sage Technologies

Acoustic Fluid Logger IV

and

Pressure Pulse Gas Gun

Operator's Manual

Version 2.3

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If you are trying to contact us from outside the United States, the phone numbers must be prefixed with the (+1) United States International dialing code

Contact us through the Internet:

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Introduction to Acoustic Fluid Logger IV

With Sage AFL software for the Acoustic Fluid Logger IV

and choice of gas guns:

- **1,500 psi Pressure Pulse Gas Gun**
  - **With optional 1,500 psi pressure transducer**
- **3,000 psi Pressure Pulse Gas Gun**
  - **With optional 3,000 psi pressure transducer**
- **5,000 psi Sage High Pressure Gas Gun**

The **Acoustic Fluid Logger IV System** lets the operator use his own portable computer in combination with our Sage AFL software to gather computerized fluid levels on oil and gas wells. The Acoustic Fluid Logger IV stores well data on the computer, and allows easy downloads or transmission of files in .pdf format. The software also allows easy calculation of bottom hole pressure and other important parameters.

The **Acoustic Fluid Logger IV** is designed to work with our entire line of gas guns: the 1,500 psi Pressure Pulse Gas Gun -- with optional 1,500 psi pressure transducer, the 3,000 psi Pressure Pulse Gas Gun – with optional 3,000 psi pressure transducer, and the 5,000 psi Sage High Pressure Gas Gun.

During a fluid level test, the stainless steel Pressure Pulse Gas Gun shoots a pulse of compressed CO^2 down the annulus of the well; the return signals are received on the gas gun's internal microphone and transmitted to the Acoustic Fluid Logger IV via the microphone cable. The gun contains a volume chamber, a valve assembly and a microphone. Both the 1,500 and 3,000 psi Pressure Pulse Gas Guns and also the 5,000 psi Sage High Pressure Gas Gun allow the use of either an implosion (using gas from inside the wellbore) or an explosion (using a compressed shot of CO^2 or Nitrogen) to complete a fluid level test. All three gas guns may be easily disassembled for maintenance.

Pipe adapters are available for all gas guns, to allow connection to any wellbore.

All of the products offered by Sage Technologies are the result of years of field experience and technical innovation. In addition, our technical and training staff and our full repair shop stand behind each piece of equipment.

Included with your Acoustic Fluid Logger IV System

- Acoustic Fluid Logger IV
  - Sage AFL software CD
  - AFL IV Field Manual
  - Wall-mount battery charger
  - Microphone cable
  - USB cable

- Pressure Pulse Gas Gun and Microphone (1,500 psi gas gun is standard)
  - 1,500 psi gauge with quick connect
  - 200 psi gauge with quick connect (for checking casing pressure)
  - Charge hose for CO^2 bottle
  - 2 ½ pound CO^2 bottle, empty
  - CO^2 refill adapter
  - 4" Spanner wrench
  - Service Tool (for valve core and o-ring maintenance)
  - Two 5/32" Allen wrenches
  - 3/16" balldrive wrench
  - O-ring and valve core repair/replacement kit
  - Waterproof carrying case

Field computer requirements

- Portable computer – with Windows 8 operating system (or Windows 7, XP or Vista) – with the Sage AFL Software installed.

Note: For ease of viewing the fluid level and proper use of onscreen tools available inside the Sage AFL software, use a computer **with at least a 13" diagonal screen**.

For Sage AFL software install on computers without a CD drive, you may use a CD-drive-equipped computer to load software onto a USB stick, and then install Sage AFL software from the USB stick to the portable. Or you may contact Sage Technologies for a copy of the Sage AFL software on a USB stick.

Other tools needed in the field

- Filled CO^2 bottle -- must be filled with gas to provide the fluid level shot. The bottle should be weighed when empty, then filled to the specified product weight of the bottle. Our standard bottle included with the system is the 2.5 lb. CO^2 bottle.

- Adjustable wrench for the CO^2 hose and wellhead valves

- 9/16" wrench for the fittings

Sage AFL software

Installation instructions

A CD-ROM containing the Sage AFL software is included with purchase of the Acoustic Fluid Logger System.

The Sage AFL software is designed to work with any Windows 8 (or Windows 7, XP or Vista) computer. This means that you can use your field portable computer to gather data and save it to a disk or USB memory stick, then use your office computer and printer to analyze the data and print a fluid level report.

To install the Sage AFL software, insert the CD into the CD-drive of your portable computer. The CD will autorun. **Please be patient during the installation, as several programs are being installed.** One of these automatic installs, the CutePDF Writer, will allow you to save the fluid level report to an Adobe PDF file, suitable for email transmission.

NOTE for computers without a CD drive: You may use a CD-drive-equipped computer to copy the **complete contents** of the Sage AFL CD-ROM disk onto a USB stick, and then use that USB stick to install the software to the portable computer. Or you may contact Sage Technologies for a copy of the Sage AFL software on a USB stick.

The Sage AFL software CD will not be required in the field, once the software is installed on the field computer. Store the Sage AFL software CD safely for future installation on additional computers.

Shooting the pumping fluid level

Quick start instructions

- Close the backside valve on the well before set-up of the Acoustic Fluid Logger system.
- Connect the Pressure Pulse Gas Gun to the annulus of the well behind the backside valve, using the spanner wrench provided.
- Open the backside valve, in preparation to pressure up the gas gun.
- Push the Pressure Pulse Gun's shuttle valve into the **Load** position. Make sure the **Pressure Bleed** valve is closed.
- Charge up gas gun chamber by feeding pressure into the gun from the CO^2 bottle through the charge hose to achieve a positive differential pressure. To do this, stab the CO^2 charge hose into the **Fill Valve** labeled on the side of the gun. **Suggested shot pressure is 200 to 300 pounds over well pressure, depending on well depth.**
- Shut in the casing flow line valve, so the shot will go down the wellbore and not down the flow line.
- Connect the **microphone cable** to both the Acoustic Fluid Logger IV and to the Pressure Pulse Gun. Connect the **USB cable** to both the Acoustic Fluid Logger IV and to the portable computer.
- Turn on the Acoustic Fluid Logger IV unit and the portable computer. Open the Sage AFL software; on the screen, click **Yes** in the **Instrument Enabled** box, and go to the **Depth Scan** tab.
- Click on the **Start Acquisition** button located on the **Depth Scan** tab.
- Quickly **shoot the Pressure Pulse Gas Gun** by pushing the shuttle valve in the **Fire** direction. You will see the shot appear on the computer screen.
- Let the fluid level run until you have seen a valid fluid level kick. On the computer screen, click the **Stop Acquisition** button on the **Depth Scan** tab to stop the fluid level data acquisition.
- Inspect the resulting fluid level graph on the computer screen for valid fluid and readable collars.
- If valid fluid is found, click the **Save Data** button near the top of the computer screen to save the fluid level graph to the portable computer. Choose the file and folder location desired on the computer, then name and save the fluid level file.
- Follow the above procedures to shoot another shot on the well.

Illustrated Fluid Level Procedure

With Pressure Pulse Gun – 1,500 or 3,000 psi

1. Mount the Pressure Pulse Gun to the wellhead; applying Teflon tape to the gas gun threads before connection to the wellhead helps achieve a better seal. Turn the gun by hand at first. Finish tightening by inserting the spanner wrench provided with the gun into the notches in the gun and tightening the gun firmly to the wellhead.

2. Open the backside casing valve, shown below left. This will allow the compressed gas shot to travel down the wellbore to find the fluid. Next, close the casing flow line valve, shown below right. This prevents the compressed gas shot from going down the flow line instead of down the wellbore.

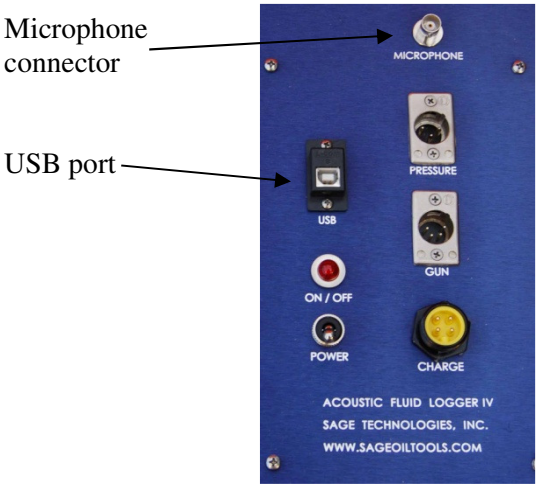
3. Push the gun's shuttle valve into the load position by sliding the shuttle firmly toward "Load."

4. To charge up the gun, first make sure the pressure bleed knob is turned closed. Open the valve on the compressed gas bottle. Press the stab-in connector on the charge hose into the "Fill" connection on the gun. Note: When the charge hose stabs into the fill valve, some gas will blow back from the insertion point. This is normal, and helps keep the charge area free of debris.

Recommended shot pressure: Well depth and other variables will affect the amount of pressure needed to charge the gun for a fluid level shot. **In general, a shot of 100 to 200 psi above wellbore pressure should be sufficient for shallow wells; use 300 to 400 psi above wellbore pressure for deeper wells.**

Watch the gauge and charge to the desired pressure. The gun is now charged, and ready to fire when connected to the Acoustic Fluid Logger IV.

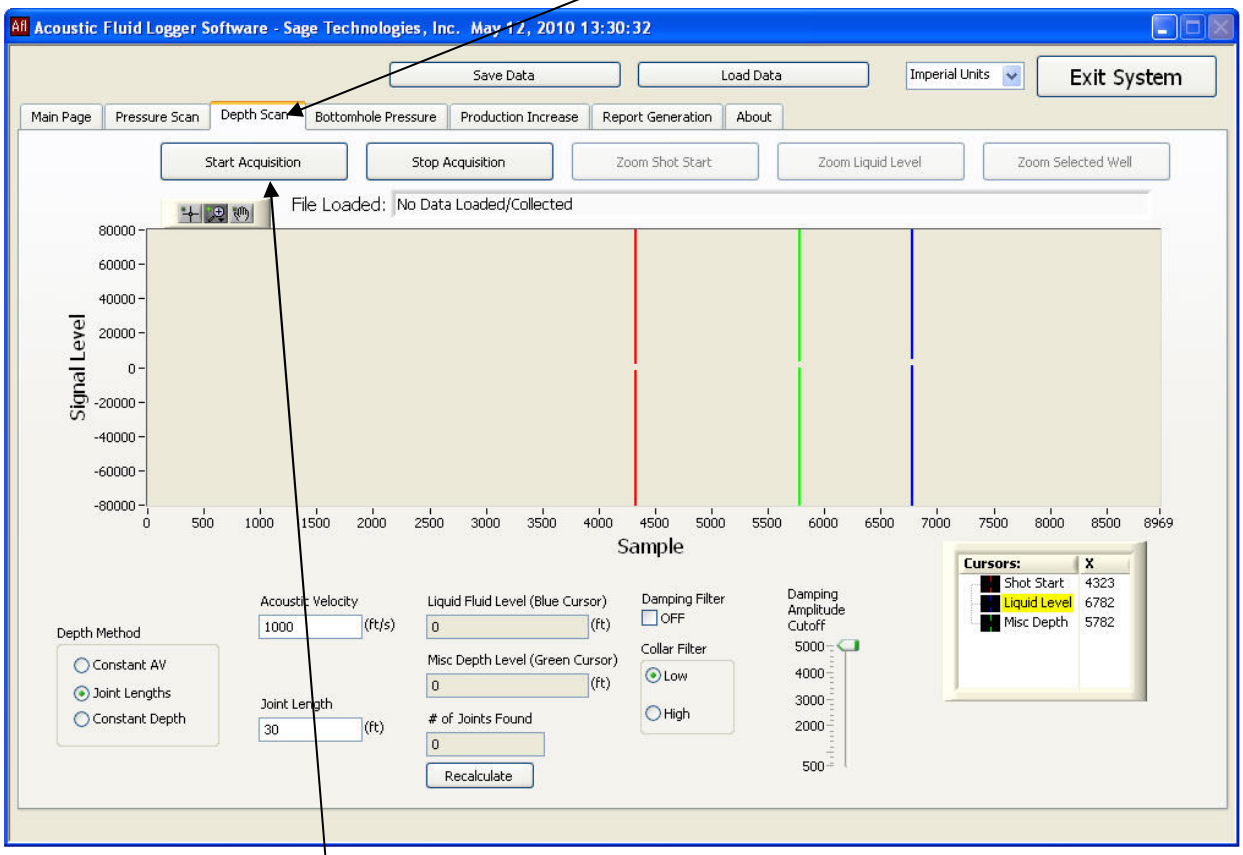
5. Attach the microphone cable from the connector on top of the Pressure Pulse Gun to the microphone connection on the Acoustic Fluid Logger IV. Turn on the power switch on the Acoustic Fluid Logger IV and the on/off light will shine. Note: In very bright conditions, the light on the front panel can be difficult to see.



6. Connect the USB cable from your portable computer to the USB port on the Acoustic Fluid Logger IV. Open the Sage AFL software on the computer; when the software loads, on the initial Instrument Control screen, click **"Yes"** to **"Enable Instrument control?"** This means the instrument is connected and ready to record data.

Note: There are times when you would click "No" to "Enable Instrument control?" such as when you are loading a saved file from the computer and the instrument is not connected. But when the instrument is connected to the computer during testing, click "Yes."

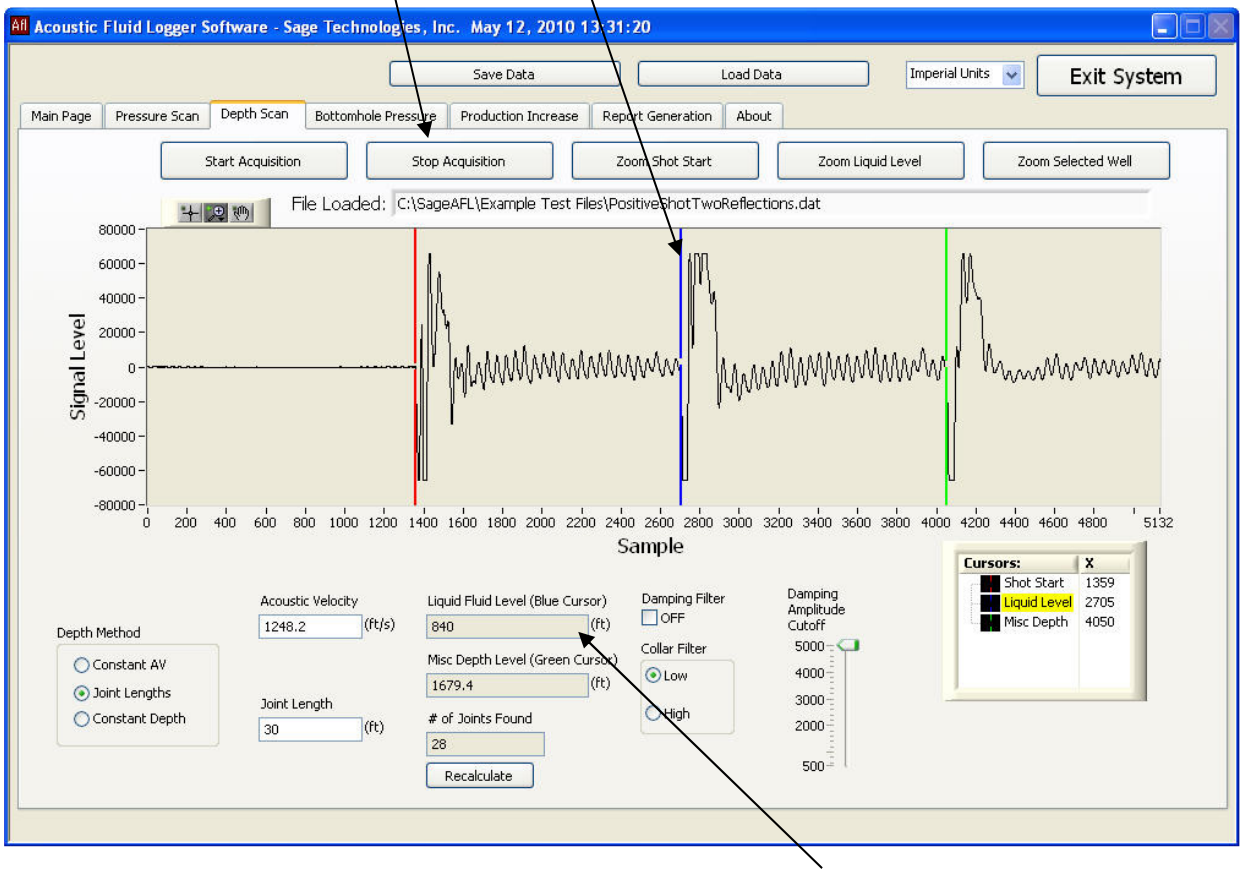
7. Be ready to fire the Pressure Pulse Gun. Go to the **Depth Scan** tab on the software.



8. Press **"Start Acquisition,"** then **quickly** fire the gas gun by pushing the shuttle valve toward **"Fire."**

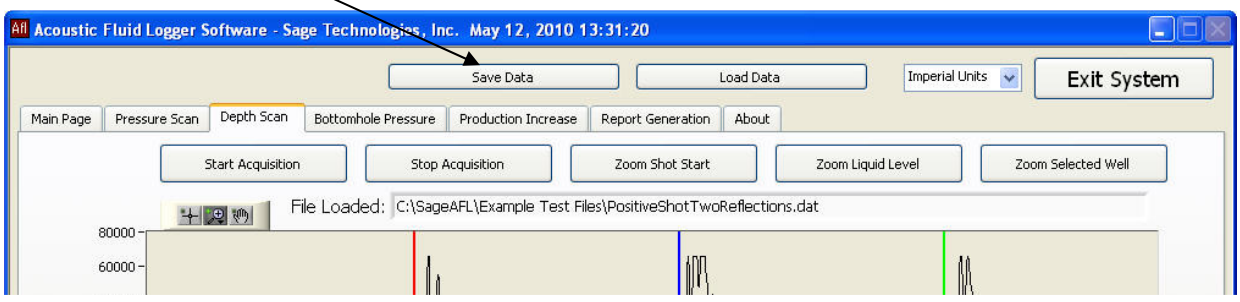
Quickly fire the gas gun

9. The fluid level signal will appear on the computer screen. When you see a valid fluid level kick on the graph, click the **"Stop Acquisition"** button. Remember that the compressed gas must travel down to the fluid and back to the surface before the signal registers on the fluid level graph onscreen. Shot return time will vary with well depth. The **fluid level signature** appears marked on the graph by the blue line cursor.



10. The calculated value for the fluid level will appear in the **Liquid Fluid Level** (Blue Cursor) box. You may now calibrate the echo using the tools in the Sage AFL software. You may do this in the field, or you may save the data for calibration at a later date.

Saving Fluid Echoes: To save the fluid level data files to the portable computer, click the "Save Data" button at the top of the screen, then name and save each file to a folder on the computer. Naming each test file with the well name and date of test can be very helpful when testing multiple wells over time. **Once all echoes are saved**, click "Exit System" to close the software program.

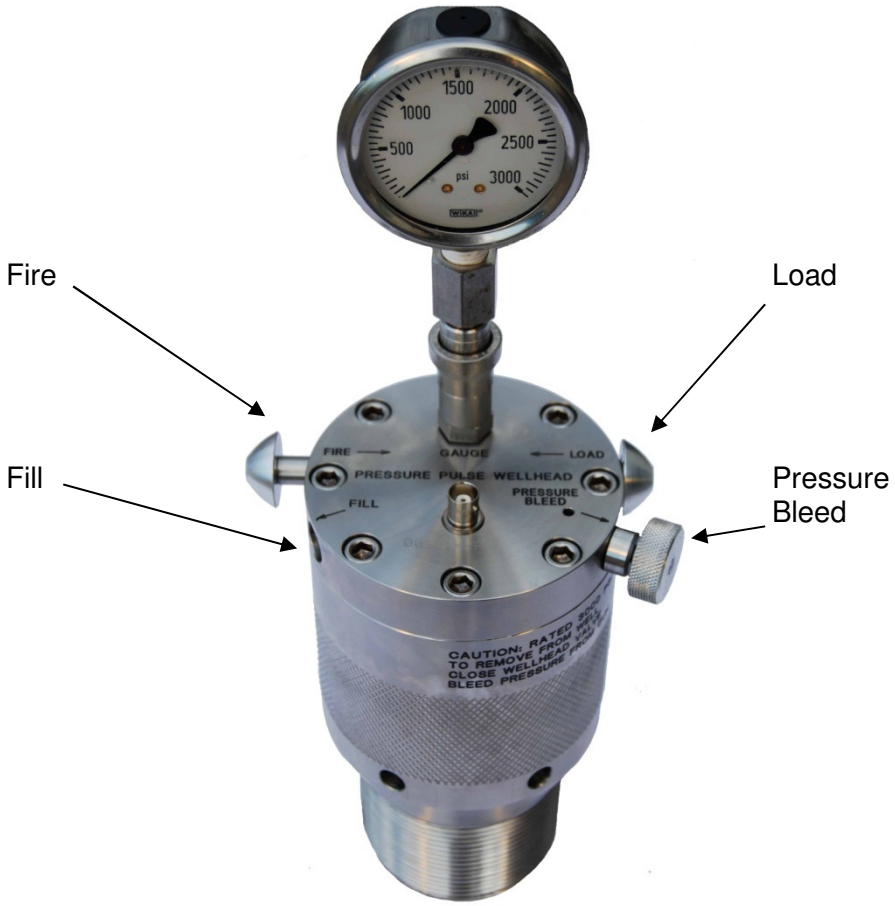


11. When testing is complete, fluid logger set-up procedures are reversed. Note: To ensure the safety of the operator, when rigging down, first BE SURE to close the backside casing valve.

12. Before removing the gun from the well, BE SURE to turn the P**ressure Bleed** knob counter-clockwise to open the bleed valve and release pressure from the gun. Also, BE SURE to put the **Shuttle Valve** into the **"Fire"** position, to fully release pressure from the gun for safe operation. **The gauge on the gun must be returned to zero psi before you begin to remove the gun from the wellhead.**

13. Use the spanner wrench to loosen the gun from the wellhead. Once loosened, the gun may be rotated and removed by hand. After the gun is removed from the wellhead, remember to open the casing flowline valve. Repack the gun and accessories into the black case for easy transport from the well site.

Pressure Pulse Gun - Illustration



Quick start instructions

Shooting a Positive Pressure Wave:

- Push the shuttle valve to the **"Load"** position (in direction of Load arrow).
- Connect the CO^2 charge hose to the gas bottle. Insert the CO^2 charge hose tip into the **"Fill"** connection on the gun. As you do this, pressure will increase on the gauge.
- When the desired pressure is reached, remove the charge hose tip from the fill connection. **A suggested shot size is 100 to 200 psi above wellbore pressure for shallow wells. A suggested shot size for deeper wells is 300 to 400 psi above wellbore pressure.** If you overfilled the gun, release some of the gas with the Pressure Bleed knob.
- To fire the Pressure Pulse Gun, push the shuttle valve to the **"Fire"** position (in the direction of the Fire arrow).

Shooting a Reverse Pressure Wave:

Most wells with a casing pressure of above 100 psi can be shot using a reverse pressure wave, if desired. (This means letting gas travel from the well into the volume chamber of the gas gun).

Reverse Pressure Wave Procedure:

- Place the shuttle valve in the **"Load"** position.
- Open the **Pressure Bleed** knob (counterclockwise) to bleed gas from the internal volume chamber.
- Close the **Pressure Bleed** (clockwise) and move the shuttle valve to the **"Fire"** position. (You will notice that the gauge on top of the gas gun suddenly travels from zero to whatever is the existing pressure inside the wellbore casing.)
- You have now produced a **reverse pressure wave**. The fluid level will also be reversed on the computer graph; **the fluid level will kick UP on the graph, instead of kicking down as it does in a positive pressure wave.**

For more information on shooting a reverse pressure wave, see Appendix C: Reverse Pressure Wave, Page 70.

To remove the Pressure Pulse Gun after a Reverse Pressure Wave:

- Close the casing valve.
- Check to ensure that the gas gun shuttle valve is in the **"Fire"** position.
- Check that the gun's Pressure Bleed is fully opened. Loosen the gas gun from well using the spanner wrench, and remove the gas gun from the well.

Safety notice: If the Pressure Pulse Gun has been left in the "Load" position while opening the Pressure Bleed, you have only vented the gas from inside the gun. **Gas at pressure is still present between the gas gun and the casing valve.** To release this gas, it is necessary to open the Pressure Bleed (turn counterclockwise) to bleed pressure the gas gun before removing it from the casing.

Pressure Pulse Gun – Using Quick-connects

Quick-connects are a useful accessory for applications that require quick coupling and change-out of gauges on the Pressure Pulse Gun.

Gauge choice options

- Use the 200 psi gauge to measure lower casing pressure readings.
- Use the 1,500 psi (or 3,000 psi) standard gauge to determine shot size

A high-pressure gauge allows the operator to get a quick check of shot size in higher pressure wells.

A low-pressure gauge allows a check of casing pressure in low pressure situations.

The quick-connects allow an operator to use a more accurate gauge for each situation. Also, the gauges rotate freely for easy viewing in any wellbore situation, from any angle.

To Couple the Quick-connect: Align stem with body. Push stem into body until it clicks. (Left photo.)

To Uncouple the Quick-connect: Pull the body sleeve on the quick-connect toward the stem of the gauge (in other words, pull the sleeve away from the gun). (Right photo.)

Warning: System pressure must not exceed 250 psig (17.2 bar) at 70° F (20° C) when coupling and uncoupling this product. When uncoupling single-end shutoff quick-connects, system pressure on the stem side will vent to the atmosphere.

Good practices for operation of Swagelok Quick-connects

- Align bodies and stems when coupling or uncoupling.

- Support hanging hoses or other equipment to prevent side load.
- Re-lubricate stem seal o-rings periodically.

Warning: Do not rotate gauge when coupled under pressure. Do not insert foreign objects into uncoupled bodies or stems.

Pressure Pulse Gun – Using the Pressure Transducer

The pressure transducer can be used to monitor the annulus pressure buildup to determine the gas afterflow in the wellbore directly before the shot. The quick-connect on top of the Pressure Pulse Gun -- both 1,500 and 3,000 psi -- allows for easy connection of a same-rated 1,500 or 3,000 psi pressure transducer in place of a gauge.

Warning: If a pressure gauge has already been in use on the gun and it is connected to the wellhead, the first thing to do is **bleed off all pressure from the gauge,** first by isolating the gas gun from the wellbore, and then by opening the Pressure Bleed wheel on the gas gun.

After bleeding pressure from the gas gun, uncouple the gauge on top of the Pressure Pulse Gun by pulling the sleeve on the quick-connect away from the gun. This will release the gauge from the gun.

ansducer to the Quick-connect: Align the stem on end of transducer with
the transducer stem into quick-connect on the gun body until it clicks.

Transducer from the Quick-connect: Pull the sleeve on the quick-connect
the transducer. (In other words, pull the sleeve away from the gun).

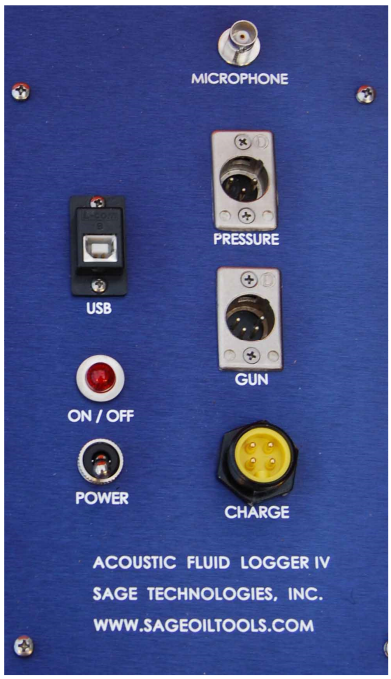
Warning: System pressure must not exceed 250 psig (17.2 bar) at 70° F (20° C) when coupling and uncoupling this product. When uncoupling single-end shutoff quick-connects, system pressure on the stem side will vent to atmosphere.

Good practices for operation of Swagelok Quick-connects with Pressure Transducer

- Align bodies and stems when coupling or uncoupling.
- Support hanging hoses or other equipment to prevent side load.
- Re-lubricate stem seal o-rings periodically.

Setting up the Pressure Transducer

When the Pressure Transducer is connected to the Pressure Pulse Gas Gun, the opposite end of the transducer cable should be connected to the **"Pressure"** connector on the Acoustic Fluid Logger IV blue panel. The microphone cable – bound to the transducer cable – should be connected to the microphone port on the top of the gun and the microphone port on the Acoustic Fluid Logger IV blue front panel.

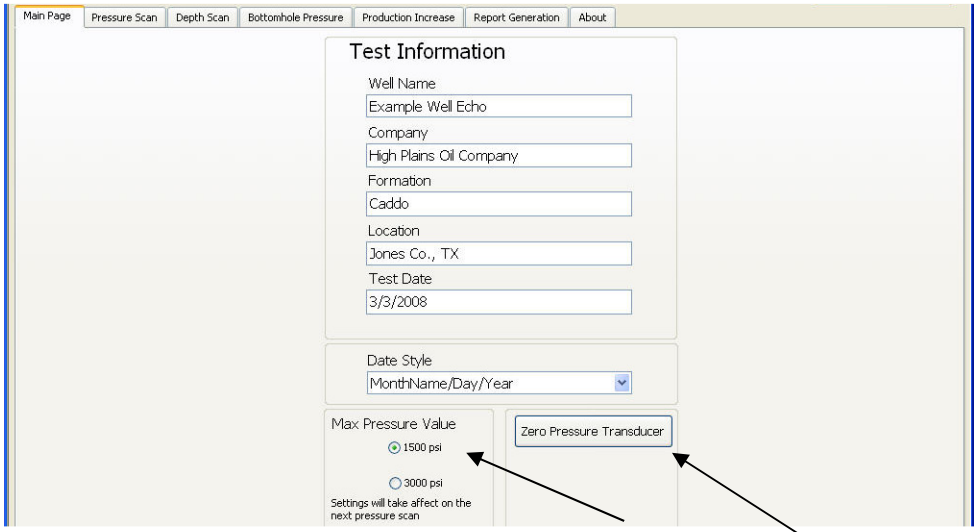


Microphone cable connection

Pressure transducer cable connection

Zeroing the Pressure Transducer

When doing a pressure buildup with a transducer, first open the Sage AFL software on the portable computer, and on the **Main Page** tab, in the **Max Pressure Value** box at the bottom of the page, click on the proper psi rating for the pressure transducer you are using – 1,500 psi with the 1,500 psi Pressure Pulse Gas Gun, or 3,000 psi with the 3,000 psi Pressure Pulse Gas Gun. Then click the **Zero Pressure Transducer** box before commencing. The Pressure Transducer will then be used to monitor surface pressure before the shot in the fluid level test.



For a larger view of the Main Page tab, Max Pressure Value and the Zero Pressure Transducer boxes, see Page 26.

Sage AFL software

The Sage AFL software works in sync with the Acoustic Fluid Logger IV and your own portable computer, eliminating the need to have a dedicated computer solely for fluid level analysis.

Installing the Software

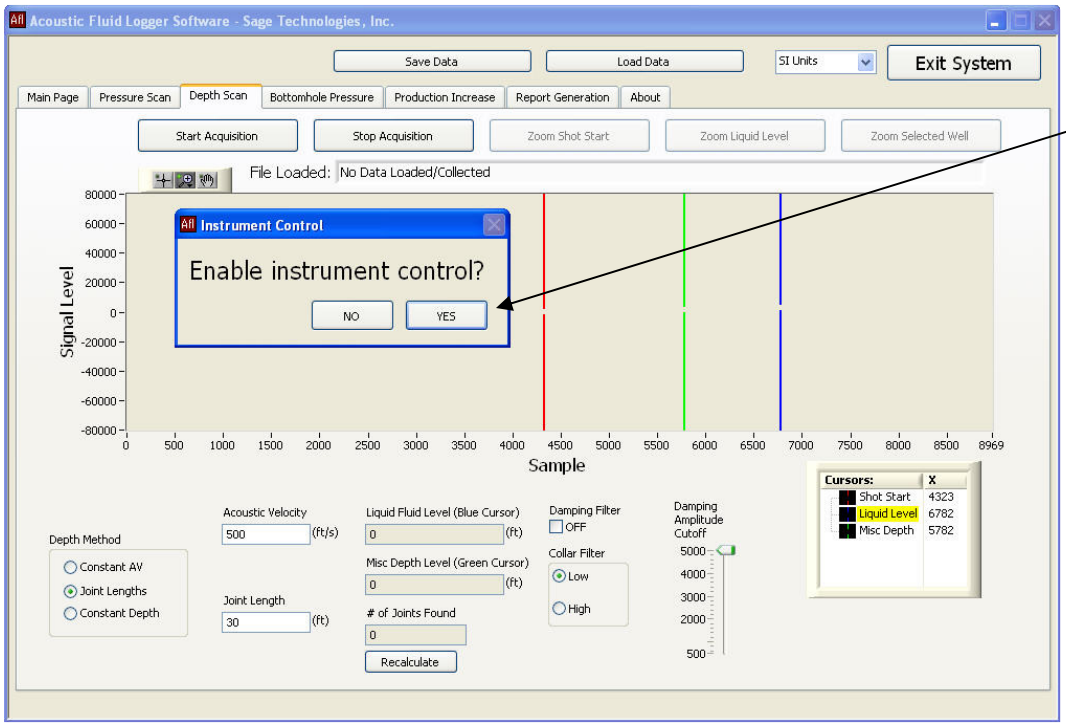
Install the Sage AFL software, using the CD-ROM supplied with your unit, before starting the first well test. Insert the CD into the CD-drive of your Windows 10 (or Windows 8, 7, Vista or XP) computer. **The CD will autorun.** (For computers without a CD drive, copy software CD to a USB stick first, or contact Sage for a copy of the Sage AFL software on a USB stick.)

Please be patient during the installation, as several programs are being installed. One of these automatic installs, the CutePDF Writer, will allow you to save the fluid level report to an Adobe PDF file, for easy email transmission. The Sage AFL software allows you to gather field data with your portable computer, to save it to a hard drive file, disk or USB memory stick. Analysis of saved data can take place on any computer which has the Sage AFL software installed on it.

Once installed on the computer, the Sage AFL software CD is not needed in the field. Store the software CD safely for future installation on additional computers.

Instrument Control pop-up box

To run a well test, first turn on the computer and load the Acoustic Fluid Logger program. On the Instrument Control screen, click "Yes," if the Acoustic Fluid Logger IV is connected to the computer through the USB cable and you are doing a well test. Click "No" if the logger is not connected.



Click **YES**
When running a **fluid level test in the field**

Click **NO**
When **viewing previously saved data – when analyzing data or preparing a fluid level report**

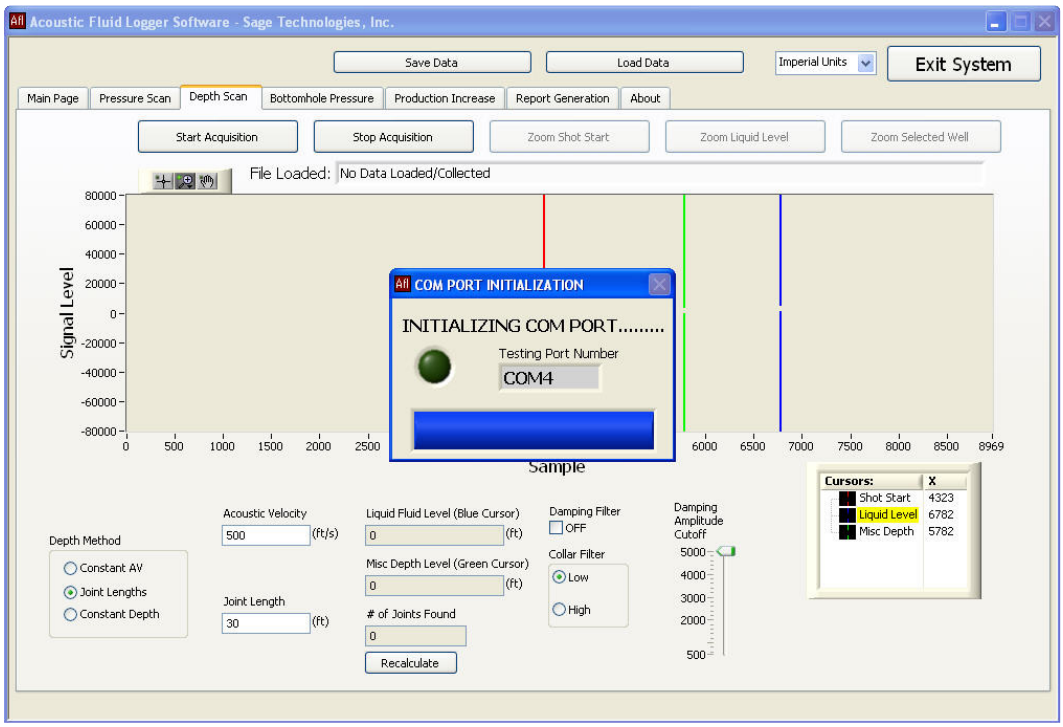
Note: When you click "No" to enable instrument control, you will also notice that the Pressure Scan and Depth Scan menus will disappear temporarily until you load up a saved fluid level echo for analysis.

Remember: If you click Yes to "Enable instrument control?" that means you are in the field collecting fluid level information.

If you click No to "Enable instrument control?" that means you have already gathered your fluid level information, and are no longer connected to the Acoustic Fluid Logger IV. You will still be able to view and process the data you collected and saved earlier in the field, as well as to analyze the data for the fluid level, and to run other calculations.

Initializing the Com Port

Once the **"Enable Instrument Control?"** box is checked, the following screen will appear briefly, while the Sage AFL software automatically picks the communication port through which the fluid logger instrument talks to the computer. No action is required. This screen will disappear once the com port is initialized.



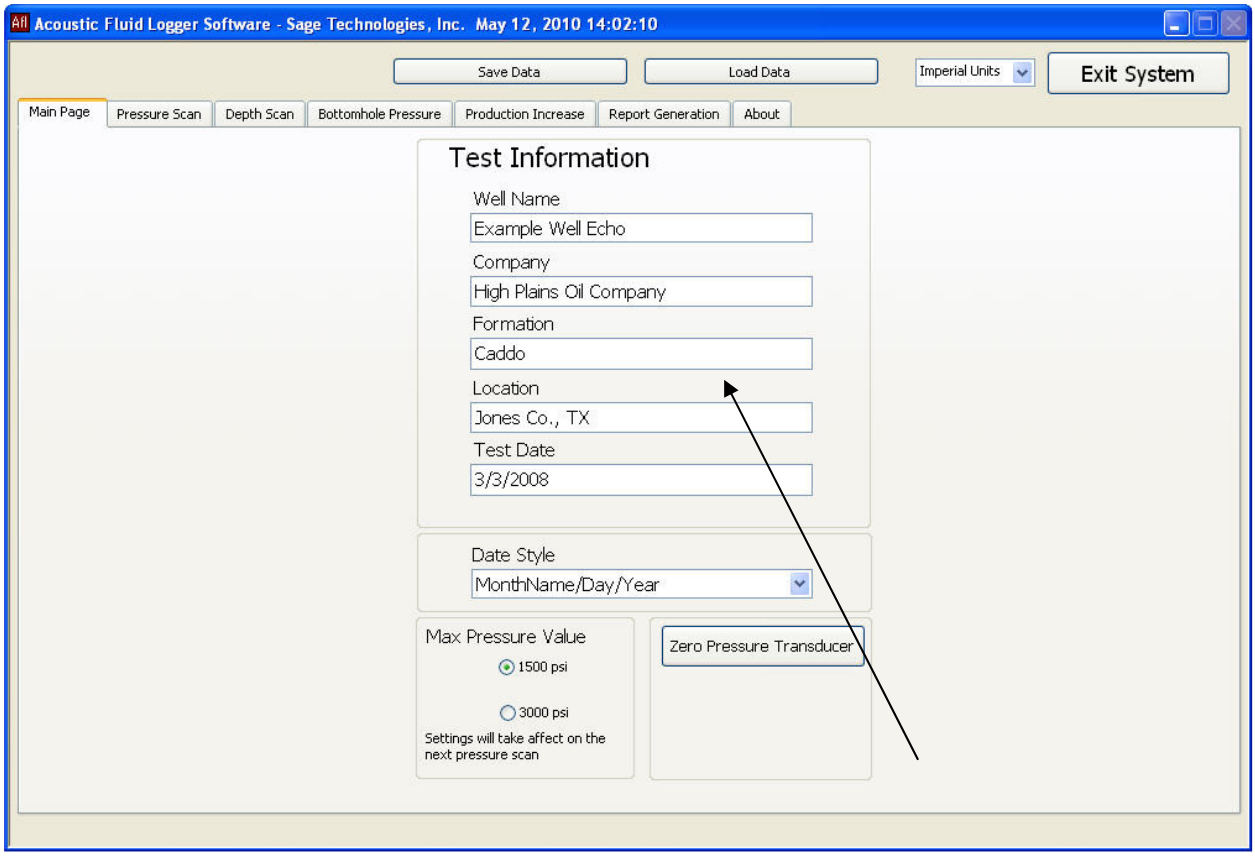
This screen displays briefly while Sage AFL Software automatically identifies the proper **com port** for the fluid logger and computer.

Main Page Tab

A series of menu tabs runs across the top of the screen of the Sage AFL software: Main Page, Pressure Scan, Depth Scan, Bottomhole Pressure, Production Increase, Report Generation, and About. Each tab allows the operator different options to enter and to analyze data for the fluid level test.

Test Information

The page allows the operator to enter the well name, company name, formation, location, and test date – all useful information for identifying the well and the fluid level test.



Enter **Well Name, Company, Formation, Location and Test Date**: useful for identification when saving and analyzing echoes, and comparing data on a well over time

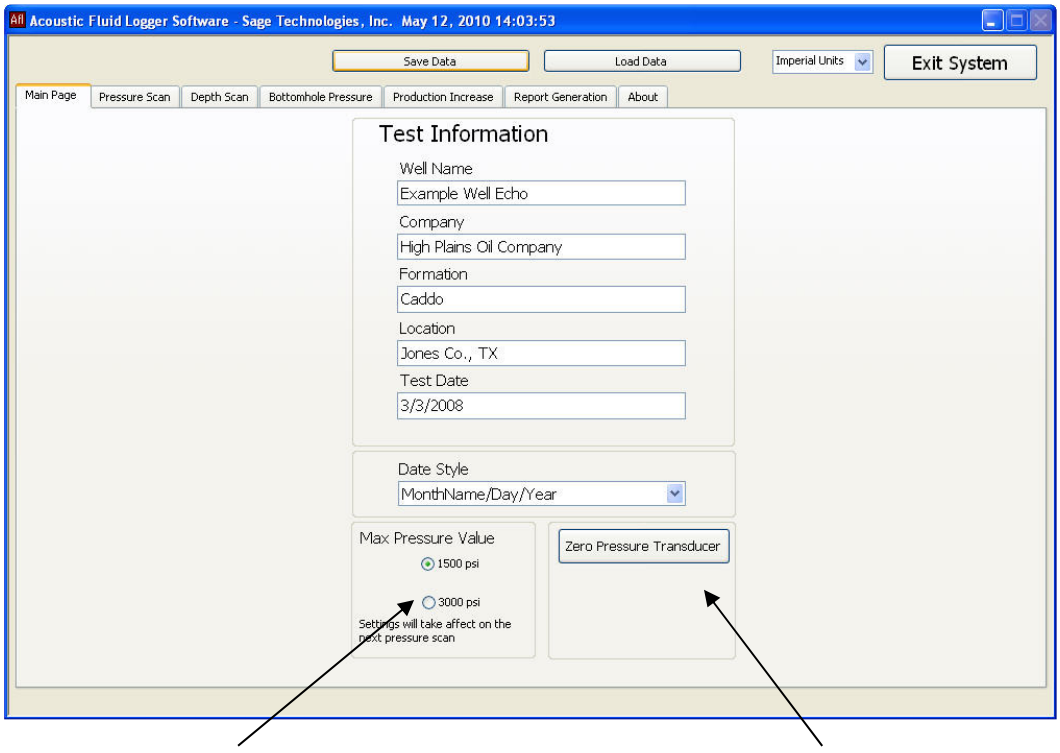
Date Style

Select the desired Date Style for recording the well test in this pull-down menu.

Pressure Transducer - Max Pressure Value

On the Main Page tab, if you are using a pressure transducer, before the test begins, you need to click the **Max Pressure Value** box that corresponds to the transducer that is being used (the 1,500 psi transducer is used with the 1,500 psi Pressure Pulse Gas Gun and the 3,000 psi transducer is used with the 3,000 psi Pressure Pulse Gas Gun).

Note: Once this step is complete, when you exit the program, the transducer value you selected will remain as your default transducer the next time you open the software program.



Select the proper psi rating of Pressure Pulse Gun in use with pressure transducer in **Max Pressure Value** check box

Zero Pressure Transducer

Zero Pressure Transducer

The Main Page tab is also the place to zero the Pressure Transducer if it is being used. However, **zeroing is not part of every test**. You will only need to zero the pressure transducer if over time it develops an offset.

With the transducer plugged into the unit, lay the pressure transducer in the open atmosphere, click **Zero Pressure Transducer**. You will see the zeroing process briefly display on the screen. Once the screen returns to the Main page, then your pressure transducer has been zeroed.

Note: Once this step is complete, when you exit the program, the transducer you zeroed will be selected as your default transducer the next time you open the program.

Pressure Scan tab

Note: Use the Pressure Scan tab ONLY if you are using a pressure transducer to monitor surface pressure before the shot.

Pressure Transducer operation

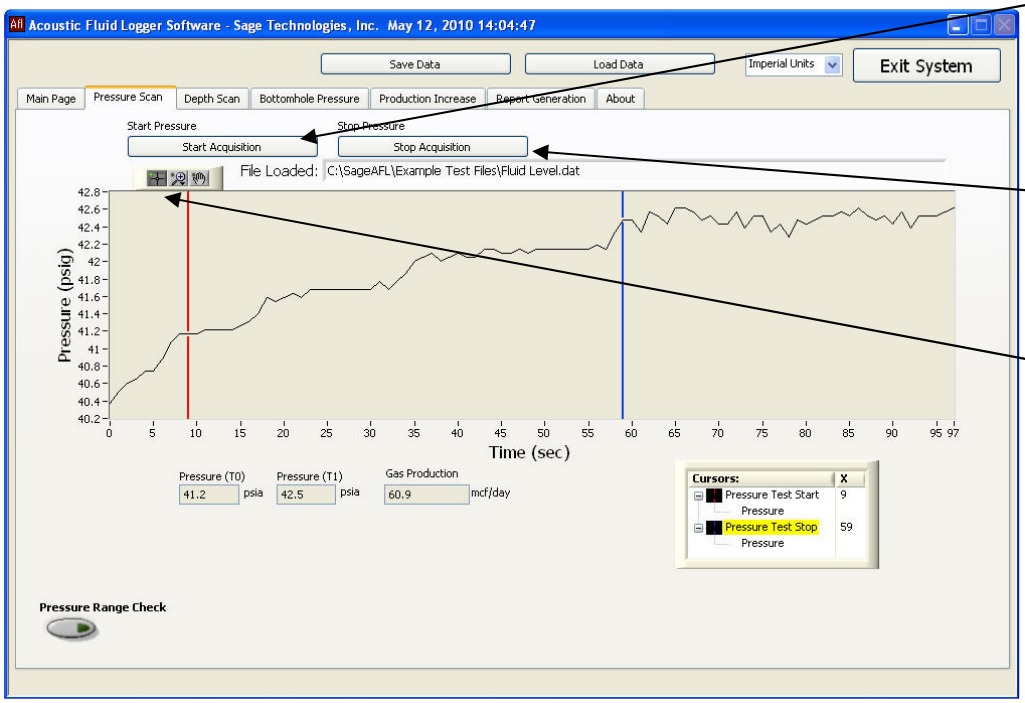
When you have the pressure transducer and the Acoustic Fluid Logger IV connected to the wellhead, before you begin monitoring the surface pressure, you will first enter the **Pressure Scan** tab on the software. The graph on the computer screen will be blank except for the red and blue cursors. Click the **Start Acquisition** button. Once you press this button, the data will start appearing on the screen at the rate of one pressure reading per second.

When you are ready to start the pressure buildup, shut in the reverse casing valve. You will see the pressure slowly increase on your graph. Usually within two to three minutes, you will see the rate of increase slow down. At this point, click the **Stop Acquisition** button.

Now, you will set the Red and Blue Cursors. To do this, click on the left **Graph Manipulation: Cursor** button (looks like a cross with a green dot on it) under the **Start Acquisition** button. This **Graph Manipulation: Cursor** button enables the cursors to be clicked and dragged.

Next, click and drag the **Red Cursor** to the point on the graph where the buildup starts. Click and drag the **Blue Cursor** to the point where the pressure buildup starts to slow down. These two parameters allow the software to set a calculation of the gas afterflow. Later, when you shoot your fluid level test, a calculation of your gas afterflow will be made on your buildup, using these two cursor points.

If you skip this screen, you can enter the gas afterflow directly into the Bottomhole Pressure tab after you have made your calculations (See Page 34). You can also come back to this screen to manipulate the cursors to get a better calculation of the gas afterflow at a later time.



Start Acquisition Before shutting reverse casing valve

Stop Acquisition when rate of increase slows

Graph Manipulation: Cursor Click graph button, click and move Red cursor to start of buildup, move Blue cursor to slowdown of buildup

Depth Scan tab

You begin a fluid level test on the Depth Scan tab, where the actual fluid level test is performed and data is acquired for later analysis. The **Depth Scan**, **Bottomhole Pressure**, **Production Increase** and **Report Generation** file tabs are for different aspects of fluid level data analysis.

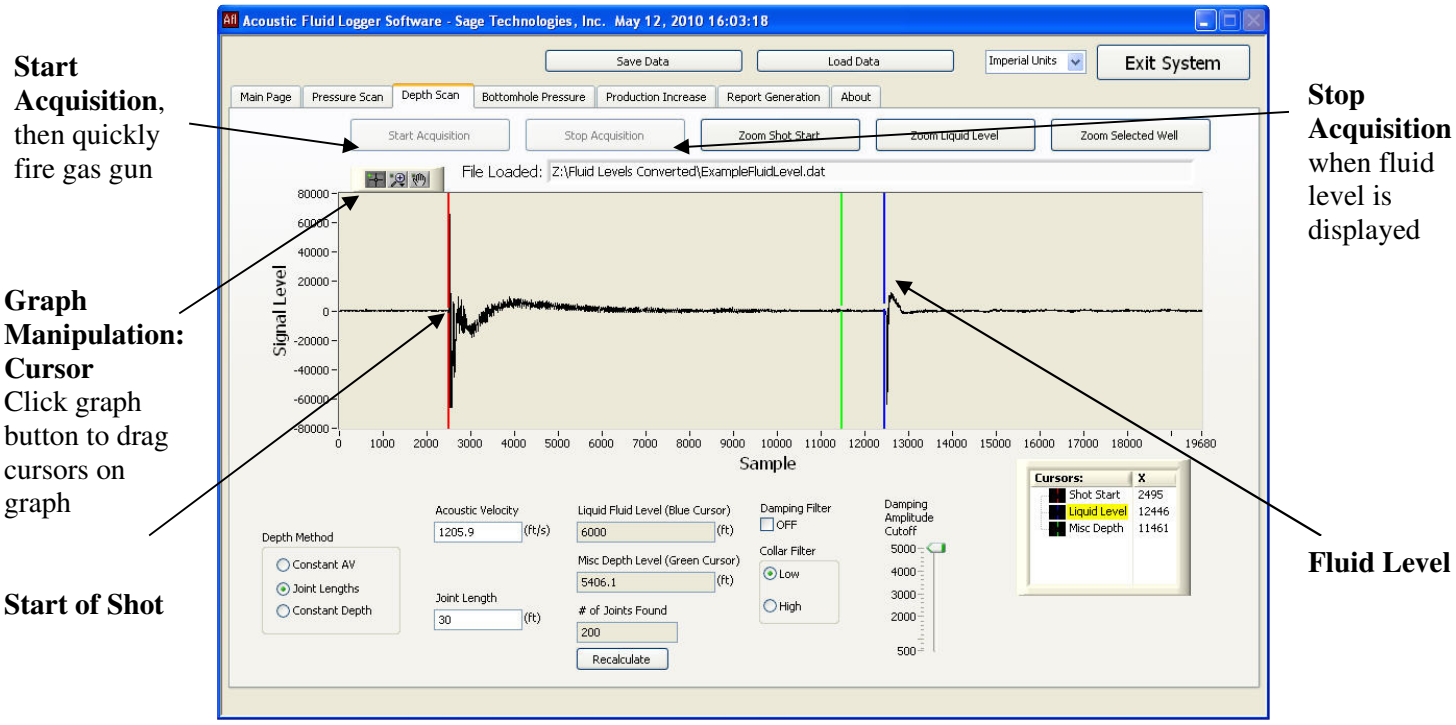
Shooting the fluid level and acquisition of data

When you click on the **Depth Scan** tab, a blank graph will appear. Make sure the Pressure Pulse Gas Gun is charged and ready to shoot. Click the **Start Acquisition** button and promptly shoot the gun. Data from the microphone will appear on the screen, at the rate of 1,000 samples per second. You will see the gas shot displayed soon after the digitization starts, and when you have seen a valid fluid level, press the **Stop Acquisition** button.

At this point, you have a fluid level loaded into memory on your computer. You can further analyze the fluid level now, or you can **save** it in its raw form by using the **Export Data** button, then naming the file and saving it.

When you hit the **Stop Acquisition** button, the Sage AFL software attempts to identify the start of the shot and the fluid level, by placing the Red Cursor at the start of the shot and the Blue Cursor at the fluid level.

If you wish, you may move the cursors to fine-tune the reading. To move the colored fluid level cursors, click on the **Graph Manipulation: Cursor** button (looks like a graph with a green dot on it). This button enables cursor movement; you may now click and drag the Red Cursor to the start of the fluid level shot and click and drag the Blue Cursor to where it crosses the baseline with the fluid level kicking down. (The Green Cursor will be explained in the Constant Depth analysis section, Page 33, and additional graph manipulations are explained on Pages 46 - 53).



Data Analysis Methods

On the **Depth Scan** tab, there are three main methods for analyzing the fluid level and calculating the total depth of fluid. In the **Depth Method** box in the lower left corner of the screen, the operator may choose one of the three analysis methods: **Constant AV, Joint Length, or Constant Depth**.

Constant AV analysis method

Once data is acquired, the **Constant AV** (Acoustic Velocity) method can calculate the total depth of the fluid. Click the **Constant AV** circle under **Depth Method** in the lower left box on the Depth Scan screen, then enter the **Acoustic Velocity**, if known. (See Appendix B: Acoustic Velocity, Page 69.)

In this analysis method, the Acoustic Velocity of gas is used to calculate the total depth of the fluid. The shot start is the Red Cursor, the fluid level is the Blue Cursor. Adjust the Red Cursor to the shot start. To do this, click on the left **Graph Manipulation: Cursor** button (looks like a graph with a green dot). Then click and drag the Red Cursor to the shot start – the first place the graph deviates from the flat line.

Adjust the Blue Cursor to the fluid level, again clicking the graph manipulation button, then clicking and dragging the Blue Cursor to the fluid level kick – the point where the graph first kicks up or down. The program then will give you a calculation of the fluid level based on the Acoustic Velocity.

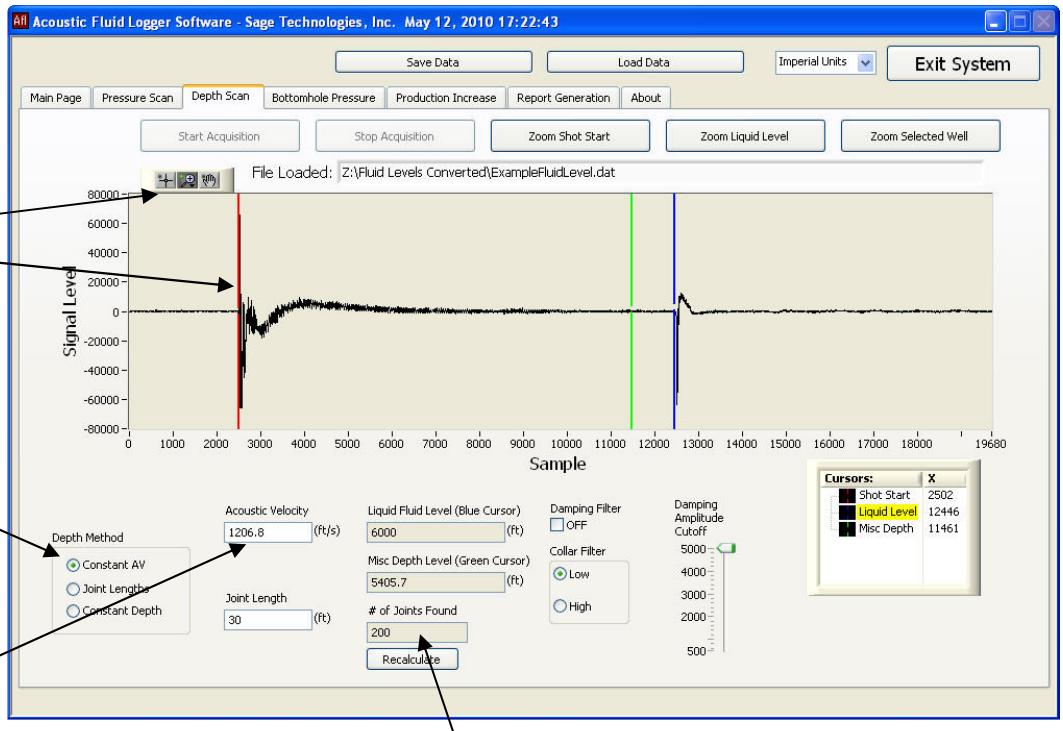
In the **Constant AV** analysis method, the travel time between the shot start and the fluid level is used in conjunction with the acoustic velocity to determine the fluid depth.

For **Graph Manipulation of Cursors**

Click graph button, then move Red Cursor to start of shot

Select **Constant AV** method

Enter **Acoustic Velocity**



# of Joints Found is calculated by software

Joint Length analysis method

Once data is acquired, **Joint Length** on the Depth Scan tab is another fluid level analysis method that can be used to calculate the total depth of fluid.

Click the **Joint Lengths** circle in the **Depth Method** box in the lower left of the Depth Scan screen; then **enter the known joint length on the well**. Click the **Recalculate** button at the bottom of the screen, and the Sage AFL software will attempt to give you a count of actual pipe joints downhole between the Red Cursor, which is the start of the shot, and the Blue Cursor, which is the fluid level. The software calculates the **# of Joints Found**.

In the Joint Length analysis method, the fluid level depth is determined by multiplying the number of joints by the entered average joint length per collar.

Select **Joint Lengths** Method

Enter Known **Joint Length**

Calculation: **# of Joints** Found

Recalculate

Constant Depth analysis method

Once data is acquired, **Constant Depth** on the Depth Scan tab is a method that can be used to calculate the total depth of fluid, when there is an event of a known exact depth on the fluid level echo.

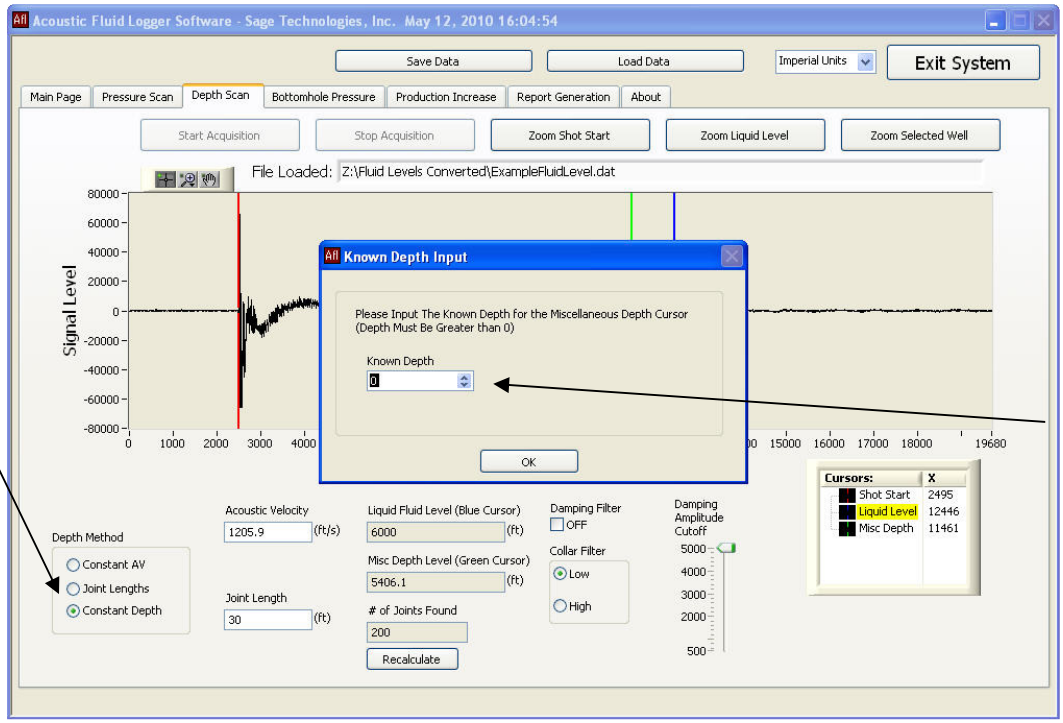
Examples of an event of a known exact depth:

- **The point where the well transitions from cased hole to open hole**
- **The point where a tubing anchor is placed at a known depth and shows up above the fluid level**
- **The location of a set of perforations very high in the well, always exposed above fluid level.**

Click the **Constant Depth** circle in the **Depth Method** box in the lower left corner of the Depth Scan tab. A **Known Depth** input box appears; **enter depth of the known constant event** or marker and click OK.

You then must move the Green Cursor to set the depth of the known constant event. Click on the **Graph Manipulation: Cursor** button (looks like a graph with a green dot on it), then click on the Green Cursor and drag the cursor to the place on the graph where you want to assign the known depth. (In other words, wherever you drag the cursor on the graph, that point is set to the known depth you entered. Then all other depths in the wellbore will be calculated using the known depth as a reference point.)

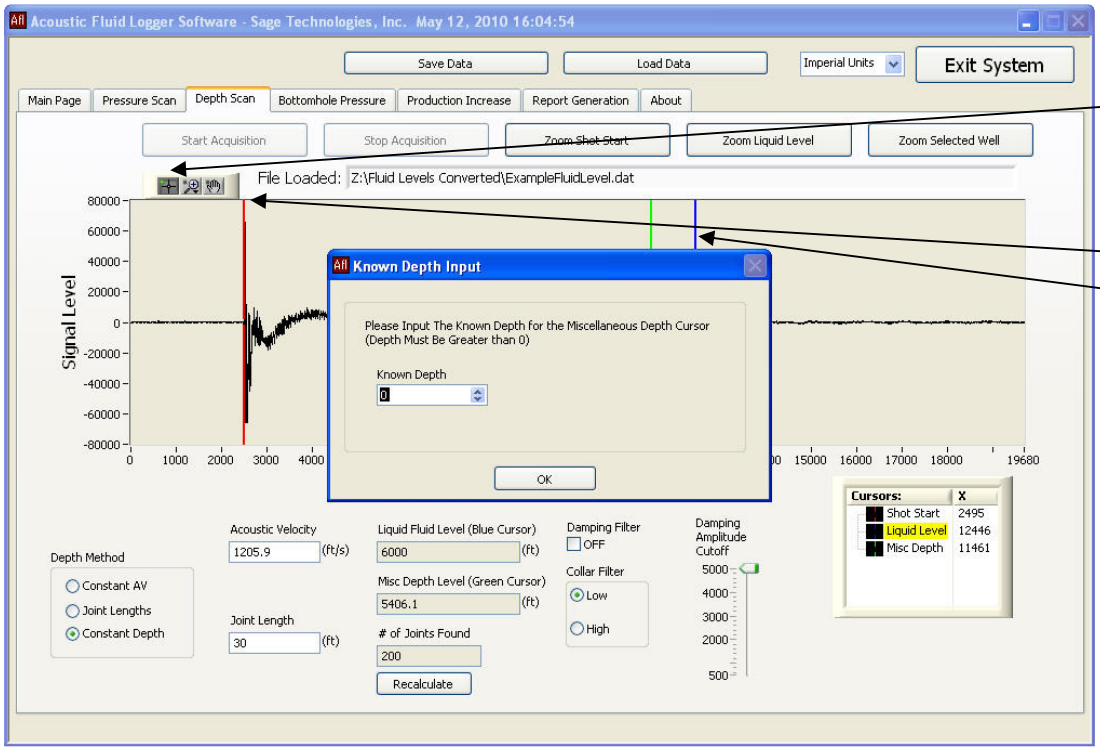
Select Constant Depth Method



Enter **Depth** of known constant event

(Continued on next page)

For the Constant Depth calculation to work correctly, the Red Cursor must still be aligned at the start of the shot, the Blue Cursor must still be on the fluid level. To move the cursors, click on the **Graph Manipulation: Cursor** button, then click and drag each colored cursor.



Graph Manipulation of cursors: Click the graph button then drag Red cursor to the start of shot, and the Blue cursor to the fluid level

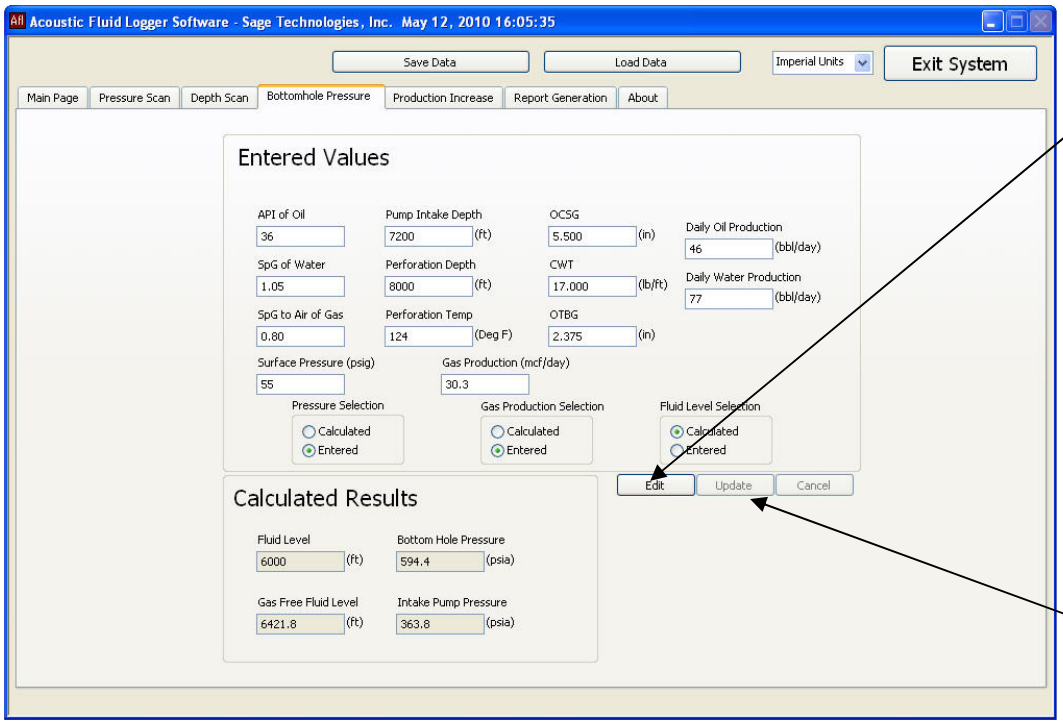
Bottomhole Pressure tab – Calculated Results

Once data is acquired, this tab is used to calculate the **Bottomhole Pressure** on a pumping well. The Bottomhole Pressure calculation requires accurate data to be entered in **all** of the boxes in the **Entered Values** section. All values must be entered by hand, except for Surface Pressure, Gas Production and Fluid Level Selection, which each have the option of Calculated results (from software) or Entered results (by hand) .

Entered Values – Value Boxes

To enter the values in the **Entered Values** section, click the **Edit** button directly below the entered values section. Enter all values. It is necessary to have a value in all of the Entered Values entry points for all of the calculations to be made. Click **Update** after data entry to see **Calculated Results.**

Failure to enter numbers in all boxes will result in **NaN (Not a Number) values** appearing in the Calculated Results. After the update button is clicked, no data can be changed unless you click the **Enter** button again. Use the **Cancel** button to remove entries from the current edit session.



Click **Edit** button, then **type in Entered Values** to enter known values

Entry of ALL values required for accurate bottomhole pressure calculation

Click **Update** button after data entry; **Bottomhole Pressure** calculation will appear

Key to Entered Values Abbreviations

- **API of Oil** – American Petroleum Institute Gravity of Oil
- **SpG of Water** – Specific Gravity of Water
- **SpG to Air of Gas** – Specific Gravity to Air of Gas (of Gas to Air)
- **OCSG** – Outer Diameter of Casing
- **CWT** – Casing Weight
- **OTBG** – Outside Diameter of Tubing

Entered Values – Calculated or Entered

Pressure Section, Gas Production Selection and **Fluid Level Selection** are three special values that can be derived either from **Calculated** data from the fluid level test, or from **Entered** data acquired from another source. In these three sections, **if you choose the "Entered" circle, you must enter a number before the software can make the calculation**. If you choose the **"Calculated"** circle, the Sage AFL software enters the number it has found and makes the calculation.

Entering Fluid Level Selection to predict new Bottomhole Pressure

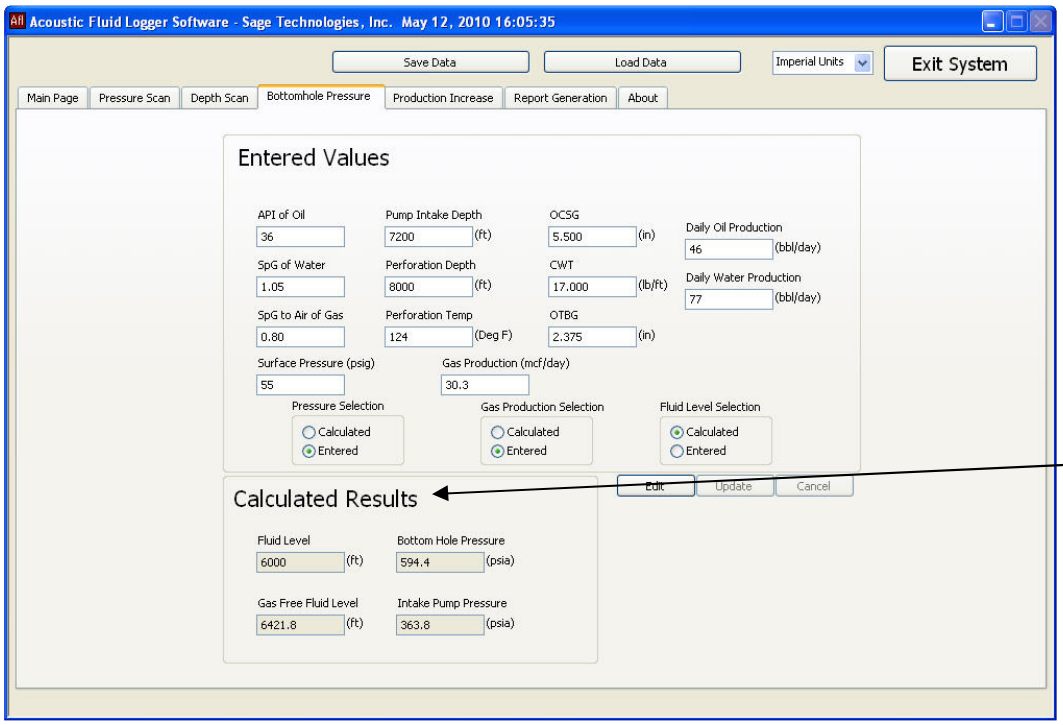
> **To predict a new Bottomhole Pressure and Pump Intake Pressure** if you raise or lower the fluid level, you will need to enter the fluid level value. **Clicking the "Entered" circle under Fluid Level Selection brings up a box** where you may enter a new fluid level value. **This box only appears when the Entered circle is checked.**

Once you have accepted the calculated data or entered the values – and all boxes **must** contain a value -- click the **Update** button and the software will make the Bottomhole Pressure calculation.

After the **Update** button is clicked, no data can be changed unless you click on the **Enter** button again.

Bottomhole Pressure - Calculated Results

Once you click the **Update** button, the **Calculated Results** section will display the working **Fluid Level**, the **Gas Free Fluid Level**, the **Bottomhole Pressure** and the **Intake Pump Pressure** (intake pressure at the pump).



View **Calculated Results** here -- **If a NaN value appears, it means Entered Values are incomplete and calculations cannot be completed**

Bottomhole Pressure Tab – Holding "Entered" Fluid Level Option

Because the Sage AFL software is designed for customized fluid level acquisition, **if you choose "Entered" in "Fluid Level Selection," and then enter your own well data, the Sage AFL software will remember this and the software will want you to enter this data the next time you use the unit.**

However, if you want the software to resume calculation of the data, you need to reset the machine for Calculated Data. You may **reset to Calculated Data** in two ways:

Bottomhole Pressure Tab – Return to "Calculated" Fluid Level Option

- To return to the automatic calculation of Fluid Level Selection at power-on, go to the **Bottomhole Pressure** tab and click the **Calculated** button under **Fluid Level Selection**. This will reset the calculation and you may continue with calculated fluid level analysis.

- At the end of a session of saving **Entered** data to the computer, return to the **Bottomhole Pressure** tab and click the **Calculated** button before turning off the computer.

Production Increase tab – Calculated Results

This utility helps determine the production that can be expected at different levels of calculated pressure.

- **If you know the static reservoir pressure, you may enter this number, along with a calculation pressure (which is probably your new pump intake pressure) to get a general estimate of what your new production would be if you were to lower or raise the well's producing pressure.**

Entered Values

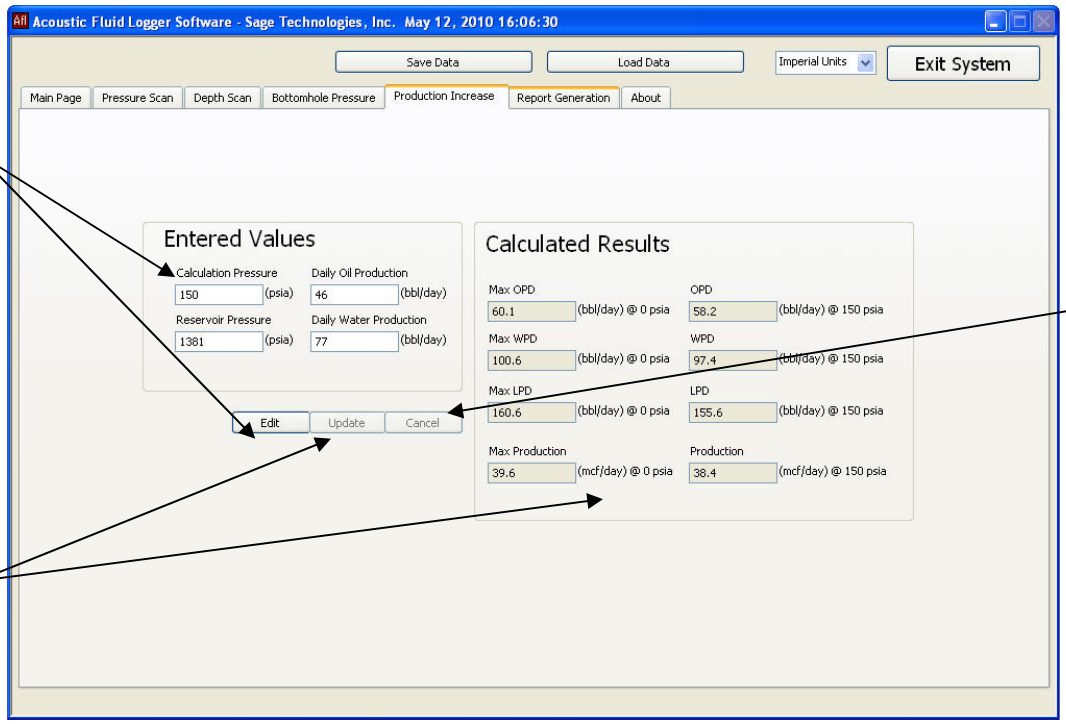
In the **Entered Values** section of the Production Increase tab: Click **Edit** to enter or change the values of the **Calculation Pressure, Daily Oil Production, Reservoir Pressure,** and **Daily Water Production**. Click **Cancel** to go back to the original values. After editing all four boxes, click **Update**.

Calculated Results

The Sage AFL software now calculates results based on the expected output values from the well if the entered values are attained.

Click **Edit** then enter anticipated new values in **Entered Values**

Click **Update,** then view predicted **Calculated Results**

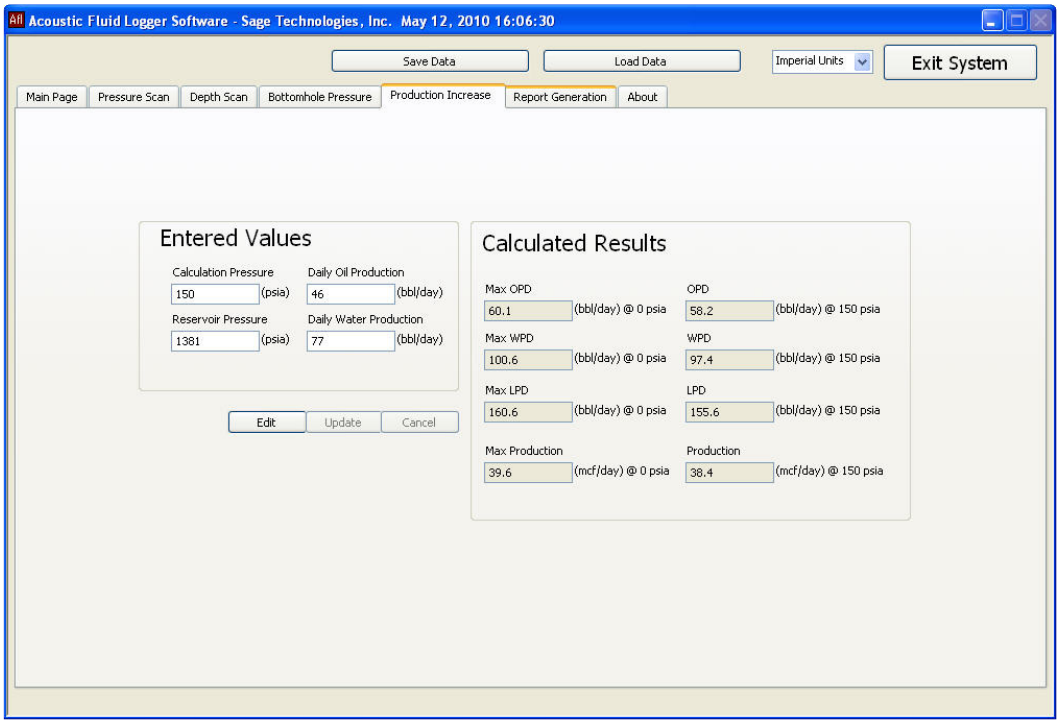


Click Cancel to return to original values

For explanation of output values, see **Key to Calculated Results** on the following page:

Key to Calculated Results:

- **Max OPD** – Maximum Oil Production per day at zero psi back pressure
- **Max WPD** – Maximum Water Production per day at zero psi back pressure
- **Max LPD** – Maximum Liquid Production (total of oil and water) at zero psi back pressure
- **Max Production** – Maximum estimated gas production at zero psi back pressure
- **OPD** – Oil Production per day at the entered Calculation Pressure value
- **WPD** – Water Production per day at the entered Calculation Pressure value
- **LPD** – Total Liquid Production (total oil and water) per day at the Calculated Pressure value
- **Production** – Estimated gas production per day at the Calculated Pressure value

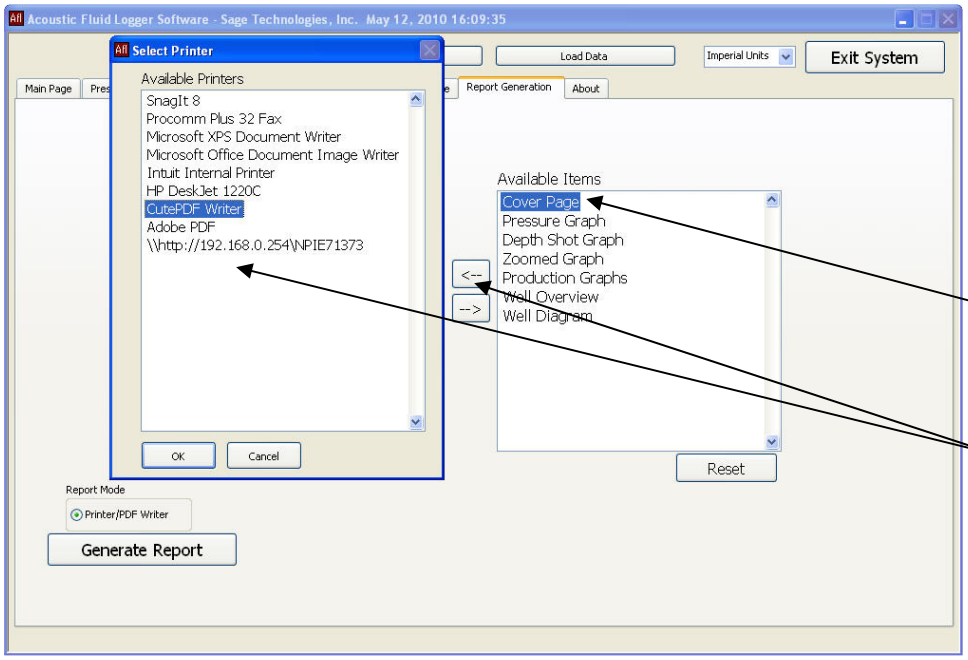


Report Generation tab

Included Items

Once data is acquired and analyzed, the Sage AFL software allows you to generate a well report. On the **Report Generation** tab, initially, the **Included Items** box will be blank. In the **Available Items** box, click an item to highlight the information you need for your fluid level report, then click the "<" button to move it to the **Included Items** box.

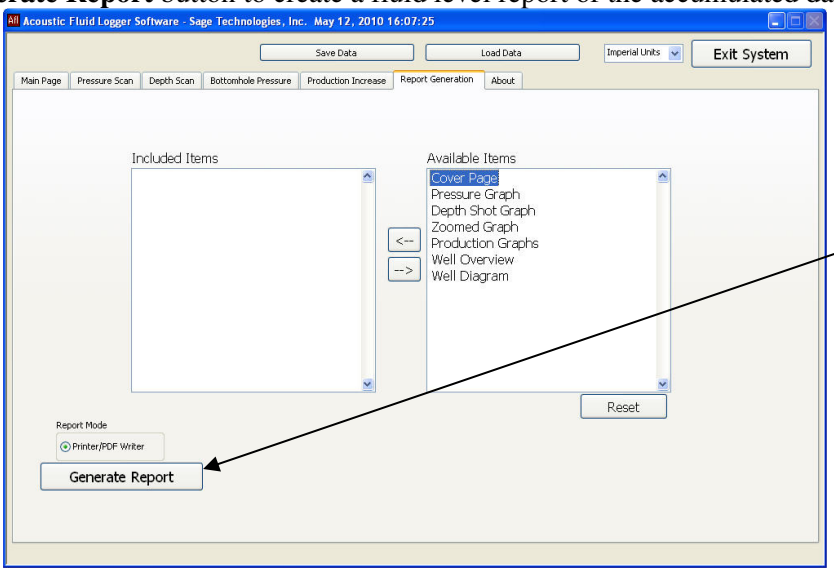
Any items on the list can be included in the fluid level report: Cover Page, Pressure Graph, Depth Shot Graph, Zoomed Graph, Production Graphs, Well Overview, and Well Diagram. To remove items from the Included Items box, highlight the items and use the ">" button to move them back to the Available Items box.



Click to highlight **Available Items** desired for well report; use arrow keys to move items into **Included Items** box

Generate Report

Click the **Generate Report** button to create a fluid level report of the accumulated data and graphs.

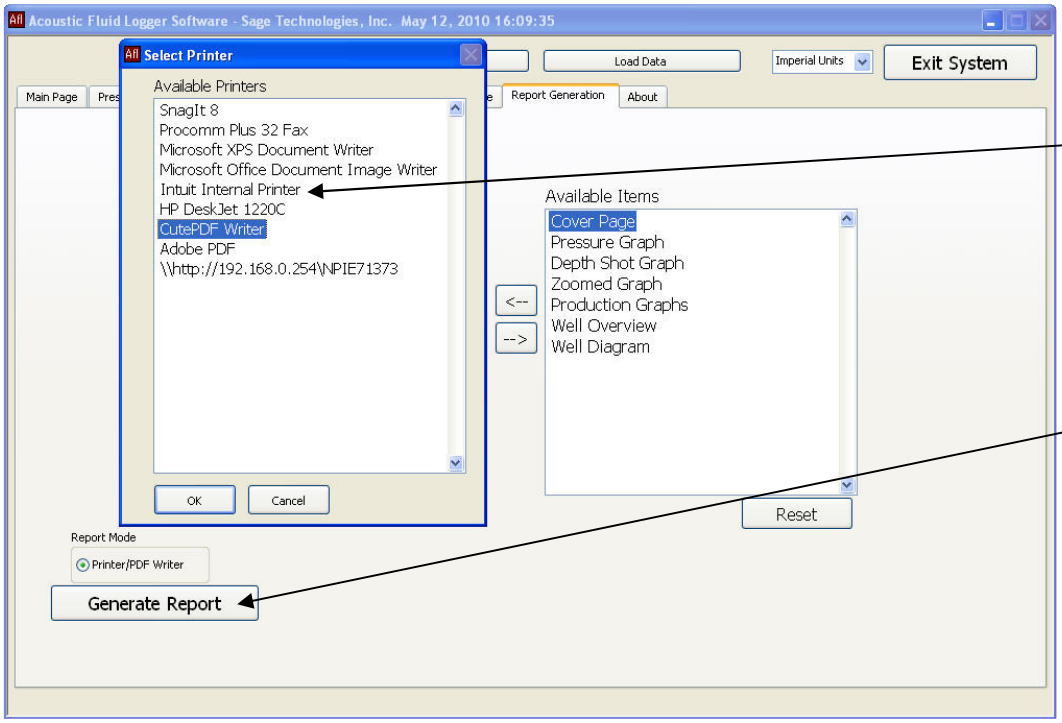


Generate Report

Creates well test report of pages listed in **Included Items** box

Output option

After you click **Generate Report**, a dialogue box will open showing available output options for your computer. Select the desired output option. Click and print your report to the desired output.

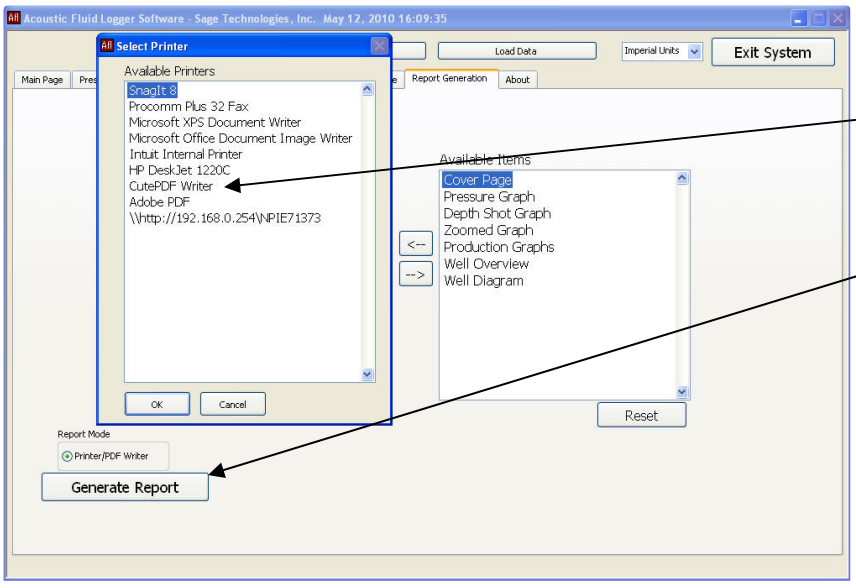


Select the **Printer** that will print the **Well Test Report.**

Then click **Generate Report again** to print

Creating PDF Files

On the dialogue box that appears when you click the Generate Report button, you will notice the CutePDF Writer, which was automatically installed on your computer when the Sage AFL software was installed. In the **Generate Report** dialogue box, select the **CutePDF Writer if you wish to produce a .pdf file** report. The CutePDF Writer will save the report to an Adobe .pdf file suitable for email transmission.

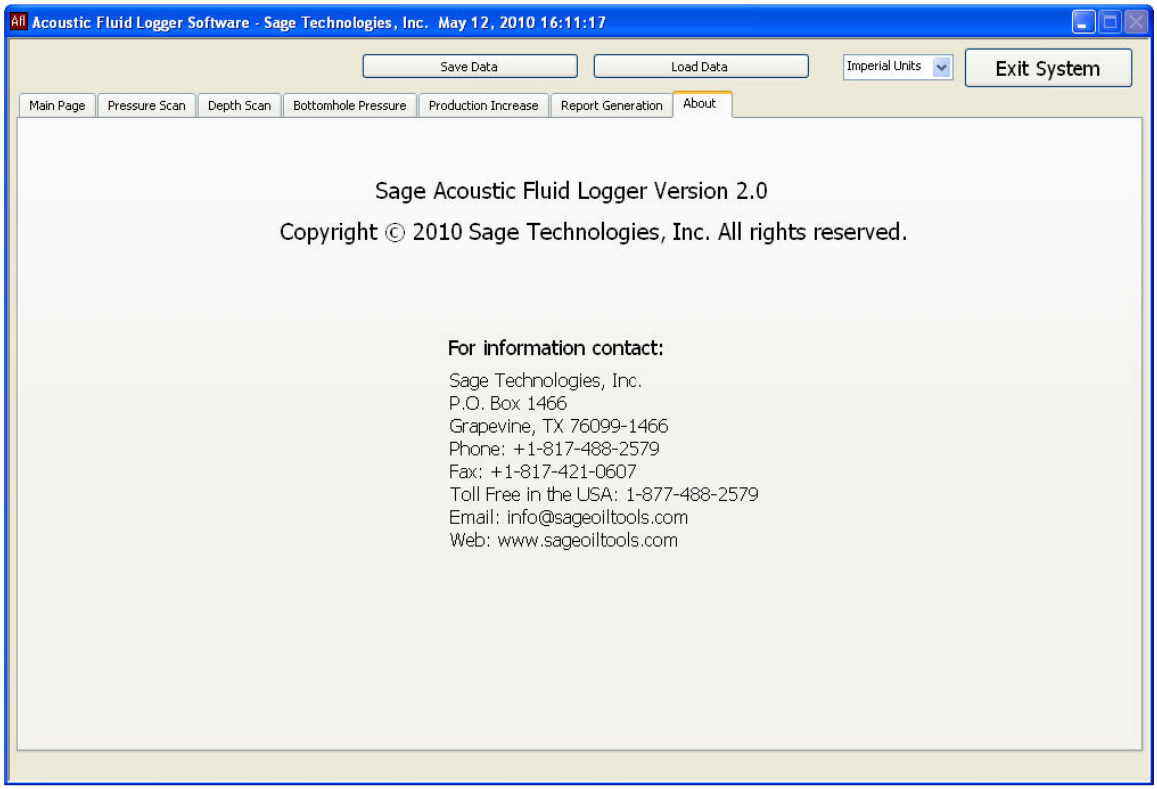


Select **Cute PDF Writer** to **create PDF files**

then click **Generate Report** to carry out PDF file creation

About tab

The **About t**ab contains the version number of your installed Sage AFL software, and the contact information for Sage Technologies, Inc.

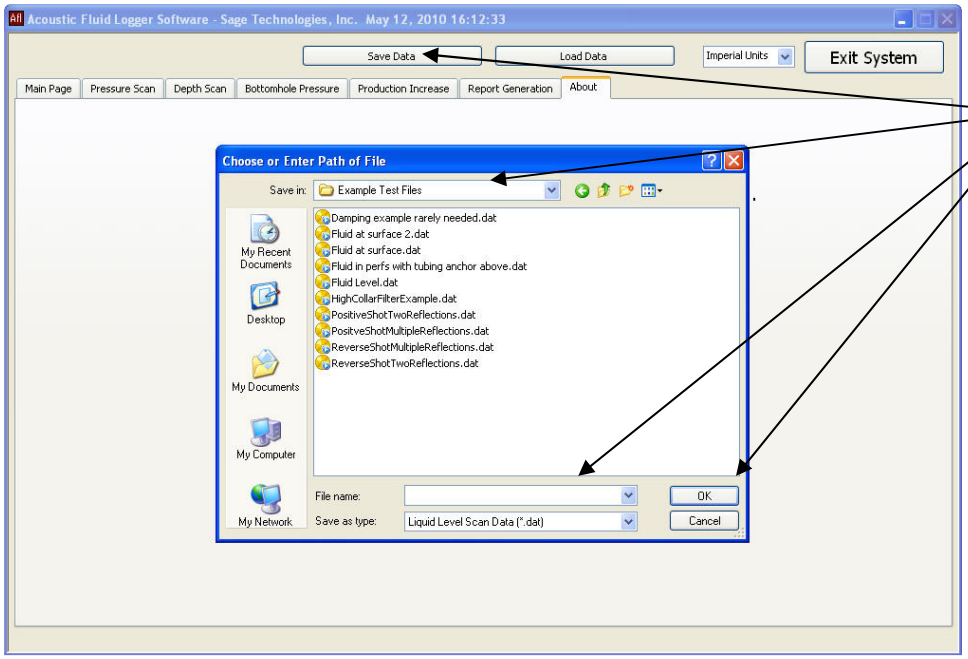


Global Options – Sage AFL software

Global Options -- shown in the beige band that runs across the screen of the Sage AFL software screen — remain active on the top of the screen at all times when the software is open.

Save Data - Save Files

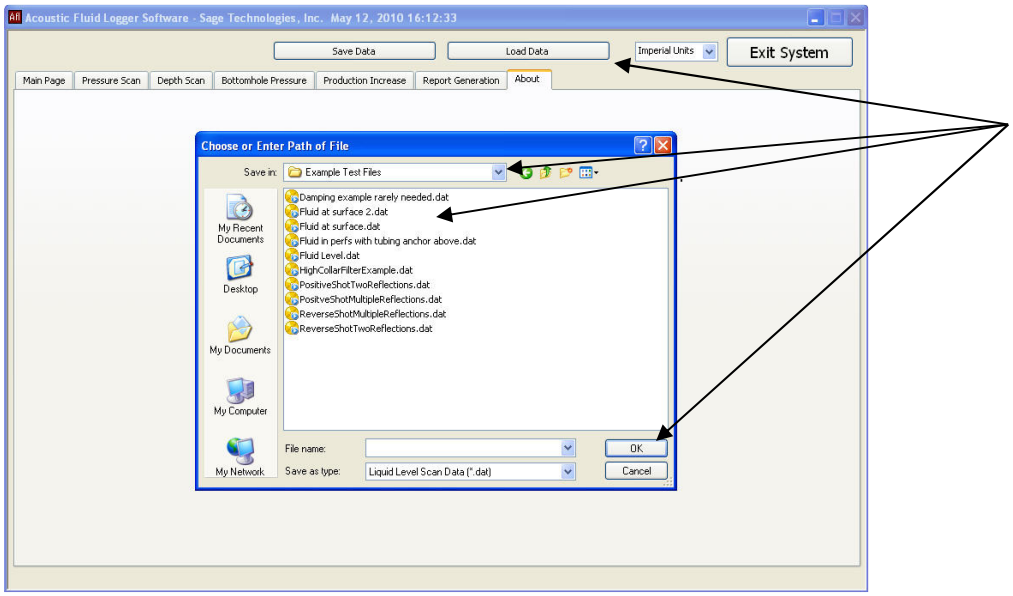
Save the test data to a file on the computer with the **Save Data** button. Click the **Export Data** button, choose the desired save directory in the computer under **"Save in,"** then type in the new file's name under **File name:** and click **OK** to save. The file will be saved with a .dat extension. Re-open the file using the **Load Data** button at the top of the screen.



To SAVE data to a file, click **Save Data**, navigate to the desired folder in the **Save in:** box, then create a **File name** for the data and click **OK** to save.

Load Data

To load a Sage AFL software data file (*.dat) previously saved to the disk or PC, click the **Load Data** button and navigate to the previously saved file under **"Look in:"** and click on the desired file, then click OK to open it.

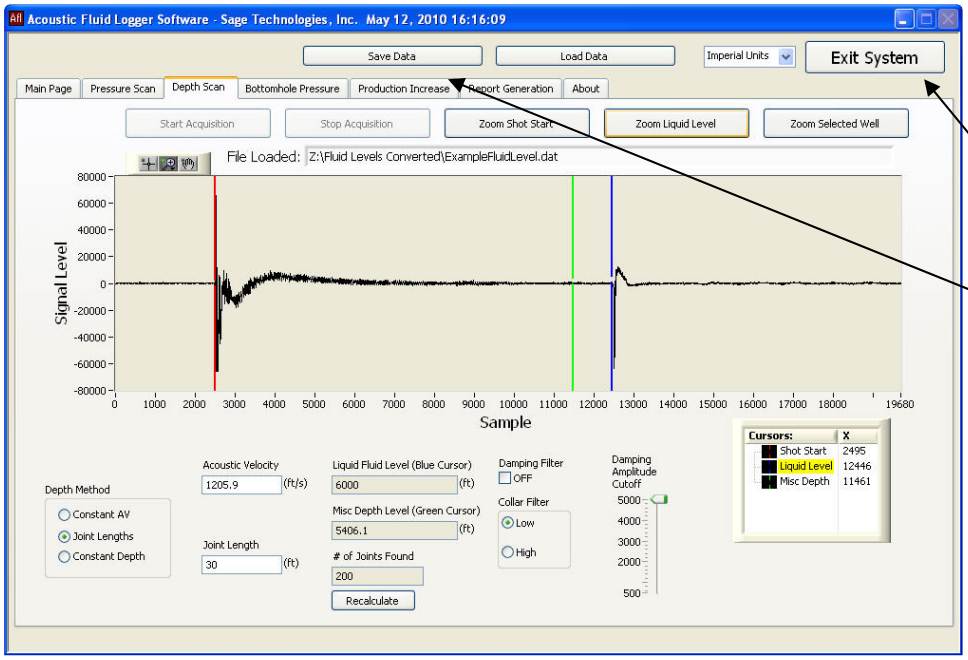


To view previously saved files, Click **Load Data**, then select folder in the **Look in:** box, then click the desired **file name** and click **OK**

Exit System

CAUTION: The Exit System button will close the program and all files associated with it. DO NOT click the Exit System button until you have saved the current data test.

To save fluid level data files, you MUST click on the "Save Data" button at the top of the screen, designate a file name for your well test, and save it to memory.



Warning: BEFORE clicking Exit System …

Click Save Data to SAVE the fluid level test to the computer's file system; once this step is complete, then you may Exit System

Imperial/SI Units

Choose the desired units for your well application.

Choose either Imperial or SI Units

Pressure Range Check

Note -- Special use only: Click Pressure Range Check to turn off ranging limits and check pressure transducer output. Click the gray button with the green arrow on it **ONLY if the pressure transducer does not show up when it is connected, and you need to turn off the ranging limits to determine the pressure transducer's output.** (See Pressure Transducer operation – Pages 27 and 28.)

Pressure Range Check is **used ONLY to turn Ranging Limits off or on in order to check pressure transducer output**

Fluid Level Identification: Basic

Graph Manipulation: Basic

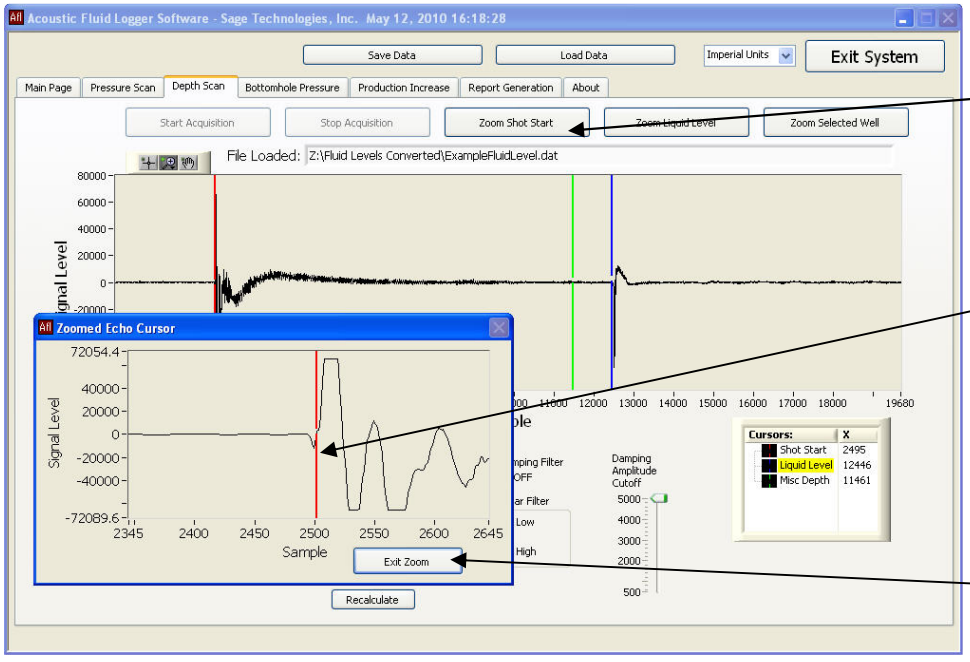
On the **Depth Scan** tab, five buttons run across the screen, above the fluid level graph, which allow the operator to control the fluid level test and analysis.

- **Start Acquisition** – Click this button to begin the fluid level test. The software begins gathering data. See Page 29: Shooting the fluid level and data acquisition.
- **Stop Acquisition** – Click this button to end the fluid level test, to stop gathering data. See Page 29: Shooting the fluid level and data acquisition.
- **Zoom Shot Start** – Click this button to pull up a graph that shows solely the Red Cursor: Start of shot
- **Zoom Liquid Level** – Click this button the pull up a graph that shows solely the Blue Cursor: Fluid level.
- **Zoom Selected Well** – Click this button to pull up a zoomed graph of the current well, between the Red Cursor: Start of shot and the Blue Cursor: Fluid level.

Onscreen Graph: Zoom Shot Start

Click on the **Zoom Shot Start** button to pull up an expanded view of the area around the shot start, marked by the **Red Cursor: Start of Shot.** This is useful for fine tuning cursor placement to ensure accuracy of the fluid level calculation. In the **Zoomed Echo Cursor** graph, click and drag the red cursor to make an exact placement of the start of shot.

In the example below, notice that the **Red Cursor**, signifying the start of the fluid level shot, is placed at the point that the fluid level graph **begins** its upward kick. Click **Exit Zoom** to close the pop-up graph.



Zoom Shot Start brings up a smaller pop-up graph

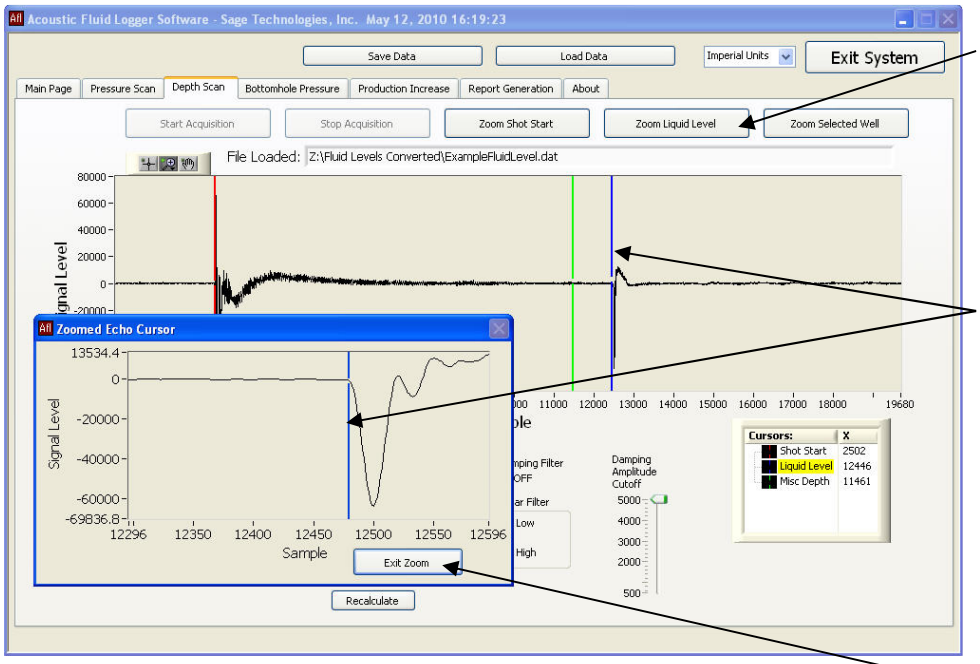
Red Cursor: Start of Shot Click and drag cursor to point where fluid begins its upward kick

Exit Zoom returns to main graph

Onscreen Graph: Zoom Liquid Level

Click on the **Zoom Liquid Level** button to pull up an expanded view of the area around the fluid level, marked by the **Blue Cursor: Liquid Level.** In the **Zoomed Echo Cursor** graph**,** click and drag the blue cursor to fine-tune placement of the liquid level in the well.

In the example below, notice that the Blue cursor should be placed in an area slightly below the point where the signal crosses the baseline (zero) on the small pop-up graph, or slightly below the baseline (zero) on the large fluid level graph tape. Click **Exit Zoom** to return to the main fluid level graph.



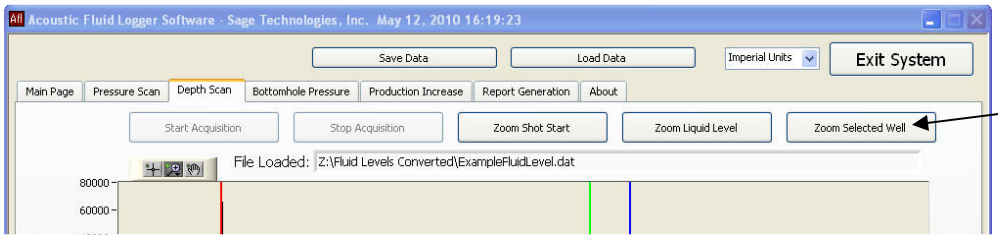
Zoom Liquid Level

Blue Cursor:Fluid Level
Click and drag cursor to area slightly below where fluid crosses the zero baseline

Exit Zoom closes small screen and returns to main graph

Onscreen Graph: Zoom Selected Well

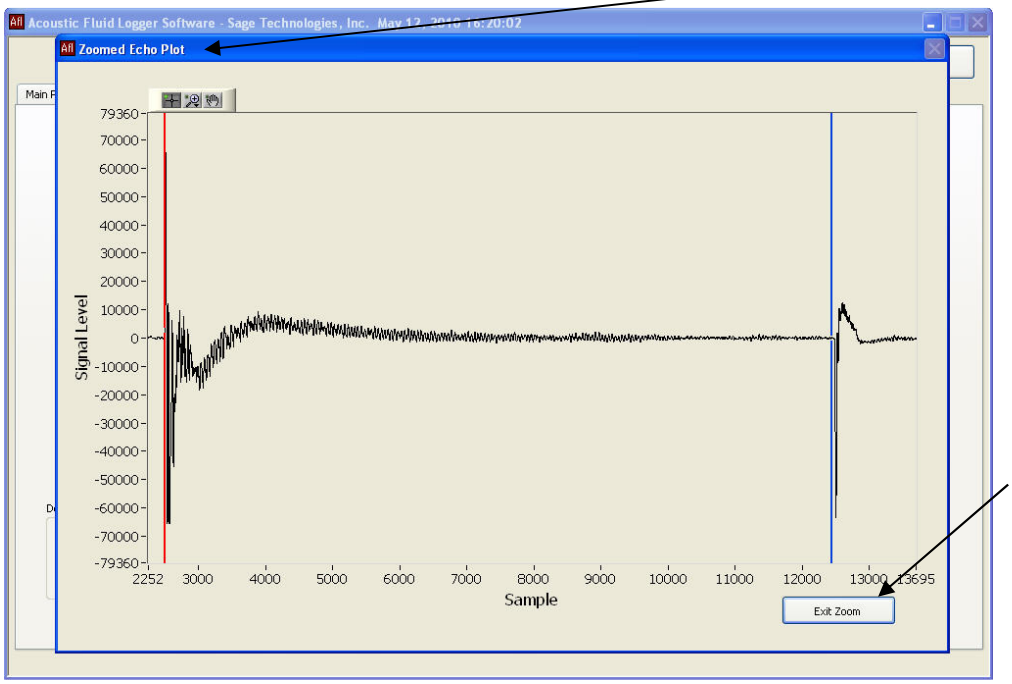
From the **Depth Scan** tab, you can zoom in on the fluid level test, which is the area between the Red Cursor: Start of Shot and the Blue Cursor: Fluid Level, by clicking the **Zoom Selected Well** button in the top right corner of the screen.



Click **Zoom Selected Well** to see magnification of fluid level

The **Zoom Cursor Plot** screen will then overlay the Depth Scan screen, with an expended view that zooms into the portion of the fluid level between the Red Cursor: Start of Shot and the Blue Cursor: Fluid Level. In this graph, both the Red and Blue Cursors can be manipulated for placement by clicking and dragging. Place the Red Cursor on the start of shot, where the first downkick occurs on the graph, and the Blue Cursor on the fluid level, where the second-largest downkick occurs.

To return to the Depth Scan screen, click **Exit Zoom** in the bottom right of the screen.



Zoom Cursor Plot pops up and zooms in on the fluid level

Click **Exit Zoom** to close this screen and return to Depth Scan tab

Fluid Level Identification: Advanced

Graph Manipulation: Advanced

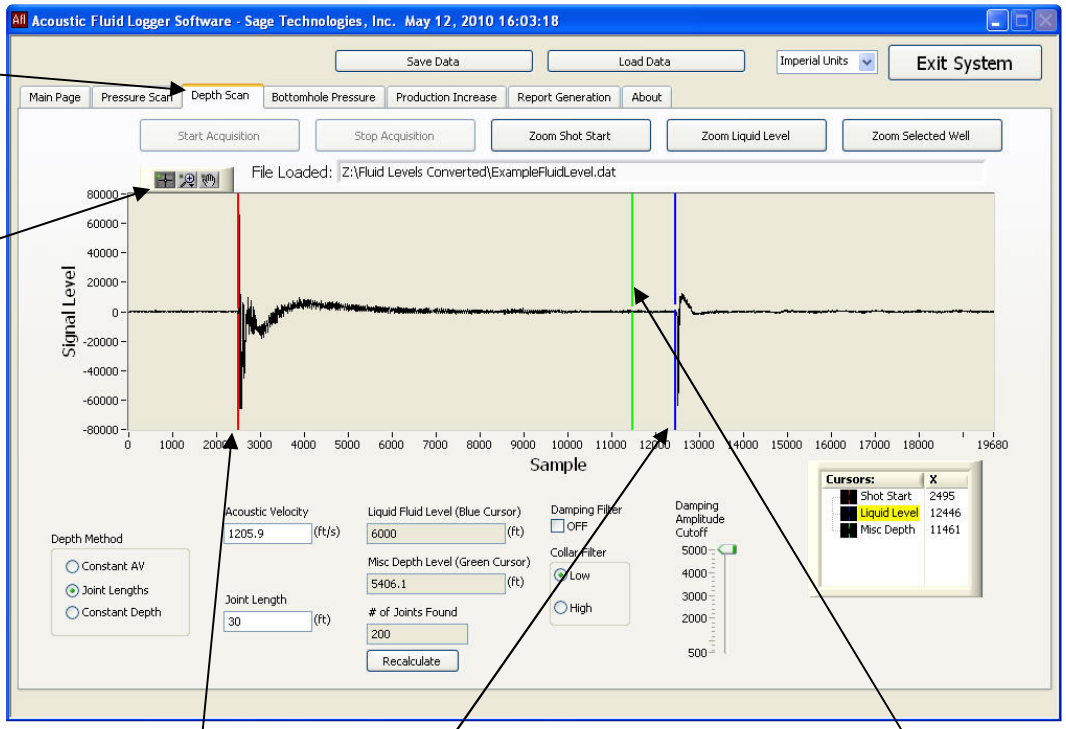
On the **Depth Scan** tab, above any graphed fluid level, there are three graph manipulation buttons that let you focus on and manipulate necessary information in the graph, using the three colored cursors. These advanced manipulation buttons are:

- **Graph Manipulation: Cursor:** This button looks like a graph with a green dot on it, and allows the exact placement of the colored cursors on the fluid level graph.
- **Graph Manipulation: Zoom:** This middle button looks like a magnifying glass, and allows a closer look at the fluid level graph with tools in the pop-up **Zoom Option Box**.
- **Graph Manipulation: Drag:** This button looks like a hand, and allow you to grab and drag the fluid level tape horizontally, to views of the fluid level test not shown on the original screen.

Depth Scan tab

Graph Manipulation tools

Three buttons allow wide range of manipulation and views of the fluid level graph



Red Cursor: Start of Shot

Blue Cursor: Fluid Level

Green Cursor: Event of Known Depth (optional use)

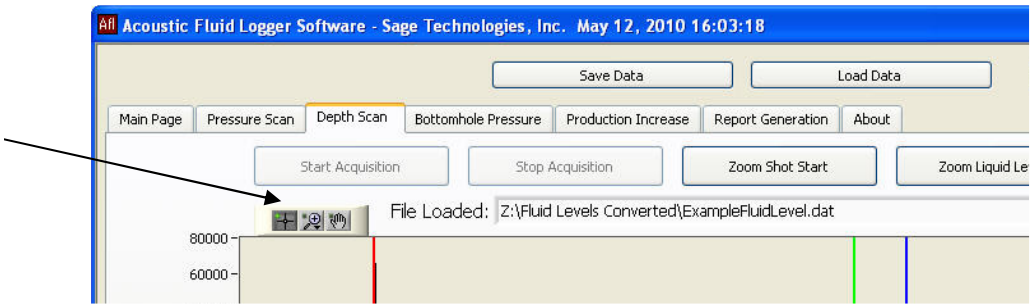
Graph Manipulation: Cursor

On the **Depth Scan** tab, there are three buttons above top left corner of the fluid level. Click on the **Graph Manipulation: Cursor** button (the left button: looks like a graph with a green dot on it) to manipulate the colored cursors on the graph. Clicking this Graph Manipulation: Cursor button lets you then click on and move each of the cursors independently:

- **Red Line Cursor:** Start of the shot
- **Blue Line Cursor:** Fluid level
- **Green Line Cursor:** Event of Known Depth **--** any event of known depth measurement in the wellbore that is meaningful and useful in determining the fluid level. **(Note: Use of the Green Line Cursor is optional. Many times it will not be used.)**

Graph Manipulation: Cursor

Looks like a small graph; allows the operator to click and drag the colored cursors



Clicking on the **Graph Manipulation: Cursor** button allows you to then click and drag each of the colored line cursors in the fluid graph.

Click and drag the Red Cursor to the start of the shot. Click and drag the Blue Cursor to the kick of the fluid level, slightly below the baseline (zero) on the graph. Click and drag the Green Cursor (if using) to any fixed event downhole (tubing anchor, perforations, etc.).

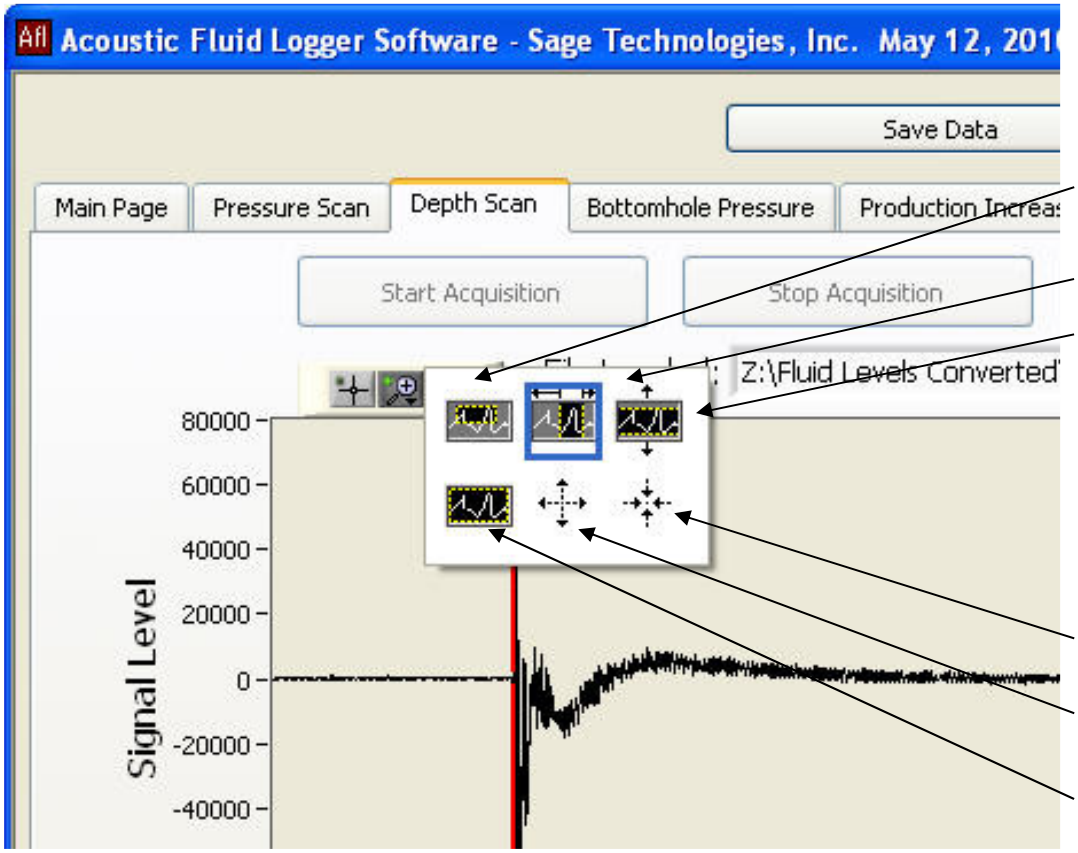
Graph Manipulation: Zoom

Three buttons are above the top left corner of the fluid level graph on the Depth Scan tab; the middle button is the **Graph Manipulation: Zoom** button, which looks like a magnifying glass with a plus sign inside of it. This **Graph Manipulation: Zoom** button allows the operator to zoom in on segments of the fluid level graph and focus on events on the echo, such as the start of the shot and the fluid level. Clicking the **Zoom** button brings up a pop-up **Zoom Option Box** that includes six additional options for graph manipulation.

Graph Manipulation: Zoom Magnifying glass allows a closer look with pop-up **Zoom Option Box** tools

Graph Manipulation: Zoom Option Box

The six buttons in the pop-up **Zoom Option Box** allow further options to zoom onto and fine-tune the fluid level graph. Note: In the pop-up Zoom Option Box, the **Bottom Left Button – Return to Original Graph -- undoes all manipulations** and returns to the original graph.



Key to Zoom Option Box:

Zoom Section (Drag and Drop the rectangle)

Horizontal Zoom

Vertical Zoom

Zoom Away

Zoom Toward

Return to Original Graph

Zoom section –

Drag and drop a rectangle to zoom into a section of the fluid level graph. To do this, click on the upper left corner where you want the zoom rectangle to begin, and holding down the mouse button, drag the mouse diagonally to the lower right, creating a zoom section rectangle. Release the mouse button. You can click on and drag the zoom rectangle to move to and magnify different points on the fluid graph.

Horizontal zoom –

Expand a "drag and drop" section horizontally. Draw a rectangle on the section of interest by clicking a point in the upper left hand side of the desired area of the graph, and holding down the mouse button, drag the mouse diagonally to the lower right, creating a rectangle of interest. The software will zoom horizontally into the desired area, enlarging it onscreen.

- Useful for closer inspection of a section of an echo.

Vertical zoom –

Expand a "drag-and-drop" section vertically. Draw a rectangle on the section of interest by left-clicking a point in the upper left hand side of the desired area of the graph, and holding down the mouse button, drag the mouse diagonally to the lower right, creating a rectangle of interest. The software will zoom vertically into the desired area, enlarging it onscreen.

- Useful for expanding the vertical size of the echo downhole to see small signals, or to greatly expand the size of the tubing collars for easy viewing.

Return to Original –

Undoes all actions and returns to the original graph of the fluid level.

- Useful for returning to the original view. To return to the original fluid level screen at any time during use of these six pop-up tools, click on the magnifying glass (Graph Manipulation: Zoom) button again, and in the pop-up Zoom Option Box, click the lower left button to Return to Original.

Zoom Toward –

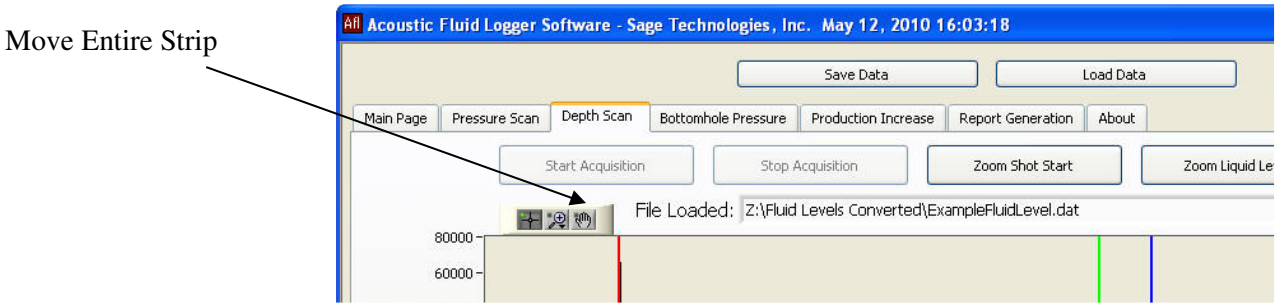
Click on this button, and then place the cursor anywhere in the graph. The software will zoom toward the click point, on each successive click, zooming toward and expanding the graph.

Zoom Away –

Click on this button, and then place the cursor anywhere in the graph. The software will zoom away from the click point, on each successive click, zooming away and making the graph smaller.

Graph Manipulation: Drag

On the **Depth Scan** graph, the right button is the **Graph Manipulation: Drag** button, which looks like a hand. This button allows you to move the focus on a particular part of the fluid level, by grabbing your view of the graph, and scrolling the view from side to side. In other words, this allows you to see parts of the fluid level graph that extend beyond the original screen.



FAQs – Frequently Asked Questions

How do I know if the gas gun is leaking?

- After pressuring up the gun, does the gauge on the top of the gun continue falling in pressure? If so, you probably need to rebuild the gun. Try to determine where the leak is originating:
    - If the leak originates in the shuttle valve load or fire area, examine the o-rings on the sliding shuttle valve and replace them if damaged. (See Pages 58-59)
    - If the leak originates in the microphone connection area, examine and replace o-rings on the microphone stem. (See Page 57)
    - If the leak originates in the fill valve area, examine the fill valve for damage, and also replace the valve core under the fill valve. (See Page 60)
- Sometimes, gas is not leaking from the gas gun, but from the connection to the wellhead. Be sure to apply several wraps of Teflon tape to the gun threads before attaching it to the wellhead. If pipe adapters are being used, tape these, also.

How do I know if the microphone is dead?

- If the signal onscreen remains flat after shooting the shot, the microphone in the gas gun may be dead and may need to be replaced.

- First, check the microphone cable for secure connection to both the fluid logger and to the gas gun. Also, look inside both ends of the microphone connector, to see if the metal pin inside the connection has been broken or damaged.

- Remove the microphone from the gun, by removing the microphone bolt inside the base of the gun and pulling the microphone from the bottom of the gun. Hold the microphone on the stainless steel portion, being careful not to press on the round microphone discs, which cover the sensitive microphone crystals. Examine the discs for damage. A blown-out or caved-in disc indicates that the microphone needs to be replaced.

- If the microphone discs (sides) do not look damaged, but the microphone is full of debris and dirt, wipe down the microphone to remove the dirt. **Use caution in cleaning**: Carefully wipe off the microphone head and discs with a cloth or paper towel. Heavy dirt and debris on the discs can stop the microphone from operating properly. If necessary, clean the microphone lightly with soapy water, but do not soak in water. **Warning: DO NOT USE chemical solvents, as they can permanently damage the microphone. Do not press on the microphone faces, as this can permanently damage the sensitivity of the microphone.**

- Examine the o-rings on the microphone stem for damage. If damaged, replace them and lubricate the new o-rings with silicone libricant or o-ring grease, then re-insert the microphone in the gas gun and tighten the microphone bolt. Repeat the well test to see if sensitivity has been improved. If not, the microphone needs to be replaced. Warning: To lubricate o-rings, use silicone lubricant or gear oil only. **DO NOT USE Vaseline-type products, pipe dope or solvents, as all can permanently damage o-rings.**

Why didn't I get a shot from the gun?

- Check the gas bottle for CO^2 -- is it empty?

- Did you charge up the gun? Check the gauge for pressure.

- Is the microphone cable fully connected to both the Acoustic Fluid Logger IV and to the gun?

- Is the USB connecter attached to the portable computer and to the Acoustic Fluid Logger IV?
- Is the Acoustic Fluid Logger IV turned on? Is the computer turned on?
- Is the battery charged – on both the Acoustic Fluid Logger IV and on the computer?

What size shot should I use for the fluid level test?

- Well depth and other variables will affect the amount of pressure needed to charge the gun for a fluid level shot. In general, a shot of 100 to 200 psi above wellbore pressure should be sufficient for shallow wells; use 300 to 400 psi above wellbore pressure for deeper wells.

Why won't the Acoustic Fluid Logger unit come on?

- Is the battery charged?
- Is the unit turned on? Check for the on/off bulb to light when the unit is turned on.

Why can't I see the Pressure Scan and Depth Scan screens at start-up?

- During your last fluid level test, did you enter data on the Bottomhole Pressure tab under Fluid Level Selection: Entered data? If so, the Sage AFL software remembers this as your preferred mode of operation, and is waiting for you to enter data again.
- To bring back the Depth Scan and Pressure Scan screens at start-up, you need to return to Fluid Level Selection: Calculated data – which lets the software do the calculations. Go to the Bottomhole Pressure tab, click "Calculated" under Fluid Level Selection. The Depth Scan and Pressure Scan tabs will then be restored for computer calculation of data.

Why can't I see the fluid level on the computer screen?

- Have you tried zooming in on the Red Cursor: Start of shot or the Blue Cursor: Fluid level? There are several ways to zoom in on selections within the fluid level graph. All are available on the Depth Scan tab, using the Graph Manipulation cursors and the Graph Manipulation tools. See Graph Manipulation: Basic on Page 46 and Graph Manipulation: Advanced on Page 49. If you have a very deep well, the fluid level won't be visible on the first screen. Use the Graph Manipulation: Drag tool on Page 53 to pull the graph horizontally and find the fluid level.

What affects collar readability?

- Shallow wells are the easiest on which to count the collars all the way down to the fluid level.
- Wells with higher casing pressure are easier than low pressure wells, i.e. wells under 15 psig.
- The tighter the fit between the casing and the tubing collars, the harder it is to get deep collars. Slim hole completions are some of the toughest, as it is very hard for the shot to make its way down the annulus area.
- Prevent excessive movement of the microphone cable or stepping on the microphone cable during the well test, as both can cause false echoes.

Why doesn't the Sage AFL software run on my computer?

- The Sage AFL software runs on any Windows 8, 7, Vista or XP computer.

- Note: For ease of viewing the fluid level and proper use of onscreen tools available inside the Sage AFL software, use a computer **with at least a 13" diagonal screen**.

How do I install the Sage AFL software if my computer doesn't have a CD drive?

- For Sage AFL software install on computers without a CD drive, you may use a CD-drive-equipped computer to load software onto a USB stick, and then install Sage AFL software from the USB stick to the portable. Or you may contact Sage Technologies for a copy of the Sage AFL software on a USB stick.

How do I print out a report of the fluid level data?

- In the Sage AFL software, go to the Report Generation tab. From the box of Available Items, choose which items to include in your fluid level report and move them to the Included Items box. Click Generate Report, choose the output location, and click OK. For more information, see Report Generation tab, Page 39.

How do I send a PDF file?

- On the Report Generation tab, on the dialogue box that appears when you click the Generate Report button, you will notice the **CutePDF Writer**, which was automatically installed on your computer with the Sage AFL software. Select the **CutePDF Writer** if you wish to produce a .pdf file report. The CutePDF Writer will save the fluid level report to an Adobe PDF file suitable for email transmission. For more information, see the Creating PDF Files, Page 41.

Maintenance

Maintenance - Pressure Pulse Guns -- 1,500 psi and 3,000 psi

Most supplies needed for care and maintenance are included with the Pressure Pulse Gun at time of purchase:

- O-ring kit containing seven O-rings (two small black, two medium black, one small white and one large black) and 2 valve cores.
- Gun maintenance tool
- 3/16" ball-end socket
- Two 5/32" Allen wrenches

Also helpful for use in repair are the following supplies:

- Standard channel lock pliers
- Large flathead screwdriver
- Tube of silicon lubricant (found at most oilfield or auto supply stores.)

When disassembling the gun for maintenance, first remove the internal microphone. To remove the microphone, first remove the microphone retainer bolt from the bottom of the gun, using a flathead screwdriver, as shown below. Then pull the microphone out of the bottom of the gun, being careful to hold the microphone by the stainless steel sides so as not to damage the round microphone crystals.

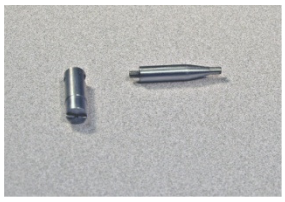
If the microphone is dirty, wipe it clean, holding the microphone by the stainless steel head and avoiding pressing on the circular microphone faces on either side. If necessary, use soapy water to clean the microphone, but do not soak. **DO NOT USE SOLVENTS to clean the microphone**, and DO NOT press on the microphone faces – both can permanently damage the microphone.

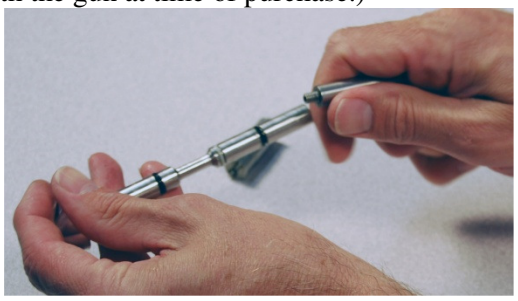
Disassemble the gun by removing the eight socket-cap screws on the top of the gun bonnet. Remove the screws in opposing fashion, using the ball-end socket, first removing one screw, then the one across from it (not adjacent to it), as shown below. Continue removing screws, alternating sides.

After removing the eight screws from the top, separate the bonnet top from the gun body for maintenance. Replace and grease the large O-ring on the gun bonnet top, as shown below right, with silicone lubricant. Reassemble the top, applying copper anti-seize to each of the socket-cap screws, and again tightening opposing screws on the bonnet top to avoid o-ring damage.

Remove the Shuttle Valve assembly by using the two 3/8" Allen wrenches, as shown below. Pull the shuttle valve out of the bonnet.

Cut off damaged O-rings with an X-acto knife. Then replace the one clear and two black O-rings on the shuttle. The o-rings can be loaded onto the shuttle valve with the maintenance tool: separate the maintenance tool into two pieces, then screw the tapered piece of the tool onto the end of the shuttle valve. The o-rings can then be pushed onto the end of the tool and slid onto the shuttle valve in order. The white o-ring is in the middle, between the two black o-rings. (These o-rings are supplied in the gun maintenance kit, which comes with the gun at time of purchase.)





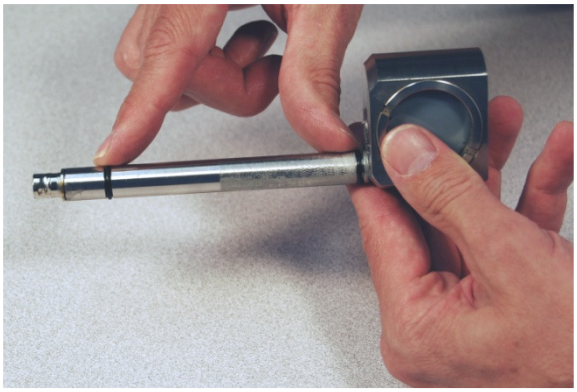
When replacing any of the o-rings, clean the shuttle valve passage and grease the shuttle valve o-rings with silicone lubricant. Reinstall the shuttle valve with the long end of the shuttle valve to the “Fire” side of the gas gun.

The inside of the gun may be cleaned by spraying it with WD-40 or soap and water and/or by wiping the surface clean. Grease O-rings with silicone lubricant before reassembling.

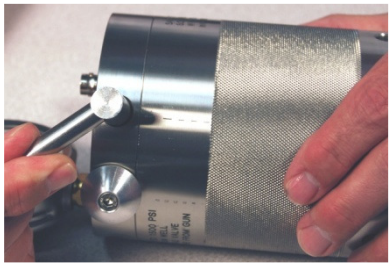
DO NOT USE PETROLEUM SOLVENTS to lubricate o-rings or clean the gun or microphone. Solvents, Vaseline-type products or pipe dope will dissolve or damage the o-rings. Use silicone lubricants or gear oil only!

Replace the bonnet top on gun, aligning the microphone holes in the top and bottom. Replace and tighten the screws as you would a flange -- tighten in opposing fashion by tightening one screw loosely, then the one across from it (not beside it). After all screws are tightened loosely, tighten with the ball-end socket wrench, again in opposing fashion.

Before reinstalling the microphone, check the o-rings for damage, and replace if necessary. **Caution: Do not press on the round sides of the microphone head.** This could cause the microphone to lose sensitivity. Lubricate the o-rings with silicone lubricant before sliding the microphone back into the gun. Apply copper anti-seize to the microphone bolt and secure the microphone bolt through the microphone and into the gun.



For maintenance on the fill valve, remove it with the thick, notched end of the gun maintenance tool, turning counter clockwise. An o-ring and the valve core will be exposed under the fill valve. Remove the valve core with the tapered, notched end of the gun maintenance tool, turning counterclockwise. Replace the old valve core with a new one, and hand tighten, using the maintenance tool. Replace the o-ring, if necessary. Replace the fill valve and tighten securely.



One Kit Gun-4 O-ring replacement kit is included with purchase of the gun. Additional kits are available by contacting Sage Technologies.

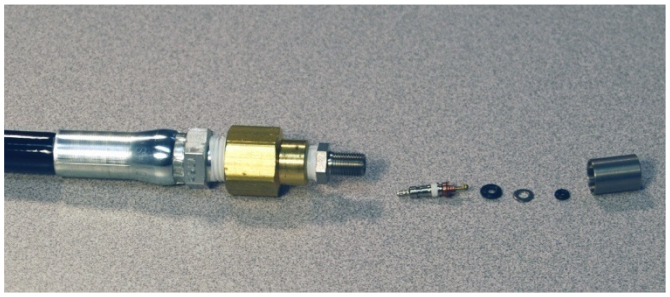
Maintenance -- CO^2 Charge Hose

The charge hose that is used to charge the CO^2 bottle may need a replacement internal valve core, if the hose leaks air during a charge.

To determine if there is a leak in the charge hose, first, make sure the hose contains a Teflon washer in the large end connector, and that the large end connector is tightened securely to the CO^2 bottle with an adjustable wrench.

Next, insert the charge hose in the gun. When the charge hose stabs into the fill valve, some gas will blow back from the insertion point. This is normal and helps keep the charge area free of debris. However, if after removing the charge hose from the gun, gas continues to exit from the charge hose tip, the valve core needs to be changed. Use one of the valve cores in the gun repair O-ring kit supplied at the time of purchase, or call Sage Technologies to order a Charge Hose Tip Kit.

Carefully remove the charge hose tip from the charge hose, with the tip pointing downward, as shown below. Inside the tip, there will be a large o-ring, a flat washer, and a small o-ring. Save these to be re-installed later. (If they are missing or damaged, you will need to order a Charge Hose Tip Kit.)



With the gun maintenance tool, unscrew the internal valve core from the end of the charge hose, and replace it with a new valve core. Hand tighten securely. Then, rebuild the charge hose tip, as shown above, first placing the small o-ring in the bottom of the tip, followed by the flatwasher and then the larger o-ring. Insert the end of the charge hose into the tip and hand tighten securely.

CO^2 Bottle Set-up

Many operators fit the compressed gas bottle with the charge hose in the shop, and transport it to the field with the hose attached. For set up, first make sure the bottle contains CO^2. A simple rule of thumb when filling the 2.5 pound bottle supplied with the Acoustic Fluid Logger IV is to weigh the empty bottle, then fill it with compressed CO^2 gas until it weighs 2.5 pounds more than the original weight.

When attaching the charge hose, first place the Teflon O-ring (attached to the charge hose at time of sale) inside the charge hose connection on the large end of the black fill hose. Then, tighten the hose connection onto CO^2 bottle with an adjustable wrench.

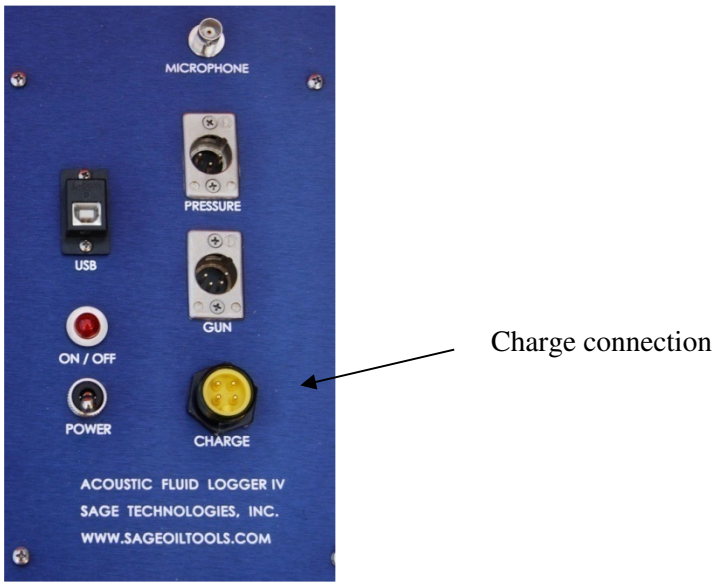
Maintenance -- Acoustic Fluid Logger IV

Charging the battery

The Acoustic Fluid Logger IV unit requires a minimum of maintenance. Batteries should be charged regularly after each day's use, using the wall-mount charger that accompanies the unit. Simply insert the round, yellow end of the charger cable over the charger port on the logger's front panel, and tighten the black thumb ring. Then plug the other end of the charger into a wall outlet.

Our charger has been designed to work automatically with 110-volt or 220-volt (50hz or 60 hz) voltage. However, if using anything other than standard U.S. 110-volt outlets, you will need a local adapter to plug the charger into the wall. Usually an overnight charge will be sufficient.

Note: Keep the power switch in the **off position** during charging.



Occasionally, a damaged battery will need to be replaced. (See Battery Replacement, Page 64.)

It is absolutely necessary to use caution not to damage the internal circuit boards or cut the internal wiring cables while changing a battery. Prior to replacing the battery, however, efforts should be made to charge the unit with the accompanying battery charger for at least 24 hours.

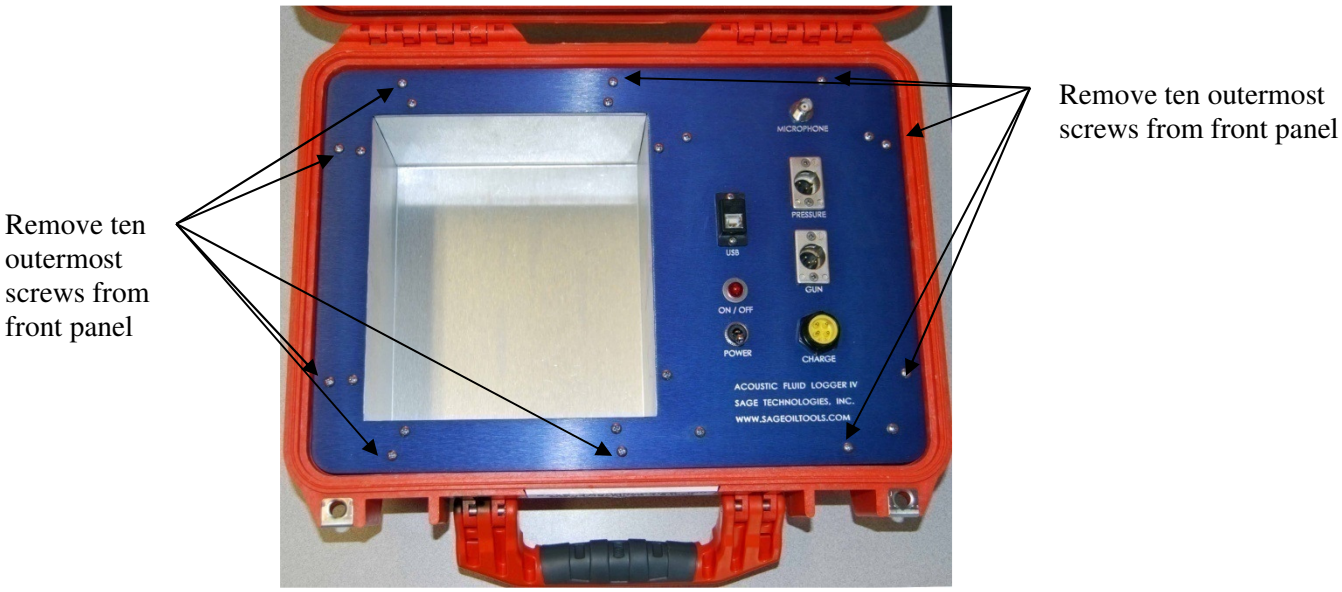
- **When storing the Acoustic Fluid Logger IV, always make sure the power switch is turned off, to avoid running down the battery.**

Battery Replacement

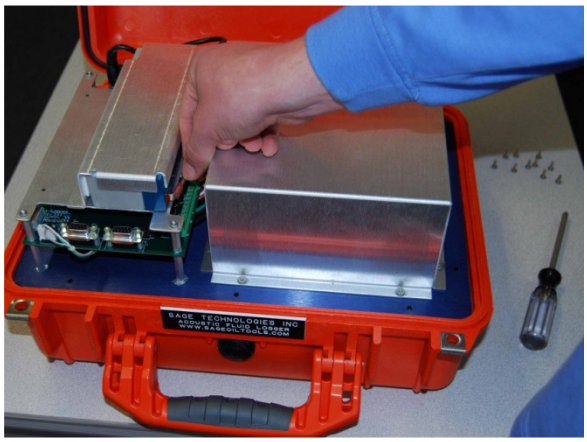
Supplies needed for changing the battery on the Acoustic Fluid Logger IV are:

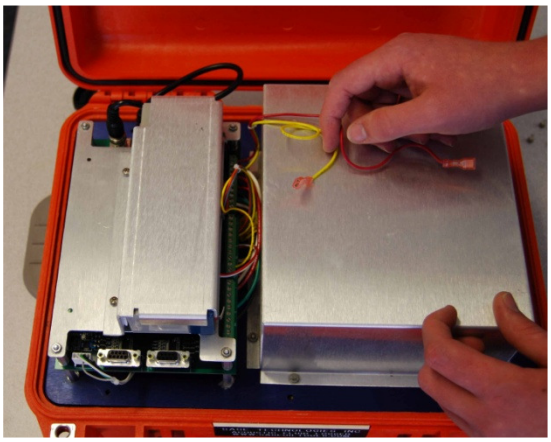
- Medium Phillips screwdriver
- New AFL IV battery from Sage Technologies

First, using the medium Phillips screwdriver, remove the ten **outermost** screws on the Acoustic Fluid Logger IV front panel – two on each side and three each at the top and bottom of the panel. These screws attach the front panel to the box. Note: The inner set of screws holds other components to the front panel – do not remove these.

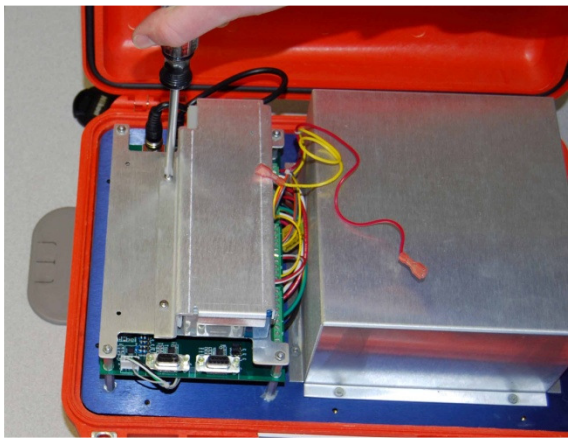


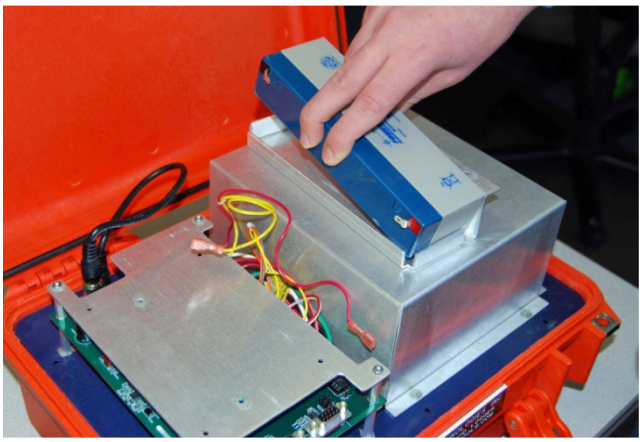
Lift and remove the front panel. The front panel holds the battery box and battery, as well as the printer, internal circuit boards and wiring. Be careful not to disturb the internal wiring. Flip over the panel and set it upside down on the orange AFL IV box. Disconnect the red and yellow battery wire connections from the battery. **Warning: DO NOT work on the unit while the battery is connected.**



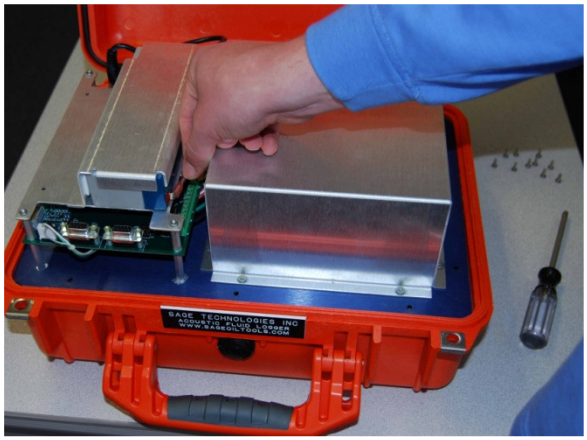


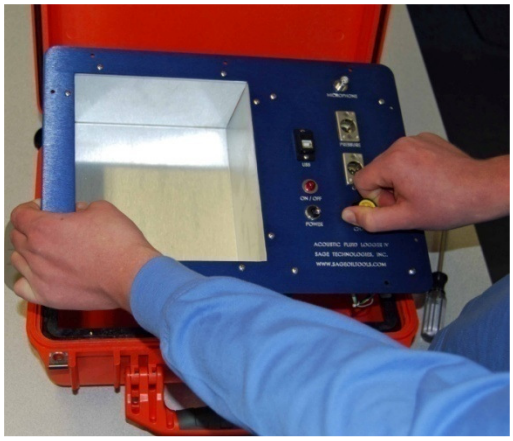
Use the medium Phillips screwdriver, remove the two screws that hold the battery box to the back of the Acoustic Fluid Logger IV front panel. Remove the old battery and replace it with a new AFL IV battery from Sage Technologies. Place the AFL battery face-up (red connector up) in the battery box, as shown below right; be sure that when the battery box is replaced and screwed onto the metal plate, the red battery connection faces toward the handle on the front of the AFL IV.





Replace the two screws that hold the battery box to the front panel. Tighten screws completely. (Screws are #6-32, 3/8" if replacement of lost screws is necessary.)





Reconnect the battery; be SURE to connect the red battery connection wire to the red battery pole, and the yellow connection wire to the black battery pole. **Important: At this point, lift the front panel and clean out any dirt or debris that has fallen inside the orange box. Any stray screws, metal parts, paper clips or excessive dirt may harm the circuit board.**

To complete battery replacement, replace the front panel in the box, being careful not to cut any cables or wires. Reassemble the unit, then reinstall the ten #6-32 3/8" front panel screws.

AFL IV System Replacement Parts and Supplies

Acoustic Fluid Logger IV parts

Wall-mount Charger

Battery

Pressure Pulse Gun parts

CO^2 charge hose

CO^2 charge hose tip

CO^2 bottle - 2.5 lb.

Charge hose tip kit: Charge hose O-rings and valve cores

Gun repair kit: Pressure Pulse O-rings and valve cores

Fill valve

Microphone

Microphone tool and allen wrenches

Operator's Manual

Microphone Cable

USB cable

Spanner wrench

T-ball wrench

Strap wrench (for 5,000 psi gun)

AFL IV System Accessories

Pipe adapters

CO^2 bottle – 5 lb.

Extra carrying case

Quick-change gauge adapters for Pressure Pulse Gun – 1,500 and 3,000 psi

Brass tools for o-ring replacement

Appendix A: Fluid Level Methodology

Identifying the fluid level

In older fluid logging machines, the operator was responsible for picking the fluid level on the graph on a thermal paper tape. Although the Sage AFL software now picks the fluid level for you and calculates the distance to fluid, the methodology remains the same. Since the software does allow the operator to fine tune placement of the Red, Blue and Green Cursors, remembering these few time-honored fluid level facts will make your understanding of the fluid level graph easier:

- The **fluid level** is usually the **deepest kick** in the well.
- When shooting fluid levels with a positive pressure wave (as with compressed gas), the fluid level always kicks **down** on the graph.
- The fluid level is the **only signal able to move** over time, on a collar count basis. (If the acoustic velocity of the gas in the well changes due to casing pressure changes, other signals in the well can appear to move, but only as far as return time is considered.)
- Check the fluid level by acquiring data long enough for the graph to display a second reflection of the fluid level -- at a distance equal to twice the original fluid level. **A double reflection from the fluid level is an excellent confirmation of true fluid level.**

When more than one fluid kick is observed

Many variables can affect the fluid level measurement on an oil or gas well, among them well depth, the size of the compressed gas shot, debris in the wellbore, and external noise, to name only a few. To help perform a more accurate fluid level test, the following are recommended:

- **Allow the casing pressure to build.** And, the **kick that moves** on a collar basis will be the fluid level.
- **Shut down the pumping unit** and give the well noise time to die down (i.e., one to five minutes). Check for and try to eliminate other sources of external noise. Then shoot the well again.
- **Shut the casing flow line**. When the casing flow line is left open, sound also reflects down the flow line, which can interfere with the gas shot moving down the wellbore.
- **Check the tubing tally** for things like tubing anchor depth, liner depth, depth of special oversized tools in the string, etc. for other objects that could show up as kicks on the fluid level tape.
- If there is **paraffin** in the well, be aware that paraffin rings can cause false fluid levels in wells, even in the face of increasing backpressure.
- Perforations in the well, or cracks in the casing, will kick **up** on the tape. Remember that the **fluid level will kick down.**

Calculation of the fluid level

In older machines, calculation of the fluid level was done by manually, by counting collars on a thermal paper tape, usually with 11-point expandable dividers to simplify the marking and counting of collars by tens. Although the Sage AFL software does this calculation for you, the methodology remains the same.

Joint length

Tubing collars are easily identifiable on most wells. And, by using an **average joint length** for each tubing joint, along with the total number of observed joints, it is possible to calculate the depth to the fluid.

Distance to the fluid

Rule of fluid level calculation: To calculate the distance to the fluid, multiply the number of casing joints found between the start of shot and the fluid level by the length of the casing joint. (This length will be available on the completion sheet for the well.) **This will be the distance to the fluid.**

For example, if there are 65 collars between the gas shot and the fluid level, and the casing joint length is 32, multiply 65 x 32, and the depth to the fluid is 2,080 feet.

Calculation: Joint length method

The most common method of getting the fluid depth is to multiply the number of collars by the average joint length. Remember that the depth to perforations is normally measured from the kelly bushing (K.B.) or from the rig floor.

Example:	in feet
K.B.	10.00
Hanger	.75
1 pup joint	6.12
180 joints tubing	5625.72
Anchor catcher	2.68
1 joint tubing	31.31
SN (seating nipple)	1.57
1 joint	31.45
Slotted Mud Anchor	28.90
Tubing Landed at	5738.50

5738.50 - 28.90 = 5709.60 feet

Since the pump intake is at the top of the mud anchor we use all lengths from K.B. to the top of the mud anchor to determine the average joint length.

5709.60 feet / 182 jts. = 31.37 feet/jt

The number of joints measured multiplied times the average joint length will give the fluid level in feet from the K.B.

Calculation: No known joint length

When no average joint length is available, then using 31.00/jt is a rule of thumb, with the understanding that there are inaccuracies involved.

Appendix B: Acoustic Velocity

Finding Acoustic Velocity of Gas

Knowing the acoustic velocity of natural gas in a well is useful in the fluid level calculation. On the Depth Scan tab in the Sage AFL software, you may choose the Constant AV method and enter the acoustic velocity of gas on a given well, which will allow for a more well-specific calculation of the fluid level.

Two methods of fluid level calculation

- **Counting returning echoes from collars and fluid** -- A shot of compressed gas is fired down the annulus or tubing of the well; the pressure wave travels down to the fluid and then returns to the surface. The depth to the fluid is determined by counting the number of casing collars between the surface and the fluid and multiplying by the joint length.

.

- **Calculating the return time from fluid by using the acoustic velocity of gas** – A shot of compressed gas is fired down the annulus or tubing of the well; the pressure wave travels down to the fluid and then returns to the surface. The depth to the fluid is determined by multiplying the time it took for the shot to travel to the fluid and back to the surface, multiplied by the acoustic velocity of the existing gas inside the casing, divided by 2 (since the gas shot travelled twice the distance to the fluid – down and back up – during the test).

  $$D = \frac{T\ A}{2}$$

  D = Distance to the fluid level (feet)
  T = Time – between the firing of the gas shot and its return to the surface
  A = Acoustic Velocity of gas (feet/second)

When to use the Constant AV method

Use the Constant AV analysis method with wells that are venting gas to the surface atmosphere or to the flowline, and have adequate pressure of gas to assure that the entire space within the annulus is filled with gas of the same composition.

When not to use the Constant AV method

Do not use the Constant AV analysis method with wells that are not venting gas at the surface -- or wells that have been shut in for a significant period of time, or wells in which air has entered at the surface – any of these wells may have a significantly different composition of gas at different points within the annulus. This could result in the presence of gas of significantly different acoustic velocity at different depths within the annulus.

In such cases, select another method of fluid level analysis on the Depth Scan tab: **Joint Length method** – where the joint length is entered, or **Constant Depth method** – where any event of known depth within the wellbore is entered.
Note: The acoustic velocity of dry air at 32º F (0º C) and standard pressure is 1087 ft./sec (331.45 meters/sec). Many shallow wells with a low specific gravity of gas of 0.55 to 0.80 exhibit velocities of 1,100 ft/sec. to 1,300 ft/sec.

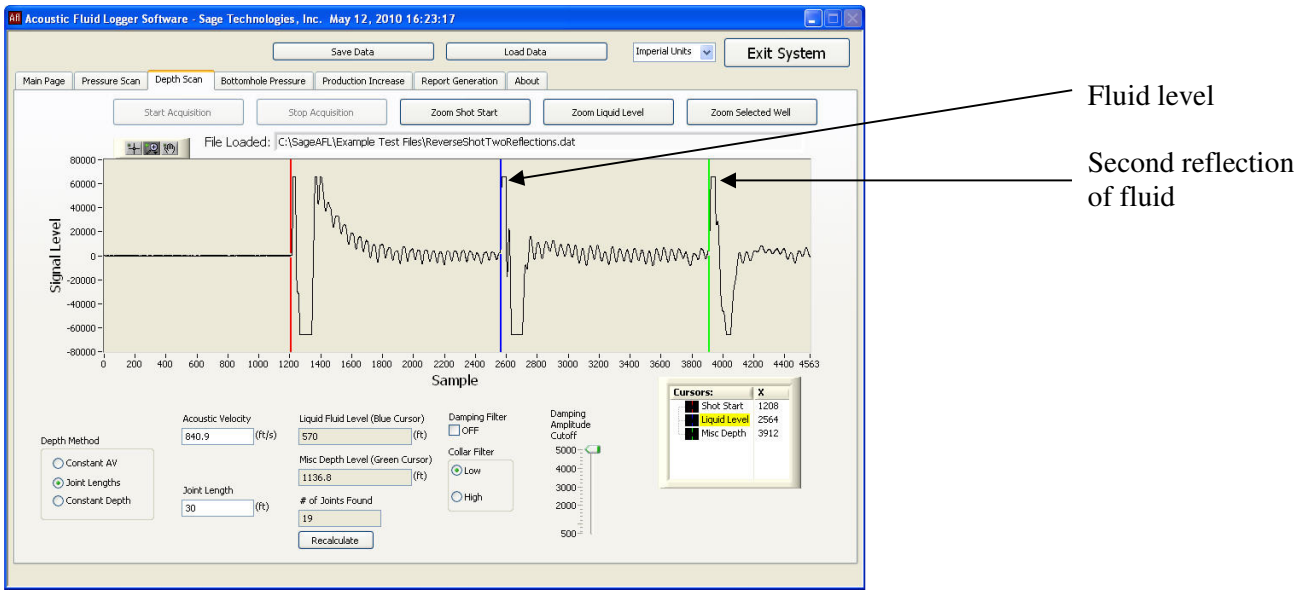
Appendix C : Reverse Pressure Wave

All Sage Technologies gas guns can be used to shoot both a positive pressure wave, using compressed bottle gas, and a reverse pressure wave, using gas from inside the well being tested. Higher pressure wells are easier to test using the reverse pressure wave form.

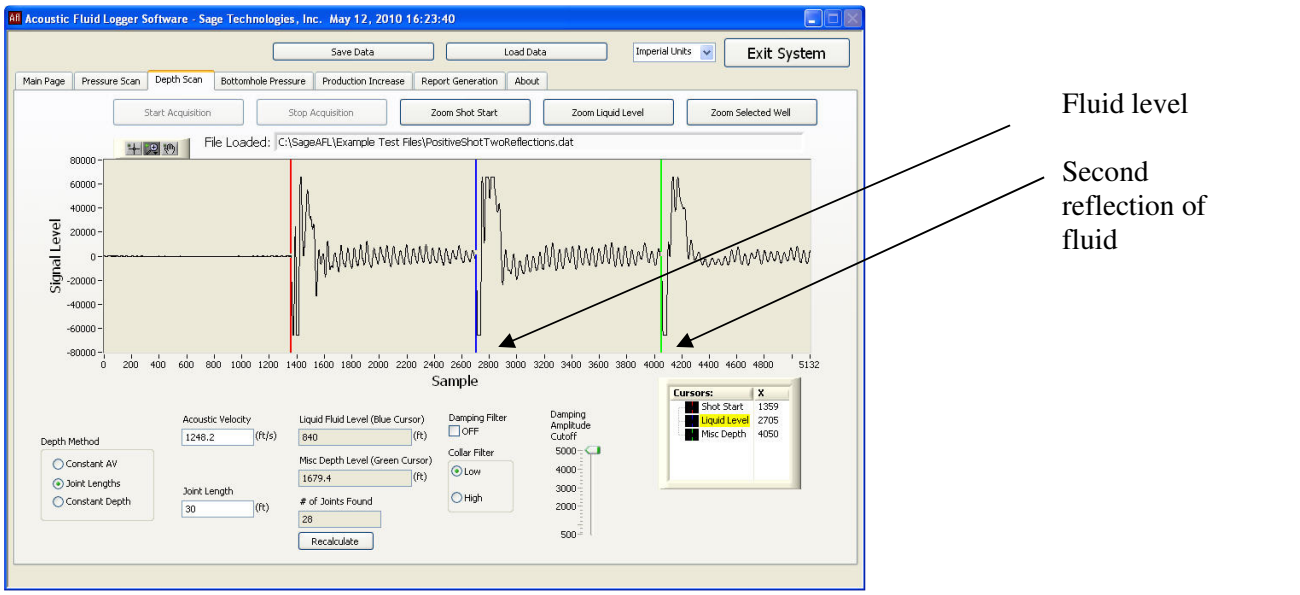
Visual difference between Reverse and Positive Pressure Waves

- A **positive pressure wave** will show the fluid level as the biggest kick **down** on the graph.
- A **reverse pressure wave** will show the fluid level as the biggest kick **up** on the graph.

Reverse Pressure Wave – fluid level kicks up on the graph, using well gas for the shot.



Positive Pressure Wave – fluid level kicks down on the graph, using bottle gas for the shot.



Shooting a reverse pressure wave

The procedure for shooting a reverse pressure shot is much like shooting a positive shot, except that gas escaping from the wellbore is allowed to shoot into the gun chamber, instead of compressed gas shooting into the wellbore from the gun chamber and back into the gun.

Reverse Pressure Wave Procedure:

- Push the shuttle valve on the Pressure Pulse Gun into load position
- Look at the gauge on top of the gun, and bleed down the pressure, with the relief valve, until the gauge reaches an adequate pressure **below** wellbore pressure.
- Close the relief valve. The well now has higher pressure inside it than the pressure inside the gun does, setting up the reverse shot.
- Fire the gas gun. When the gun is fired, gas shoots from the wellbore into the gun, and the fluid logger will record the reverse shot.

For more on shooting a Reverse Pressure Wave, see Page 20.

Note: Repeated use of the Reverse Pressure Wave will result in more debris from the wellbore being blown into the gun chamber and onto the microphone. When using this method, clean the gun and microphone frequently. Exercise care when cleaning the circular microphone surface. See Maintenance, Pages 57 – 60.

Appendix D : Pressure Pulse Gun Adapters

Line Pipe Adapters

Attaching 3,000 psi Gas Guns to 2" Line Pipe

1. In the fluid level set-up photographs below, the standard 3,000 psi Pressure Pulse Gun is being attached to standard 2" line pipe with the addition of pipe adapters. First, attach the adapters necessary to fit the gun to the wellhead. Make sure to tighten the adapter with a pipe wrench.

2. Hand-fit the gun to the adapter. Finish tightening the gun with the provided spanner wrench, which fits into the notches on the base of the gun body. Proceed with the fluid level test.

CO^2 Refill Adapter

A refill adapter is included with the Pressure Pulse Gas Gun – 1,500 or 3,000 psi – for refilling the 2.5 lb. bottle from a larger bottle of compressed carbon dioxide -- CO^2.

When using the refill adapter, first make sure the Teflon ring is inserted into both sides of the refill adapter. This will ensure a good seal and eliminate leaks when the brass adapter is securely fitted to the empty CO^2 bottle and the refill cylinder with a pipe wrench.

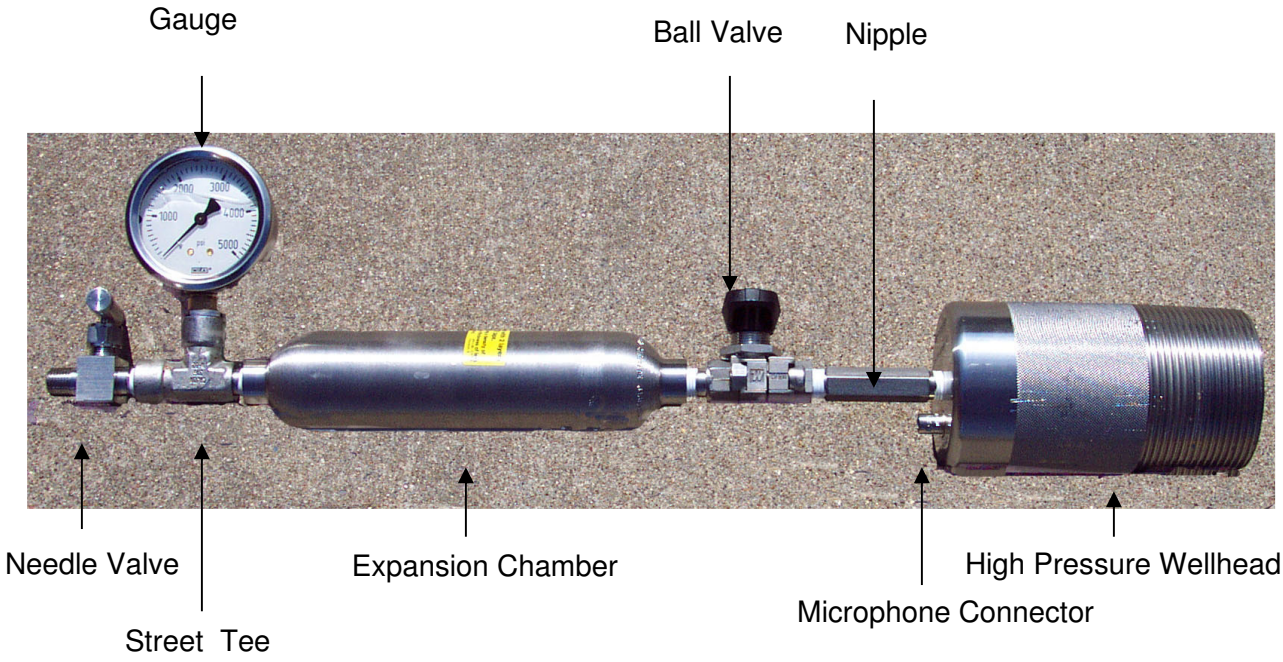
Be careful not to overfill the 2.5 lb. gas cylinder or its internal diaphragm will become damaged or disabled. The recommended method of refilling the cylinder is to weigh the empty cylinder, then fill it with 2.5 lb. of compressed gas (empty cylinder weight plus 2.5 lb.). On average, depending on well depth, the Acoustic Fluid Logger system can take approximately 200 fluid level shots with a single 2.5 lb. cylinder of compressed gas.

Nitrogen Adapter

In extremely cold weather conditions, nitrogen -- N^2 -- becomes the preferred compressed gas for fluid level testing. If you have a nitrogen bottle and would like to test your wells with N^2, Sage offers a Nitrogen Adapter for the standard CO^2 charge hose end that will allow you to use the Sage charge hose with a nitrogen bottle.

Appendix E : 5,000 psi Sage High Pressure Gas Gun

In special high pressure situations, the Sage High Pressure Gas Gun is the preferred gas gun. Gas escaping from the well is used for the fluid level shot, so compressed bottle gas is not required.

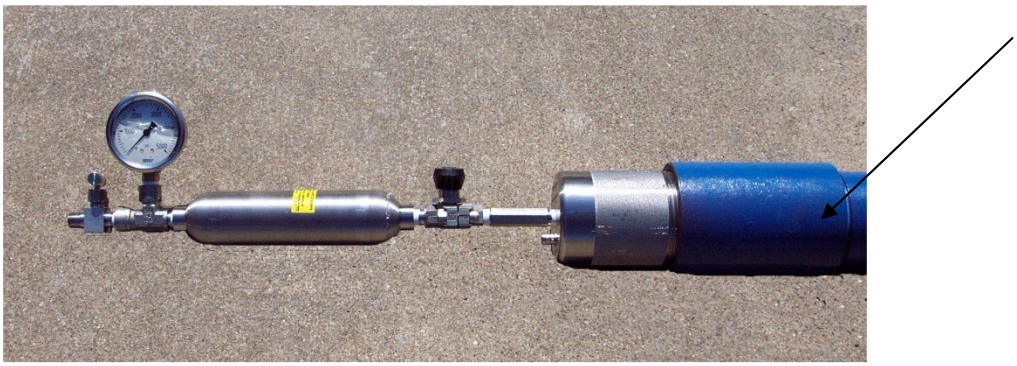


Quick instructions – Sage High Pressure Gas Gun

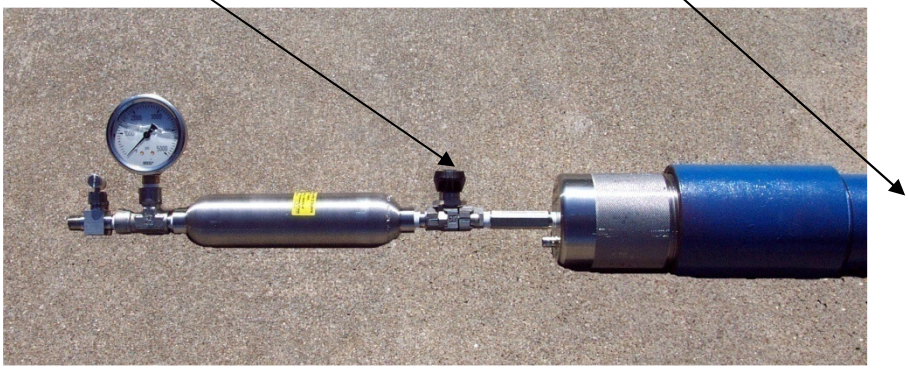
- Make sure both the needle and the ball valve are closed.
- Connect the Sage High Pressure Gas Gun to the annulus of the well.
- Open up well pressure slowly to the gun.
- Slowly open the ball valve to fill the chamber with gas.
- Close the ball valve to allow bleeding of gas from the chamber.
- Bleed the chamber down below wellbore pressure using the rear needle valve. Close the needle valve.
- If needed, shut in the casing flow line valve, so the shot will not go down the flow line. You may have to allow some settle time for the well to quiet down after this step.
- Connect the microphone cable between the Acoustic Fluid Logger IV and the high pressure gas gun. Connect the USB cable to both the Acoustic Fluid Logger IV and to the portable computer.
- Turn on the Acoustic Fluid Logger IV unit and the portable computer; start the Sage AFL software. Click **"Yes"** in the **"Instrument Enabled"** box, and go to the **Fluid Level** Tab.
- Be ready to shoot the gas gun. Click on the **"Start Acquisition"** button located on the Fluid Level tab.
- **Quickly** shoot the gun by opening the forward ball valve (the one nearest the well) on the high pressure gun. You will see the shot appear on the computer screen.
- Let the fluid level run until you have seen a valid fluid level kick. Click the **"Stop Acquisition"** button at this point to stop the fluid level data acquisition.
- Click the **"Export Data"** button to save the signal to a file on the portable computer. Enter a file name and choose a folder location on the computer, then save the file.

Fluid Level Procedure – Sage High Pressure Gas Gun

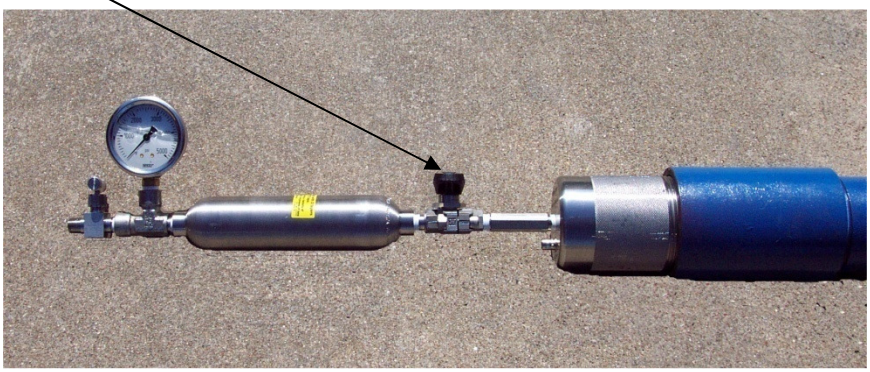
1. First, shut the backside casing valve. Then mount the 5,000 psi Sage High Pressure Gas Gun on the well, as shown below.



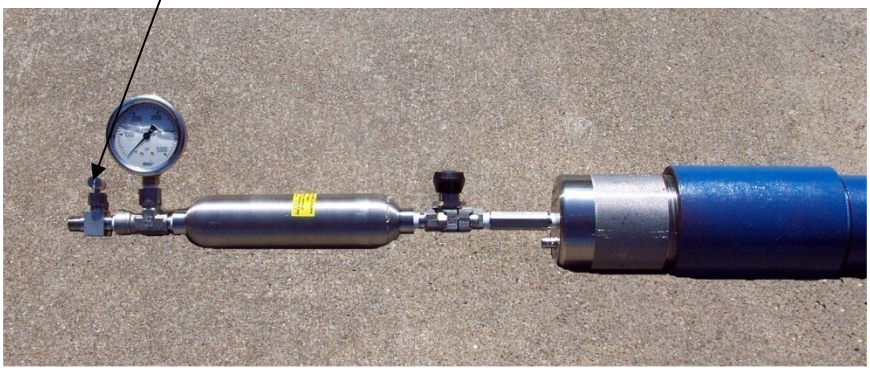
2. Open the **valve** from the wellbore to the gun.
3. Open **ball valve** to allow pressure into the expansion chamber.



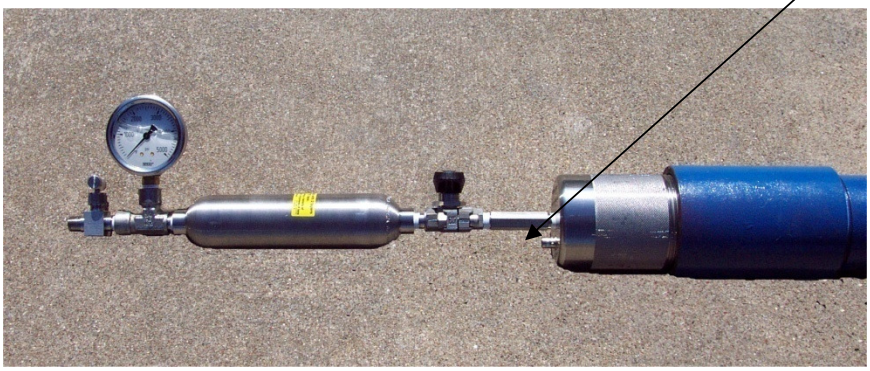
4. Fill expansion chamber with wellbore pressure. The gauge will register pressure. Close the **ball valve** to seal off the expansion chamber from the wellbore.



5. Use the **needle valve** (the valve closest to the gauge) to bleed down the pressure in the expansion chamber to below wellbore pressure by watching gauge. Close the needle valve once the correct pressure is reached.

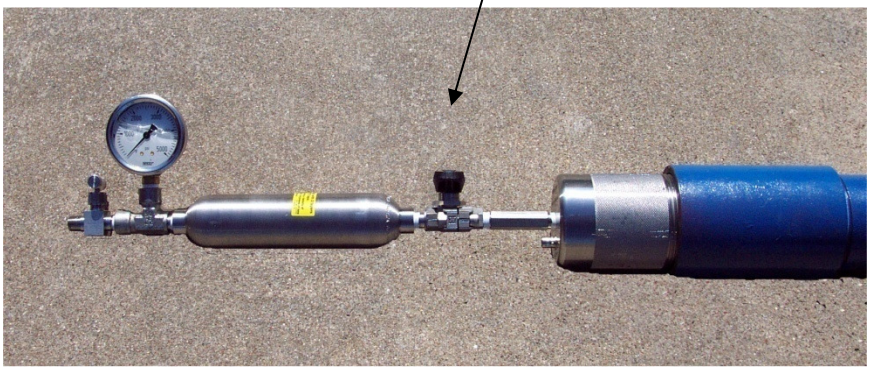


6. Attach the **microphone cable** from the gun to the unit, using the **microphone port** on the gun and the microphone port on the Acoustic Fluid Logger IV. Attach the USB cable to the Acoustic Fluid Logger IV and to the portable computer.



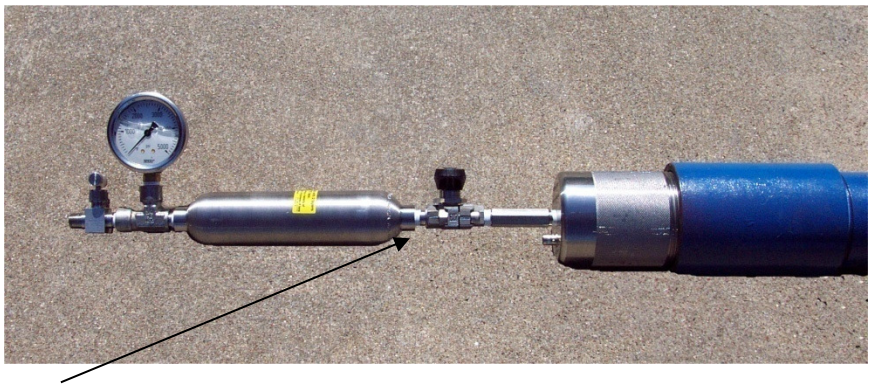
7. Turn on the Acoustic Fluid Logger IV and the portable computer; start the Sage AFL software. Click **"Yes"** in the **"Instrument Enabled"** box, and go to the **Depth Scan** tab. Be ready to shoot the High Pressure Gas Gun. Click on the **"Start Acquisition"** button located on the Fluid Level tab.

8. **Quickly** shoot the gun by opening the **ball valve (**the valve farthest from the gauge) on the gas gun. You will see the shot appear on the computer screen. Watch for the fluid kick, then click **"Stop Acquisition"** on the Fluid Level tab. Click **Export Data** to save data to a computer file.

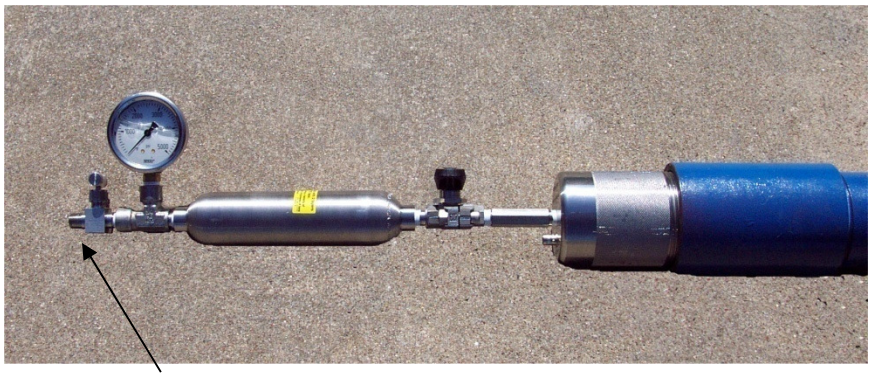


Removing high pressure gun from well

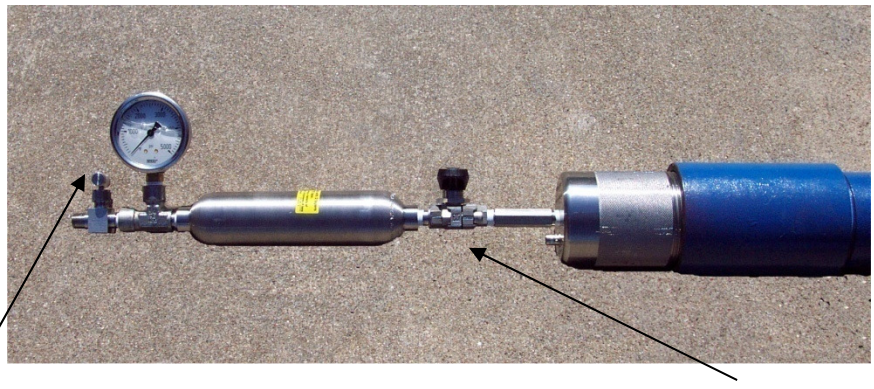
1. To remove the Sage High Pressure Gas Gun from the well, start by shutting off wellbore pressure from the gun by closing the backside casing valve.



2. Open the **ball valve** to connect all pressure passages in the gun.



3. Slowly open the **needle valve** to remove all pressure from the gun.



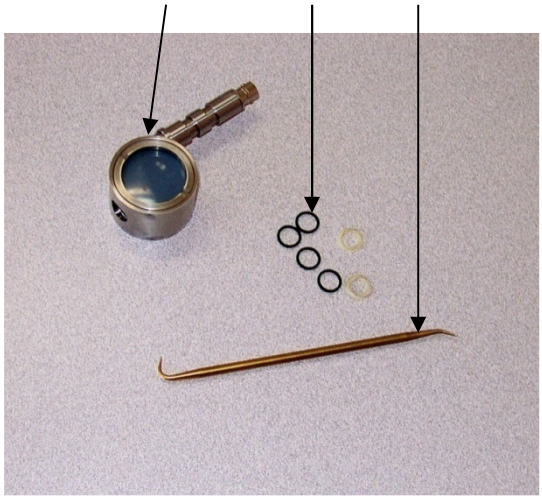
4. With the high pressure gas gun shut off from wellbore pressure, the **ball valve** open and the **needle valve** open, the unit is ready to be removed from the **wellhead**.

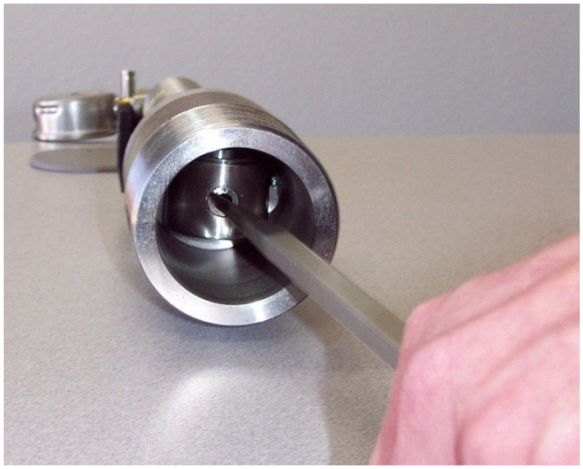
5. Use the **strap wrench** provided with the gun to remove the gas gun from the well.

Maintenance – Sage High Pressure Gas Gun

Supplies needed for maintaining the Sage High Pressure Gas Gun are two sets of O-rings (four black backup o-rings and two hard white special o-rings). A brass o-ring tool is also provided with the unit, as shown below.

Microphone, O-rings, O-ring tool

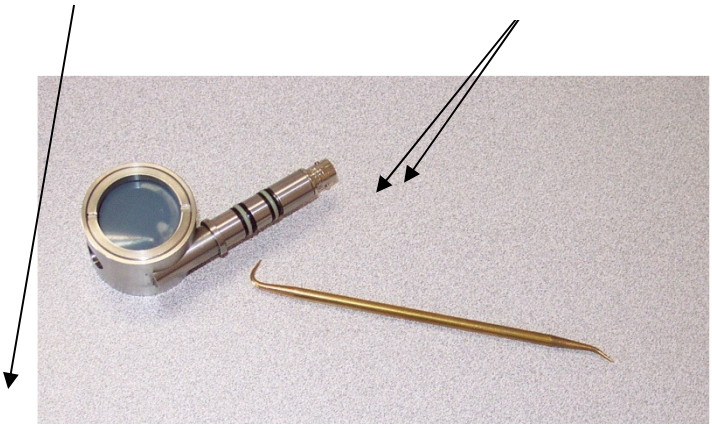




To disassemble the gun for maintenance, first remove the **internal microphone by** removing the microphone retainer bolt from the bottom of the gun, using a flathead screwdriver or your maintenance tool, as shown above right.

Remove
retainer bolt

Black – White – Black
pattern of O-rings



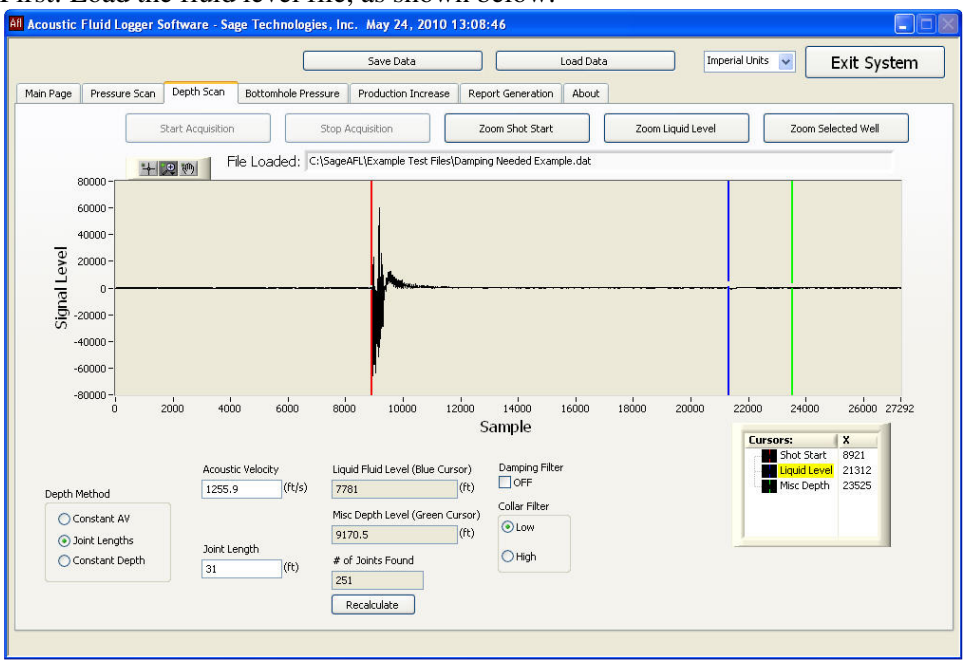
Cut and remove worn or damaged O-rings microphone stem. Using the O-ring tool, place new O-rings in the following order: One Black Backup, One White Special, and One Black backup. Complete the black-white-black pattern on each of the two indentations in the microphone stem, shown above. Grease O-rings with silicone lubricant. Replace microphone and retainer bolt in gun, careful not to press on the microphone faces, to prevent damaging the microphone.

Appendix F: Example Fluid Level Situations

This section of the AFL IV Manual details some special situations with common problems and solutions.

Situation 1: Find Fluid Level Using Damping Filter

Some fluid levels, like the example below, are difficult to calibrate because the shot is so large versus the signal. First we will handle this using the Damping Filter, a new feature of AFL Software, Version 2.0. First: Load the fluid level file, as shown below.



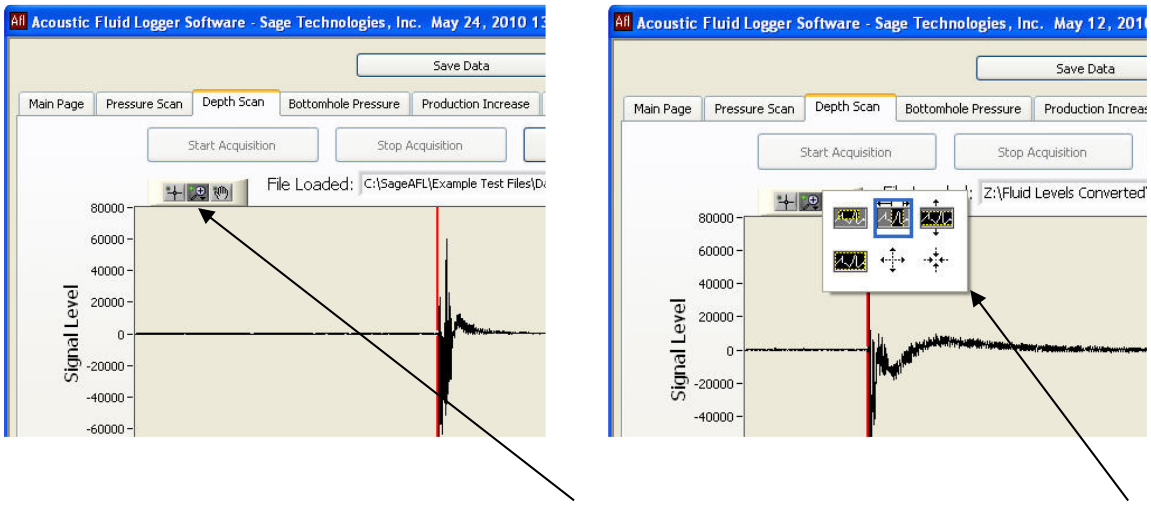
Example:
Using Damping Filter

First, load the fluid level file

Red Cursor:
Start of shot

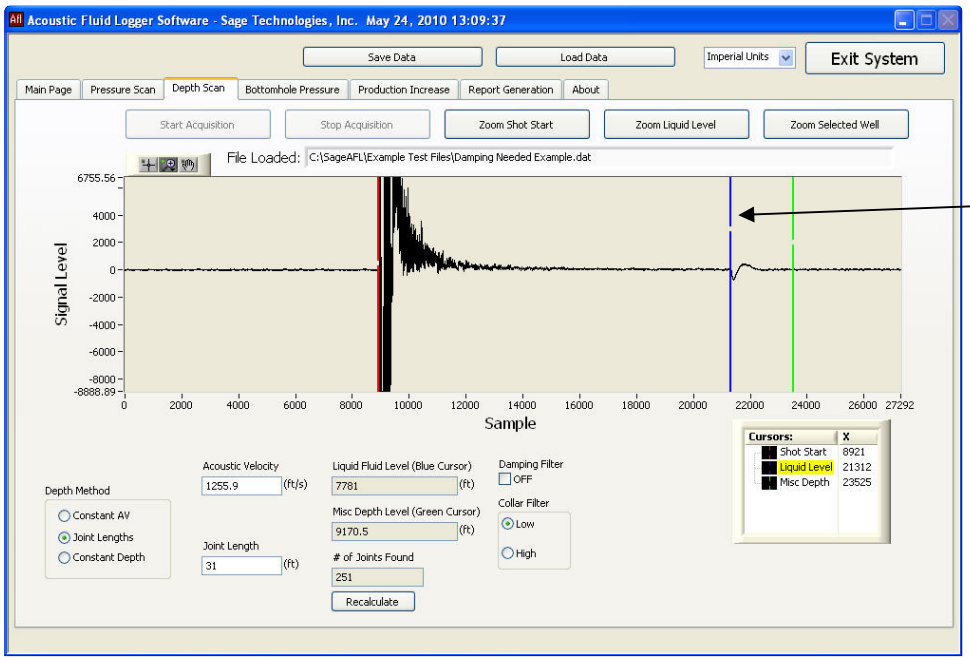
Blue Cursor:
Fluid level not readily apparent

Next, zoom in on the fluid level portion of the graph, using the zoom tools.



Focus on the Start of Shot: Red Cursor with Zoom (picture of magnifying glass). The Zoom Option Box will pop up. Use these tools to find the desired zoom area. (See Page 50 – 52 for instructions on Graph Manipulation: Zoom Tools.) Use the bottom left icon if you want to return to the original graph screen.

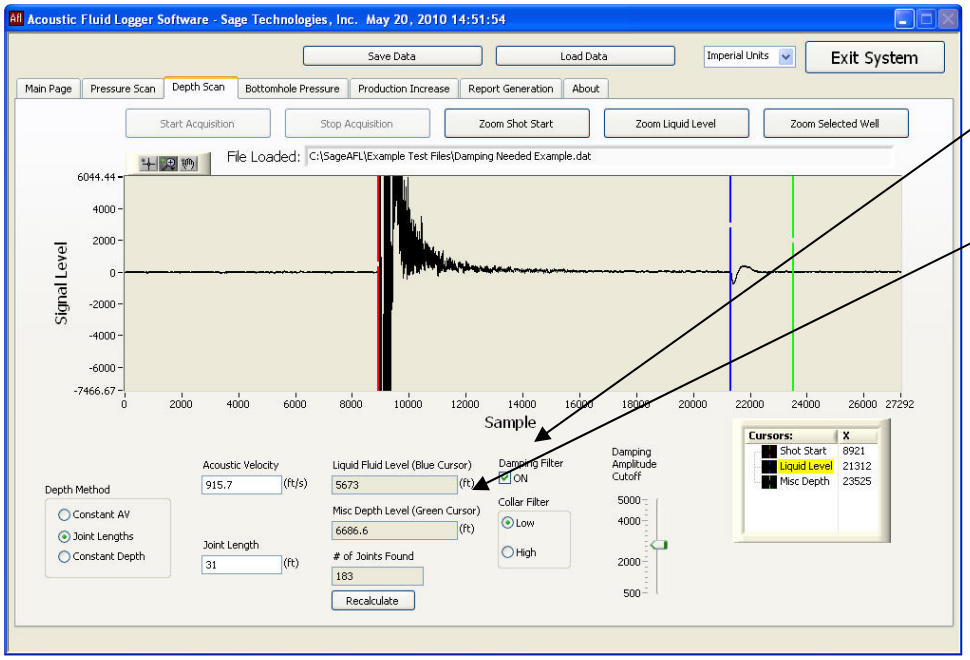
The graph below shows the fluid level, after zoom-in.



Zoom in on fluid level

Next, turn on the Damping Filter. This will reveal the Damping Amplitude Cutoff slider bar. Since Damping is not needed for every fluid level, this slider remains hidden until the Damping Filter is turned ON.

Note that in the following example, the Damping Filter is ON and the Collar Filter is LOW. The Damping Amplitude slider is set to 3,000. The fluid level depth is correct.



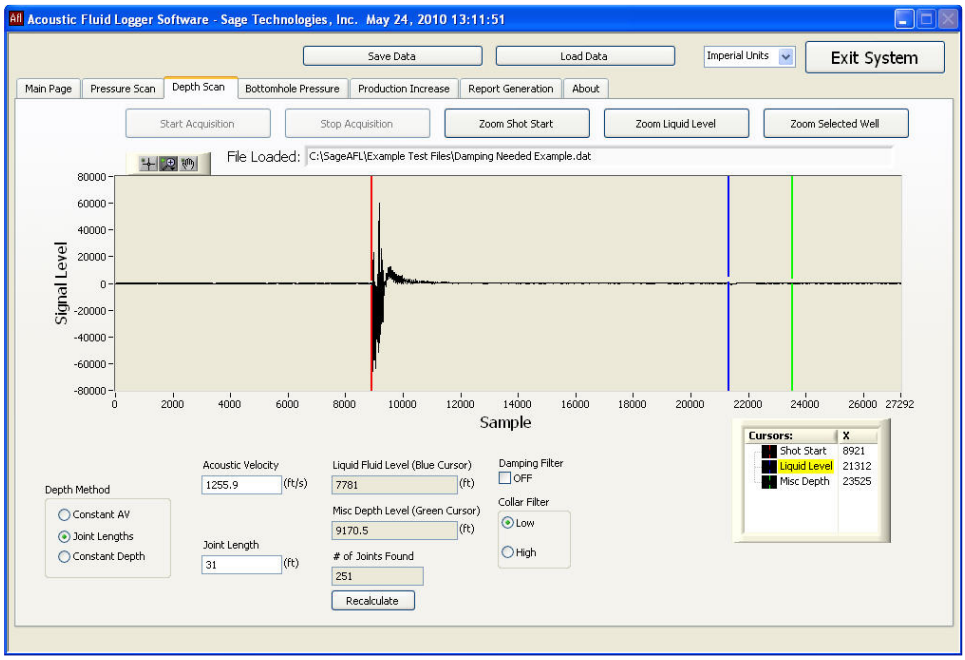
Turn ON the Damping Filter

Read the Fluid Level Depth

Situation 2: Redoing a fluid level using Constant AV

Constant AV (constant acoustic velocity of gas) and the Damping Filter can both be used to get close to the same fluid level value. Selecting Constant AV as the Depth Method is a more generic way to handle large gas shots or other special situations in a fluid level test.

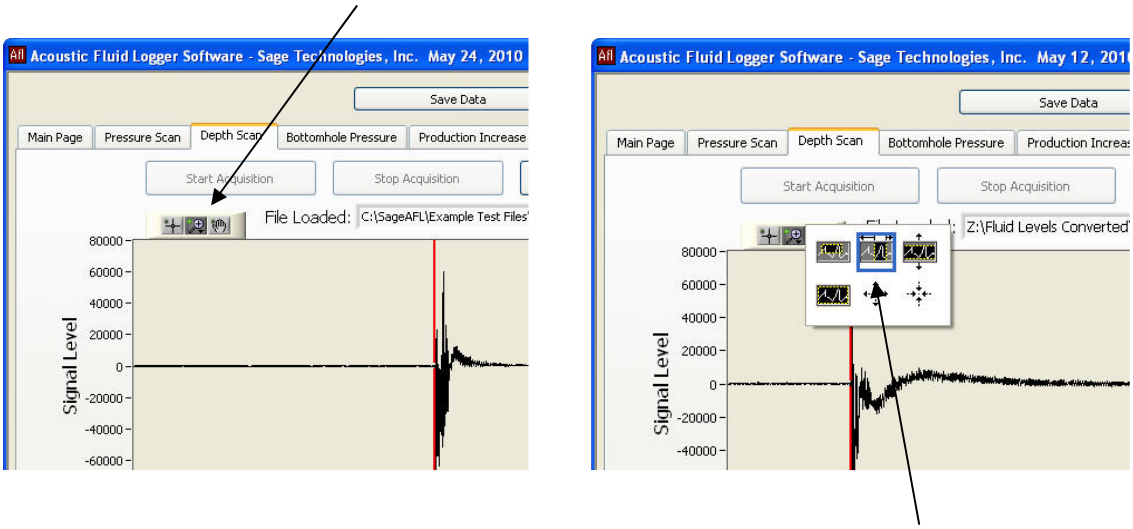
As shown below, we reload the fluid level used in Example One. This time, DO NOT turn on the Damping Filter. (We can also switch to using the method from the above screen, by turning the Damping Filter OFF.



Example: Redoing the previous fluid level using Constant AV depth method

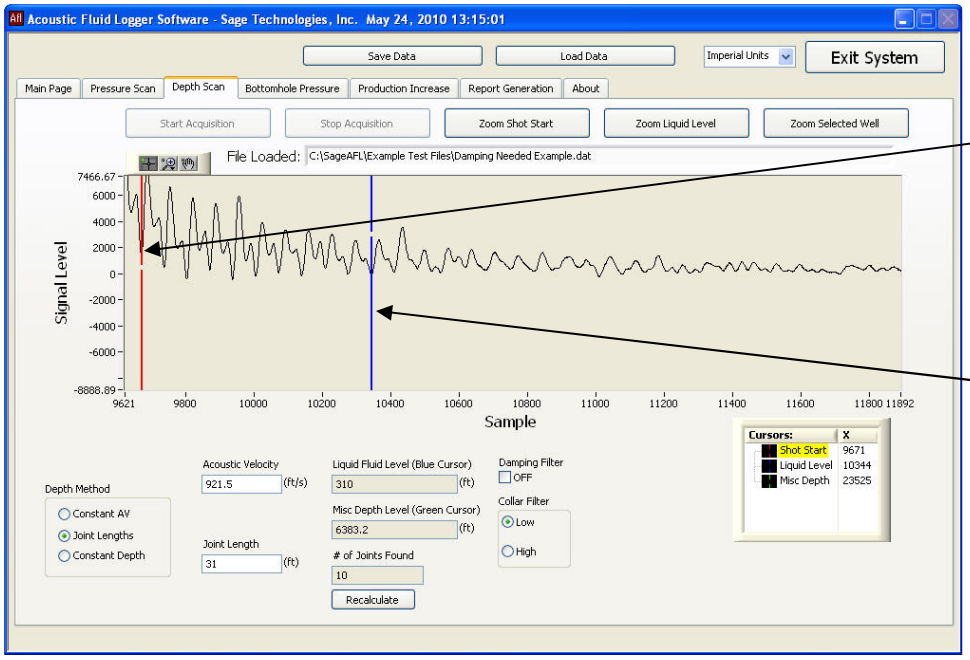
Note: Fluid level and collars are hard to determine

Then, zoom in on a desired area of early collars, as shown below, using the Zoom Tools. (Click on the magnifying glass icon, as shown below left.)



The Zoom Option Box will appear, shown above right. From the six diagrams, choose the desired expansion or movement on the graph. For more on the Zoom Option Box, see pages 50-52. In this example, we zoom in on early collars in the fluid level – after the shot, to the right of the Red Cursor, but near the start of shot. We will take a closer look at these collars.

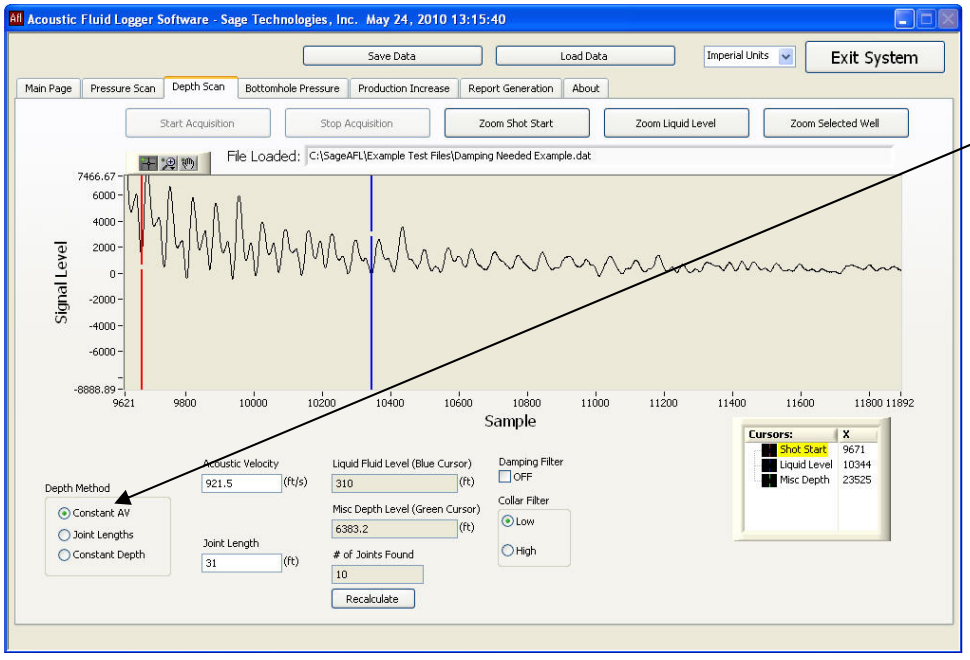
Once you have zoomed in, move the red and blue cursors onto a 10-collar section of the graph, by clicking and dragging the cursors so that the space between them counts 10 collars. Don't count the red line, then count every down-kick to the blue line, including the collar that falls on the blue line. This defines a 10-collar segment, as shown.



Red Cursor: Defines the starting point for a 10-collar count on the fluid level graph.

Blue Cursor: Defines ending point of the 10-collar count.

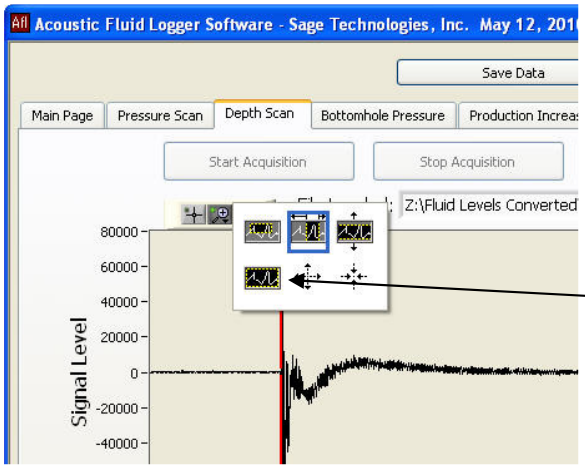
Now, change to the Constant AV mode for the analysis method.



Change Depth Method to Constant AV

This applies the constant velocity found to the whole well. (The constant acoustic velocity is determined by the software when you mark the 10 counted collars.)

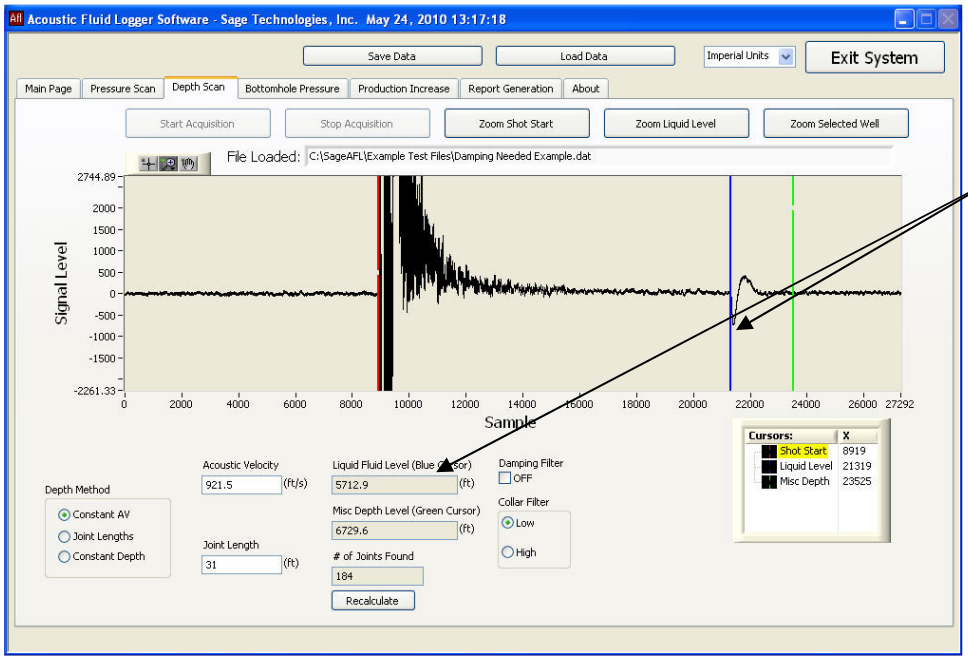
Return to the original graph using the Zoom Tools pop-up box: Choose the bottom left button, which is the original graph icon, shown below.



Click on the Magnifying Glass again to bring up the Zoom Option Box.

Click on the bottom left button: Return to Original Graph

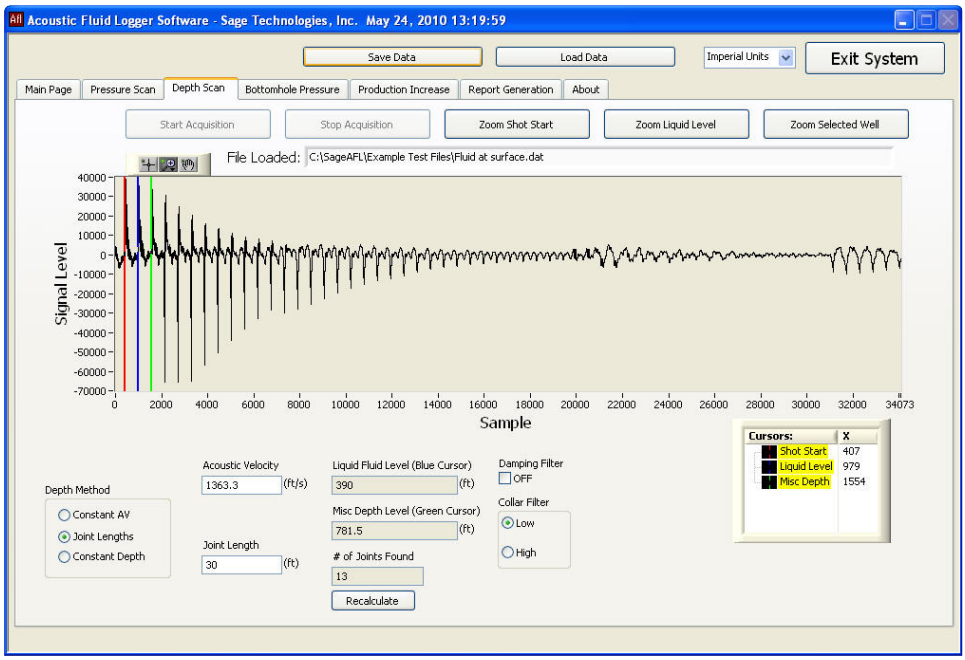
On the original fluid level graph, read the Liquid Fluid Level. The liquid fluid level reads nearly the same depth found using the Joint Length analysis with the Damping Filter.



Liquid Fluid Level

Situation 3: Fluid at Surface

In Example One, below the fluid level kick occurs directly after the shot, and then echoes back and forth from the fluid to the surface in a graduated decreasing pattern. This is an example of fluid at or near the surface of the well. Note that the red and blue cursors sit almost on top of each other, but the first big downward kick after the gas shot is the fluid level.



Fluid at Surface: Example One

Red Cursor: Start of shot

Blue Cursor: Fluid level

In Example Two, below, we again see a graph of fluid at the surface, with successive echoes showing the gas shot traveling from the surface to the fluid and back again multiple times. Note that the first big downward kick after the gas shot is the fluid level.

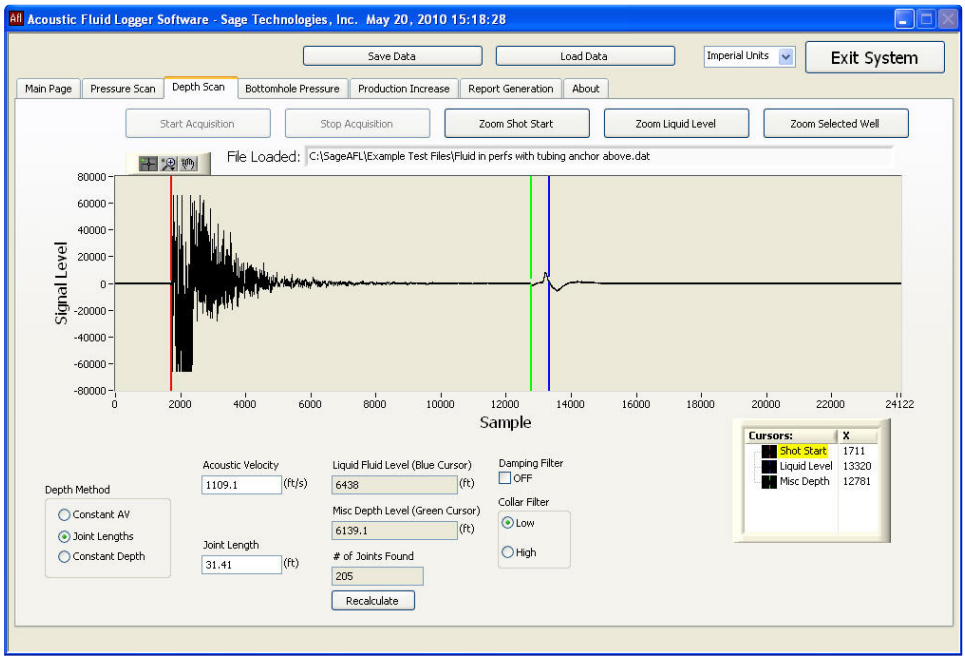
Fluid at Surface: Example Two

Red Cursor: Start of shot

Blue Cursor: Fluid level

Situation 4: Fluid in Perforations with Tubing Anchor

In the fluid level below, fluid is in the perforations, and a tubing anchor at a known depth is above the perforations.



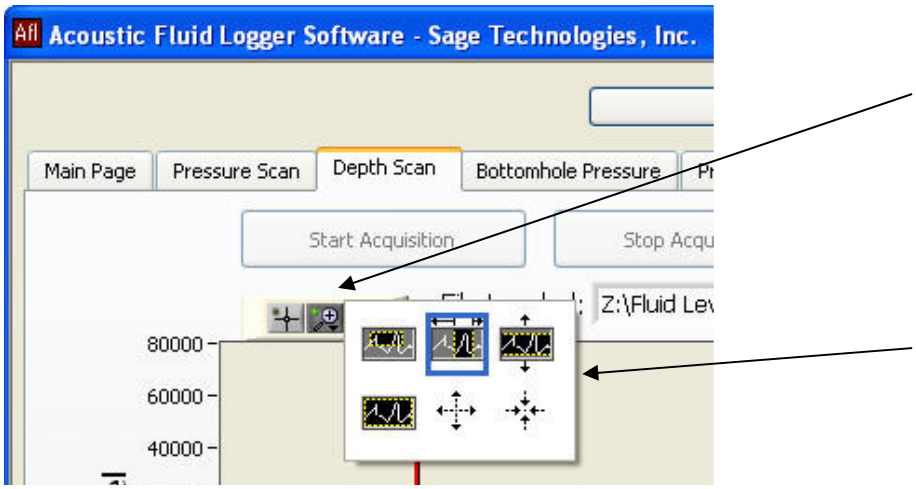
Example: Fluid in Perforations

Red Cursor: Start of shot

Blue Cursor: Supposed fluid level

Green Cursor: Not yet placed at Tubing Anchor depth

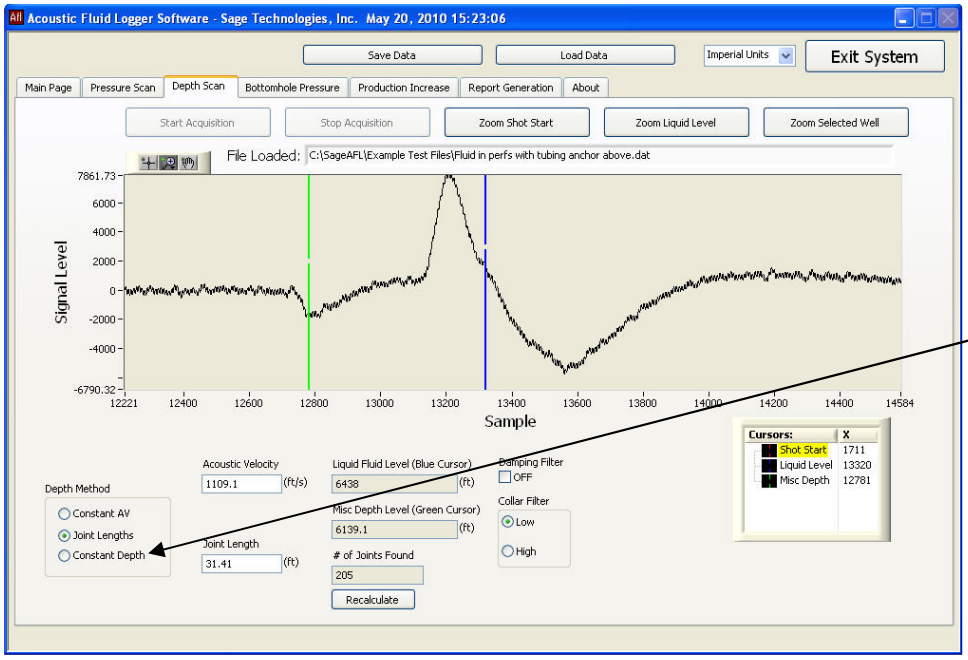
Zoom in on the area of known depth – in this case the Tubing Anchor depth – by clicking on the Zoom Tool (magnifying glass icon), as shown below left. This will bring up the Zoom Option Box, as shown below right. Zoom in to the Tubing Anchor depth. For more on using Zoom Tools, see Pages 50-52.



Click on the Zoom Tool (magnifying glass icon) to bring up the Zoom Option Box.

Use these tools to move the graph to the spot of known depth, where you will be placing the Green Cursor

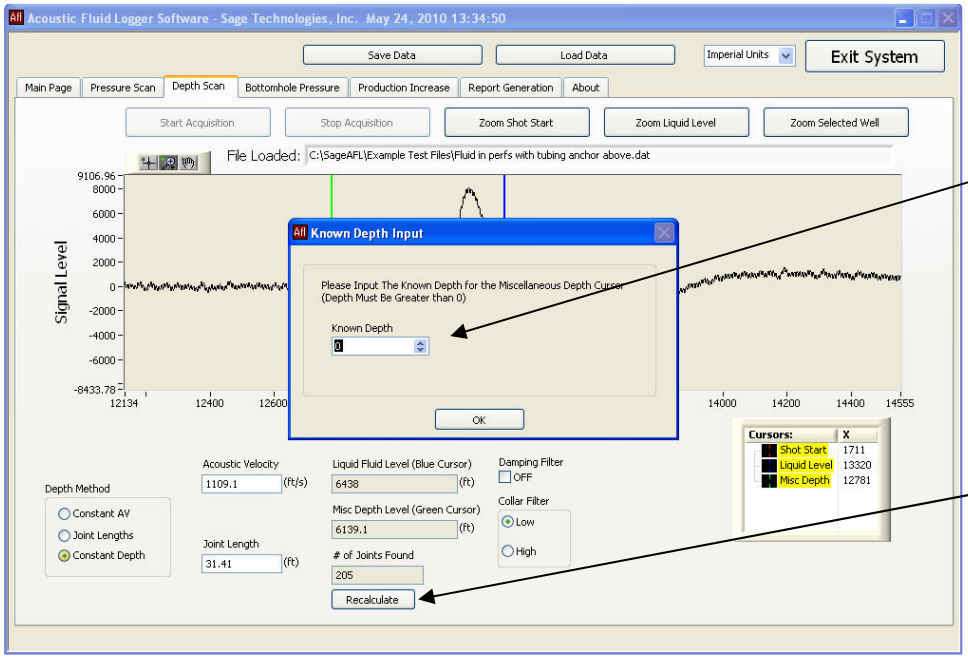
Note the depth at the tubing reported for the Misc. Depth Level (Green Cursor).



Note the Misc. Depth Level (Green Cursor).

If the known depth is incorrect, switch to the Constant Depth method of analysis.

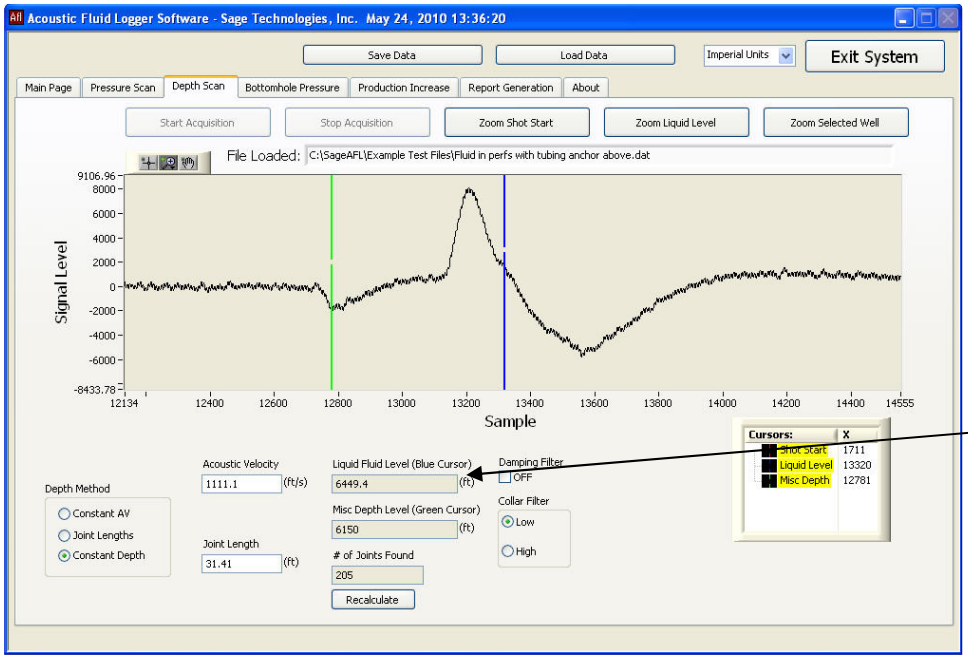
If this is the incorrect known depth, click on the Constant Depth button under the Depth Method. The Known Depth Input box appears. Enter the correct known event (tubing anchor) depth.



Enter the known depth. Click OK.

Then click Recalculate, so the software will use the new numbers in fluid level calculations.

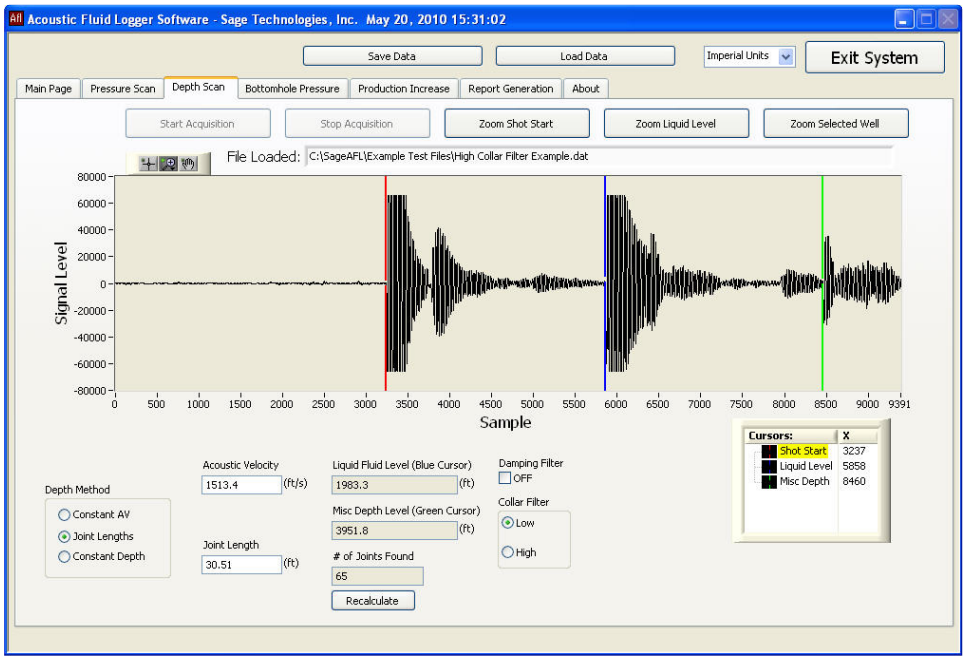
The correct Liquid Fluid Level depth will appear after recalculation.



Read the correct **Liquid Liquid Level**

Situation 5: High Collar Filter

The following graph is an example of a well with very high acoustic velocity. Note that the collars are very close together.

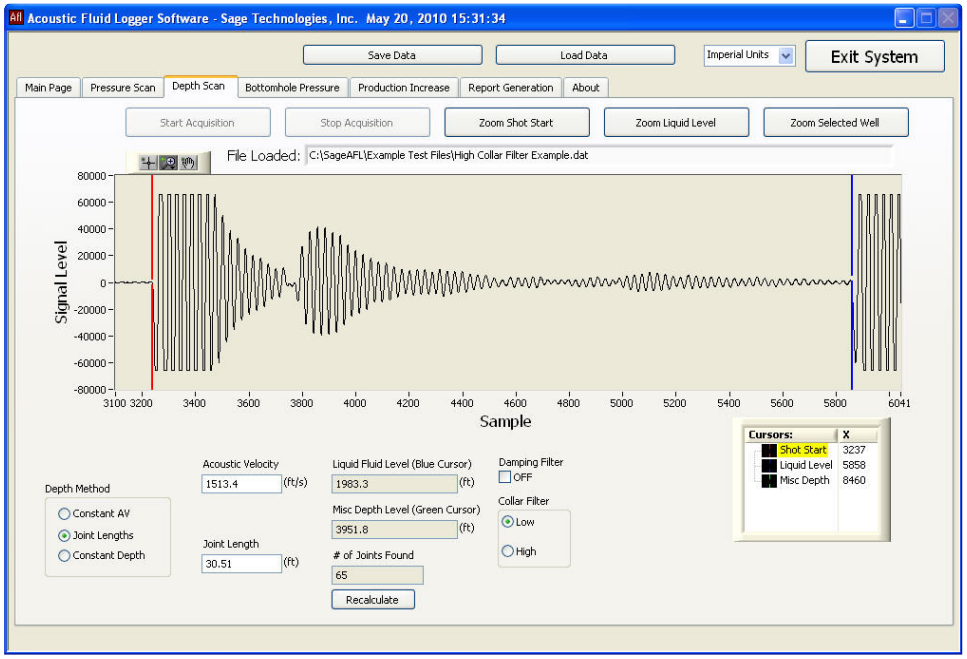


Example: High acoustic velocity in well

Red Cursor: Start of Shot

Blue Cursor: Supposed fluid level

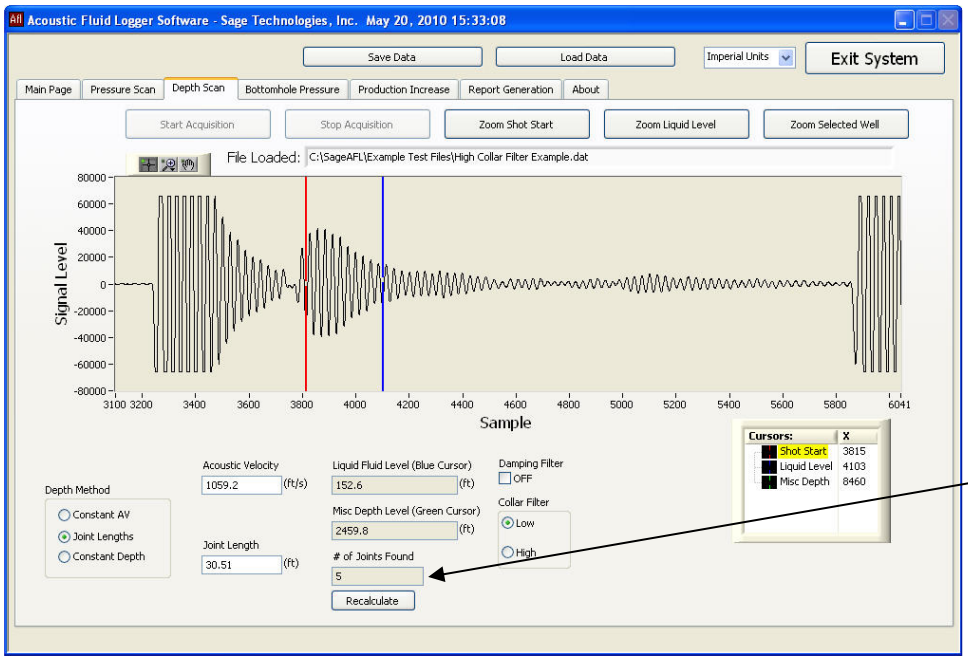
To read this fluid level, we need to zoom in on a single fluid level section. Below, we have zoomed in on the area between the Red Cursor and the Blue Cursor in the above example. Because the collars are still very tight, and very high, we will zoom in again, to better see the collars.



Red Cursor: Start of shot

Blue Cursor: Fluid level

Click and drag the Red Cursor: Start of Shot and the Blue Cursor: Fluid Level to one section of visible collars, as shown below. Note that under "# of Joints Found" box, it reads "5" when 10 collars are readily visible in this zoomed section. We will correct this with the Collar Filter.

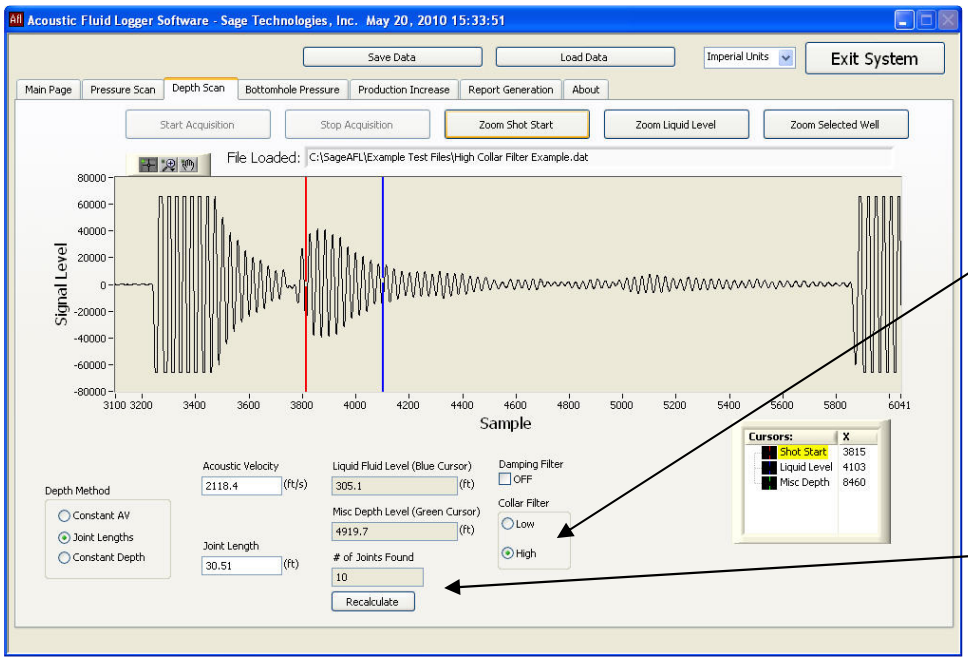


Red Cursor:
Start of zoomed section of collars

Blue Cursor:
End of zoomed section of collars area

# of Joints Found: 5
Looking at the graph, we see that this number is wrong.

Rest the Collar Filter to "High." This resets and corrects the "# of Joints Found" to "10."



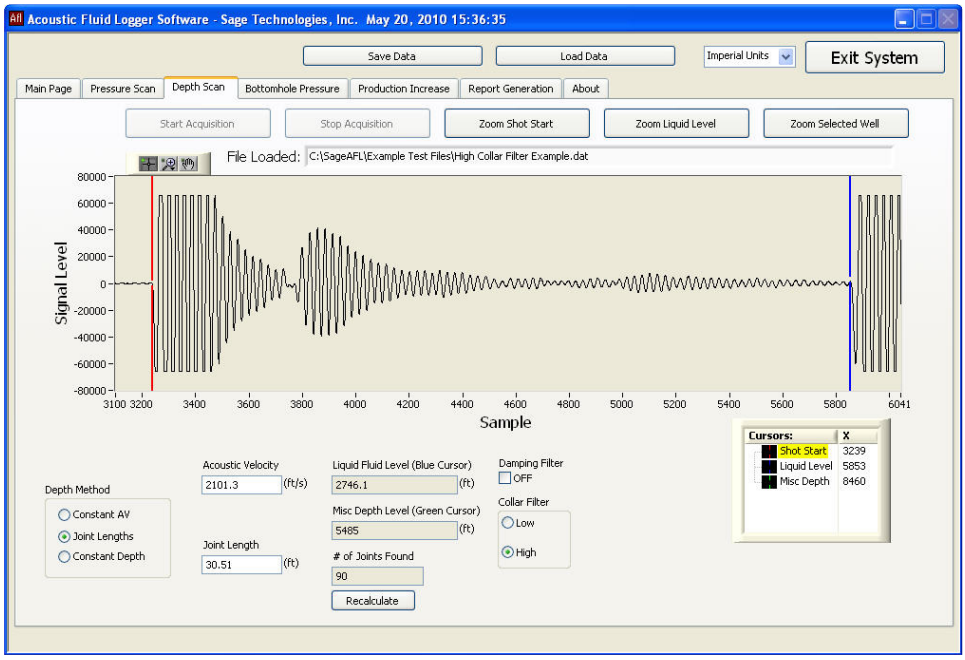
Collar Filter: High

Red Cursor:
Start of zoomed section of collars

Blue Cursor:
End of zoomed section of collars

# of Joints Found: 10

Now to find the fluid level, return the Red Cursor to start of shot and the Blue Cursor to the fluid level downkick. The software will reveal the correct fluid level to be at 90 joints.



Collar Filter: High

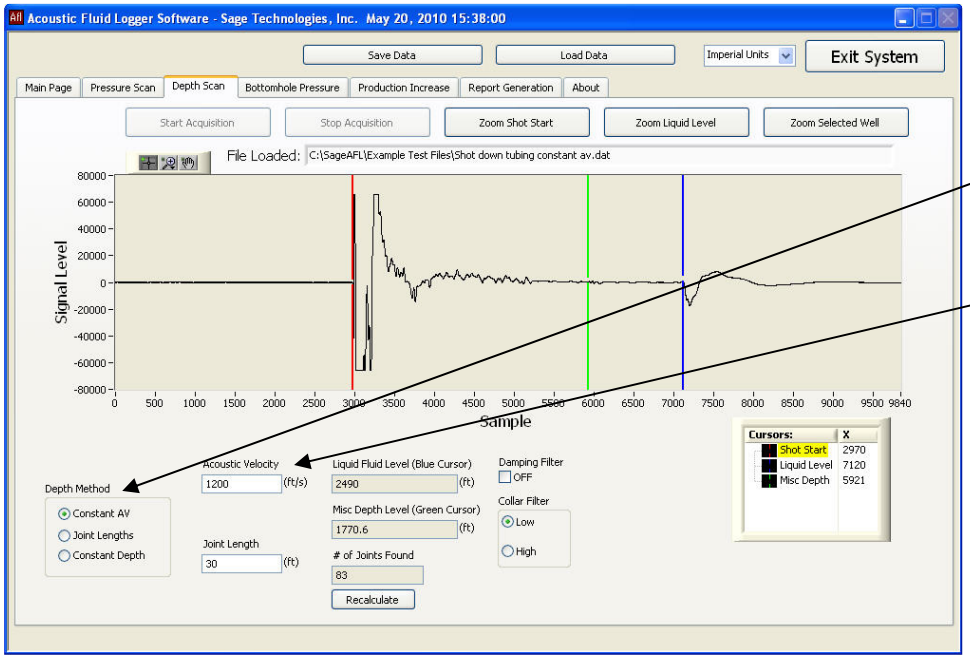
Red Cursor:
Start of Shot

Blue Cursor:
Fluid Level

# of Joints Found:
90

Situation 6: Shooting Fluid Levels Down the Tubing with Constant AV

In this fluid level graph, the Depth Method selected is Constant AV, since the gas shot is shooting down the tubing of the well. There will be no collars to count, but the Constant AV method will produce a fluid level. A good starting point is to set the Acoustic Velocity of 1,200 ft/sec.

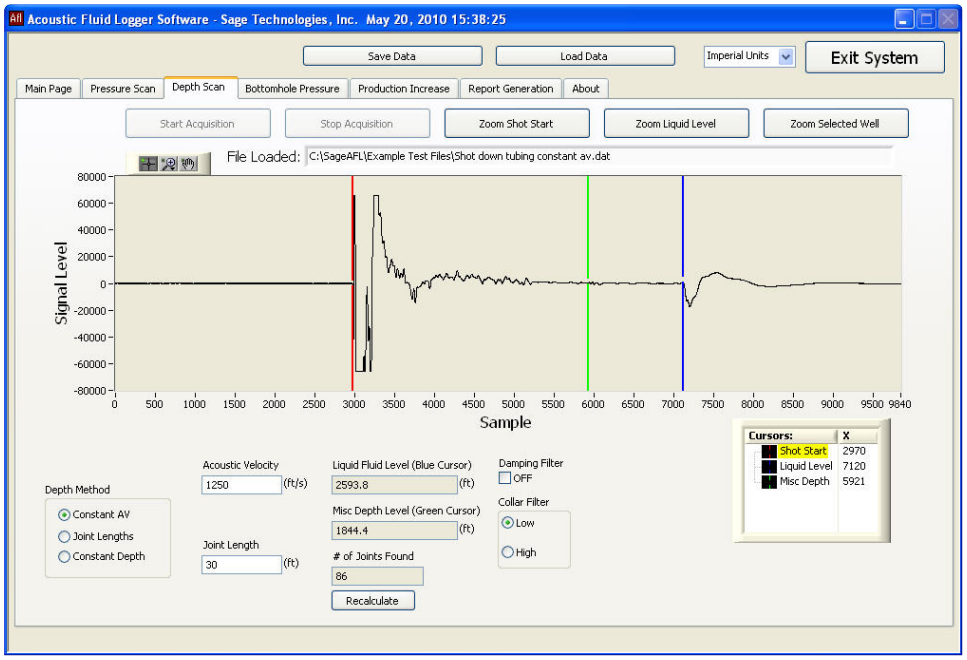


Example Shooting Down the Tubing

Depth Method: Constant AV

Enter the Acoustic Velocity – a good starting point is 1,200 ft/sec

Notice in the example above, with 1,200 ft./sec as the entered Acoustic Velocity, the software finds 83 joints to the fluid. But the depth will change if the acoustic velocity changes. In the example below, with 1250 ft./sec. entered as the Acoustic Velocity, 86 joints to the fluid are found. So, it is important to use an appropriate AV for your field.



Depth Method: Constant AV

Enter the Acoustic Velocity – this is the same as the above example, but with entered A/V of 1,250 ft/sec

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