FREEDOM DATA PC PLATFORM

Crosshole Sonic Logging (CSL)

System Reference Manual

Freedom Data PC with WinCSL Software Version 1.4

Olson Instruments, Inc.

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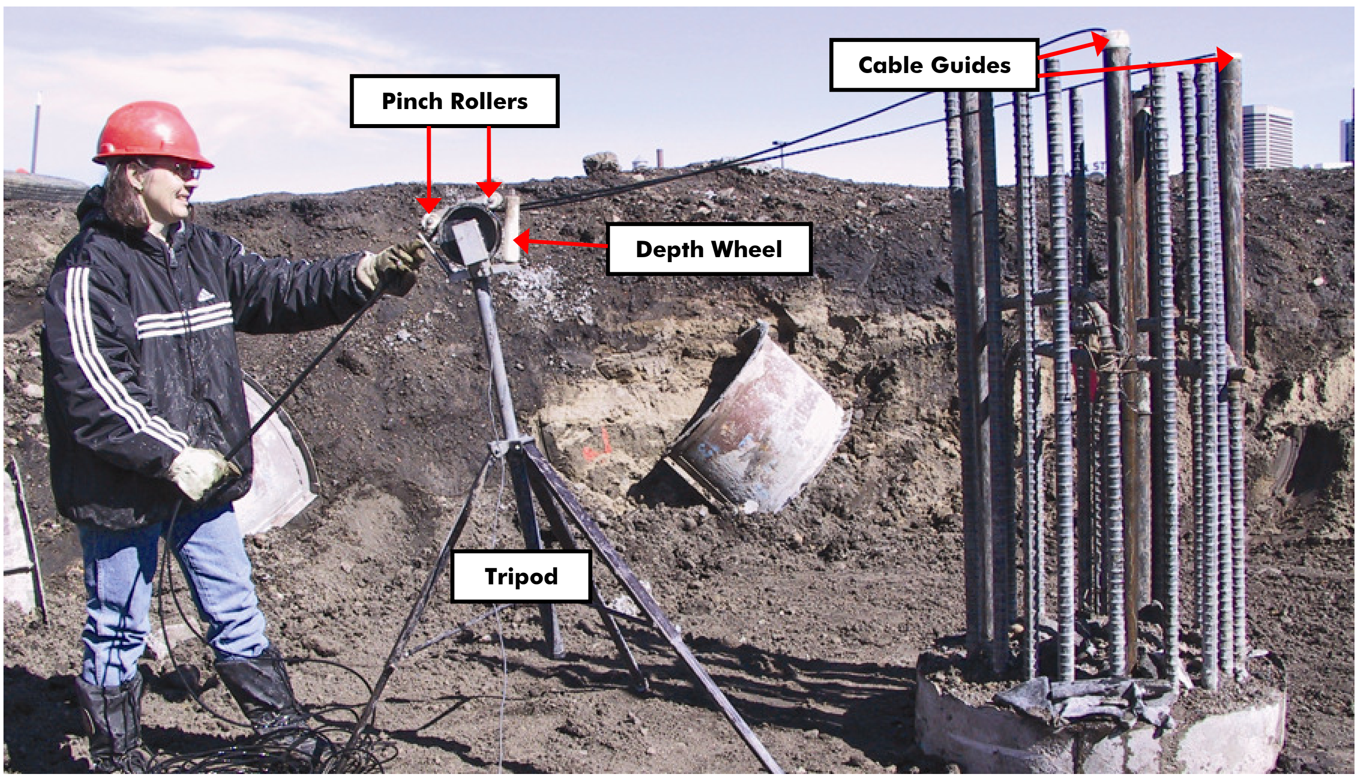
1.0 INTRODUCTION

The Olson Instruments Crosshole Sonic Logging (CSL) system is used for quality assurance testing of a variety of concrete foundations and slurry walls as shown in the figure below. The basic requirement for any structure to be testable by this system is that some form of access (such as cast-in-place tubes or boreholes) must be provided for the transducers. When used for quality assurance testing on drilled shafts, slurry walls, etc, the sonic logging system is a powerful, state-of-the-art tool in verifying concrete integrity, locating defects, and evaluating repair effectiveness.



The Crosshole Sonic Logging system (CSL-1) consists of 4 basic components for most testing applications:

1. Freedom Data PC with high-speed data acquisition card, Windows based WinCSL acquisition and analysis software installed
2. CSL Pulser and Input Modules, installed
3. Depth Measurement Wheel Assembly

4. Interchangeable source/receiver hydrophones (2). CSL-2 option for 3rd hydrophone for two simultaneous logs.

These components are connected with cables to form a complete system (see **Section 3.0**).

The Windows CSL software included in the system is a real time display program supporting circular shaft and rectangle diaphragm wall templates. This includes real time displays of waveforms, first arrival time logs, velocity plots, time and energy logs and waterfall plots.

The Software acquires the data for 1 channel (CSL-1 system) or 2 channels (CSL-2 system) simultaneously. The software can also be used to perform tomographic data acquisition to image defects (with purchase of TOMO-1 option). If a TOMO-1 system is purchased, an additional manual is available for details on tomography data collection and processing. The system is designed/manufactured to be in accordance with ASTM D6760-02 Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing.

This manual covers hardware setup and operation instructions for the Olson Instruments Freedom Data PC CSL-1 and CSL-2 systems. This manual covers step-by-step instructions for data acquisition, data analysis, and report generation (or output generation for tomography that links the summary report and CSL logs directly to a Microsoft Word document).

1.1 Organization and Scope of Manual

This operation manual for the Olson Instruments Crosshole Sonic Logging system includes all required instruction for the use of the software and hardware included with the system. Also included is a troubleshooting guide to help overcome any problems experienced and answer any questions. If any problems occur that are not covered in this manual, please call Olson Instruments at the number included in the front of this manual. Note that training in the use of the system by Olson Instruments personnel is recommended for the most effective operation of this system.

1.2 System Requirements and Components

The Crosshole Sonic Logging system can only be purchased with the OLSON Freedom Data PC (FDPC), as the pulser and amplifier modules are custom designed for this computer. When the system is purchased, Olson Instruments personnel will install the required software. Each software installation is based on the options purchased.

1.3 Test Methodology

Crosshole Sonic Logging (CSL) – The CSL test relies on propagation of ultrasonic waves between two or more **water-filled** access tubes to measure the velocity and signal strength of the propagated waves. The testing can be performed on any concrete foundation provided two or more access tubes or coreholes capable of holding water are present in the foundation. CSL can also be used to check the integrity of underwater concrete piers and foundations by strapping access tubes to the sides. Crosshole Tomography can be performed to image critical anomalies found in CSL tests as discussed. A companion of the CSL test is the Singlehole Sonic Logging (SSL) test, which can be performed in one access tube or corehole to check the integrity of the concrete foundation around the tube in a fashion similar to Gamma-Gamma nuclear density tests.

CSL tests are typically performed on concrete, particularly concrete drilled shafts. Other materials which support transmission of ultrasonic waves can be tested such as: slurry, rock, grout, water saturated media, cemented radioactive wastes.

2.0 FREEDOM DATA PC HARDWARE

The one or two channel Crosshole Sonic Logging system, CSL, consists of several basic components packaged into a padded carrying case plus the Freedom Data PC in its own case. The padded case stores the hydrophones, depth wheel, tripod, and cables. A description of each of these components as well as their connection and operation is included in the following section.

2.1 Main Components of Freedom Data PC

Main Components of Freedom DATA PC

1. Case Latches
2. Backlight Switch Control
3. External Power Supply Jack
4. CRT, LAN USB (2), COM, and Parallel Port Location
5. Lithium Ion Battery pocket with cover in place
6. Input Module
7. Power On/Off Buttons and
   Battery Condition Indicator Lights
8. Pulser Module
9. Mouse Buttons
10. Pressure Relief Valve

Before the computer is turned on, verify that the correct Input (6) and Pulser Module (8) are installed in the computer for the test method you are performing. Each test has its own set of modules that come pre-installed by Olson Instruments, Inc. Should you ever need to remove/replace the modules, the Input Module is installed in the top pocket and the Pulser Module in the bottom pocket.

2.2 Freedom Data PC Hardware Component List

COMPONENT NAME	QTY	DESCRIPTION
 Freedom DATA PC [National Instruments A/D Data Card]	1	12" Diagonal LCD Transflective Screen (1024x768) for Sunlight/Night Viewing, Windows XP based low power 1.1 GHz Intel Pentium M Processor, 512 MB DRAM, 120 GB Hard Drive with external CD-RW, 10/100MB LAN, USB (2), C RT, Serial and Parallel Ports.
 Input Module (top right slot) Newer models will not have rings on thumbscrews	1	Olson Instruments built electronic unit configured for the system method purchased. The CSL Module includes 1 Channel (for CSL-1) or 2 Channel (for CSL-2) hydrophone signal amplification and filtering circuits with internal interface cable to data acquisition card. Mounts into Freedom Data PC top right slot.
 Pulser Module (bottom right slot)	1	Olson Instruments built electronic unit configured for system method purchased. Mounts into the Freedom Data PC bottom right slot. Note: Not all systems require a pulser module, in which case a blank cover plate is substituted into the slot.
 External Power Supply/Charger  12 VDC Automobile Adapter	1	120/240 VAC 50-60 Hz autoswitching power supply for Freedom Data PC plus 12 volt DC Automobile Adapter.
 Lithium Ion Batteries	1	Shown with the cover removed, exposing 2 Internal Lithium Ion Batteries, with 8 to 10 hours of operation time.

2.3 Freedom Data PC Hardware Setup

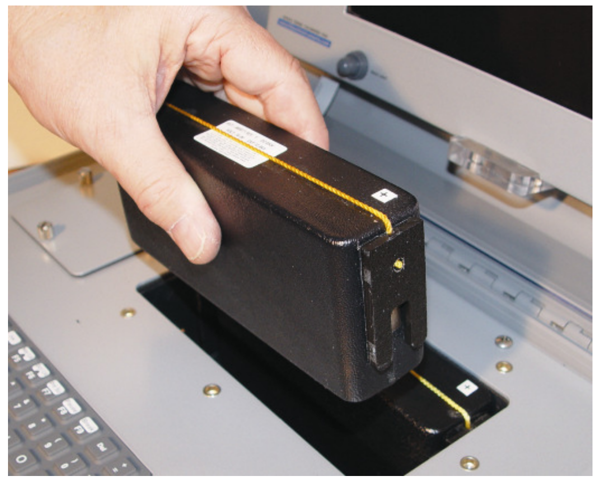
A step-by-step procedure for connecting the various system components is illustrated below. Please refer to these figures during connection of the components.

1. Lay the instrument case and Freedom Data PC down on a flat, stable surface. Unlock the case if locked. Next, open the Freedom Data PC case. The location of the Freedom PC should be within 15 m (50 ft) of the subject/material to be tested.

2. Next, if desired, connect the Freedom Data PC to the external power supply with the 120/240 VAC Power Supply/Charger. The external power supply/charger automatically switches between120/240 Volts AC.

The computer is designed to be resistant to light rain or other moisture but should not be exposed to heavy rain.

3. BATTERY INSTALLATION: If it is necessary to replace the batteries, remove the battery cover as shown. Insert both batteries with the (+) polarity to the right (photo below).



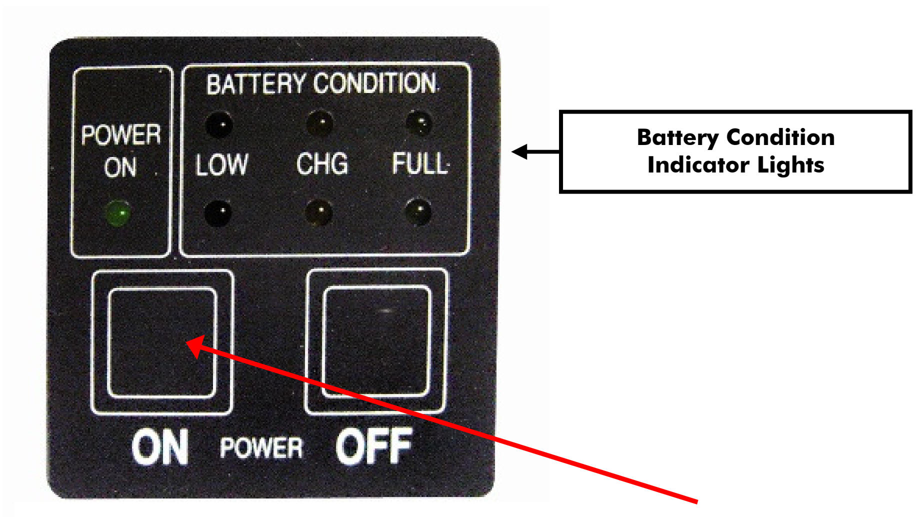
Fully charged batteries should power the IE system for 8 – 10 hours depending on the processor speed of the unit used. The Freedom Data PC can also be powered from a car cigarette lighter socket using a 12 VDC adapter. However, this may drain a weak car battery in a few hours if the engine is not running.

BATTERY CONDITION INDICATOR LIGHTS
Green Light – Batteries are fully charged
Yellow Light – Batteries are charging
Red Light – Low Battery, ~ 15 minutes usage left, apply external power supply at this point

2.4 Freedom Data PC Hardware Operation

After the Freedom Data PC hardware is properly set up, operation is straightforward and primarily involves the use of the Freedom Data PC and the installed modules. The use of the Input Module and Pulser Module is described in this section.

1. Power



Power on Freedom Data PC by pressing the "ON" Button as shown.

If the battery LED is ***red***, do not try to operate the computer, as the batteries are very low. In this case, the system should be run on external power rather than off the batteries. Charging of the batteries will begin once external power is attached. A running automobile outputs approximately 14.2 VDC, which will charge the batteries to around 85% of full charge. To achieve 100% charging power, use the 16 VDC AC powered external power supply that is shipped with your instrument.

> ***When operating the computer on external power with partially or fully discharged batteries, a "Fault" light may appear after a period of time. This yellow flashing light is normal, and is due to the combined current drain of the computer operation and the battery charge current. The batteries will charge normally when the power supply is connected with the computer shut off (such as overnight). Totally drained batteries will require 12 – 13 hours for full charging.***

2.4.1 Freedom Data PC Operation Notes

The Freedom Data PC is a self-contained data conditioning, collection, and processing platform usable for a number of types of NDT tasks as well as general data acquisition. The data acquisition tasks for which the Freedom Data PC is capable, depends on the modules installed (up to two at a time). The following section discusses the basics of the hardware operation of the Freedom Data PC, including module replacement, battery charging and replacement, external powering, and general maintenance.

2.4.1.1 General Maintenance and Usage

The Freedom Data PC is a rugged unit designed for field conditions. It is normally water and air tight when closed and latched, which will protect it in most storage and transportation conditions.

While the Freedom Data PC is watertight when closed, it is water resistant (not water tight) when open or operating. Thus, rain or other normal moisture should not bother the unit, but it should **NOT** be submerged or sprayed at high pressure. Also, water should not be allowed to collect on the face of the computer unit.

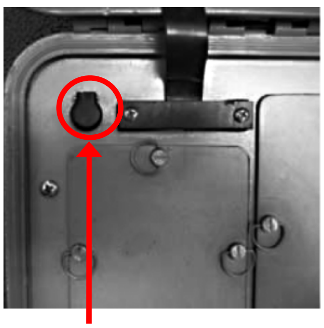
> ⚠ ***Never expose the external power supply/charger to rain or moisture.***

When used in a field environment, the Freedom Data PC should be expected to get dirty. If this happens, wipe the unit with a damp (not wet), clean towel. Do not allow water to flow into any of the components, and do not wipe the screen with a dry or dirty towel.

> ⚠ ***The screen is subject to damage if impacted or pressed on.***

2.4.1.2 Battery Charging and Usage

The batteries inside the Freedom Data PC consist of 2 sealed units, each of which is 12 VDC, 11 Ampere-Hours. Depending on the usage, these batteries should last for 8-12 hours of continuous use. After this, the batteries should be recharged or switched out with a fully charged pair. The batteries used are Lithium Ion batteries with internal protection circuitry. There is no memory effect, so batteries can be used freely with only a partial charge.



External power supply jack

Opening battery cover

Cover removed, exposing 2 Lithium Ion batteries

Charging the Batteries

1. Turn off “POWER” to the Freedom Data PC.
2. Plug the external power supply/charger into the jack in the upper left-hand corner on the front panel of the unit (top left photo). The yellow “CHARGE” lights will come on for each battery for the bulk of the charge cycle. At 85% of capacity, the green “FULL” lights will light, with all lights out when the battery is completely charged. Always charge the batteries in a protected environment, at normal room temperatures. The batteries red “charge” light indicates that the batteries are nearly fully drained and need recharging.

To prolong battery life, always recharge the batteries immediately after use.

Do not disassemble, incinerate, short out, or otherwise abuse the batteries as there is a possible risk of fire or explosion.

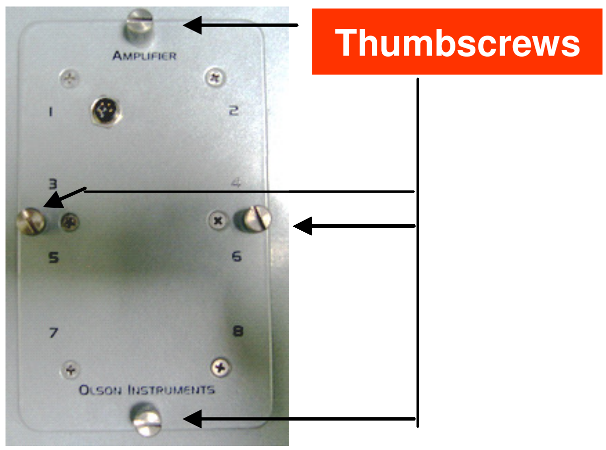
If power is available at the field site (110/220 VAC), the external power supply/charger can be used to power the Freedom Data PC with or without batteries installed. The external power supply/charger will run the unit and start to charge the batteries if installed. Note that the Freedom Data PC should be turned OFF before connecting or disconnecting the external power supply/charger. Disconnecting the power supply/charger during operation may cause the Freedom PC to reboot and lose data in memory, especially if the batteries are very low. If it does reboot, turn off power, then turn on again for normal operation. A 12VDC adaptor can also be used to power the unit off of a car battery.

Notes on maximizing battery life. The following can help maximize the run-time of the batteries:

- Turn off the computer when not in use (when moving or setting up other equipment)
- Use external power when easily available
- Recharge the batteries immediately after each use to preserve capacity

2.4.1.3 Removing/Replacing Batteries and Modules

The batteries and Amplifier/Pulser Modules on the Freedom Data PC are field replaceable. They all use thumbscrew fasteners for securing. To remove the modules, turn off power to the Freedom Data PC, disconnect all cables from the module, and unscrew the thumbscrews counterclockwise. Then pull up firmly and evenly on the screws to remove the module. To replace, simply press the module fully into the slot and tighten the screws.



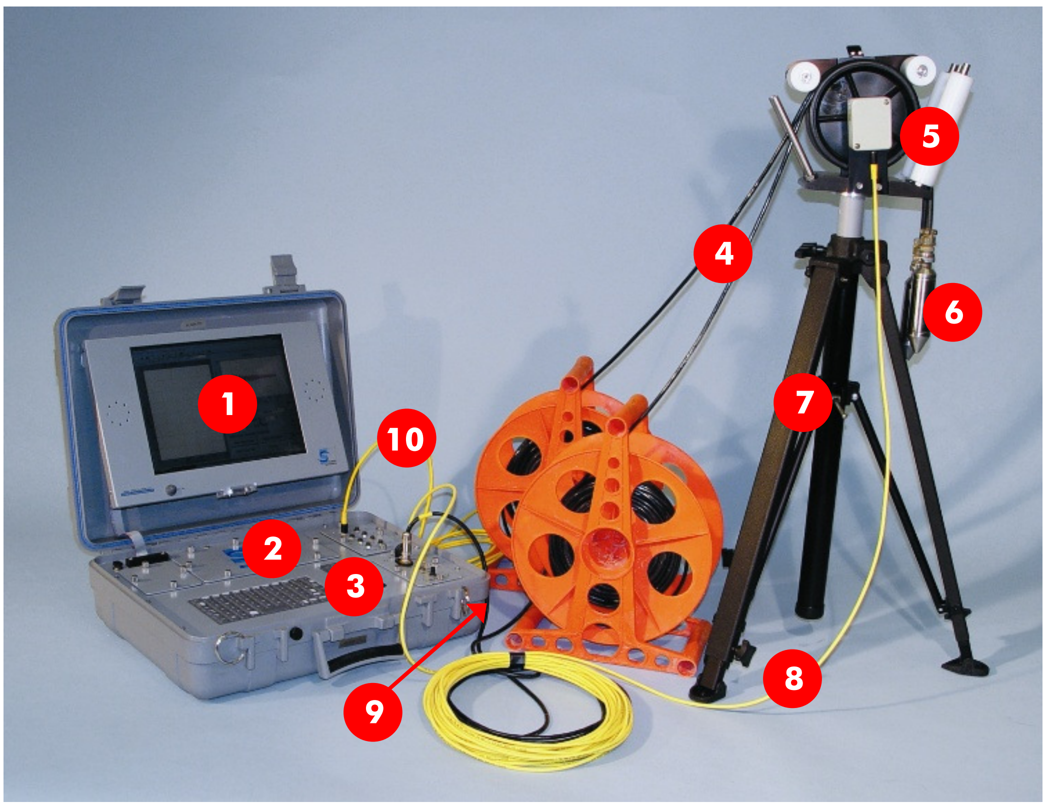
The amplifier module should be in the upper position and the pulser module, if required, in the lower position. No damage will occur by switching the locations, but no signal will be coupled from the amplifier module to the data acquisition card, and thus the modules must be placed in the right position.

Replacing the batteries in the Freedom Data PC is a similar operation. Unscrew the 8 thumbscrews then lift off the battery cover. The battery cover should lift up freely. Next, lift the batteries out by the lifting cord. Install new batteries by dropping them into the compartment (they are keyed for polarity and cannot be inserted wrong). Replace the cover. Finally, press and tighten each of the thumbscrews.

3.0 CSL HARDWARE SETUP

3.1 Equipment List for Crosshole Sonic Logging (CSL)

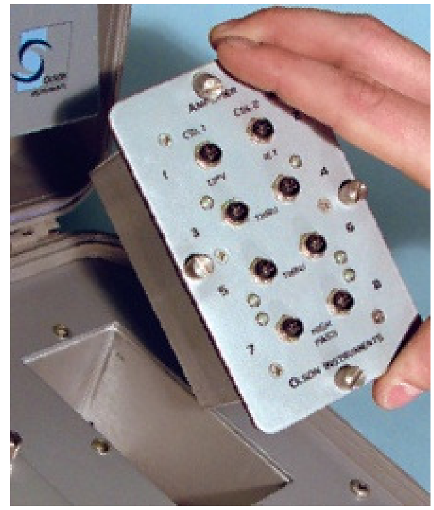
(1) - 1 Olson Freedom Data PC
(2) - 1 CSL Input Module (1 Channel High Pass)
(3) - 1 CSL Pulser Module
(4) - 2 Orange Reels of CSL Cable (3 Pin MS to Phone Jack)
(5) - 1 Depth Wheel
(6) - 2 Hydrophones
(7) - 1 Tripod
(8) - 1 Depth Wheel Cable (Yellow Cable, 3 Pin Adapter)
(9) - 1 CSL Source Cable (Phone Plug to Phone Plug)
(10) - 1 CSL Receiver Cable (Phone Plug to 4 Pin Adapter)
(11) - 4 Cable Guides (2- 1-1/2" diameter, 2- 2" diameter guides)



Equipment/Software Required for Testing Not Shown in Photo:
- 1 Tape Measure
- Latest CSL2 Software
- Field Notebook & Pen

3.2 Step by Step Guide for Hardware Setup

1. Insert the Input Module



After opening the Freedom Data PC, insert the input module into the top module pocket if not already present. This pocket is reserved for the input module.

2. Insert the Pulser Module

Next insert the CSL Pulser module into the bottom right module pocket if not already present. This pocket is reserved for the pulser module.

3. Secure Modules

Now that the modules for this test are resting in their appropriate module pockets, hand-tighten the screws on each module to secure them into the Freedom Data PC. The screws must be properly aligned with the holes in the Freedom Data PC.

4. Set Up the Tripod

a. Open the tripod's legs by loosening the locking lever connected to the center of the tripod and pulling the legs in the outward direction.

b. Set the tripod to the desired height and tighten the locking lever by hand.

c. Loosen and tighten the thumbscrew at the bottom of each leg to adjust the legs of the tripod.

d. The center of the tripod can be raised or lowered by adjusting the knob at the top of the tripod.


4a

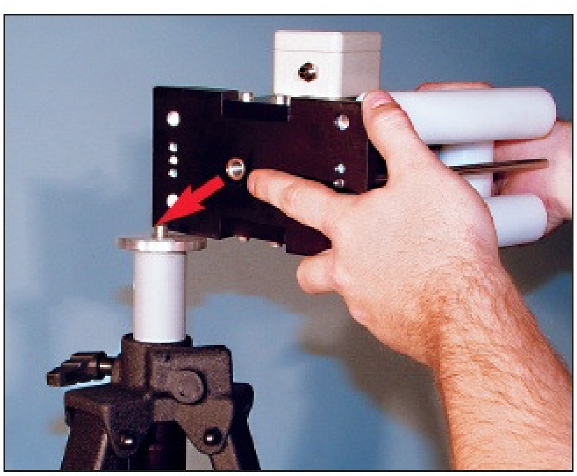

4b

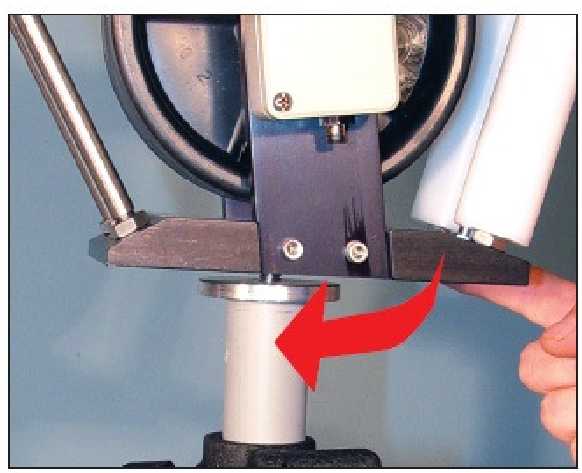

4c


4d

5. Attach Depth Wheel to Tripod

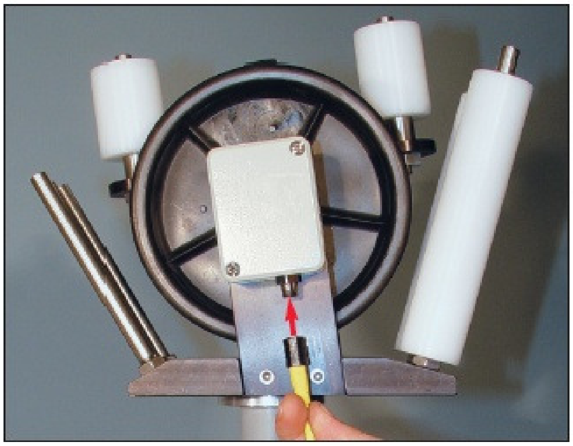
a. Carefully screw the depth wheel onto the tripod by aligning the screw with the hole in the bottom of the depth wheel. Rotate clockwise and hand-tighten.

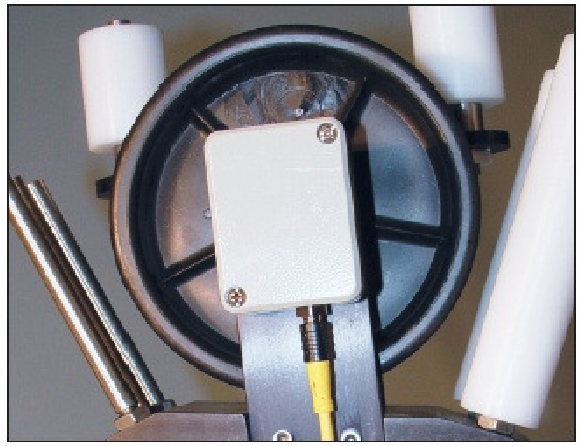




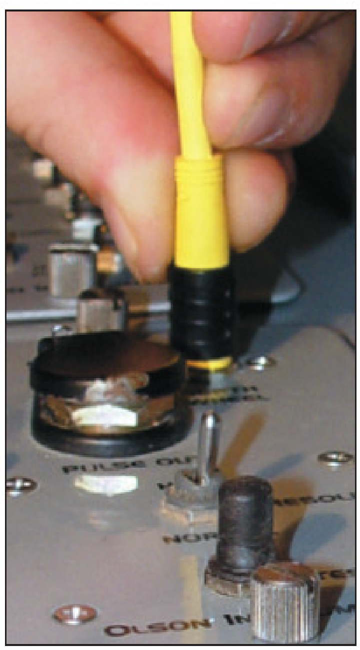
6. Connect Depth Wheel to Freedom Data PC

a. Attach the yellow three-pin depth wheel cable to the encoder on the depth wheel. This is done by pulling back on the small black sleeve at the end of the cable and carefully lining up the three holes on the cable with the three pins on the encoder.



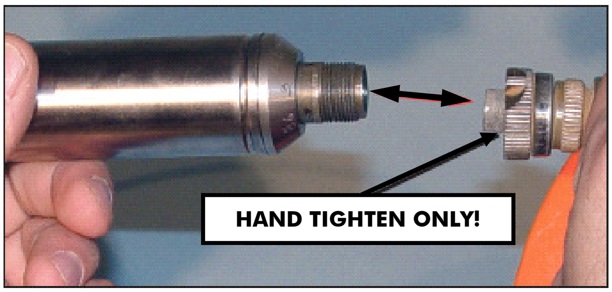


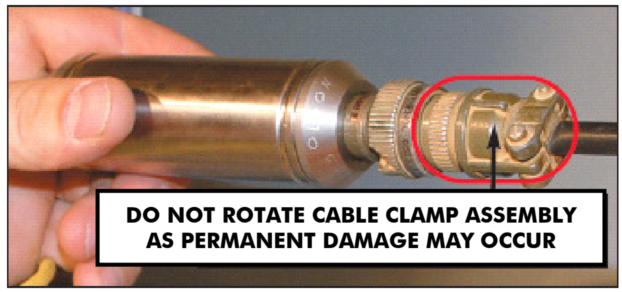
b. The other end of the yellow cable will then attach to the pulser module on the computer. Attach the cable to the input port on the pulser module labeled "DEPTH WHEEL" by aligning the three pins with their appropriate holes.



7. Connect Hydrophone to CSL Cable

Attach a hydrophone to one of the orange reels of CSL cable by aligning the three pins of the hydrophone with the three holes on the 3-pin MS end of the CSL cable and carefully hand-tighten the hydrophone to the cable as you push the connector in. Reverse the step to remove the hydrophone(s).

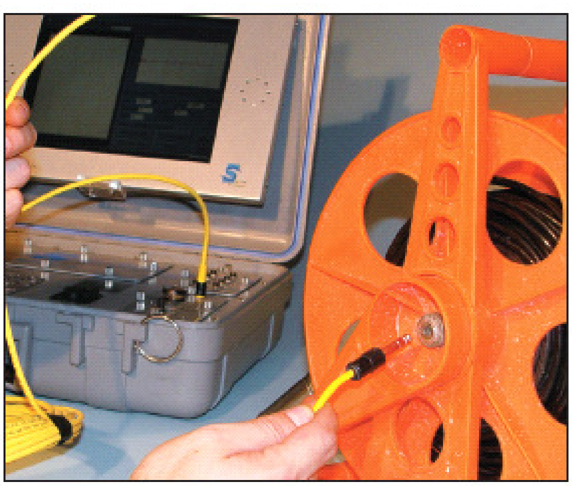




The transducers are subject to damage if impacted. NEVER *drop a transducer, or allow one to swing on a cable end and impact any hard object. Olson Instruments* DOES NOT WARRANTY *transducers against physical damage.*

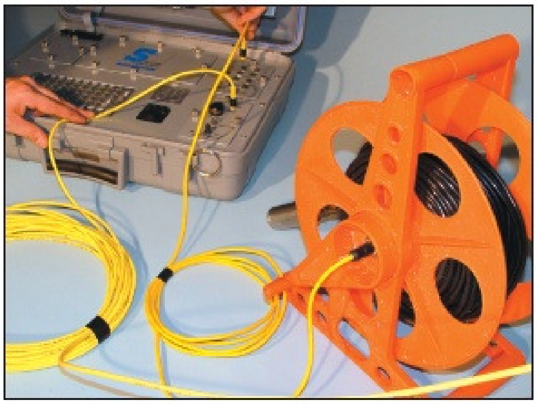
8. Connect Adapter Cable to CSL Cable

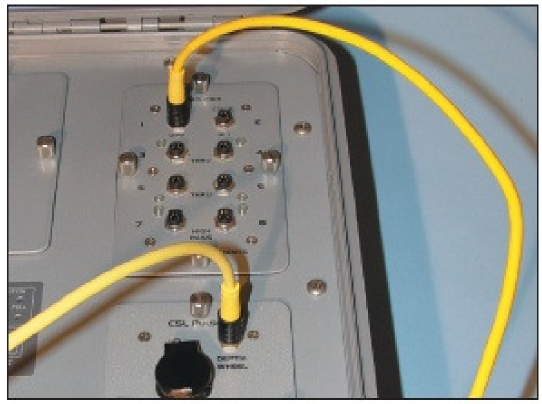
Next attach the yellow receiver cable to the side of an orange reel of CSL cable. The phone plug can simply be inserted into the side of the orange spool by pushing it in; alignment is not necessary. The yellow cable will have a four-pin connection on the other end of it to connect to the input module on the Freedom Data PC.



9. Connect Adapter Cable to Input Module

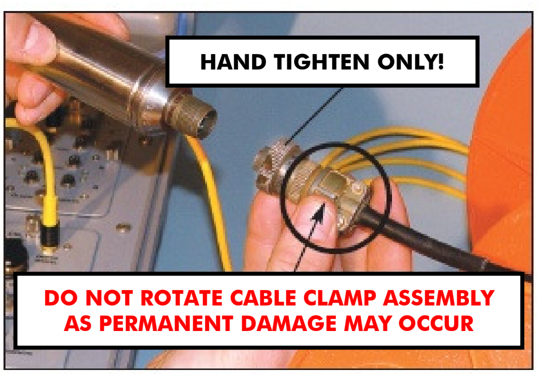
Once the phone plug has been securely attached to the orange spool, the four-pin adapter can be attached to the computer. This can be done by pulling back on the small black sleeve at the end of the cable and carefully lining up the four holes on the cable with the four pins on the input module.

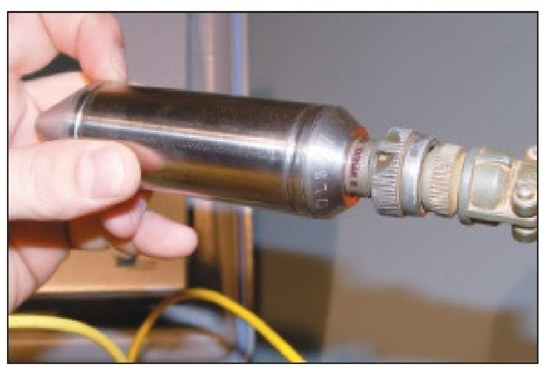




10. Connect Hydrophone to CSL Cable

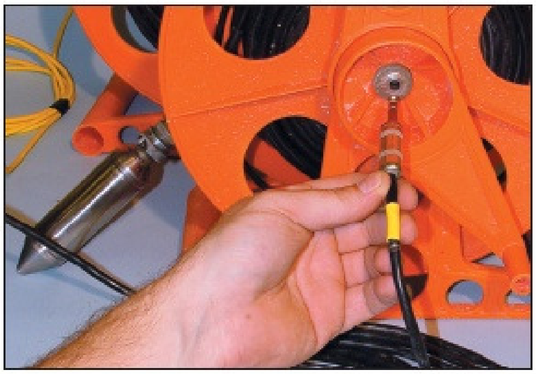
Next you will need to attach the other hydrophone to the other orange reel of CSL cable. Attach the hydrophone to the CSL cable by aligning the three pins of the hydrophone with the three corresponding holes on the 3-pin MS end of the CSL cable and carefully hand-tighten.





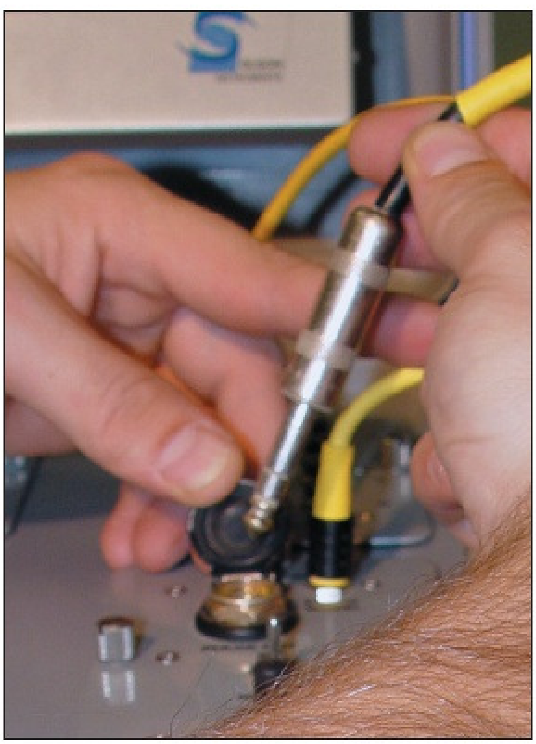
11. Connect Adapter Cable to CSL Cable

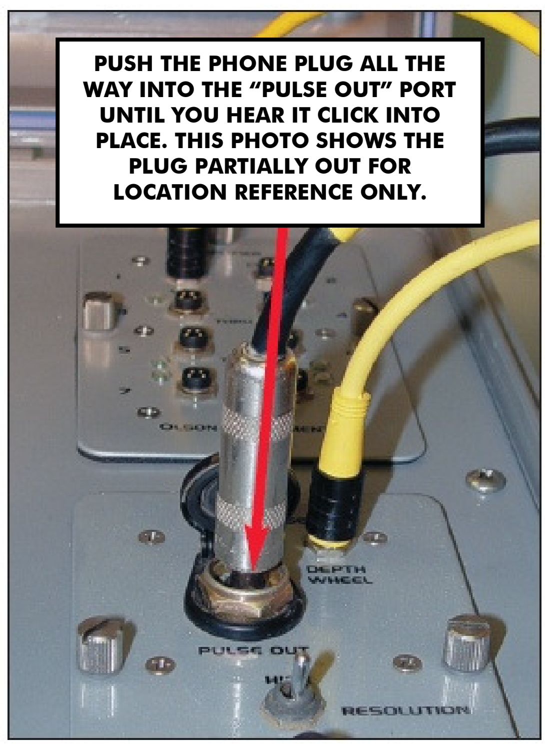
Attach the phone plug source cable to the side of the 2nd orange reel of CSL cable. Both ends of the cable have phone plug adapters. Insert one of the phone plugs into the side of the orange reel by pushing it in; alignment is not necessary.



12. Connect Adapter Cable to Pulser Module

Once the phone plug has been securely attached to the 2nd orange reel, the other end can be attached to the pulser module on the computer. Insert the phone plug into the pulser module where the words “PULSE OUT” appear. Lift the black cover and insert the phone plug fully until you hear it click.





13. Align CSL Cables on Depth Wheel

The Depth Wheel requires the downhole cables to be placed in the grooves of the wheel for accurate depth measurements. Refer to the following steps:

13a -Squeeze latch spring and rotate pinch roller assembly upward at the same time, as shown.

13b - Holding wires, rotate pinch roller assembly back to LOCK position.

13c - Slack adjusted in cable, rollers in LOCK position.

- Squeeze the pinch roller latch spring with one hand and with your other hand, rotate the pinch roller assembly upwards until it can go no further (photo 13a).
- Place downhole cables in outer grooves of depth wheel. You will not use the center groove for the CSL-1 test. Pull cables enough to remove any slack in the downhole cable, leaving the hydrophones at bottom of tubes.
- While holding slack from cables, rotate pinch roller assembly back to its LOCK position (photo 13b and photo 13c).
- It is now OK to let go of the cables as the one way clutch in the depth wheel prevents cables from going slack.

4.0 CSL FIELD TEST PROCEDURE

You are now ready to begin Field Testing Procedures using CSL. The following are the simplified steps that need to be followed in order to collect data in the field:

1. Set up the equipment at the test site as described in **Section 3** - the CSL Hardware Setup.

2. Place the tripod with depth wheel 3 - 6 feet (1 - 2m) away from the shaft and ensure the depth wheel is higher in elevation than the tops of the test tubes. Failure to properly elevate the depth wheel will result in slippage and improper depth measurements.

3. Assign tube numbers to each of the test tubes, starting with 1 (one) and increasing in a clockwise order. If testing more than one shaft, it is recommended to have tube 1 on all shafts oriented in the same direction (i.e. northernmost tube).

4. Measure tube spacing for all tube pairs (center of tube to center of tube).

5. Set up the computer for WinCSL data acquisition as described in **Section 6**.

6. Lower hydrophones in the first tube pair (1 - 2) and ensure cable guides are properly inserted. Inserting the cable guides will prevent abrasion of the cables. Failure to insert the cable guides will decrease the life of the hydrophone cables.

7. Ensure that the tips of the hydrophones are gently resting at the bottom of the test tubes. The hydrophones should be within 3 - 6 inches (7.5 - 15cm) of each other in elevation in order to collect accurate data. The bottom can be felt by removing all slack in the cables and gently raising and lowering the hydrophone several inches (cm).

8. Once the hydrophones are at the proper elevation, lock the cables into the depth wheel to prevent slippage.

9. Test the signal and set the gain as described in **Section 6.5**. If a strong signal is displayed, proceed to step 10. If the signal is weak (requiring too high a gain) or not seen at all, check all connections and re-adjust hydrophone elevations to ensure they within 3 - 6 inches (7.5 - 15cm) in elevation from each other and not laying on their sides. Test signal and repeat if necessary.

10. Start WinCSL data acquisition as described in **Section 6.6** of the manual.

11. Raise both of the hydrophones at same time, at a rate of no faster than 2 ft/second. (0.6m/s). When the hydrophones reach the top of the test tubes, make sure that the hydrophones are within 6 inches (15cm) or less in elevation of each other. If the elevation difference is greater than 6 inches, (15cm), repeat Steps 5 - 9 for the same tube pair. If the tubes are of different lengths, repeat the log and measure the cables for the source and receiver hydrophones to lower them to the depth of the shortest tube.

12. If the hydrophones are within six inches in elevation of each other, **Finish Logging** the data set for this tube pair.

13. Place the hydrophones and cable guards in the next tube pair. It is strongly recommended to unlock the depth wheel before moving the hydrophones in order to prevent knocking over the tripod.

14. Repeat Steps 7 - 12 until all tube pairs have been tested.

Photo showing field testing setup and procedure

5.0 WinCSL SOFTWARE SETUP

The software for the CSL System is pre-installed and thoroughly tested at the manufacturer. If for any reason you need to reinstall/uninstall the software, or if you are installing software on a desktop/laptop computer, the steps required are included in this section.

5.1 WinCSL Software Installation

1. National Instruments Data Acquisition (NIDAQ) software is necessary to run the Olson Instruments WinCSL program. Your FDPC was supplied with the required version of NIDAQ and a copy was included on a separate jump drive for installation on your personal computer. The NIDAQ driver can be downloaded at:

http://joule.ni.com/nidu/cds/view/p/id/2888/lang/en

It is very important to uninstall any previous versions of NIDAQ before installing a new version.

NIDAQ Version 9.5 is required for Windows XP, Vista, Windows 7 – 32 bit and 64 bit.

There are two options for retrieving the driver from the web. The first option and the more stable option is to download the NI Downloader. The second option is to download the zip file. The second option can be a less stable experience for downloading files, especially if the download is unintentionally interrupted due to dropped connectivity. Note that an account (free of charge) may be required to proceed to the download page.

!

Failure to install the prerequisites will result in an error when running the WinCSL software.

Installing the WinCSL Software:

2. Uninstall the previous version of WinCSL
3. Run “WinCSL Setup.exe” from the Olson Instruments installation jump drive
4. Follow the default setup
5. After finishing the installation, the “WinCSL.exe” file will be found on: C:\Program Files\Olson Instruments\WinCSL\ for the 32 bit system and C:\Program Files (x86)\Olson Instruments\WinCSL for the 64 bit system. The shortcut to “WinCSL.exe” will be placed on the desktop

!

Failure to uninstall the previous version of WinCSL will prevent the installation of the new version.

5.2 WinCSL Software Uninstallation

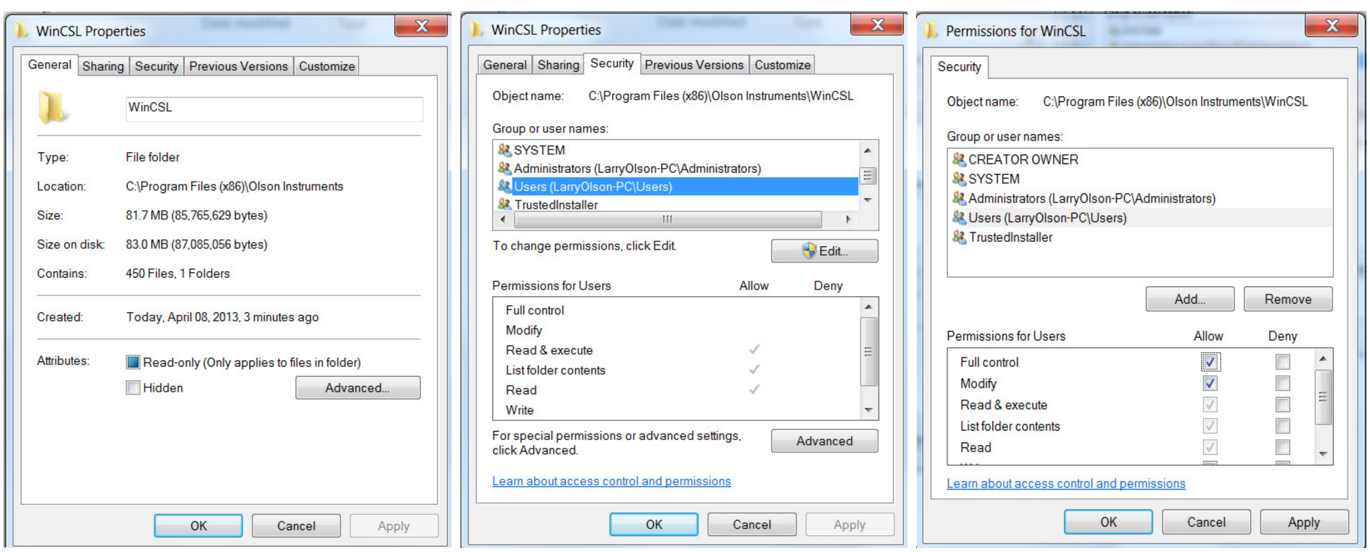
1. Click on Start/Settings/Control Panel
2. Select “Add/Remove Programs”
3. Highlight WinCSL Setup, select “Remove”

The uninstall process will begin automatically, removing all installed components including shortcuts. This uninstall process might take up to five minutes. Do not exit the installation until it is completed.

5.3 Before Running the WinCSL Software on Windows 7 or Vista

On Windows 7 and Vista operating systems, the files installed from the installer are automatically marked as “read only”. The WinCSL file uses several parameter files that allow the user to save customized parameters into these files. Therefore, the steps below must be performed to ensure that Windows allows access to these files.

1. Per the figure below, the “Read Only” check box must be unclicked for the following files: parameter.prm, printparameter.prm and template.prm. This is to ensure that the WinCSL software can save the parameters into these files for a customized setup.
2. Full permission must be allowed for the user profile per the figure below.

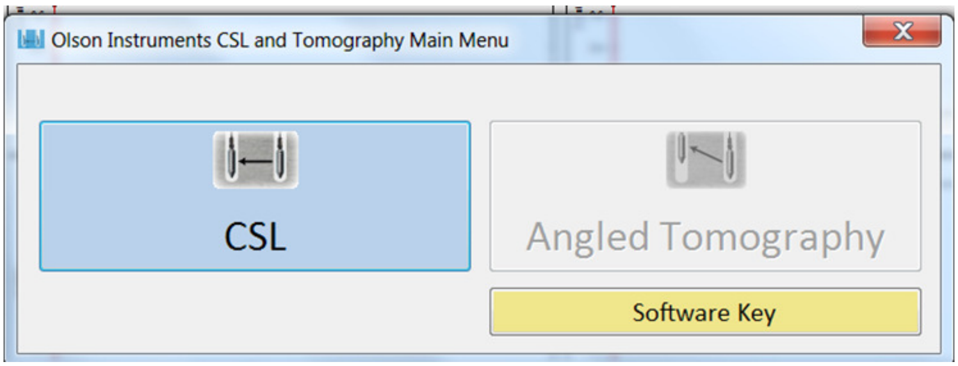


These steps are not necessary for Windows XP.

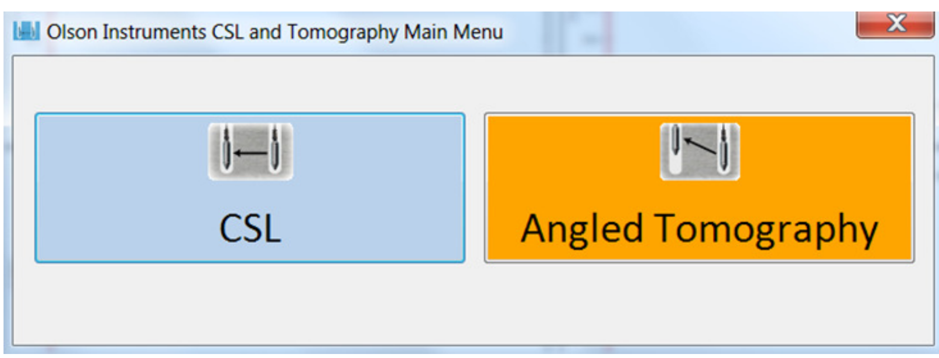
6.0 GUIDE TO CSL DATA ACQUISITION

6.1 Start WinCSL Software

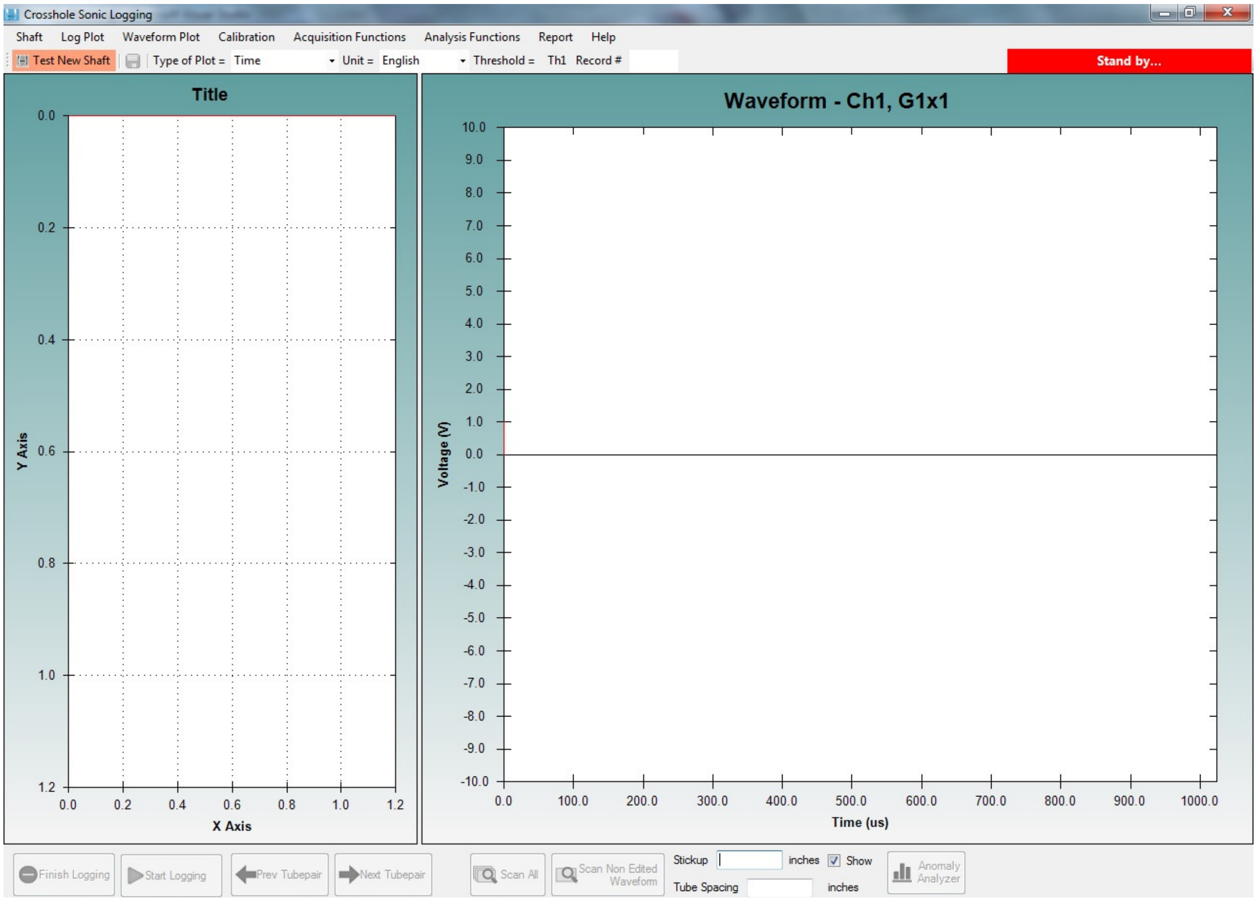
1. Locate the "WinCSL.exe" file or its shortcut
2. Double click on either the "WinCSL.exe" file or the shortcut on the desktop
3. The following dialog box should appear on the screen if the Tomography option is not included in the package.



4. If the Tomography option is purchased with the package, the following dialog box will appear on the screen. Note that the software Key button will not be visible.



5. Click on the CSL Button (or just press Enter – the default is the CSL button) to perform the CSL test to acquire data, and the program will open the following screen with a plot box on the right side of the screen to display individual waveform records and a plot box on the left side of the screen to display a log of the arrival times for all of the waveform records.

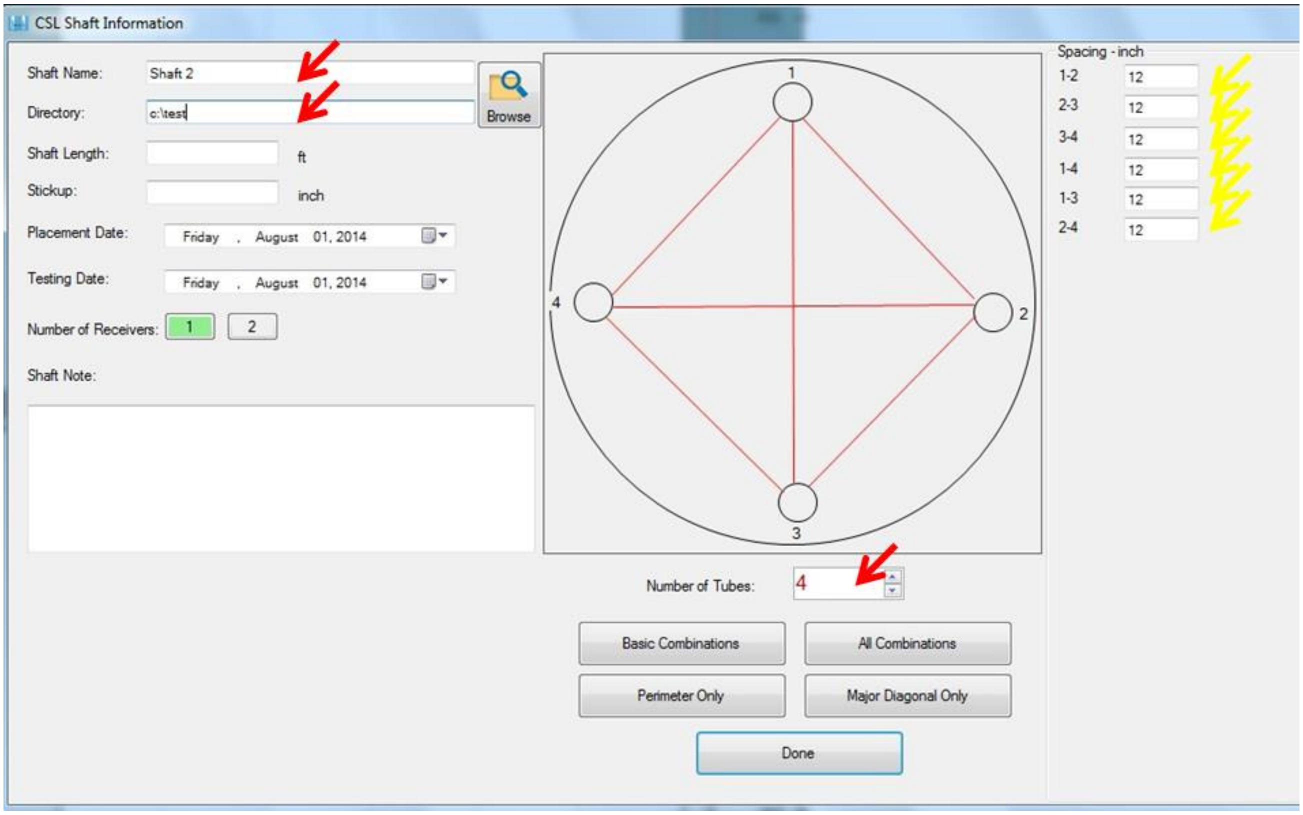


At this time, the "Type of Plot" can be selected from the dropdown menu on the toolbar. The "Time" plot is the suggested option for display during data acquisition. Other options are not recommended for use during data acquisition because the high resolution display and other calculations slow down the program and affect the computer's ability to collect data.

At this time, English or Metric units can also be selected from the dropdown menu on the toolbar. If the software detects the existence of data acquisition, it will automatically highlight the "Test New Shaft" button. Note that the software highlights buttons with light red to guide the user to the next suggested step.

6.2 Set Up Shaft Information

1. Select "Test New Shaft" by clicking on the "Test New Shaft" button (highlighted in light red color as shown in the figure above). You can also use the shortcut 'F1' to start a new shaft.



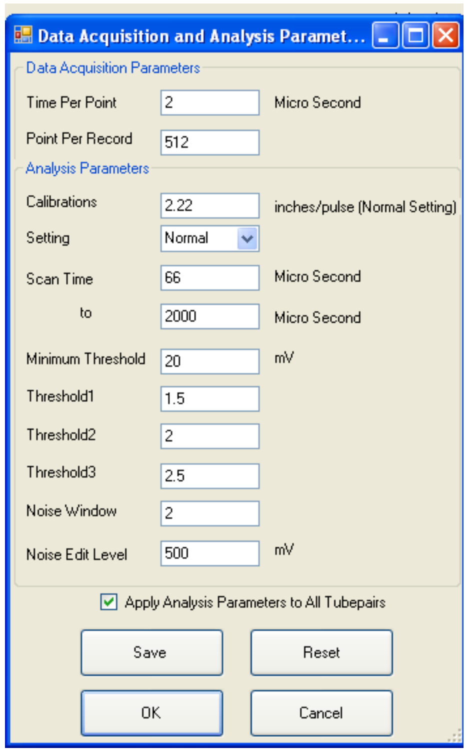
Fill in the "CSL Shaft Information" dialog box per the guidelines below.

1. Enter the desired shaft name in the top entry field. This name will be used as a filename when saved. <u>This field input is mandatory.</u>
2. Use the second entry field to create a new directory if the directory does not already exist. If the directory already exists, you can click on the "Browse" button to select the existing directory. <u>This field input is mandatory</u>.
3. Use the third entry field to enter the estimated shaft length. This field input is not mandatory. If this field is not filled in, an estimated length of 40 ft will be assumed. This shaft length will be used in a real time, first arrival time scanning. After the logging process is completed, the actual shaft depth will be calculated based on the depth wheel calibration and the actual number of records collected.
4. Use the fourth entry field to enter an average measured tube stickup height above the top of the shaft. This field input is not mandatory. This stickup will be used in real time first arrival time scanning only. This data can be changed after the data collection is complete.
5. Check the date in the fifth entry field. It will default to the current date, using the computer's calendar, but should be changed to reflect the placement date. This field is mandatory if the report generation option is desired. However, this placement date can be changed later in the analysis.

6. Check the date in the sixth entry field. It will default to the current date, using the computer's calendar. If the date is wrong, enter the correct date. Correct the clock on the Freedom Data PC if necessary. This field is required if the report generation option is desired.
7. Click on the correct number of receivers in the seventh entry field. For CSL-1 with two hydrophones (1 receiver and 1 source) enter 1. For CSL-2 with three hydrophones (2 receivers and 1 source) enter 2. CSL-2 allows for faster data collection by simultaneously acquiring data from two tube pairs at the same time.
8. A large entry field is available at the bottom of the dialog box for any necessary notes or comments such as cracked concrete, water below tops of tubes, etc. This field is not required.
9. Enter the number of access tubes in the entry field below the shaft diagram in the center of the dialog box. This field is mandatory and cannot be changed later in the analysis. Four buttons are available to facilitate selection of the number of tubes, "Basic Combinations", "All Combinations", "Perimeter Only" and "Major Diagonal Only".
10. Use the entry fields on the right side of the dialog box to enter the measured center-to-center spacing between tube pairs. These entry fields can be accessed by clicking on the shaft diagram showing the tube pair combinations. This input is not mandatory during the data collection, but strongly suggested since some of the scanning parameters are calculated from tube spacing. If they are not entered during data collection, a spacing value of 12 inches will be assumed between each tube pair and the calculated velocity during real time data collection will not be correct. In addition, the real time scan may not be correct due to the assumed parameters.
11. When all of the information is entered, click on the "Done" button at the bottom center of the "CSL Shaft Information" Dialog Box to proceed to the next screen.

6.3 Set up Parameters for Data Acquisition and Analysis

After you have completed the "CSL Shaft Information" form, the "Data Acquisition and Analysis Parameters" dialog box will appear with the default settings as shown below. These parameters can also be accessed by going to the Main Menu and clicking on "Shaft/Acquisition and Analysis Parameters". The software will reload the default data collection parameters from the file parameter.prm on program start-up, and then will automatically adjust the scan time parameter based on current input (such as tube spacing).



Fill in the "Data Acquisition and Analysis Parameters" dialog box per the guidelines below.

1. Time Per Point is the sampling rate. In the example case show above, the default is set at 2 microseconds. This means the system will acquire data at 2 microsecond intervals. For the CSL-2 system with 2 transducers, the minimum Time Per Point is 2 microseconds and for the CSL-1 system, the minimum Time Per Point is 1 microsecond. This value can not be changed after the data is collected.
2. Points per Record is the number of sampling points for each waveform. The higher this value, the more data acquired in each waveform (also dependent on Time Per Point). This value can not be changed after the data is collected.
3. Depth Wheel Calibration is specific to each depth wheel. In the example case shown above, the depth wheel calibration is 2.2. This means that the CSL system will produce a pulse every 2.2 inches (5.6 cm).
4. The Depth Wheel Pulse Setting can be set to two different pulse interval options:

   1. "Normal" pulses approximately every 2 inches (5 cm) per the calibration value.
   2. "High Resolution" pulses at ¼ the calibration value for four times as much data.

   The default value for the Depth Wheel Pulse Setting is "Normal". The Normal setting is appropriate for data collected using the Normal switch on the CSL pulser module (down position for Normal). The High Resolution setting is appropriate for data collected using the High switch on the CSL pulser module (up position for High).

The recommended Pulse Setting for a regular CSL test is “Normal”

5. There are two entry fields for Scan Time. The initial scan time value is calculated from the input tube spacing (with an assumed faster concrete velocity of 15,000 ft/sec or 4570 meter/sec) and the finish scan time value is 2000 microseconds unless changed by the user.

6. Minimum Threshold is the minimum voltage level that can be accepted as a CSL signal arrival in millivolts (mV).

7. Threshold 1 is the multiplier that is applied to the maximum background noise in the Noise Window to set the threshold for each record that the signal must be greater than (positive or negative) to pick the signal arrival time. Threshold 1 must be less than Threshold 2 and a typical value might be 1.5 (ranging from 0.8 to 2 depending on signal).

8. Threshold 2 is the second multiplier threshold and it must be greater than Threshold 1 and less than Threshold 3.

9. Threshold 3 is the third multiplier and it must be greater than Threshold 2.

10. The value entered into the Noise Window entry field is a divisor that is used to define the Noise Window preceding the CSL signal. This window is used to evaluate the background noise and set the thresholds mentioned above. The available range of the Noise Window begins at time zero and ends at the initial scan time. A Noise Window value of 2 divides this range in half and only considers the noise signal in the last half of the range. A Noise Window value of 4 divides the range into fourths and only considers the noise signal in the last quarter of the range.

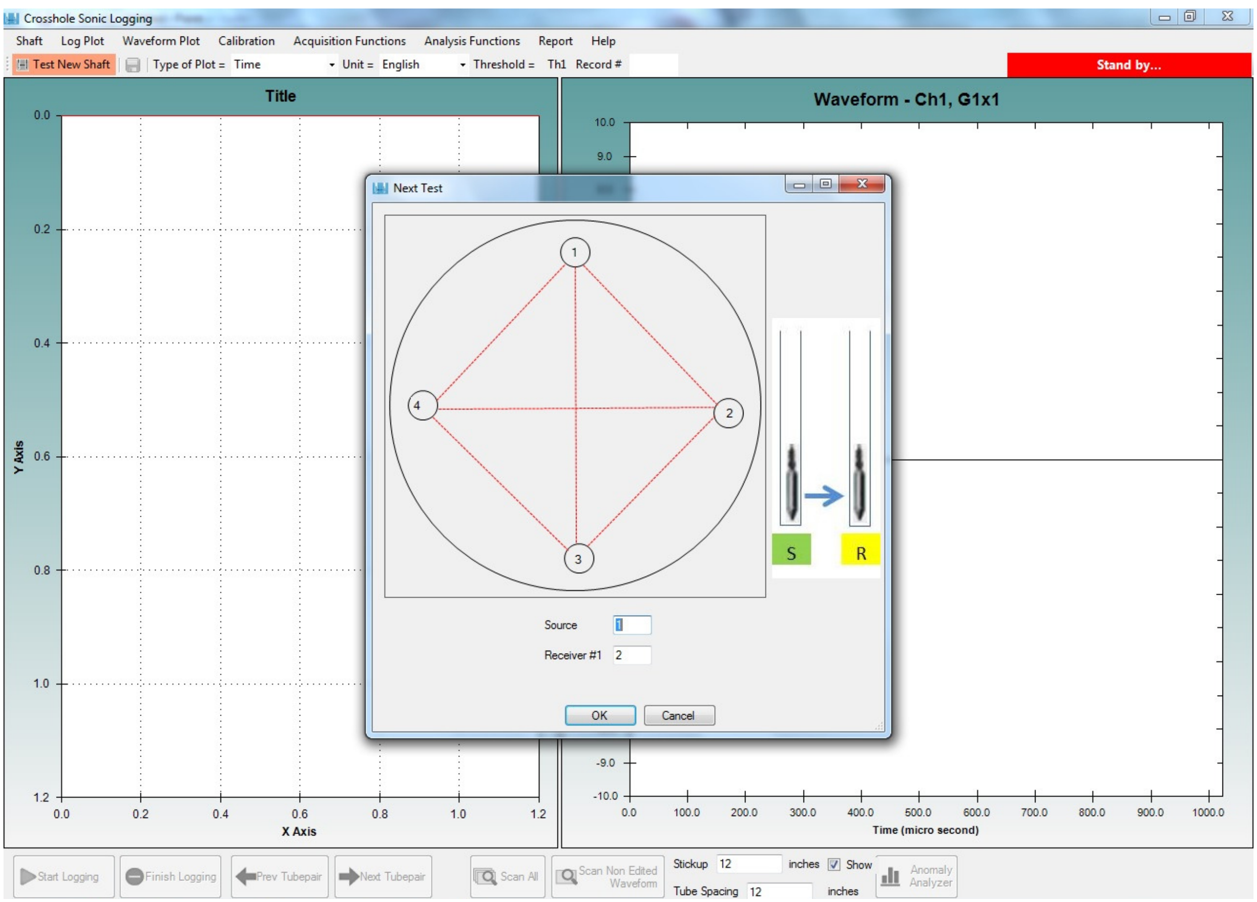
11. Noise Edit Level is the signal voltage level at which, if a noisy signal (from hydrophone receiver bouncing) exceeds this value in mV, then the CSL log is marked with a black dot at the signal arrival time. A typical value is 1000 mV, while setting this value to 10000 mV turns off the automatic Noise Edit Level feature.

After the data parameters are set, the user can apply these parameters to all tube pairs for the current shaft by clicking the appropriate box labeled “Apply Analysis Parameters to All Tube Pairs”. Then the user can choose to continue by clicking the “OK” button. If the user wants to save these parameters to the default file to be used at the next startup, the “Save” button should be used. The “Reset” button can be used to revert to the most recently saved default settings. The “Cancel” button can be used to cancel any changes entered during the current session.

After clicking on the “OK” button, the Windows “Save As” dialog box will appear. After you have selected the desired file name, click on the “Save” button.

6.4 Select Tube Pair

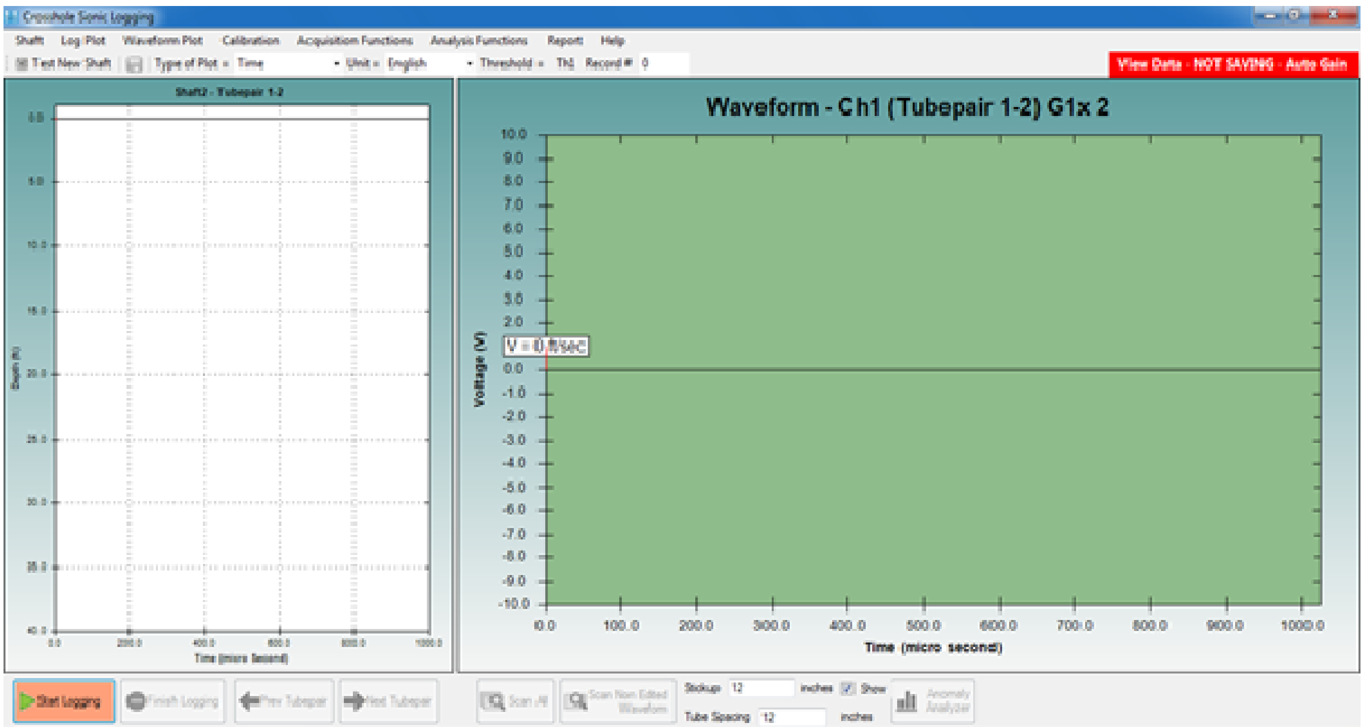
After you have completed the “Data Acquisition and Acquisition/Analysis Parameters” form, the “Next Test” Dialog Box will appear with a diagram of the shaft top to help you select your first tube pair. The diagram of the shaft top will display a solid red line between untested tube pairs and a solid blue line between tested tube pairs. Tube pairs will be automatically suggested but can also be selected by manually typing in the individual tube pair numbers. Note that for the CSL-2 system (2 receivers), the tube pairs will not be automatically suggested and the tube pairs must be input manually.



When a tube pair has been selected or input, click on the “OK” button or press Enter to continue.

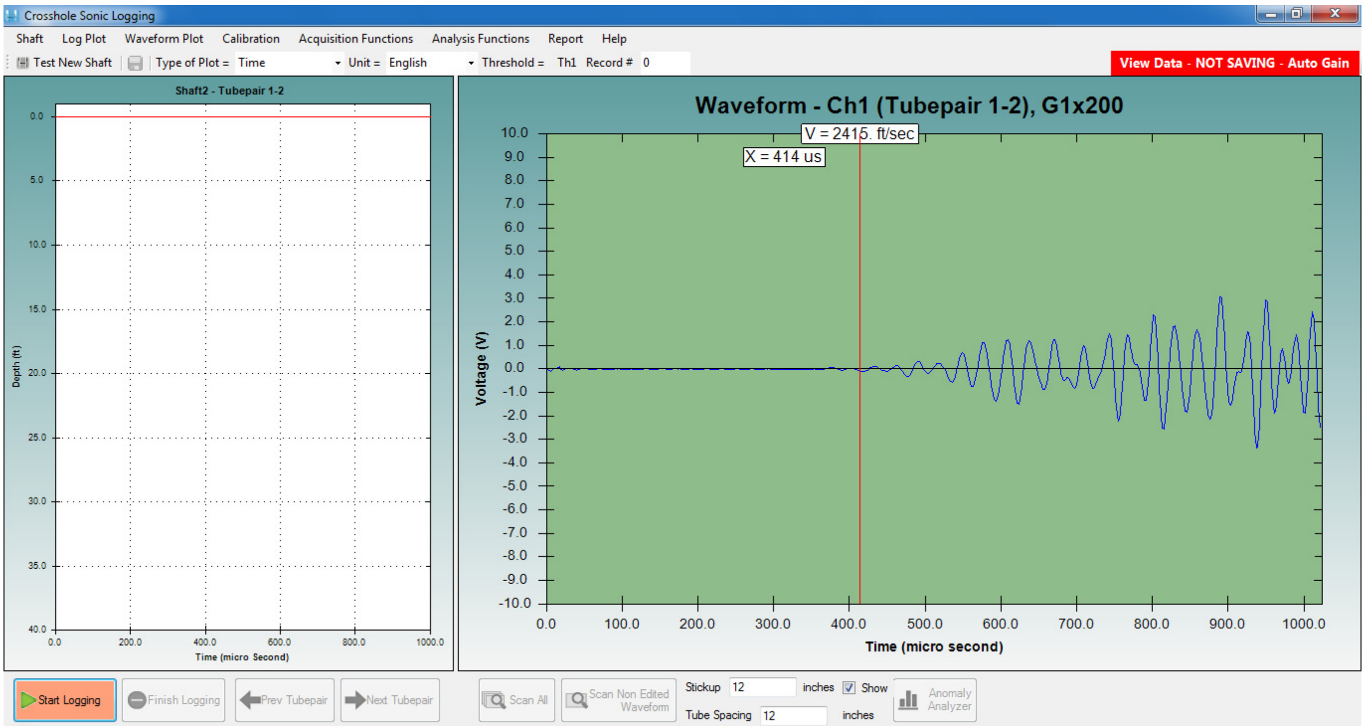
6.5 Establish Gain

When the data collection screen appears on the monitor, it will be in view mode as the status box will display “View Data – NOT SAVING – Auto Gain” and the program will allow the user to view the waveform signal in order to set the gain without recording the data.

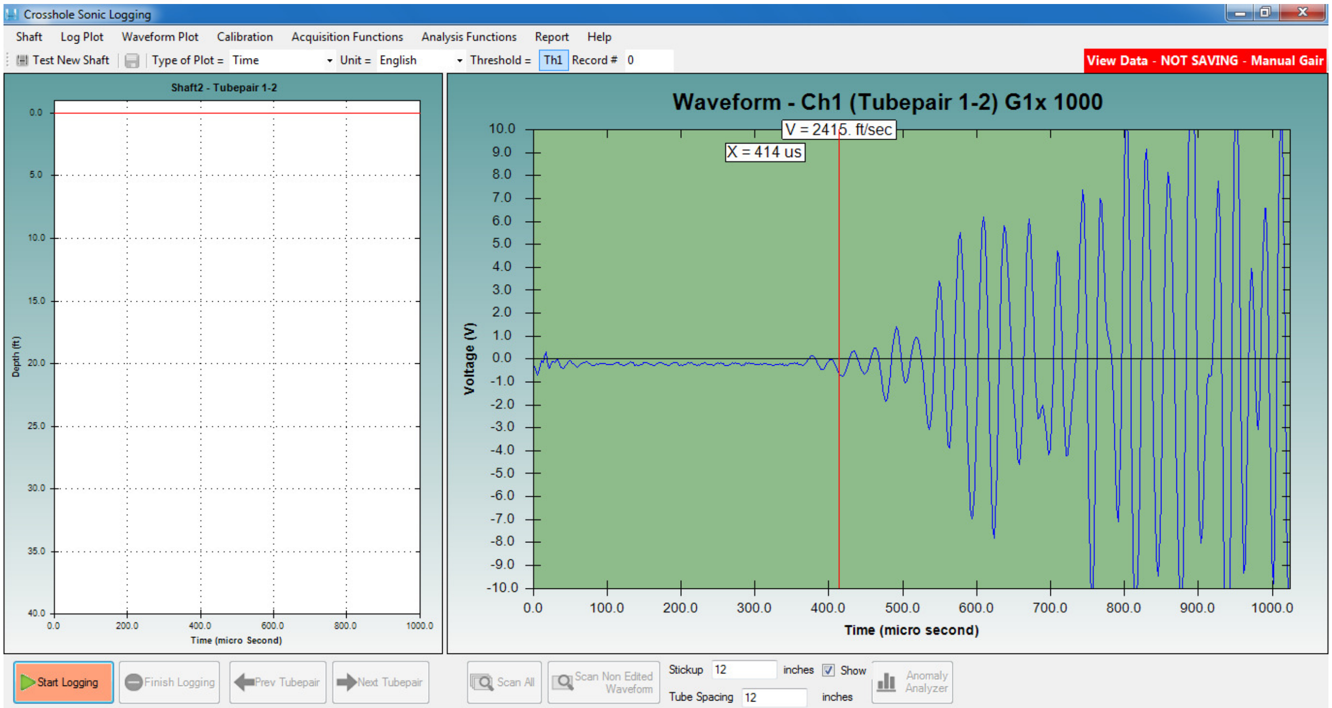


This gain setting process can be performed with the hydrophones at the bottom of the shaft if the shaft is sound, or with the hydrophones elevated to a higher position in the tube if there is a soft bottom.

The program automatically defaults to the Autogain feature and the operator can use the “Test” button on the CSL pulser module to automatically set the gain which is displayed in bold font at the top of the waveform plot. When viewing the signal, the waveform will appear on the waveform plot on the right side of the screen as shown in the figure below. If CSL-2 is being performed, there will be two waveform plots, one for each hydrophone receiver. The signal amplitude will stabilize after a few seconds (gain will be increased or decreased so that the peak signal amplitude of the signal is between 4 – 8 v) when the autogain feature is on.



If the user wants to manually control the gain, use the UP and DOWN arrow keys to increase or decrease the gain which is displayed in bold font at the top of the waveform plot. Note that the auto gain mode will be disabled if the manual gain is set (if UP and DOWN arrow keys are pressed). To activate the auto gain mode, go to “Acquisition Functions/Auto Gain Mode” to turn on this function. Note that the status in the status box will change to “View Data – NOT SAVING – Manual Gain” as shown below (and UP arrow key was pressed to increase the gain to two steps higher);

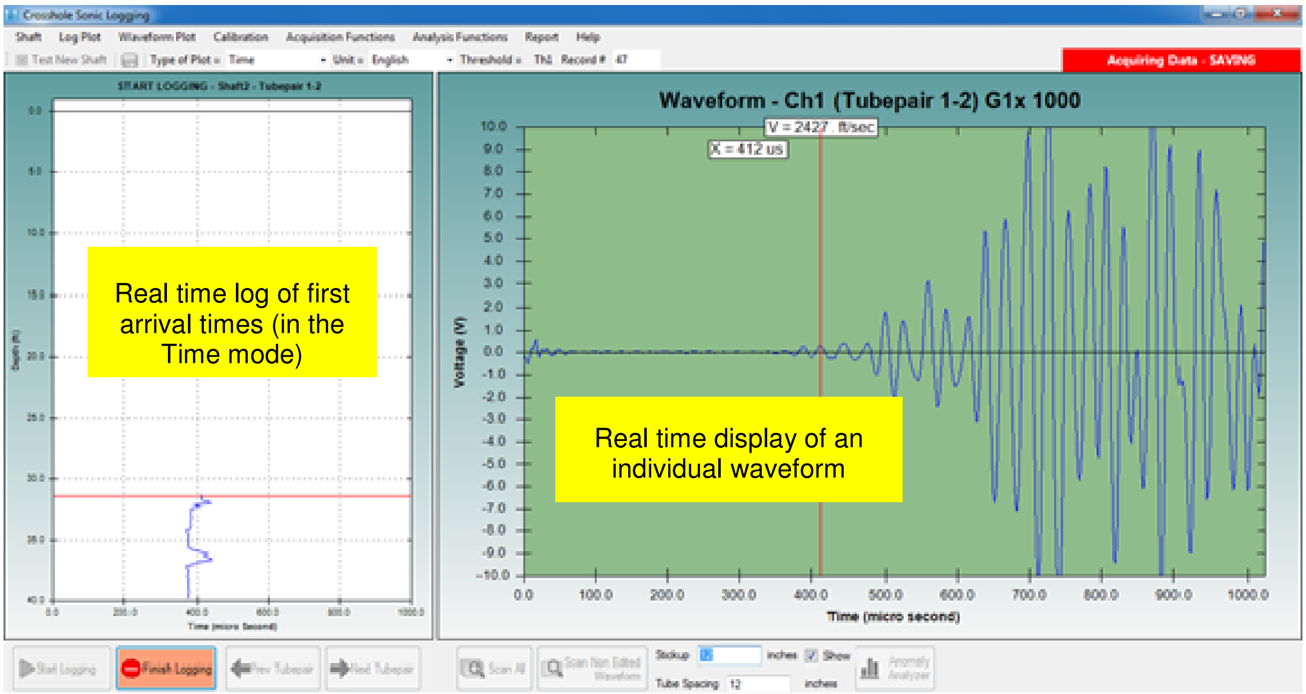


6.6 Acquire Data

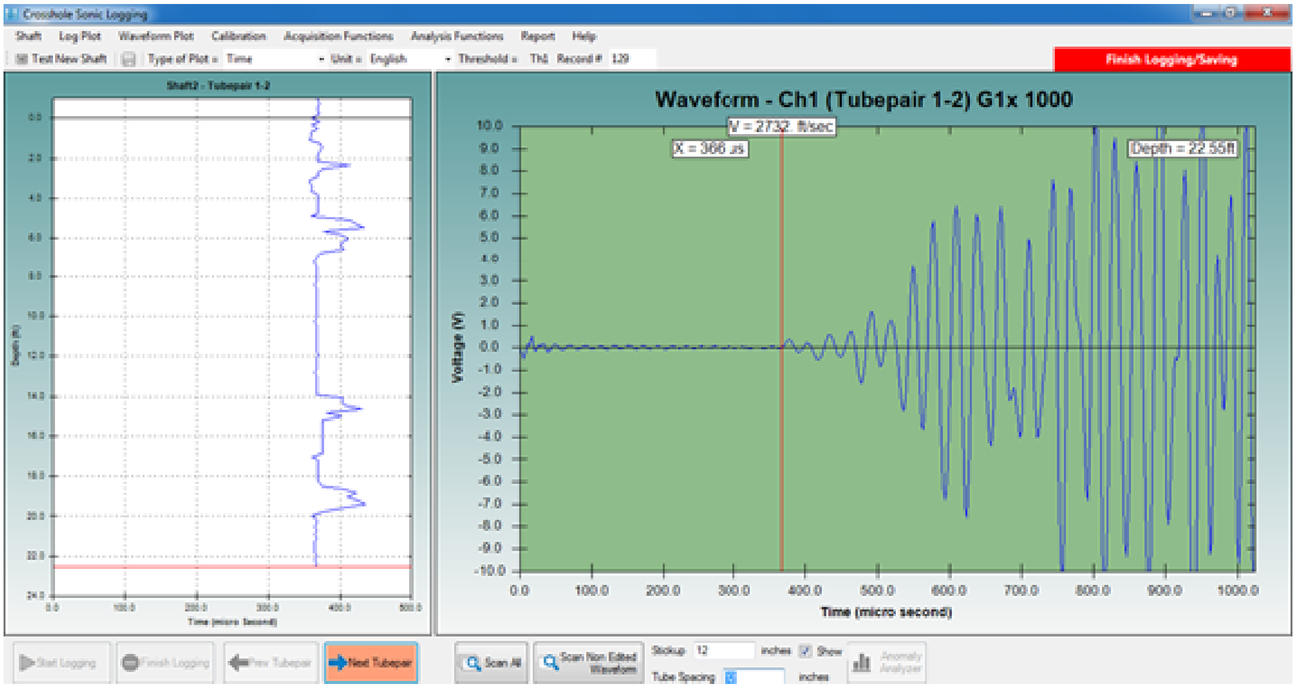
The following is a step-by-step guide for CSL data acquisition once the gain has been established. Note that the gain cannot be changed once the data acquisition in save mode has started.

1- Click on the "Start Logging" button to initiate data acquisition (or press Enter – the program is ready to activate the Start Logging function as the button is displayed in light pink color. The status box will display "Acquiring Data – SAVING". Now the software is ready to take and save data. Note that the log display mode should always be set to "Time" during the data acquisition.

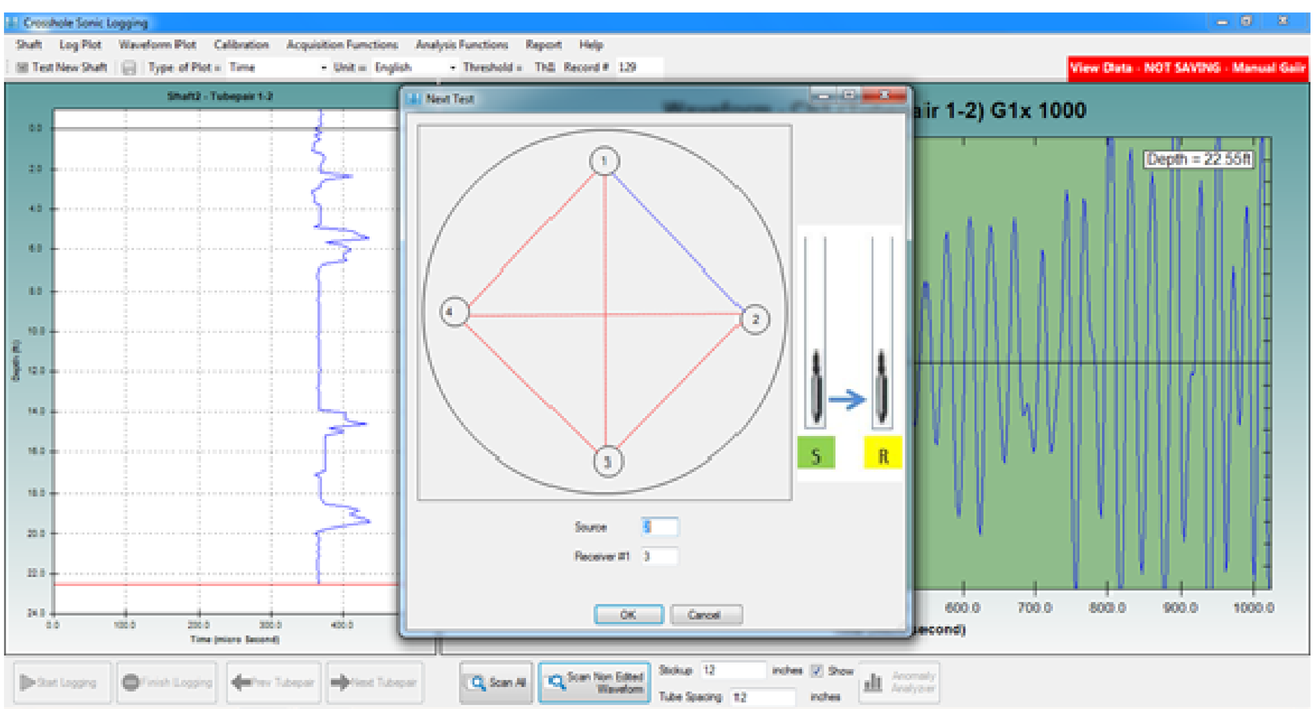
2- After the CSL logging process is finished for the current tube pair, click on the "Finish Logging" button (or press Enter – Note that the Finish Logging button is displayed in light orange color and is ready to be activated with the Enter key) to recalculate the actual logging depths and save the data. Remember that the shaft depth previously entered in the "CSL Shaft Information" dialog box is just an estimated maximum depth for real time first arrival time scanning purposes. The actual depth will be calculated after the logging is completed. A small dialog box will appear reporting "Scanning and Saving Data Complete" and will disappear after 3 seconds.



3- If it is necessary to retest the current tube pair, go to "Acquisition Functions/Retest Current Tube Pair" or press 'F9'. Then the program will be ready to view data. Click on the "Start Logging" button when the user is ready to pull the CSL cables. Follow the instructions in Steps 1 and 2 to finish logging and save the data.



4- To continue the CSL test on the next tube pair, click the "Next Tubepair" button (or press Key N or Enter key – Note that the Next Tubepair button is displayed in light orange meaning it is ready to be activated with the Enter key). The program will display a new screen allowing the user to view untested tube pairs, tested tube pairs, and designate the next tube pair to be tested.



5- Repeat Steps 1 to 4 until all the tube pairs are tested.

If for some reason, the user wants to test a previously tested tube pair, click on "Prev Tubepair" until the desired tube pair is reached. Then perform the retest by hitting 'F9' and repeat Sections 6.5 and 6.6 (Steps 1 to 4).

6- After completing the CSL tests for all necessary tube pairs in the shaft, go to the Toolbar and click on "Test New Shaft" to proceed to data collection for the next shaft.

6.7 Retest Existing Shaft

This option allows the user to perform CSL data collection on a previously tested shaft. Go to the Main Menu and click on "Shaft/Retest Existing Shaft" or use the shortcut 'F2'.

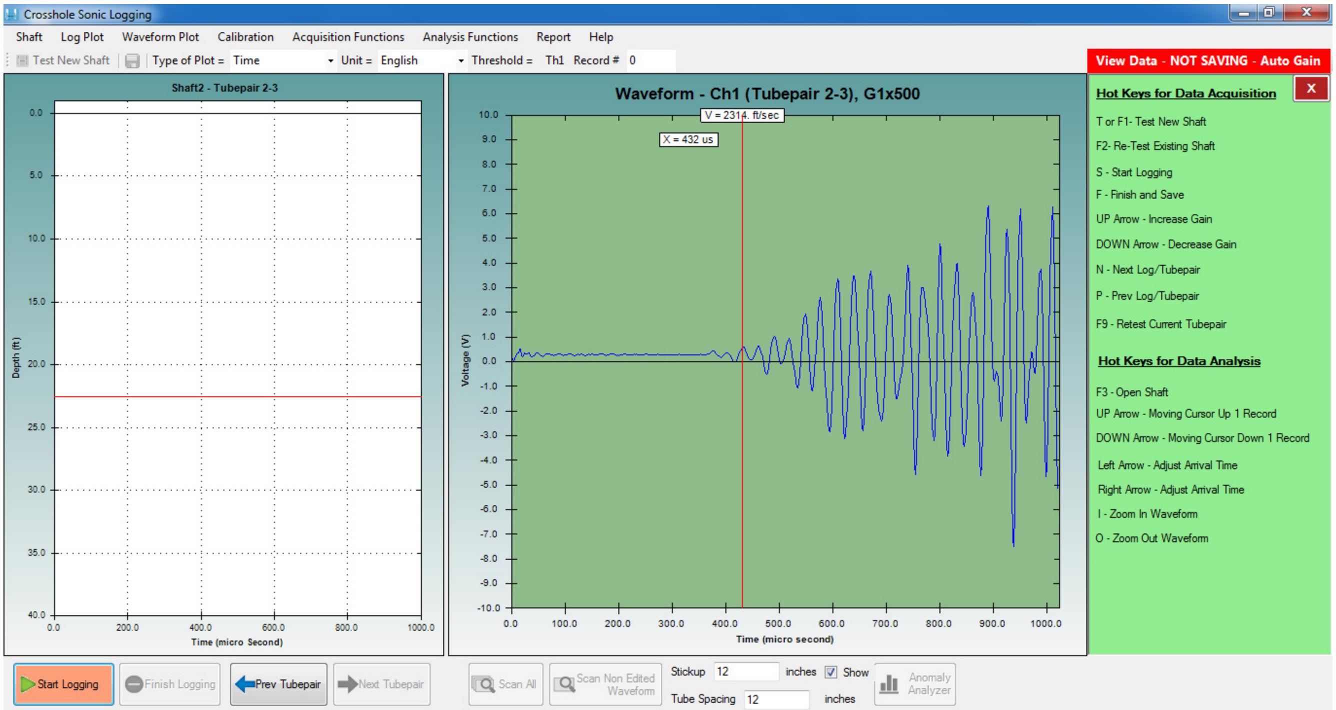
The Windows "Open" dialog box should appear on the screen to let the user select the existing shaft (or file). Select the shaft that needs to be re-tested and click on "Open".

1. The program will load the data from the selected shaft. If the selected tube pair has been tested, the program will load the plots with the saved data. If the selected tube pair has not been tested, the plot will appear blank and is ready for viewing and data acquisition. Use "Next Tubepair" and "Previous Tubepair" to navigate to the appropriate tube pair you want to retest. Then go to the Main Menu and select "Acquisition Functions/Retest Current Tubepair".

2. The program will warn you that your data will be deleted if you proceed, and ask you to confirm. After confirming, view the signal and set the gain as described in **Section 6.5** then click on "Start Logging" to collect new data for the tube pair.

6.8 Help

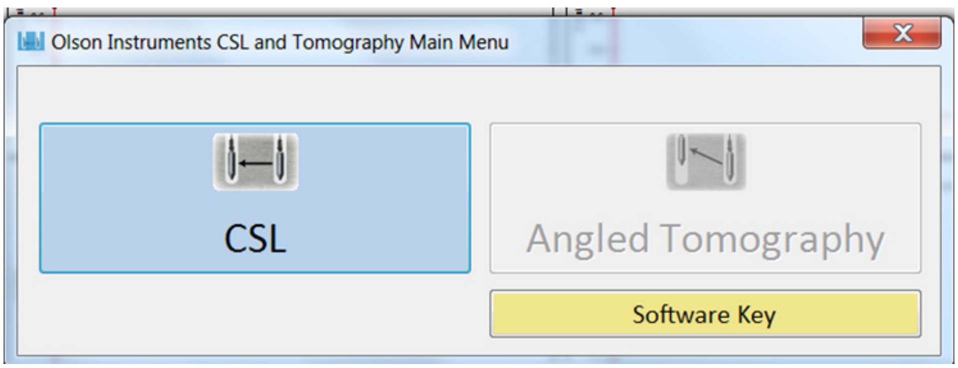
Go to "Help/Hot Keys" to open short cut keys for data/analysis as shown in the figure below.


Crosshole Sonic Logging
Shaft Log Plot Waveform Plot Calibration Acquisition Functions Analysis Functions Report Help
Test New Shaft
Type of Plot = Time
Unit = English
Threshold = Th1 Record # 0
View Data - NOT SAVING - Auto Gain
Shaft2 - Tubepair 2-3
Depth (ft)
Time (micro Second)
Waveform - Ch1 (Tubepair 2-3), G1x500
V = 2314. ft/sec
X = 432 us
Voltage (V)
Time (micro second)
Hot Keys for Data Acquisition
T or F1- Test New Shaft
F2- Re-Test Existing Shaft
S - Start Logging
F - Finish and Save
UP Arrow - Increase Gain
DOWN Arrow - Decrease Gain
N - Next Log/Tubepair
P - Prev Log/Tubepair
F9 - Retest Current Tubepair
Hot Keys for Data Analysis
F3 - Open Shaft
UP Arrow - Moving Cursor Up 1 Record
DOWN Arrow - Moving Cursor Down 1 Record
Left Arrow - Adjust Arrival Time
Right Arrow - Adjust Arrival Time
I - Zoom In Waveform
O - Zoom Out Waveform
Start Logging
Finish Logging
Prev Tubepair
Next Tubepair
Scan All
Scan Non Edited Waveform
Stickup 12 inches
Show
Tube Spacing 12 inches
Anomaly Analyzer

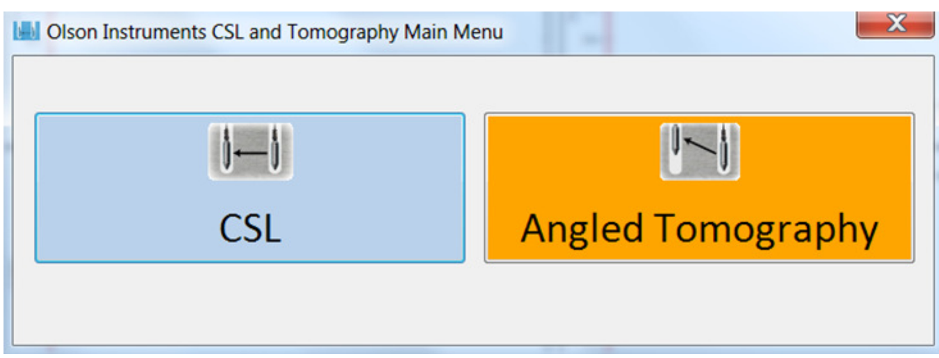
7.0 GUIDE TO CSL DATA ANALYSIS

7.1 Start WinCSL Software and Open Existing File

1. Locate the "WinCSL.exe" file or its shortcut
2. Double click on either the "WinCSL.exe" file or the shortcut on the desktop
3. The following dialog box should appear on the screen if the Tomography option is not included in the package.



4. If the Tomography option is purchased with the package, the following dialog box will appear on the screen. Note that the software Key button will not be visible.



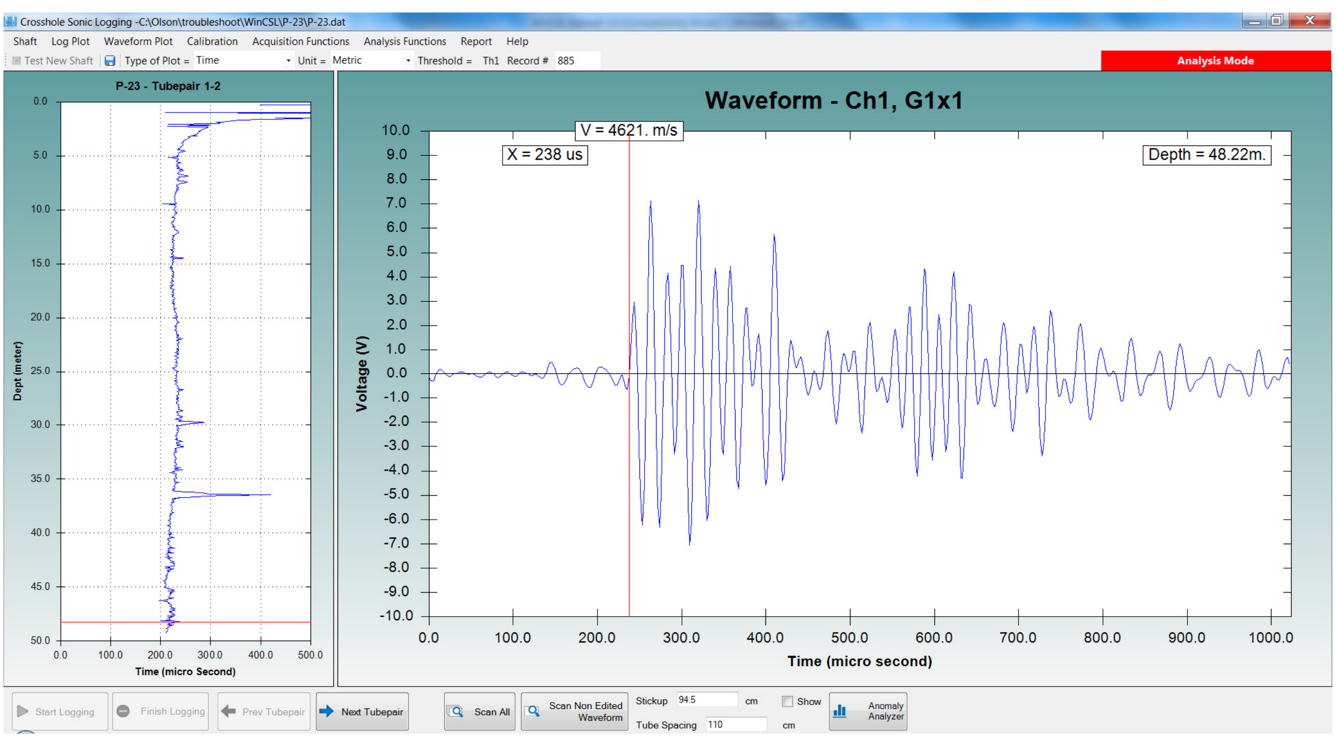
5. Click on the CSL Button (or just press Enter – the default is the CSL button) and the program will open a screen with a plot box on the right side of the screen which will be used to display individual signal records and a plot box on the left side of the screen which will be used to display a log of the arrival times for all of the signal records.

6. Click on “Open Tested Shaft” by going to the Main Menu and clicking on “Shaft/Open Tested Shaft” or Press ‘F3’. The Windows “Open” dialog box should appear on the screen to let the user select the existing shaft to be analyzed. Select the shaft that needs to be analyzed and click on “Open”. The dialog box will automatically list files with an extension of .csl. If you do not see the file you are looking for it might be

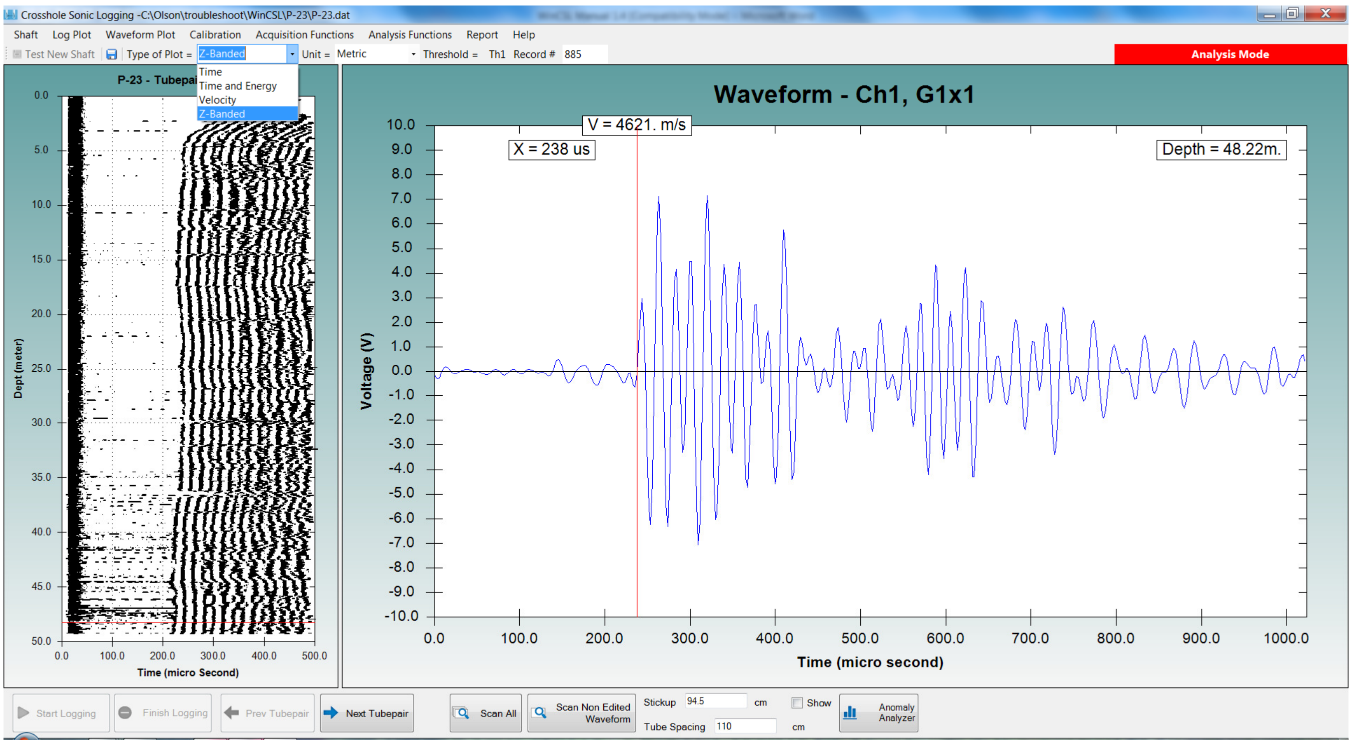
because it has a different file extension. When that is the case, use the "Files of Type" dropdown menu to view other files.

> ***Data files previously acquired with Olson's CSL2 software will have a ".DAT" extension and can be opened in WinCSL.***

7. As shown below, the program will open the existing file and display the data previously collected along with the saved information (such as shaft name, shaft length, tube stickup length, and tube spacing etc.). In the right (waveform) plot box, a record of each waveform collected is displayed. In the left (log) plot box, a log of the first arrival times from all the waveforms are displayed. At any given time, the waveform plot will display the record selected by the cursor in the log plot. A black dot on the log plot means the waveform has high noise (higher than NSE) and the scanning routine has automatically used the data from the previous record. The user can change the tube spacing by typing in the "Tube Spacing" entry field. The user can change the tube stick up information by clicking in the "Stickup" entry field then clicking on the log at the desired location. The user can also choose to display the signal that is included in the stickup length or hide it by clicking or unclicking the "Show" box.



8. The user can display one of four different plots (Time, Time and Energy, Velocity or Z-Banded) for the CSL log by going to “Type of Plot” on the Toolbar and selecting one of the options from the dropdown menu.



9. The user can change units by going to “Unit” on the Toolbar and selecting either English or Metric from the dropdown menu.

7.2 Shaft Analysis Functions

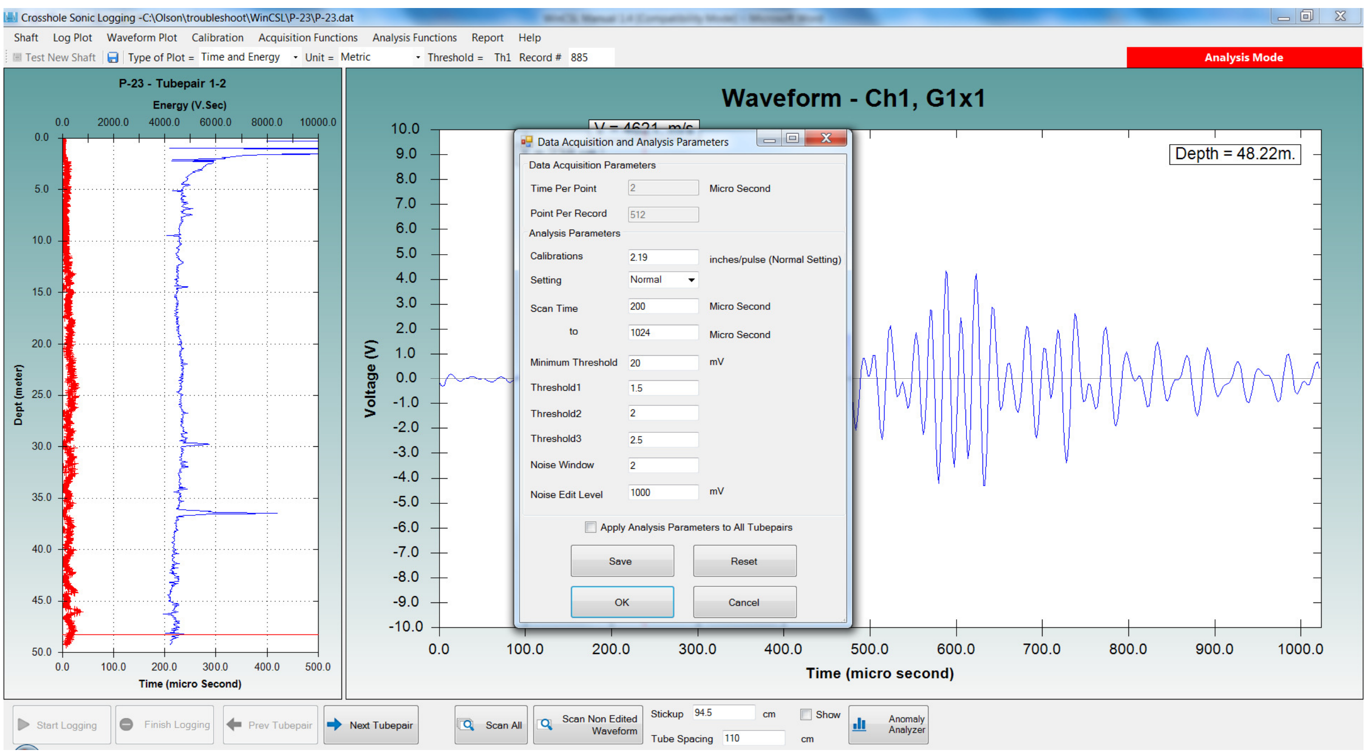
The user can now analyze the previously collected CSL data. The user can alter and resave the processed data (such as time of arrival, energy, etc.), but the original raw waveform data cannot be changed. The following functions are available for the analysis procedure.

7.2.1 Key Strokes for Up, Down, Right Left, Zoom In, Zoom Out

Use the Arrow Keys (Up and Down) or click with the mouse to move the cursor to the desired record on the log plot. Use the Arrow Keys (Right and Left) or click with the mouse to move the cursor to the desired location on the waveform plot. Use the “I” Key and “O” Key to zoom in or out on the waveform plot.

7.2.2 Scanning Parameters

If the scanning parameters (such as Scan Time, Threshold Level, Noise Edit Level, etc.) need to be adjusted, go to the Main Menu and select "Shaft/Acquisition and Analysis Parameters". A dialog box will appear on the screen as shown below. **Section 6.3** explains the function of each parameter. The user can change any of the saved analysis parameters, but can not change the saved data acquisition parameters (Time Per Point and Point Per Record). After the parameters have been adjusted, click on “Scan All” to apply these changes and rescan for first arrival times. After changing ANY of the scanning parameters, the user must rescan the data for the changes to take effect.



Please note that when the data is rescanned, any manually picked arrival times will be removed. If the user has made edits to the data by manually selecting arrival times on the waveform, the user should use “Scan Non Edited Waveform” instead of “Scan All” in order to retain those edits. Then the program will scan all waveforms except those that have been manually edited.

7.2.3 Manual Picking of Arrival Times

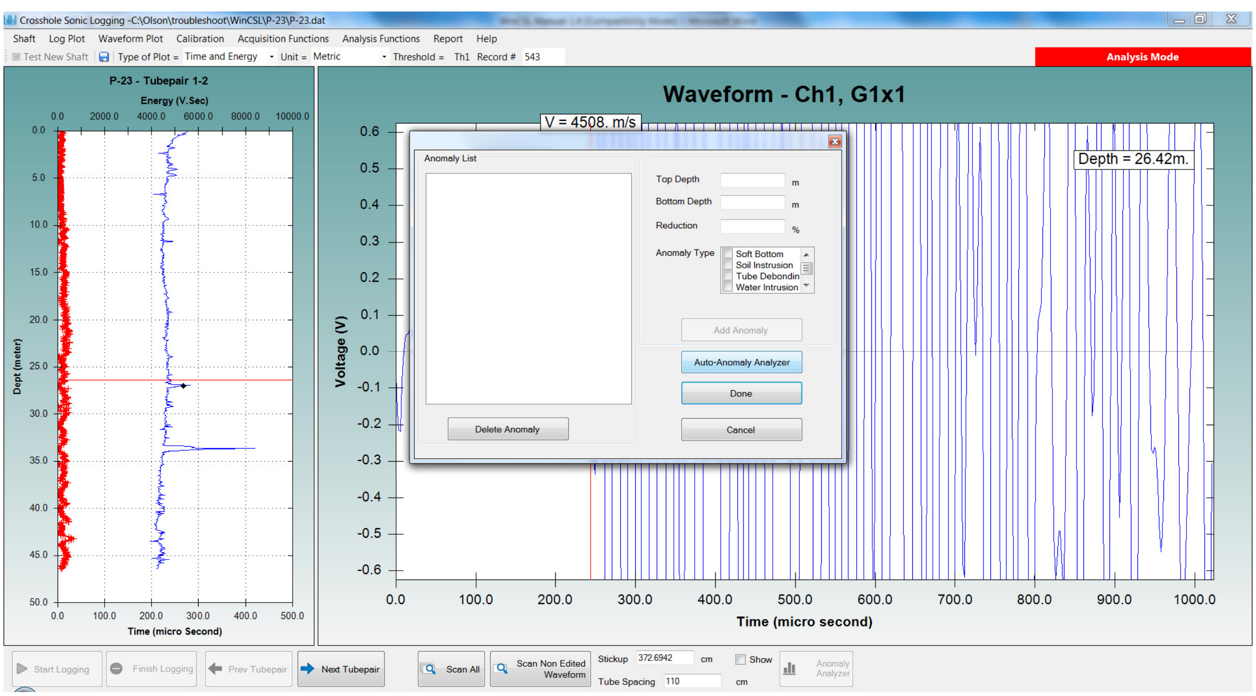
If the automatic scanning routine results in an incorrect pick of first arrival time, the user can manually pick the arrival time by moving the cursor to the correct position on the waveform plot and clicking on the new location. After a manual pick has been made, a small black dot will appear on the log plot. If the black dot appears on the record without the manual pick, it means the waveform has high noise (higher than NSE) and the scanning routine has automatically used the data from the previous record. If the automatic scanning routine yields numerous bad picks, the user might want to change the scan time.

7.2.4 Set Stickup

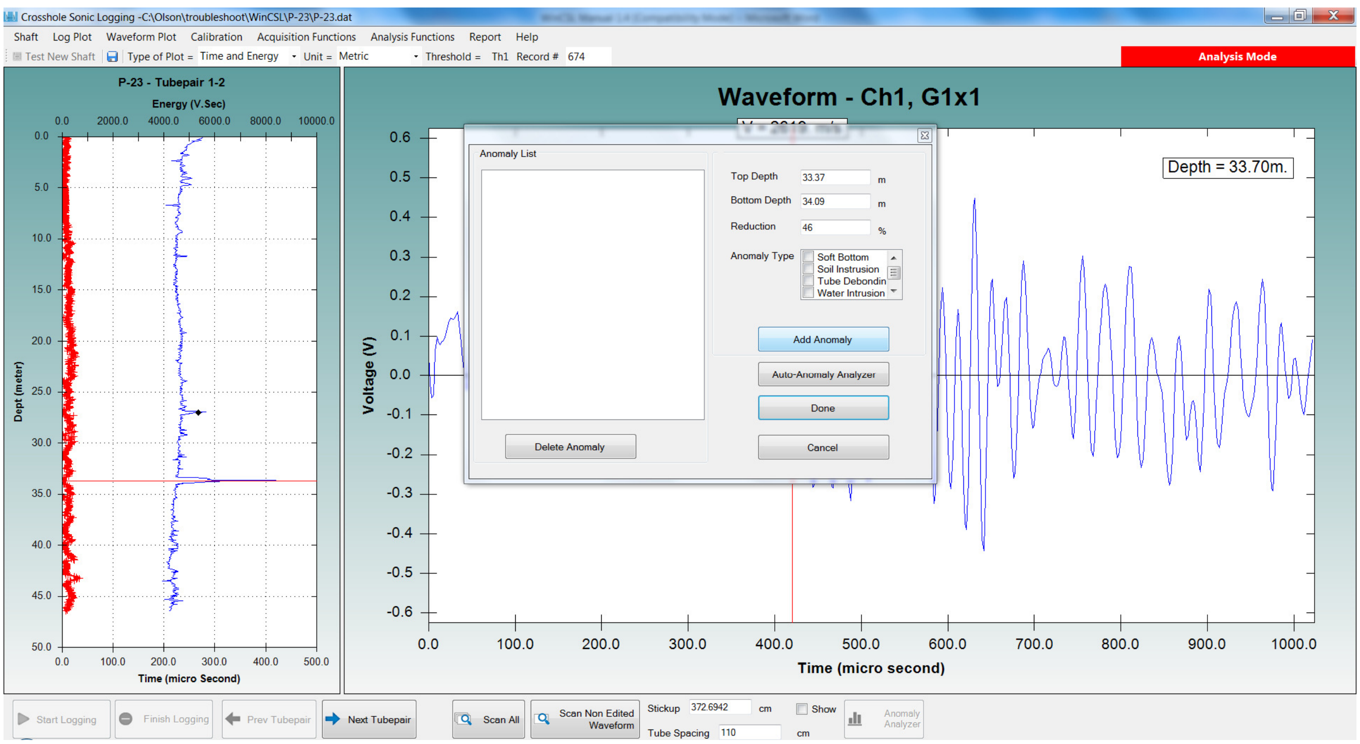
There are two ways to set the stickup height. 1.) Click on the "Stickup" entry field to input the stickup length of the tested tubes, then click on the top of the shaft (bottom of the stickup) on the log plot. 2.) Type the stickup value directly into the "Stickup" entry field. Note that the units for the stickup are either in "inches" or "cm". After inputting the stickup length, the user has the option of either showing the stickup or hiding the stickup. If the "Show" option is selected in the check box, the plot will be zeroed at the bottom of the stickup and the stickup portion is shown as a negative value on the log. If the "Show" option is not selected in the check box, the plot will be zeroed at the bottom of the stickup and the stickup portion will not be shown.

7.2.5 Defect Analyzer

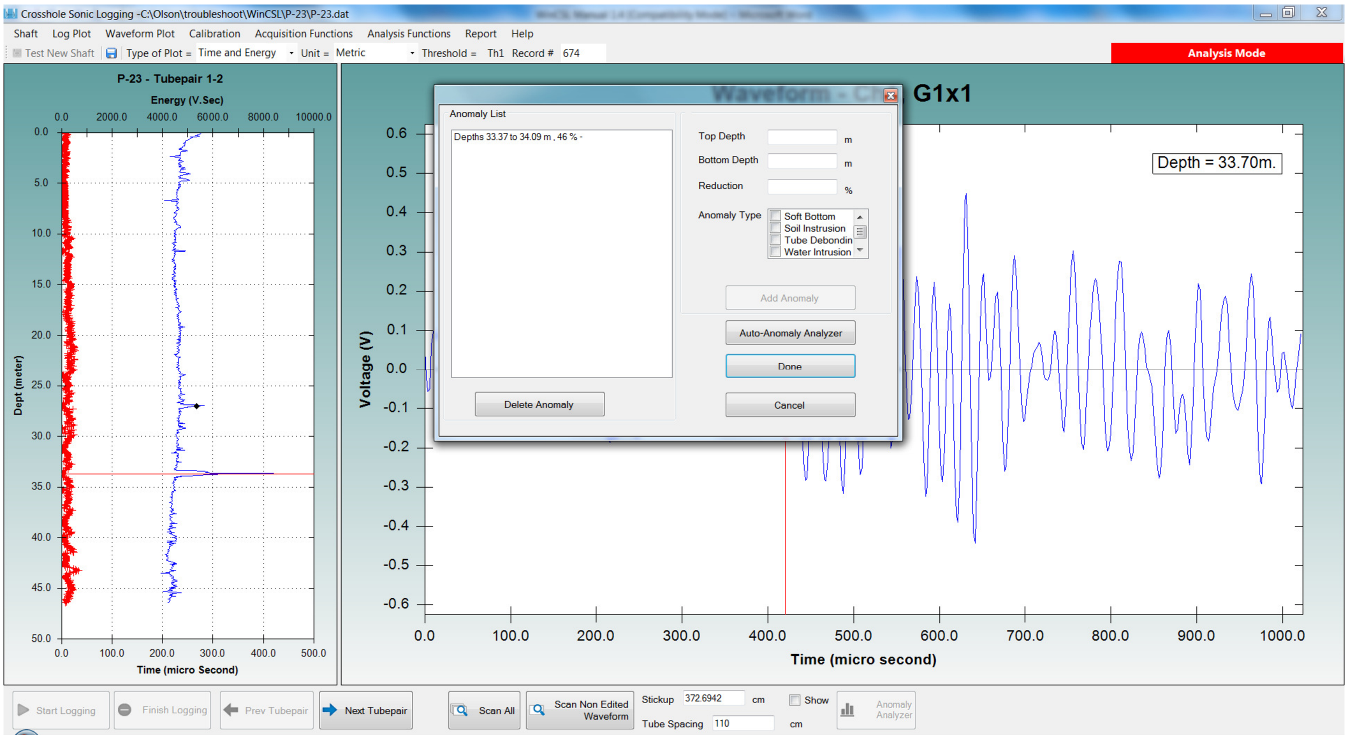
Click on the "Anomaly Analyzer" button to automatically analyze the log for defect zones in the shaft. This step is optional. However, if the user wants to use the automated report generation feature (see **Section 8.0**) that comes with the program, this step is required. At this point, the "Defect Analysis Form" Dialog Box should appear on your screen as shown below.



If the user does not want to use the Auto-Anomaly Analyzer to identify defects, they can be entered manually as shown in the figure below. Manually enter the Top Depth and Bottom Depth of the defect by clicking on the appropriate entry field then clicking on the log plot to automatically generate the depth value. When the user manually adds a defect, the velocity reduction can be calculated by clicking on the log plot directly at the point that has lowest velocity in the defect zone; the program computes the velocity reduction based on the mean velocity. The user can also select an Anomaly Type from the available dropdown menu. After Top Depth, Bottom Depth and Reduction have been entered, the user can click on the "Add Anomaly" button to add the defect to the Anomaly List on the left side of the dialog box.



Alternatively, the user can use the "Auto-Anomaly Analyzer" button to let the program look for the defect zones as shown in the figure below. The defect analyzer function is designed to automatically detect any low velocity zones in the tubepair. When performing this function, the program calculates the average velocity of the entire log and then searches for data points that have a velocity reduction of more than 10%, starting from top to bottom of the tubepair. Once the program finds a location with low velocity, it goes back up to look for the starting location of this anomaly by looking for the first encountered location that has a velocity of at least the average velocity. Then the analyzer starts from the detected low velocity zone and goes down to find the end of this anomaly by looking for the first location that has a velocity of at least the average velocity. The program automatically calculates the velocity reduction by looking for the data point with lowest velocity in the defect zone and computes the velocity reduction based on the mean velocity. The top and bottom of the defect, along with the velocity reduction is reported in the Anomaly List on the left side of the dialog box. The starting and ending locations for the automatically generated defect might be slightly different than the actual locations. In this case, the manual feature can be used to correct the locations.



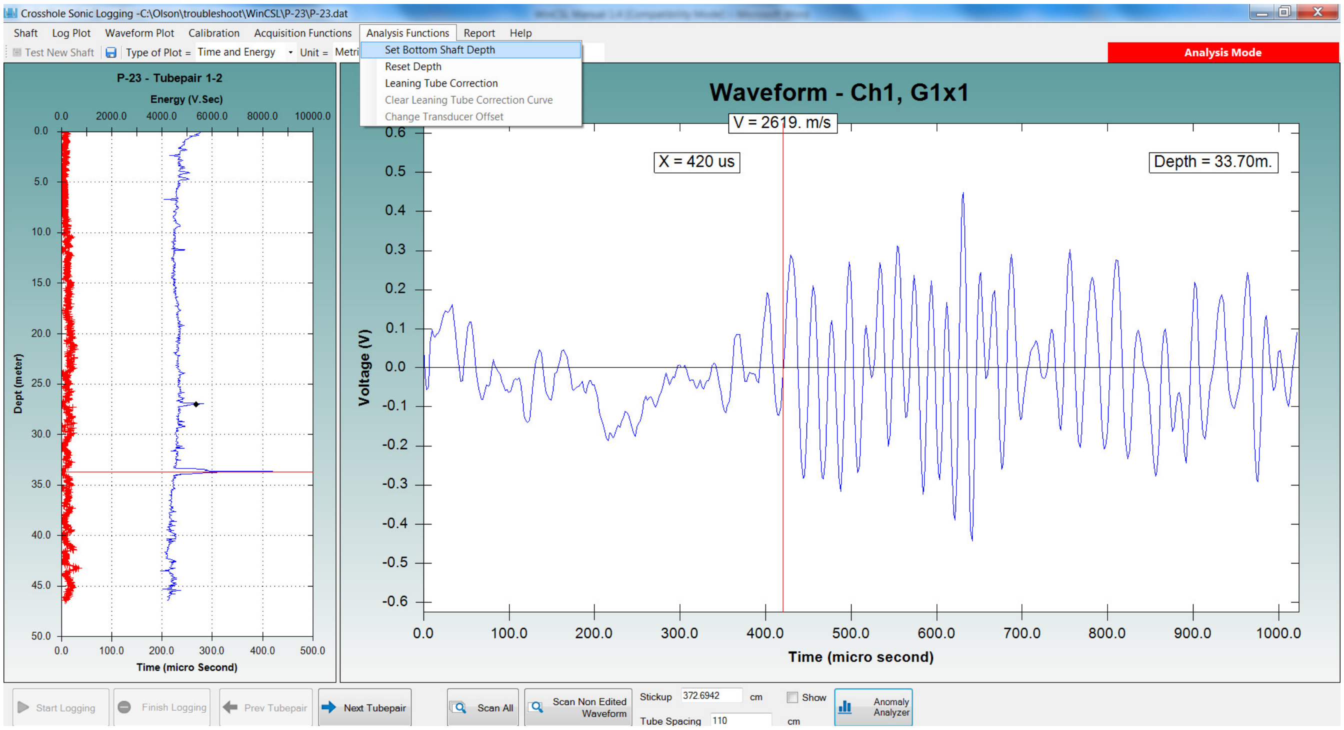
The user can delete defects from the list using the “Delete Anomaly” button. After the defect analyzing process is complete, click on the “Done” button to save the defects and go back to the previous screen.

7.2.6 Next Tube pair

To proceed to the next tube pair, click “Next Tubepair”. To go back to the previous tube pair, click “Previous Tubepair”.

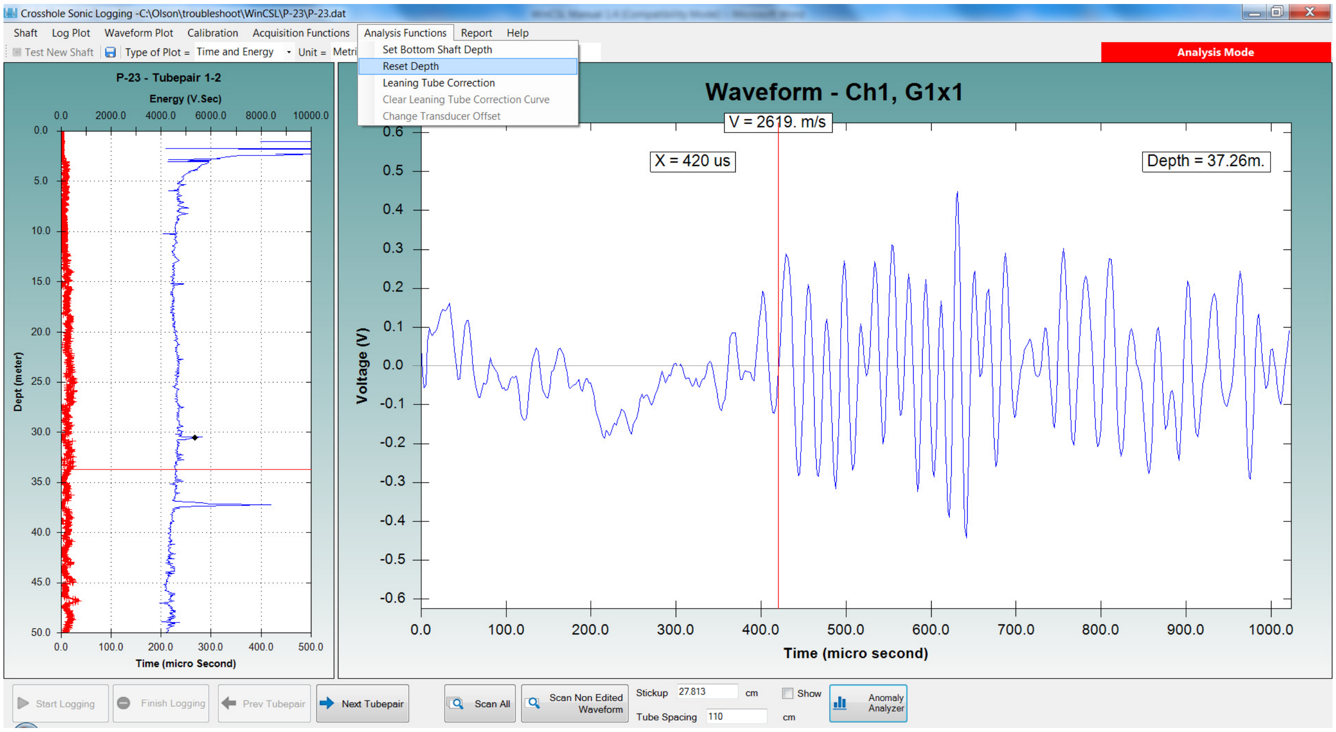
7.2.7 Set Bottom Depth

The bottom depth of the CSL logs can be set by going to the Main Menu and selecting “Analysis Functions/Set Bottom Shaft Depth” as shown below.



Then a “Bottom Depth” dialog box will be displayed as shown below to set the bottom depth of the current log. Enter the desired depth and click on “OK”. The set bottom depth function will assign the bottom depth input to the very last record and uses the calibration number to back calculate the depths of the rest of the data.

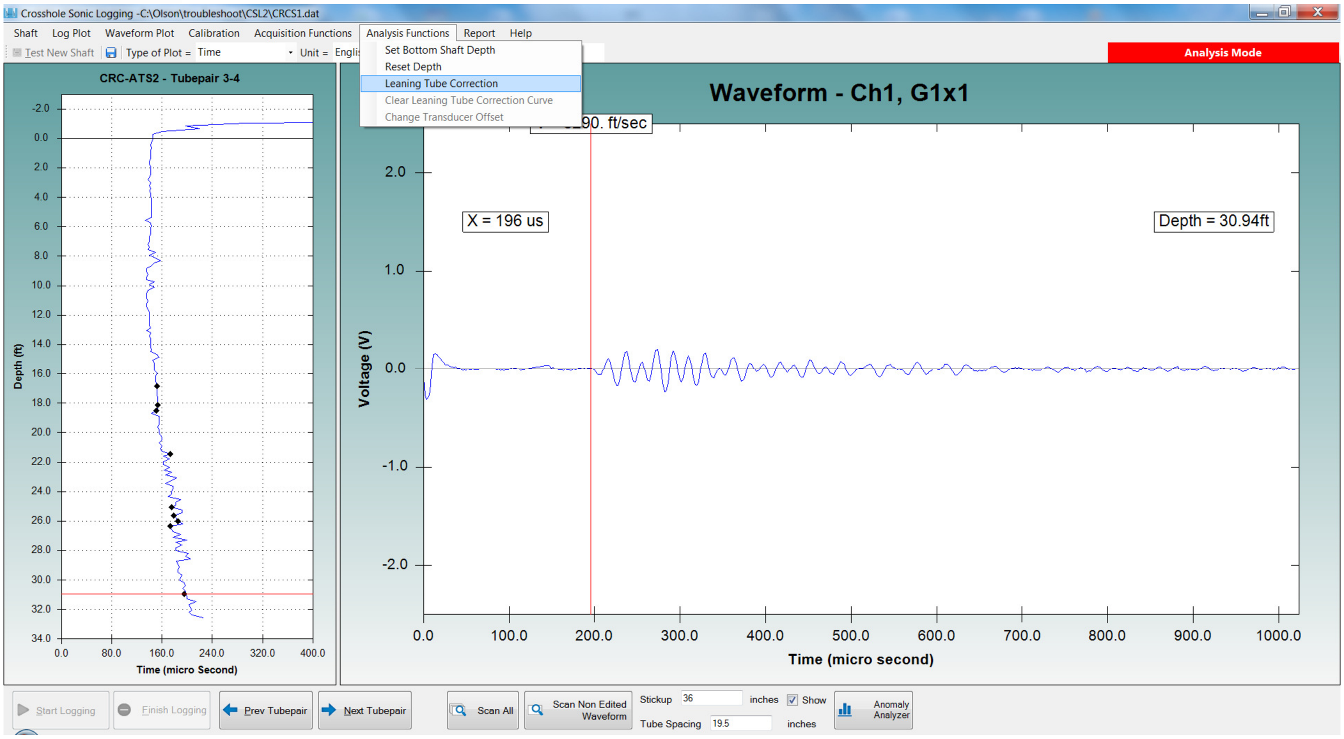
The shaft depth can be reset by going to the main menu and selecting “Analysis Functions/Reset Depth” as shown below.



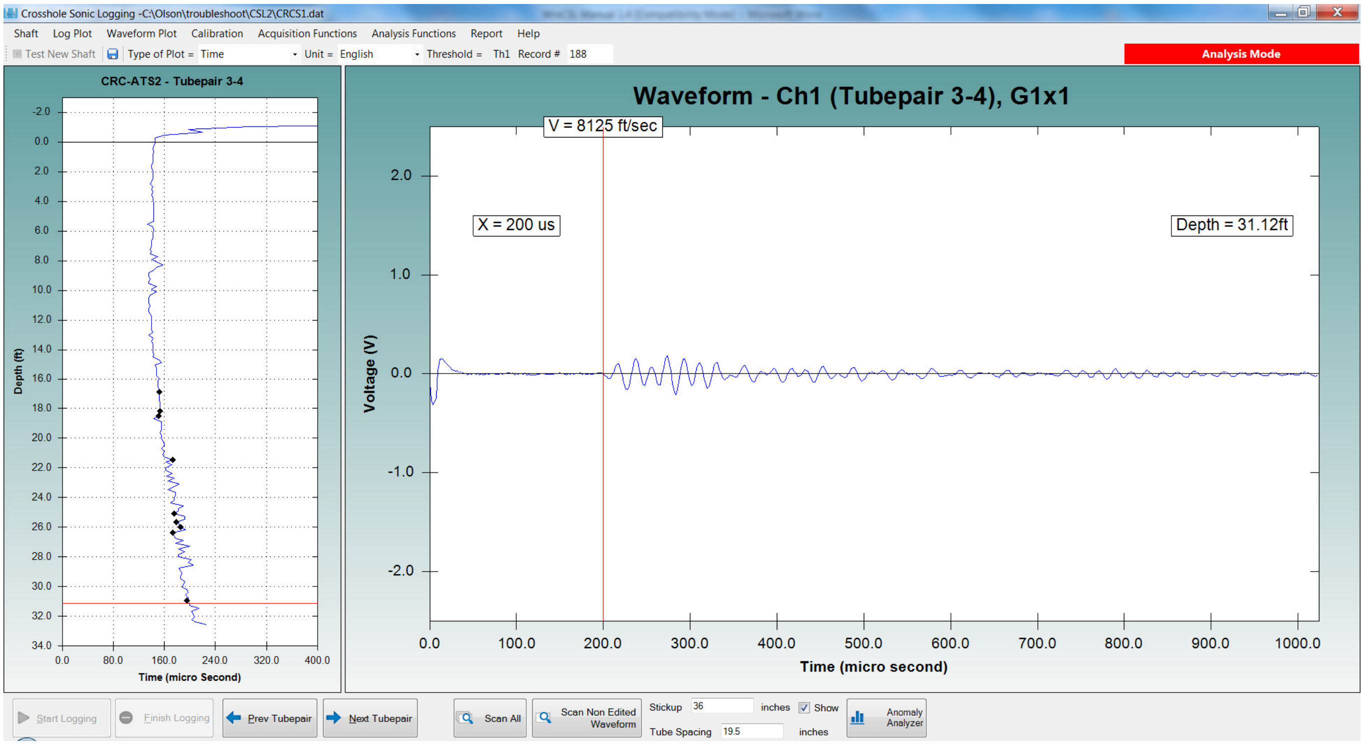
Upon selecting “Reset Depth” from the menu, the depth will be automatically reset to the original value.

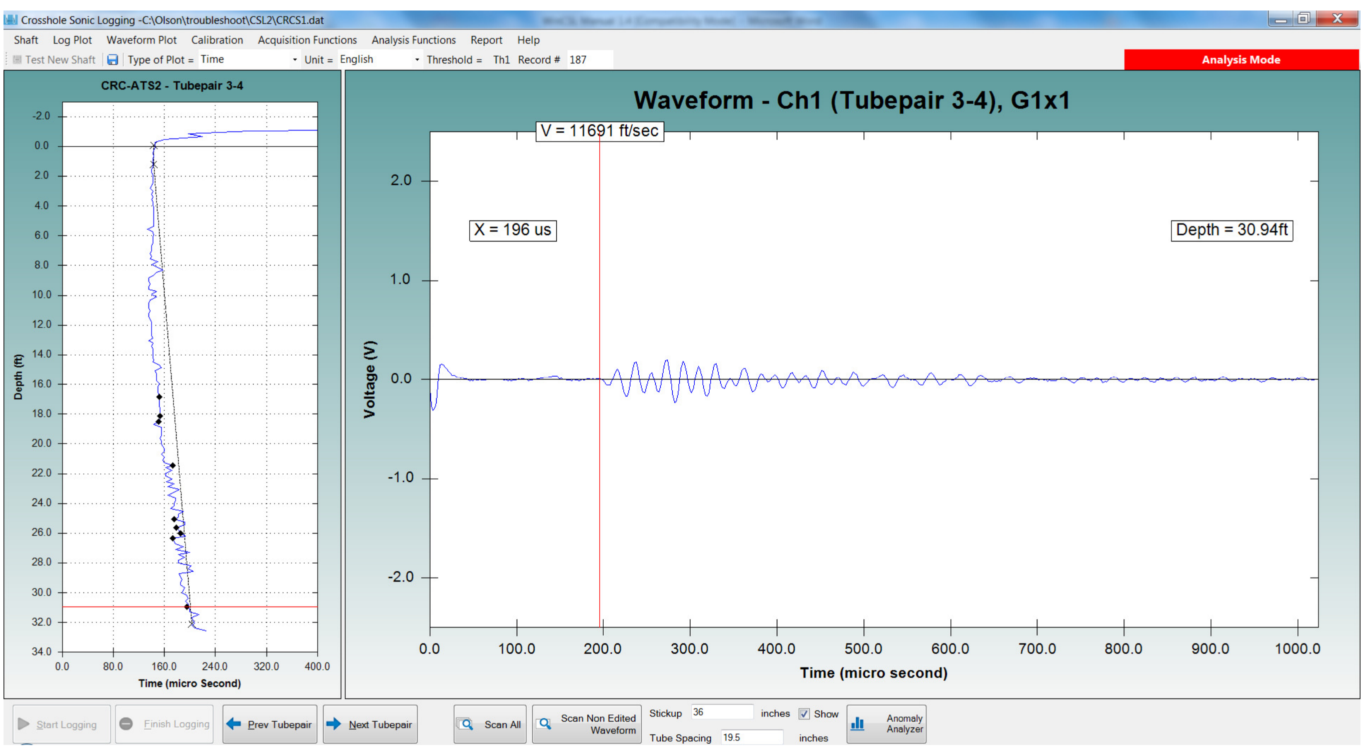
7.2.8 Leaning Tube Correction

On occasion, the user will encounter tubes that have not been installed completely vertical. When this happens, the software can not accurately scan and report the correct velocity because the distance between the tubes at depth is not the same as the distance between the tubes at the top of the shaft. This situation can be corrected by using the “Leaning Tube Correction” function. To use this function, go to the Main Menu and select “Analysis Functions/Leaning Tube Corrections” as shown below.

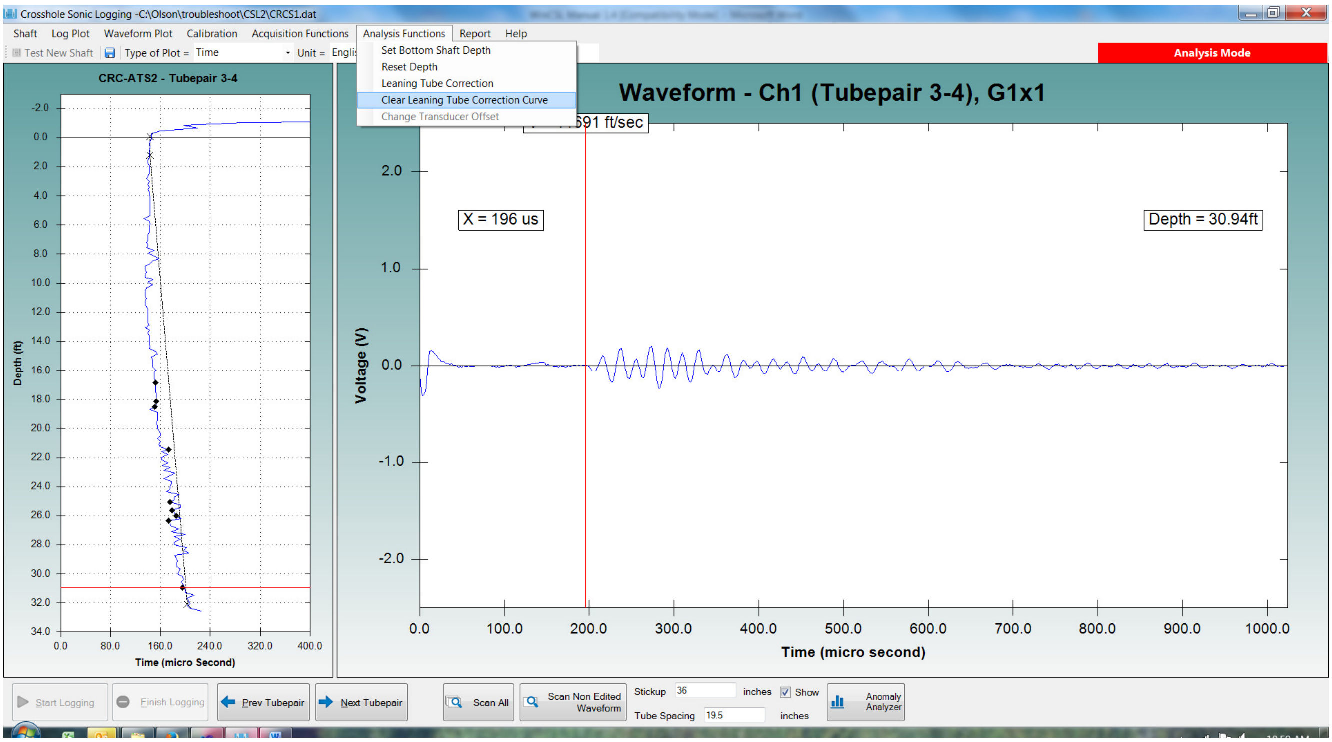


A dialog box will appear with instructions to click on the time log at the top of the shaft and the time log at the bottom of the shaft. After you do this, this slope of the leaning tube will be calculated and displayed in a green dotted line as shown below. Velocity values will be automatically recalculated and displayed. The next two figures show a velocity comparison of Record # 188 before (velocity of 8125 ft/sec) and after the leaning tube correction (velocity of 11,691 ft/sec)


Crosshole Sonic Logging -C:\Olson\troubleshoot\CSL2\CRCS1.dat
Shaft
Log Plot
Waveform Plot
Calibration
Acquisition Functions
Analysis Functions
Report
Help
Test New Shaft
Type of Plot = Time
Unit = English
Threshold = Th1
Record # 188
Analysis Mode
CRC-ATS2 - Tubepair 3-4
Depth (ft)
Time (micro Second)
Waveform - Ch1 (Tubepair 3-4), G1x1
V = 8125 ft/sec
X = 200 us
Depth = 31.12ft
Voltage (V)
Time (micro second)
Start Logging
Finish Logging
Prev Tubepair
Next Tubepair
Scan All
Scan Non Edited Waveform
Stickup 36 inches
Show
Tube Spacing 19.5 inches
Anomaly Analyzer


Crosshole Sonic Logging -C:\Olson\troubleshoot\CSL2\CRCS1.dat
Shaft
Log Plot
Waveform Plot
Calibration
Acquisition Functions
Analysis Functions
Report
Help
Test New Shaft
Type of Plot = Time
Unit = English
Threshold = Th1
Record # 187
Analysis Mode
CRC-ATS2 - Tubepair 3-4
Depth (ft)
Time (micro Second)
Waveform - Ch1 (Tubepair 3-4), G1x1
V = 11691 ft/sec
X = 196 us
Depth = 30.94ft
Voltage (V)
Time (micro second)
Start Logging
Finish Logging
Prev Tubepair
Next Tubepair
Scan All
Scan Non Edited Waveform
Stickup 36 inches
Show
Tube Spacing 19.5 inches
Anomaly Analyzer

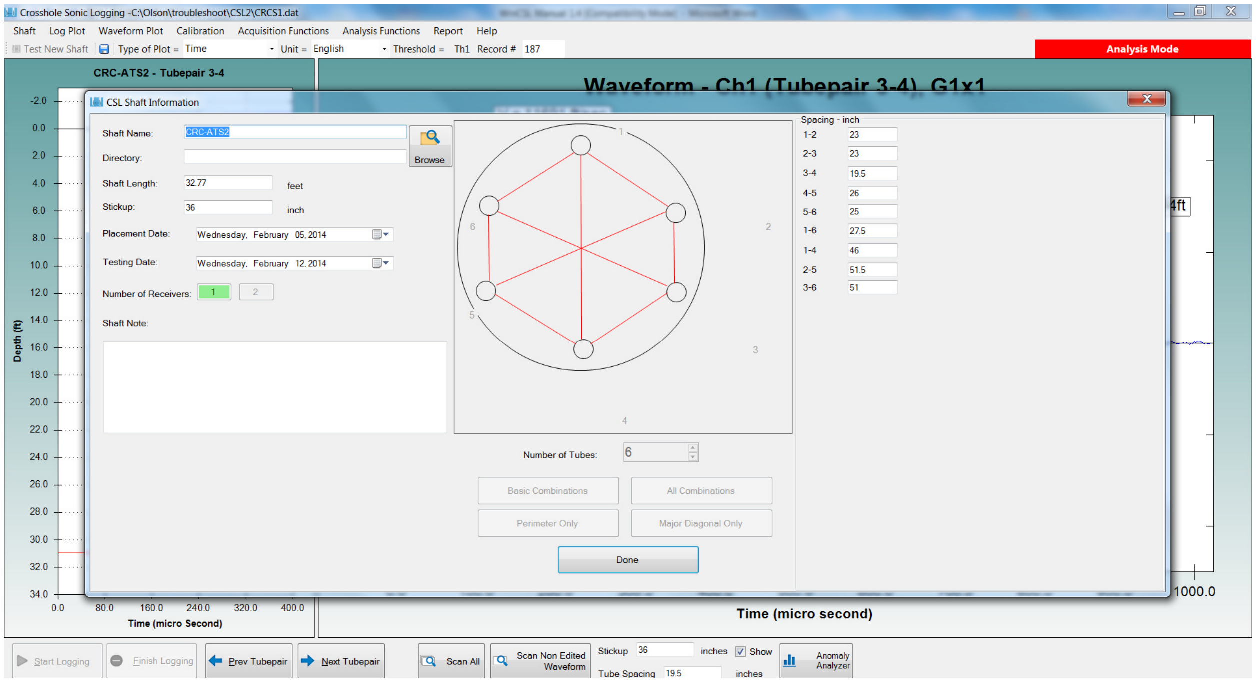
To remove the leaning tube correction, go to the Main Menu and select "Analysis Functions/Clear Leaning Tube Correction Curve" as shown below.



Upon selecting "Clear Leaning Tube Correction Curve" from the menu, the green dotted line will be removed and the velocity values will be automatically recalculated and displayed.

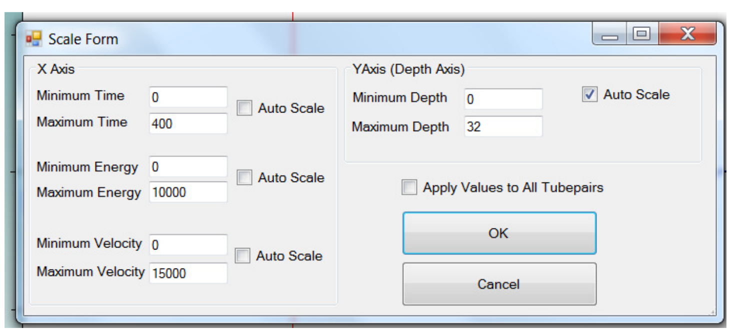
7.2.9 View Shaft Information

The saved shaft information can be viewed at any time by going to the Main Menu and selecting "Shaft/View Shaft Information". Then the "CSL Shaft Information" dialog box will appear as shown below.



7.2.10 Change Scale

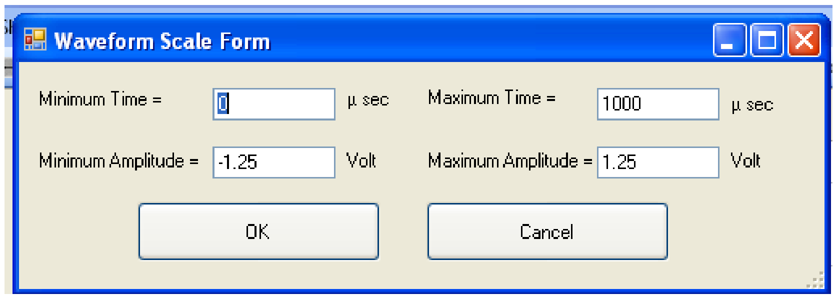
If the user wants to change the Log Scale, go to the Main Menu and select "Log Plot/Change Scale" as shown in the figure below. Or use the shortcut 'F7'. Then the "Scale Form" Dialog Box will appear as shown below.



On the X Axis of the log plot, the user can apply minimum and maximum values for Time, Energy and Velocity or can select Auto Scale instead. On the Y Axis, the user can alter the value for the page depth or can select Auto Scale. The Maximum Depth entry field is useful when the user wants all of the pages to be same length, usually the length of the longest shaft. These values will be automatically applied to the current log. If the "Apply Values to All Tubepairs" is selected in the check box, then the program will apply these values to all of the tube pairs in the shaft. Click on "OK" to accept these changes.

To change the Waveform Scale, go to the Main Menu and select “Waveform Plot/Change Scale” or use the shortcut ‘F8”.

Then the “Scale Form” Dialog Box will appear as shown below.



On the X Axis of the log plot, the user can apply minimum and maximum values for Time. On the Y Axis, the user can apply minimum and maximum values for Amplitude (Voltage). These values will be automatically applied to the current log. Click on “OK” to accept these changes.

7.2.11 Save Data

After analysis of the current tube pair is complete, go to the Main Menu and select “Shaft/Save” or “Shaft/Save As”

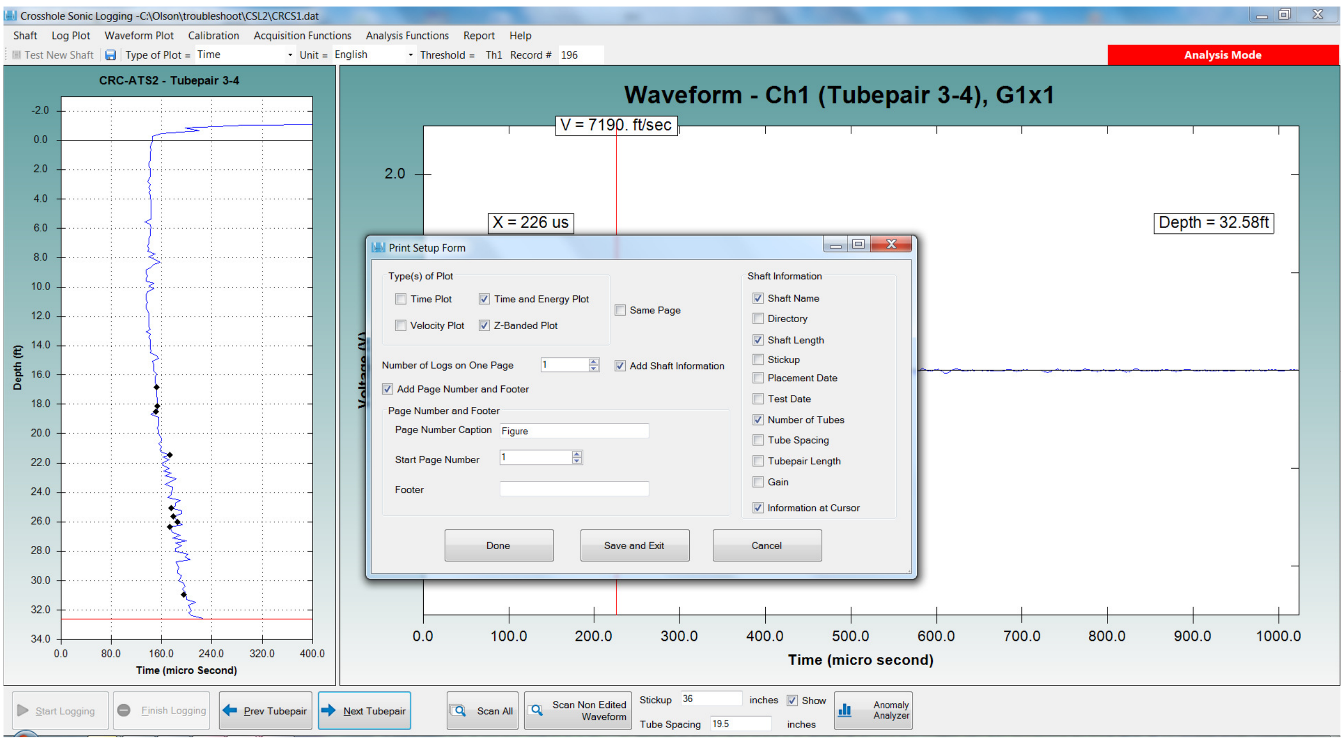
When WinCSL saves a file, it gives it a “.CSL” extension. If a file with a “.DAT” extension is opened (acquired with Olson’s earlier CSL2 software), the file will be saved with a “.CSL” extension and changes made during analysis will not appear on the original “.DAT” file. For this reason, the user might want to rename the file to avoid confusion.

8.0 GUIDE FOR LINKING LOGS/REPORT TO MICROSOFT WORD

This section covers the necessary steps to send the logs to MS Word and print a CSL report.

8.1 Log Setup

Before you can send the logs to MS Word, you must perform the Log Setup. Go to the Main Menu and select "Report/Log Setup". Then a "Print Setup Form" Dialog Box will appear as shown in the figure below.



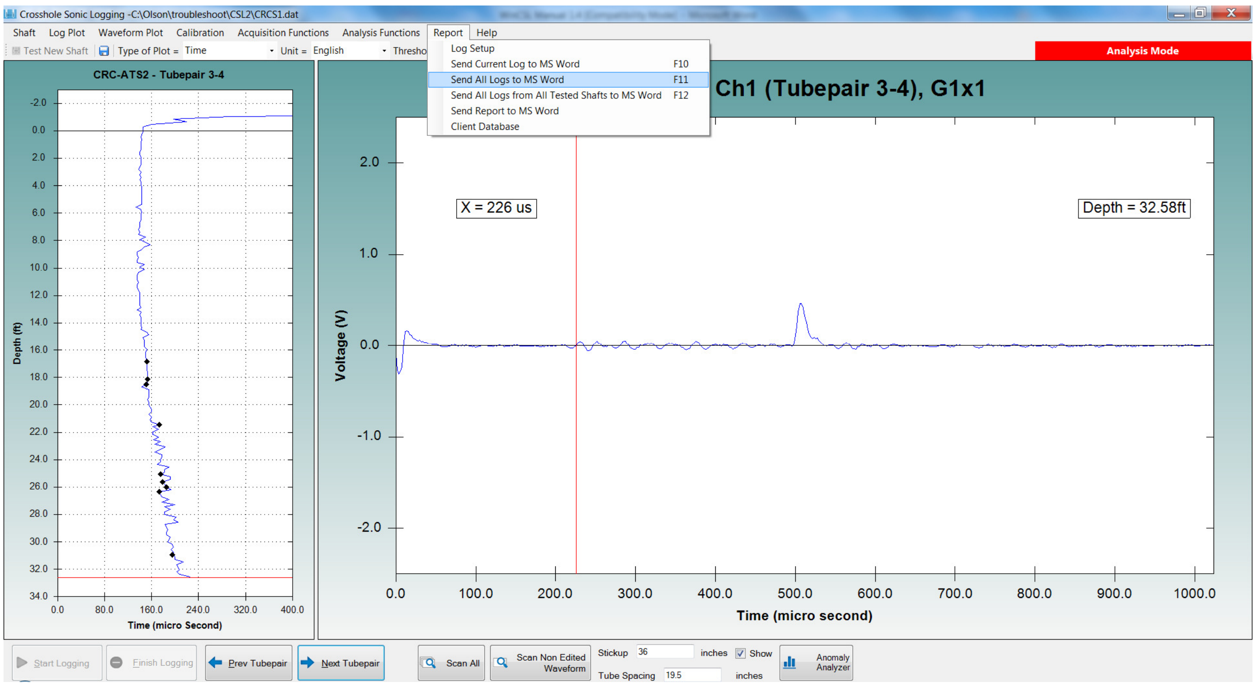
The user can select from four types of plots including Time, Time and Energy, Velocity or Z-Banded. The program allows up to four logs per page to be linked to MS Word but if more than one log per page is set, the shaft information and template cannot be included in the printout due to space limitations.

Use the "Number of Logs on One Page" entry field to input the number of logs you wish to display on each page. Use the "Same Page" check box to print the logs on the same page. If this option is selected, the entry field for "Number of Logs on One Page" is disabled.

Page number and footer can be added as well as a selection of shaft information when only one log per page is printed. When the form is complete, click on the "Done" button.

8.2 Print Logs

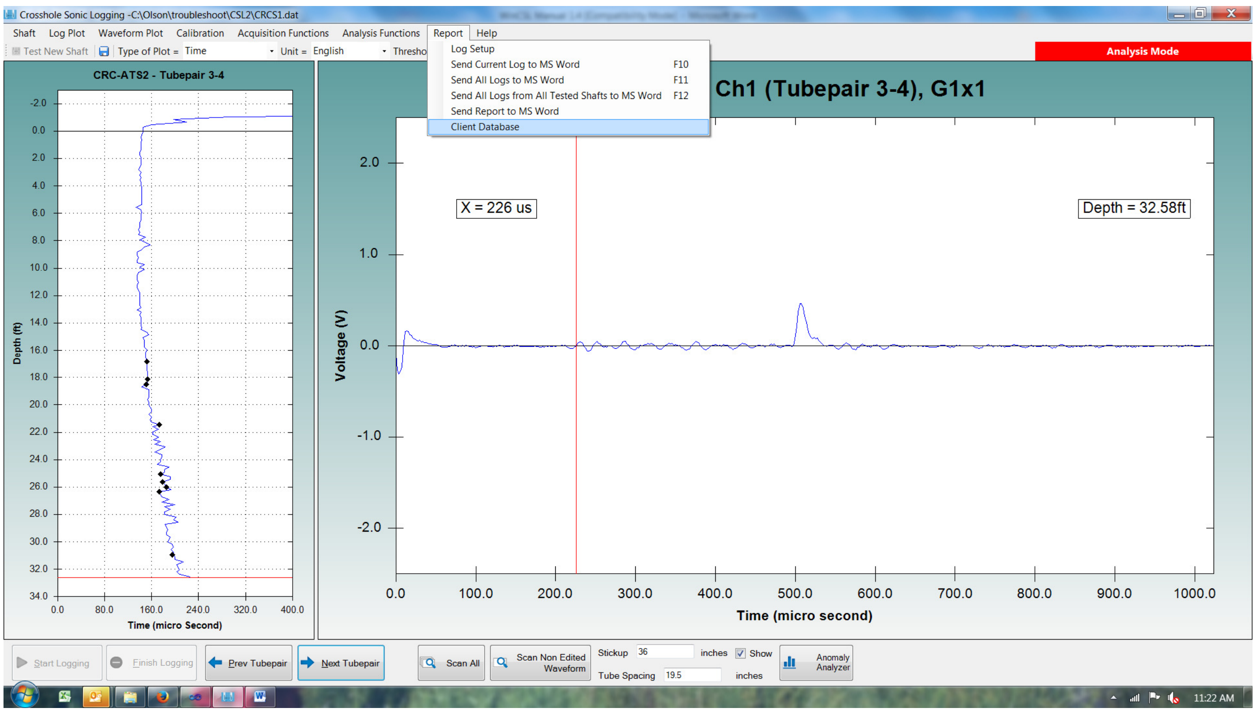
To send the logs to MS Word for printing, go to “Report” on the Main Menu and select from the options offered in that menu as shown below. There are three options: Send only the Current Log, Send all logs from this shaft or Send all logs from all the tested shafts.



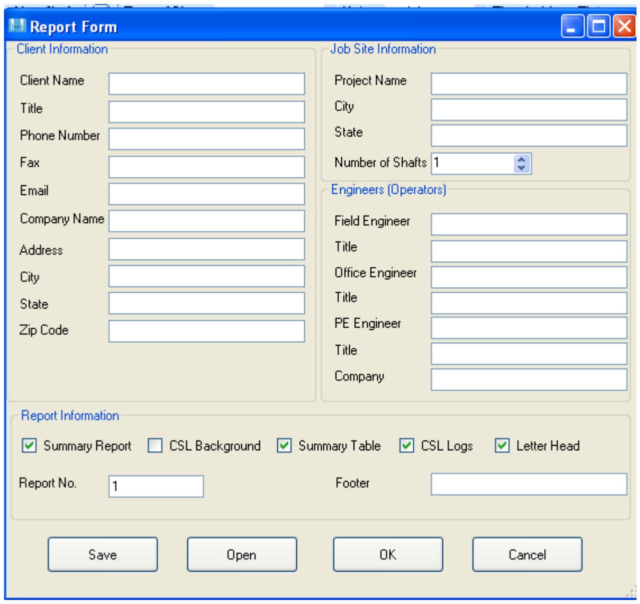
After you have made your selection, the software will open up MS Word (Version 2007 and higher) and send the log(s) to the program for saving or printing.

8.3 Report Setup

Before you can print a report, you must set up the client database. Go to the Main Menu and select “Report/Client Database” as shown in the figure below.



Then a “Report Form” Dialog Box will appear as shown below.



Enter the desired Client Information, Job Site Information and information about your Engineers, all of which will be saved in a client file that can be reloaded in the future. The report can be generated with a selection of features including a Summary Report, CSL Background Information, a Summary Table, CSL Logs and your Company Letterhead. After you have filled in the Report Form, click on the “OK” button.

8.4 Print/Generate Report

To send the report to MS Word, go to the Main Menu and select “Report/Send Report to MS Word”.

The software will then open up MS Word (Version 2007 and higher) and link the automatically generated CSL report to Word, using the client information database incorporated into the WinCSL program. The report can then be saved and/or printed.

If you select to send all logs from all tested shafts, you will be required to fill out a “Question Form” Dialog Box indicating the number of shafts you want to include in the report. After entering the number of shafts into the “Enter Number of Shafts” entry field, Click on “OK” then select the same number of files from the Windows “Open” Dialog Box. After each file has been selected, click on “Open” to open the shafts to be included with the report.

The CSL summary report includes basic client information and a summary of the conditions of the tested foundations including number of defects, locations of each defect, the affected tubepairs as well as the maximum percentage of velocity reduction. The CSL background included in the report is a standard CSL brief written by Olson Engineering, Inc. The summary table included in the report lists the condition of the shafts (as analyzed and saved during the defect analysis process). An example CSL report is included in Appendix A.

9.0 TEST HYDROPHONES

This section covers the necessary steps to test two hydrophones and ensure their proper functionality. This test must be performed with the hydrophones placed in the nylon test block provided with your CSL system. During the test, a signal will be sent by one of the hydrophones and received by the other hydrophone. If the signal arrives at the expected time appropriate for the test block, the program will inform you that the hydrophones have been calibrated successfully.

If the hydrophones do not calibrate successfully, they can be switched and retested. Both hydrophones are capable of either sending or receiving a signal. Either hydrophone might perform one of those functions successfully while failing at the other function.

If the hydrophones do not calibrate successfully, then one or both of the hydrophones might need to be replaced.

To test the hydrophones:

1. Connect the CSL hardware per the instructions in **Section 3**. It is not necessary to connect the depth wheel or set up the tripod because the "Test" button can be used to operate the CSL pulser module and send the necessary signal between the hydrophones in the nylon test block.
2. Place a small amount of water in the nylon test block that was provided with your CSL system. Most of this water will be displaced by the hydrophones so only a small amount of water is needed.
3. Insert two hydrophones in the test block.
4. Start the CSL program per the instructions in **Section 6.1**.
5. Go to the Main Menu and select "Calibration/Test CSL System in the Test Block"

6. Then the following Windows "Save As" Dialog Box will appear. Enter a filename for the test and click on "Save."

7. Press the "Test" button on the CSL pulser so that it pulses once. If the velocity is in an acceptable range, a small dialog box will appear reporting "Calibrated Successfully" as shown below. Click on the "OK" button.

10.0 DEPTH WHEEL CALIBRATION

This section covers the necessary steps to calibrate your depth wheel. The depth wheel is calibrated at the time of manufacture and the calibration value is entered into your Data Acquisition and Data Analysis Parameters for the computer sold with that depth wheel. It should not be necessary to change this value unless you are using a different depth wheel than the one originally sold with your computer.

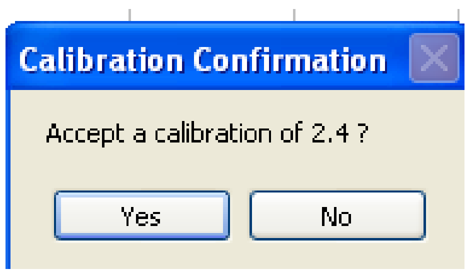
To calibrate your depth wheel:

Start the CSL program per the instructions in **Section 6.1**. Go to the Main Menu and select "Calibration/Depth Wheel Calibration".

Then the following Windows "Save As" Dialog Box will appear.

Enter a filename for the test and click on "Save." Then the following "Question Form" Dialog Box will appear.

Enter the **exact** length of cable that you intend to pull through the depth wheel. Fifty feet is suggested as a good length to use. After you have entered the length, click on "OK". Then click on "Start Logging" and pull the cable through the depth wheel. When you are finished, click on "Finish Logging" and the following dialog box will appear asking you if you want to accept the calculated calibration value.



If the value is acceptable, click on "Yes" and this value will be saved in the parameter file. Then the following small dialogue box will appear reporting that "Scanning and Saving Data Complete. Click on the "OK" button to proceed.

If the calculated depth wheel calibration value is not acceptable, click on "No" and repeat the test.

11.0 HARDWARE TROUBLESHOOTING

This section will allow the user to check the CSL system to verify everything is working properly. If the recommendations do not solve the problem, or if the particular problem is not covered, please contact Olson Instruments.

11.1 Hardware System Check

There are several procedures which can be used to check the operation of the system prior to data collection, or if problems are encountered during data collection. These procedures are described in the following sections. Note that not all procedures apply to all systems.

11.1.1 INPUT Module Test

The primary way to test the Input Module unit is to set the gain to a high level with a transducer attached, and then view the signal in the data collection mode. Press the test switch on the pulser module and observe the screen. If the transducers are connected to the input module and pulser module, and the two transducers are near each other (or horizontally opposed in a water bath or concrete shaft), a signal should appear on-screen. If no pulser transducer is connected (or it is suspected that the pulser is not functioning), the receiver signal on-screen should show noise or other signals on-screen (gain=8000). Tapping the transducer while holding the test button on the module should result in a large signal on-screen. If not, check the signal connections, raise the gain on the amplifier, and make sure that the transducer cables at the cable reel and amplifier module are fully connected as tugging on the short transducer interface cable may pull it part way out of the socket on the cable reel. If all else checks out, but the test signal is still not visible, contact Olson Instruments at 303.423.1212.

11.1.2 PULSER Module Test

Testing the Pulser Module involves one simple test. This test will also verify the functionality of a cable and transducer pair. The test is performed by connecting a transducer to the pulser output and listening for a clicking sound in the transducer when it pulses. To do this, first connect the transducer to a cable, and then the cable to the pulser output. Next, connect the box to power (power light should be on). When the TEST switch is depressed, the transducer should click at 2-10 clicks/second. If no clicking is audible from the transducer, first verify that the computer is turned on and the pulser module firmly seated. If this does not result in the clicking being heard, retest the system with another transducer and/or cable to verify that the problem is not in either of these components. If no combination of cables and transducers produces the clicking sound, then the Pulser Module is suspect and Olson Instruments should be contacted. A final check of both the Pulser and the Input Modules can be made with the two transducers lowered into a water bath. Submerge the source and receiver transducer in water about 30 to 60 cm apart (this must be measured) and check that the velocity of water is measured for the known spacing and water temperature. Typical water velocity at 21 degrees C is 1,493 meters per second.

APPENDIX A

EXAMPLE CSL REPORT

Olson ENGINEERING
Corporate Office:
12401 W. 49th Ave.
Wheat Ridge, CO 80033-1927 USA
phone: 303.423.1212
fax: 303.423.6071

May 24, 2010

My Construction, Inc.
1234 4th Ave.
Aurora, CO 80011

Attn: Mr. Jimmy John
Phone: 303-123-4567
Fax: 303-123-5678
Email: jjohn@myconstruction.com

RE: Report No.8
Crosshole Sonic Logging (CSL) Results
Shafts B871.7 P3 S1 and B872.2 P5 S1
My job site
Abo, New Mexibco
OE Job No: 1234H

Ladies and Gentlemen:

This letter presents the results of Nondestructive Testing (NDT) performed on 2 drilled shaft foundations for Ames Construction at the above mentioned project in Abo, New Mexico. The CSL testing was performed on May 24, 2010 by James Knox of Olson Engineering, Inc. using the Crosshole Sonic Logging (CSL) Method. The detailed CSL results are included in Table I and the CSL logs are presented in Appendix A. The following is a brief summary of the CSL test results:

- The CSL results showed that Shaft B872.2 P5 S1 is sound with no anomalies identified.

- The CSL results showed that Shaft B871.7 P3 S1 had 1 anomaly identified as follows:
1) One anomaly was detected from depths of 23.1 to 25.7 ft (Tubes 2 - 3, 3 - 4, 4 - 5, 5 - 6) resulting in velocity reductions of up to 42%.

There is not a direct measurement relationship between the low-strain velocity and the high strain strength of concrete. However, modulus is proportional to velocity squared and based on correlations between modulus and compressive strength (ACI 228.1R-89), In Place Methods for Determination of Strength of Concrete), strength can be related to velocity. Based on the relationship that is stated in the American Concrete Institute (ACI) reference, strength is proportional to modulus squared which translates to strength being proportional to velocity to the power 4. If sizes and shapes of the defects stated above are desired, Olson Engineering can perform Crosshole Tomography (at additional cost) to measure the size and shape of the defects. The CSL logs show plots of signal arrival time and signal energy versus depth for each of the tube pairs tested in the shaft. Tube 1 is always the northernmost tube.

CLOSURE

For additional information as to the interpretation of the logs, please refer to Table II in this report. If you have any questions, or require further information, please do not hesitate to call.

Respectfully submitted,

Olson Engineering, Inc.

____

James Knox
Project Engineer

____

Yajai Tinkey, Ph.D., P.E.
Associate Engineer

(1 copy faxed or emailed and 2 copies mailed)

TABLE I
CSL RESULTS SUMMARIES
VELOCITIES, LENGTH, TEST DATE AND ANOMALY ZONES

Shaft Name	Avg. Vel. (ft/sec)	Test Length (ft)	Test Date	Age When Tested (days)	Appendix A Figure Numbers	Concrete Condition Rating	Anomalous Concrete Zones (Tubes, Depths, %Velocity Reduction)
B871.7 P3 S1	13300	25.7	05/24/2010	5	1 - 9	P/Q	Tubes 2 - 3, Depths 25.3 to 25.7 ft, 16%. Tubes 3 - 4, Depths 24.8 to 25.5 ft, 29%. Tubes 4 - 5, Depths 23.1 to 25.5 ft, 21%. Tubes 5 - 6, Depths 24.6 to 25.7 ft, 42%.
B872.2 P5 S1	14000	31.	05/24/2010	13	10 - 18	G	

**Notes:*	All depths are measured from the top of concrete.**
****	The percentage of velocity reduction is relative to the measured compression wave velocity of sound concrete adjacent to the anomalous zone**

TABLE II

CROSSHOLE SONIC LOGGING (CSL) CONDITION RATING CRITERIA

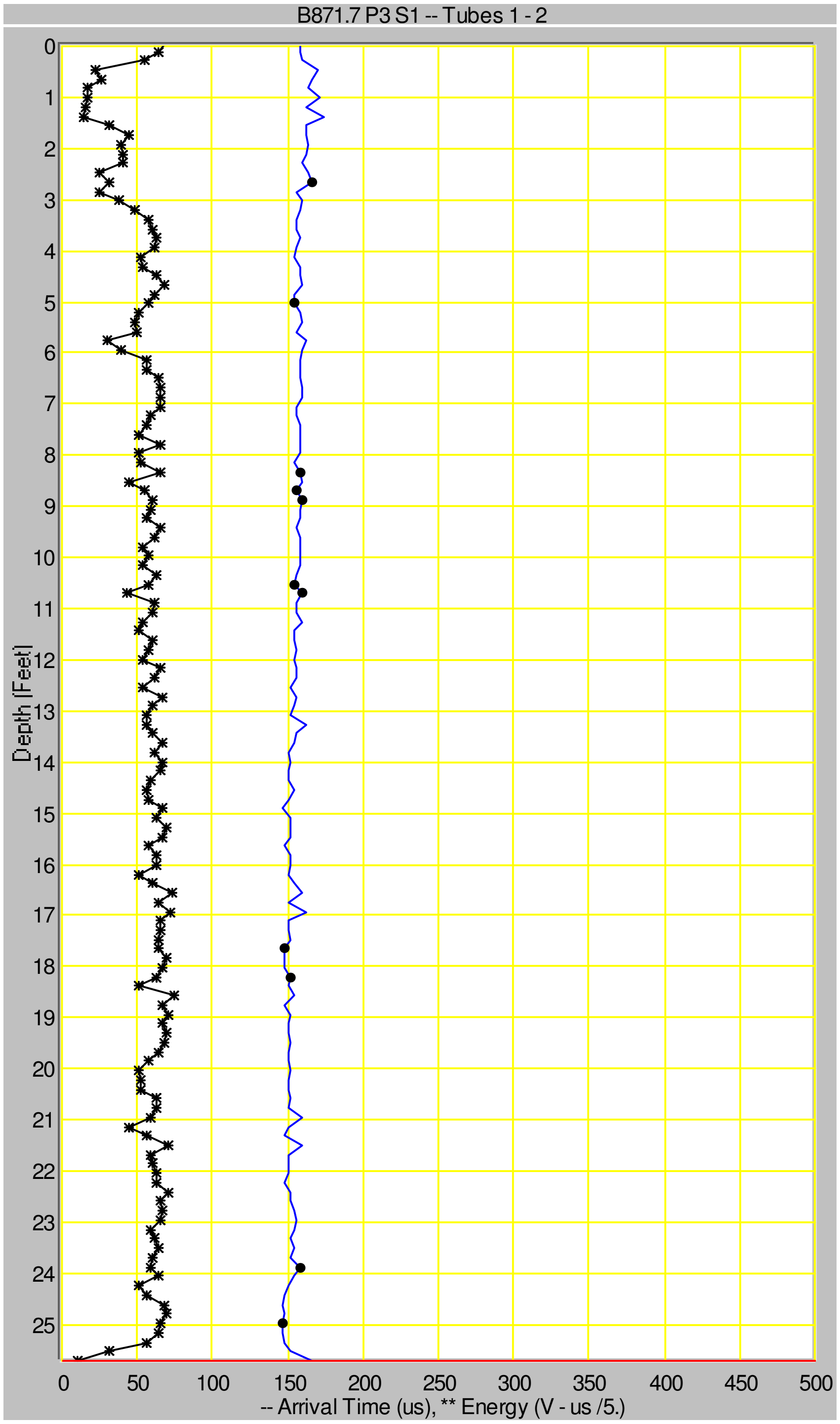
This CSL rating criteria categorizes abrupt increases in the signal arrival times that correspond to decreases in the average signal velocity of the material between the test probes. These abrupt changes are a result of one or more of the following conditions: (1) increased signal path length as the signal travels around the flaw; (2) a decrease in the signal velocity as it travels through a lower velocity material such as weaker concrete, honeycomb, or contaminated concrete; and (3) deterioration of the bond between the access tube and the concrete. Of the three conditions that cause increased signal arrival times, the deterioration of the tube-concrete bond is the least common and is typically identified only in the upper portions of shafts and in shafts with PVC access tubes.

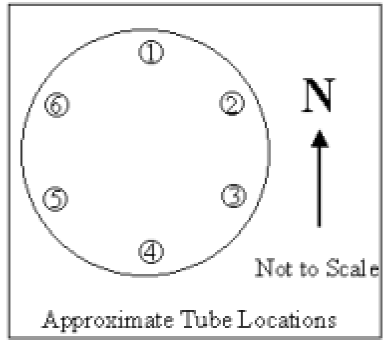
This CSL rating criteria is based on the percentage reduction of the signal velocity through the flawed area versus the signal velocity through sound material immediately adjacent to the flaw. This ensures that the signal arrival times used to calculate the signal velocities are measured through the same amount of material, which is very important if a tube pair is not evenly spaced from shaft top to bottom. This CSL criteria is in large part based on experience with ultrasonic pulse velocity measurements of structural concrete, which uses signal velocities to determine material integrity. However, the calculated signal velocities in the CSL testing are reduced by inherent delays due to the slower water, and PVC tube materials. This signal delay yields artificially lower signal velocity for path lengths of 24 inches or less. In contrast, the percentage change in signal velocity between good and flawed material is unaffected by inherent signal delays. Our general rating criteria for CSL results appears below.

Rating NDT Results indicative of Drilled Shaft Concrete Condition

Good (G)	No signal distortion and decrease in signal velocity of 10% or less is indicative of good quality concrete.
Questionable (Q)	Minor signal distortion and a lower signal amplitude with a decrease in signal velocity between 10% and 20%. Results indicative of minor contamination or intrusion and/or questionable quality concrete. Investigation of anomalies with 10% to 15% reductions in velocity have identified sound concrete at some sites and flawed concrete at others.
Poor/Defect (P/D)	Severe signal distortion and much lower signal amplitude with a decrease in signal velocity of 20% or more. Results indicative of water slurry contamination or soil intrusion and/or poor quality concrete.
No Signal (NS)	No signal was received. Highly probable that a soil intrusion or other severe defect has absorbed the signal (assumes good bonding of the tube-concrete interface). If PVC tubes are used or if measurement is from near the shaft top the tube-concrete bonding is more suspect.
Water (W)	A measured signal velocity of nominally V = 4,800 to 5,000 fps. This is indicative of a water intrusion or of a water filled gravel intrusion with few or no fines present.

Appendix A
CSL Logs

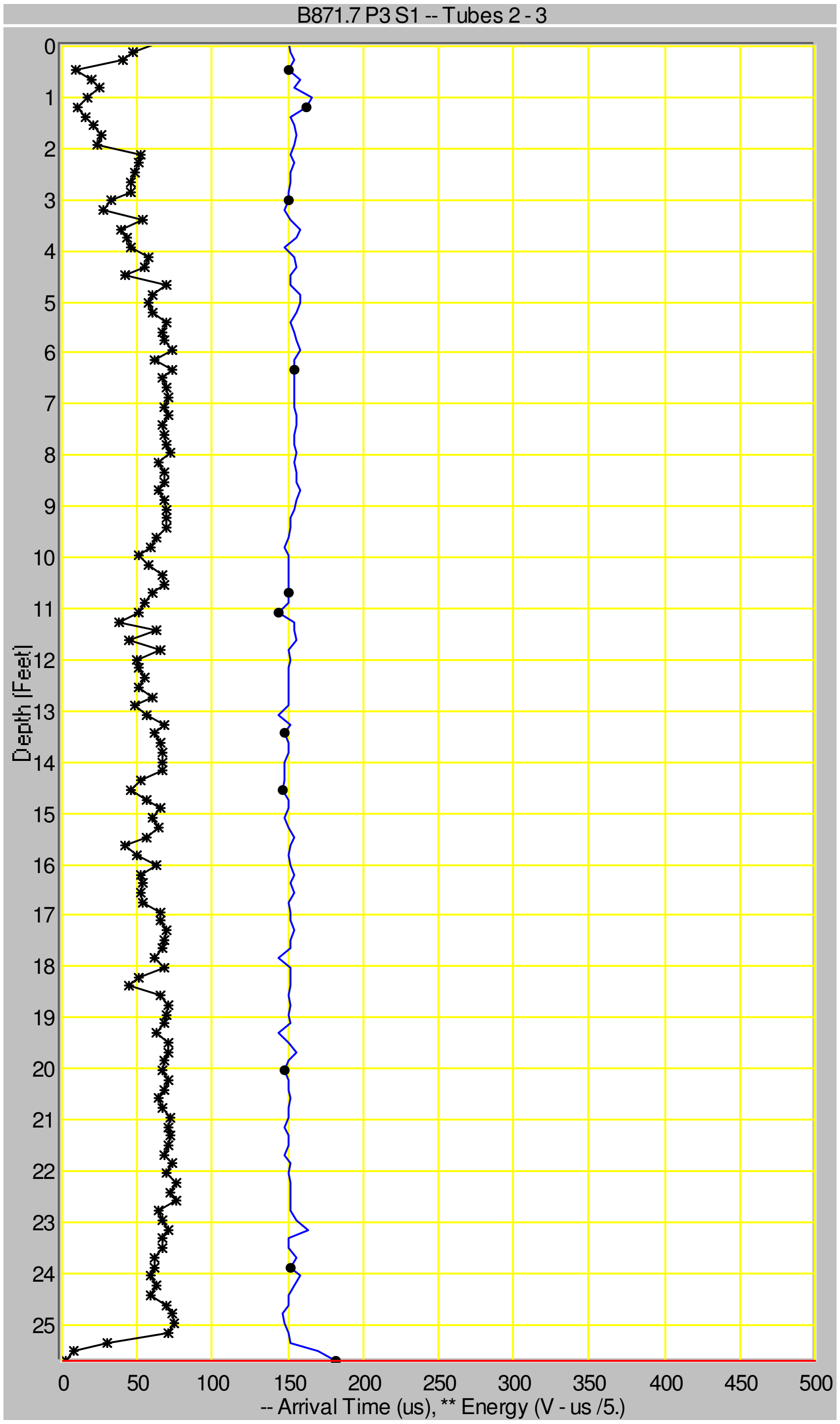


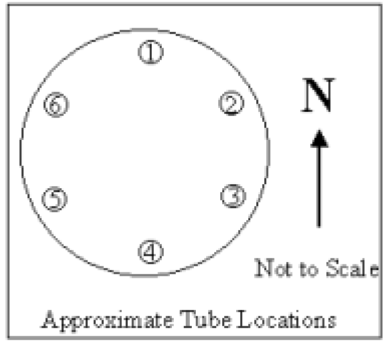


Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 25. inches
Cursor Depth: 25.706 ft
- Velocity = 12550 ft/sec
- First Arrival Time =

- Signal Energy = 0.3842



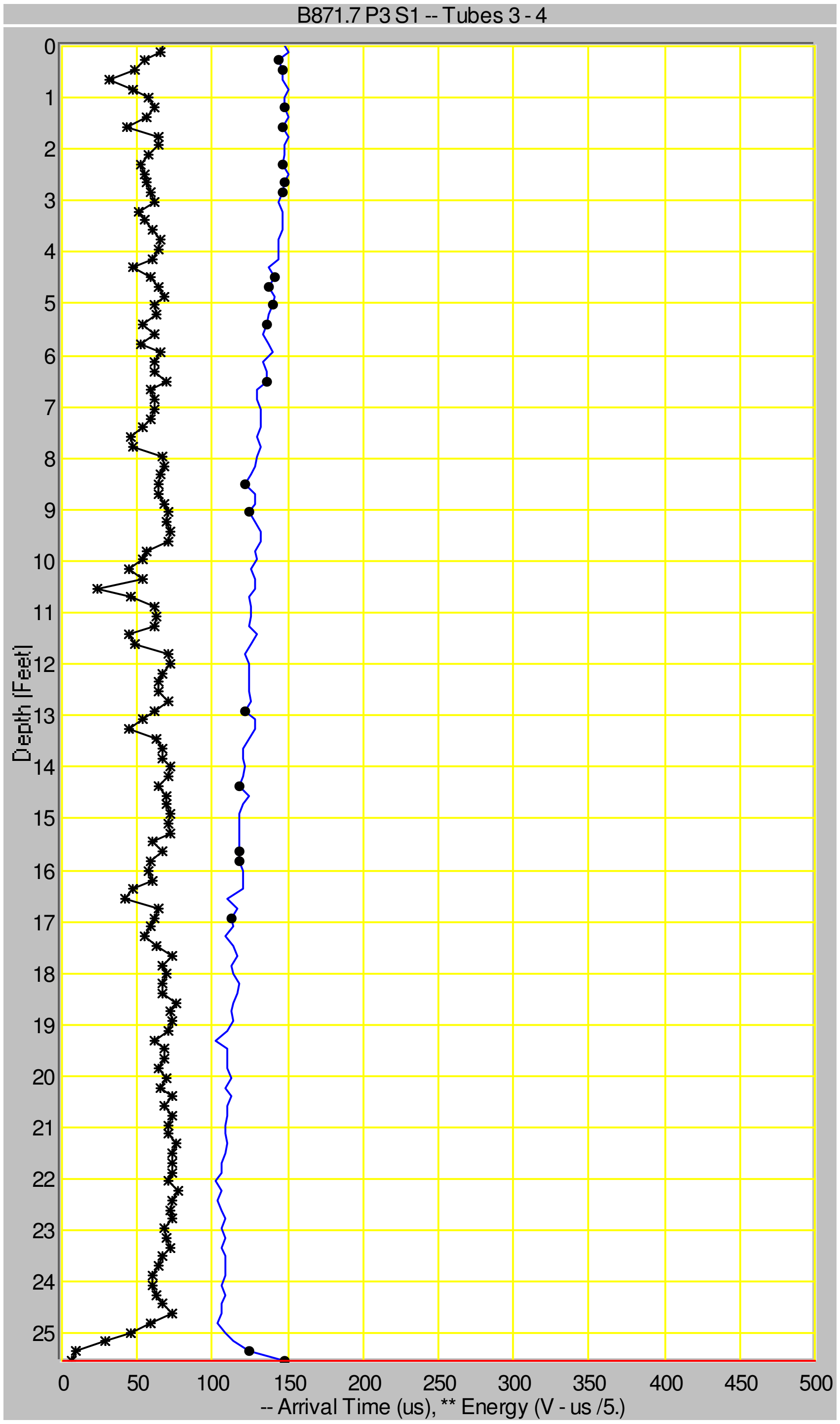


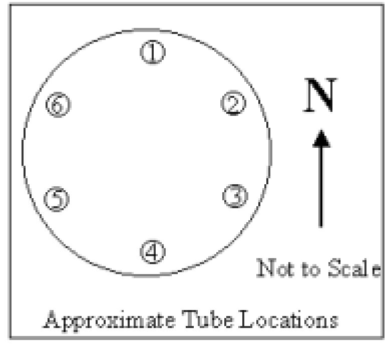
Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 23.5

Cursor Depth: 25.706 ft
- Velocity = 10760 ft/sec
- First Arrival Time =

- Signal Energy = 14.35

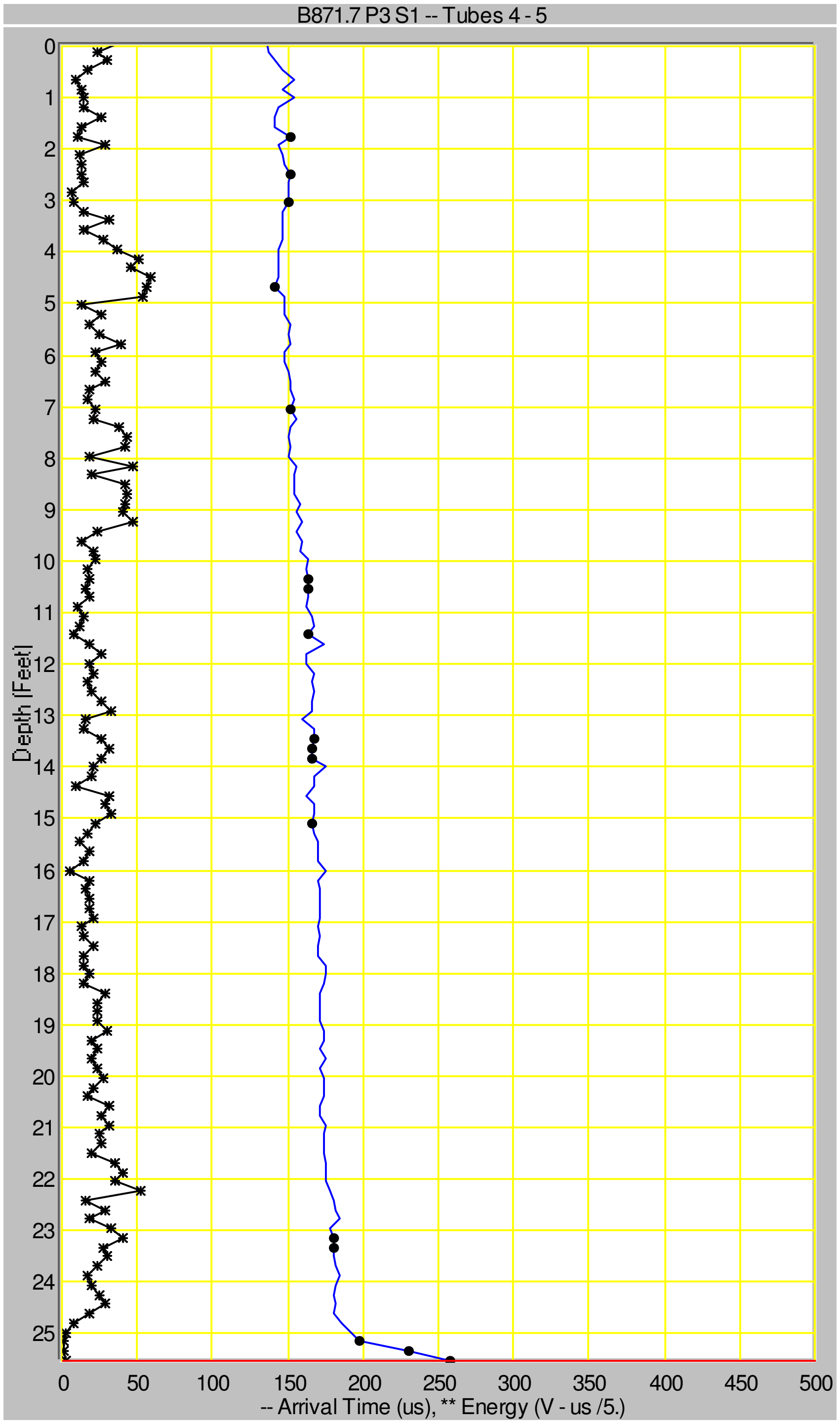


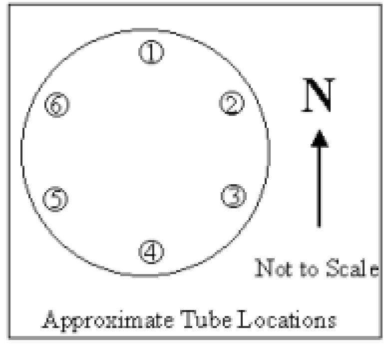


Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 24. inches
Cursor Depth: 25.523 ft
- Velocity = 13514 ft/sec
- First Arrival Time =

- Signal Energy = 22.95



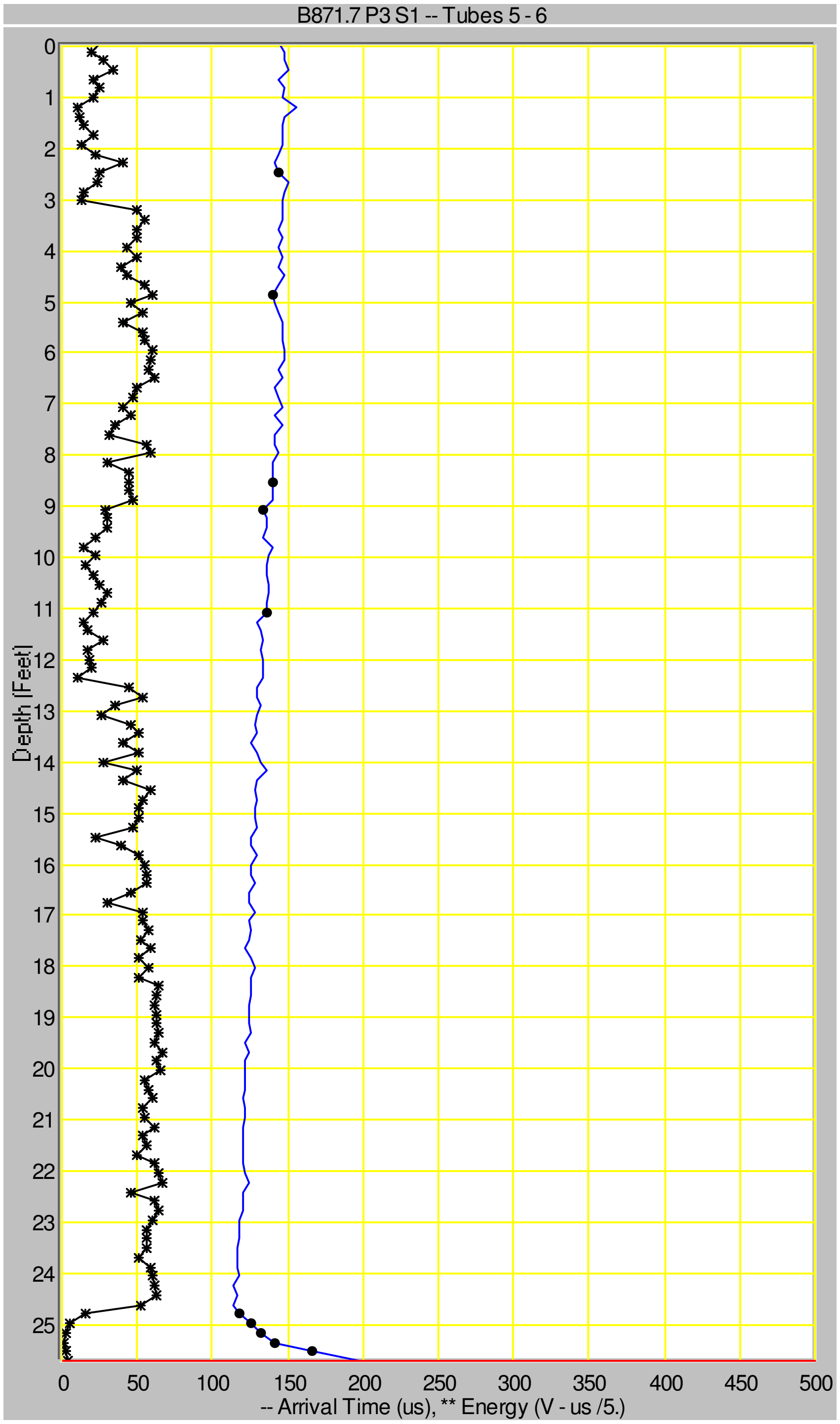


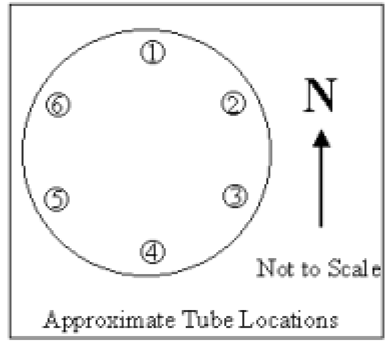
Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 21.5

Cursor Depth: 25.523 ft
- Velocity = 6944.4 ft/sec
- First Arrival Time =

- Signal Energy = 8.509

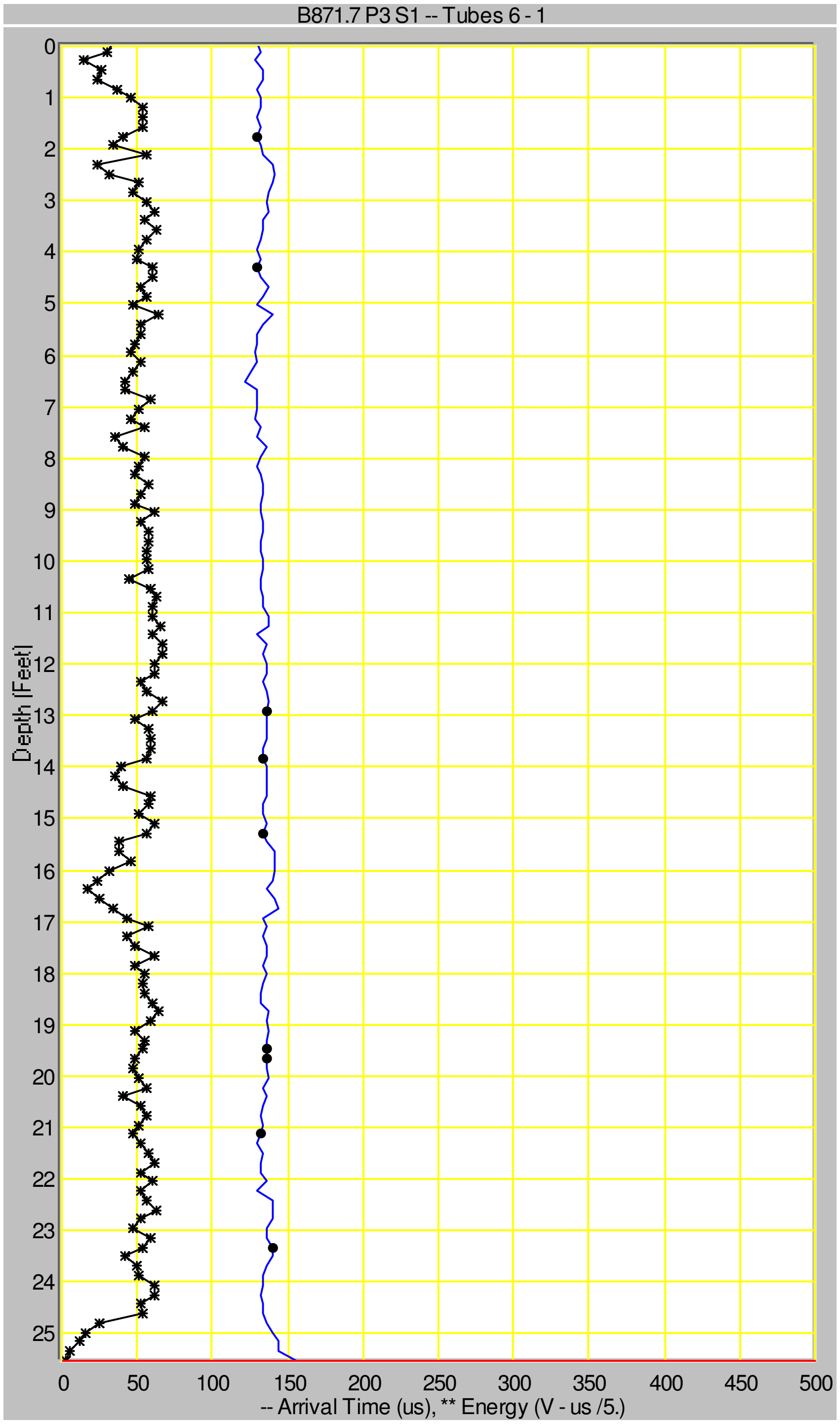


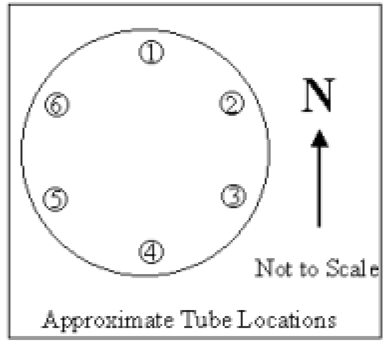


Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 24. inches
Cursor Depth: 25.706 ft
- Velocity = 10101 ft/sec
- First Arrival Time =

- Signal Energy = 5.644



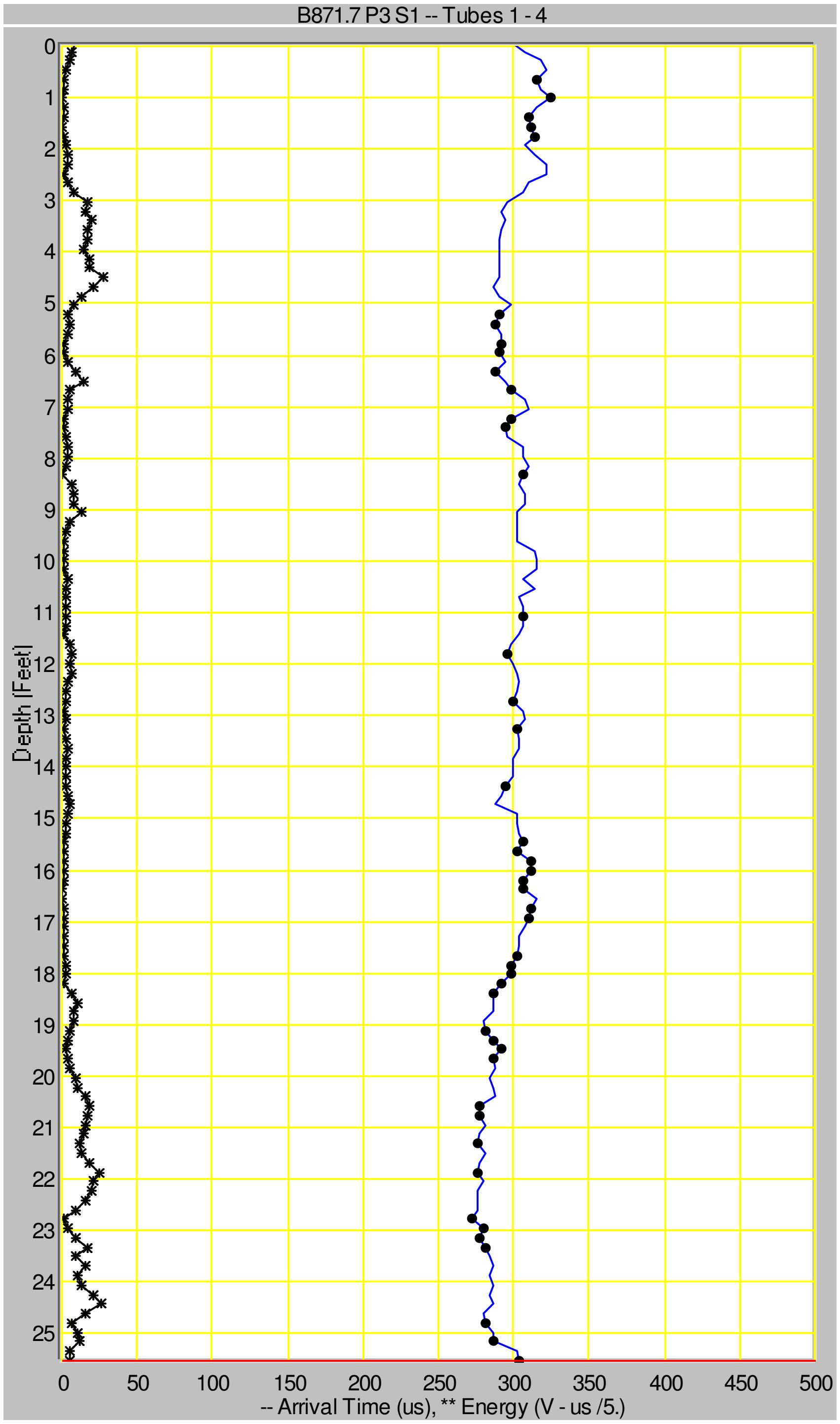


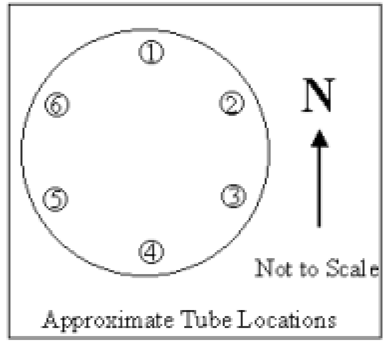
Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 20.5

Cursor Depth: 25.523 ft
- Velocity = 10951 ft/sec
- First Arrival Time =

- Signal Energy = 9.359



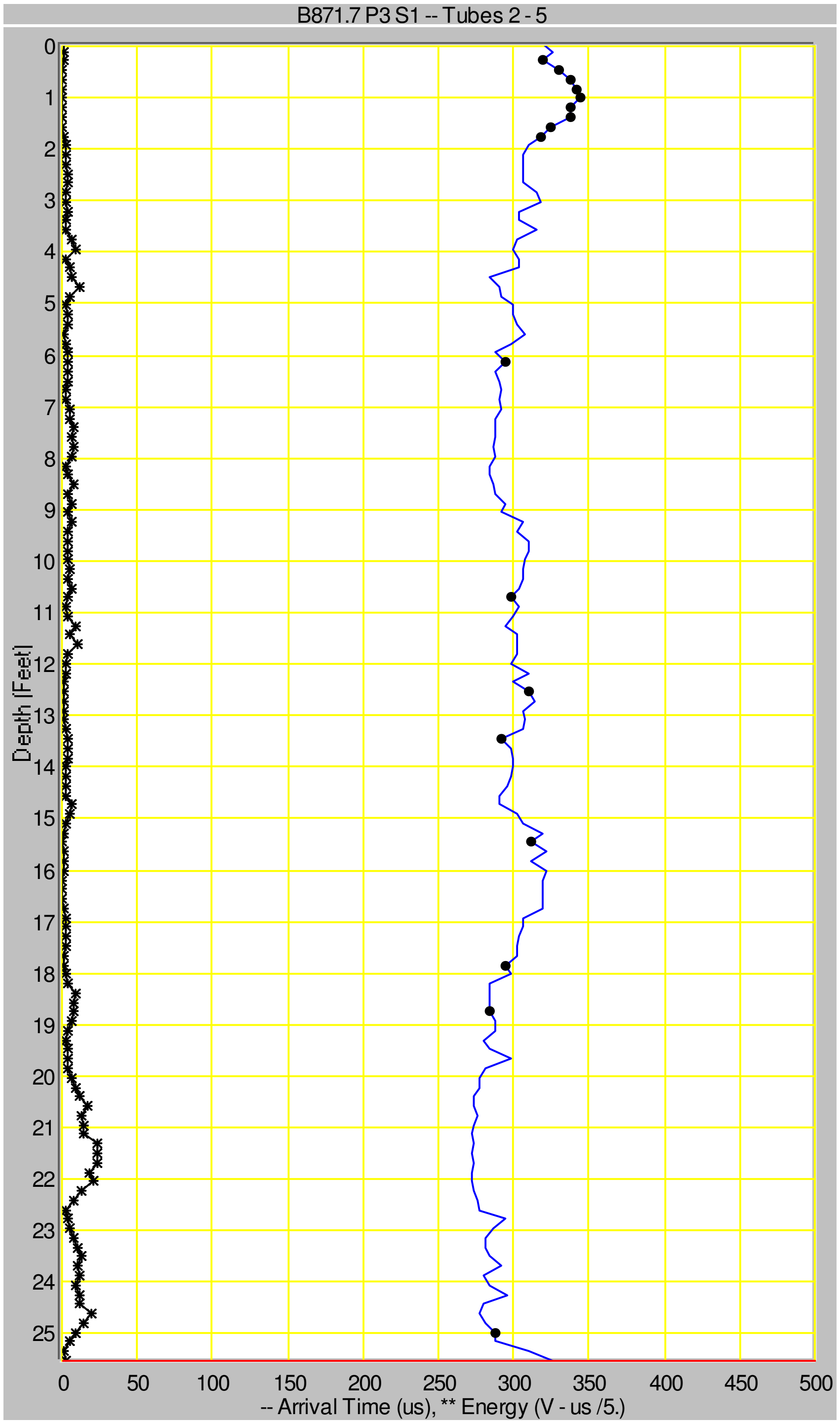


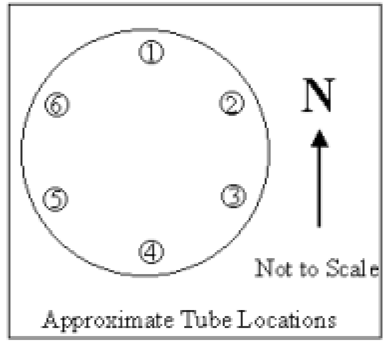
Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 46.5

Cursor Depth: 25.523 ft
- Velocity = 12747 ft/sec
- First Arrival Time =

- Signal Energy = 25.6 V-

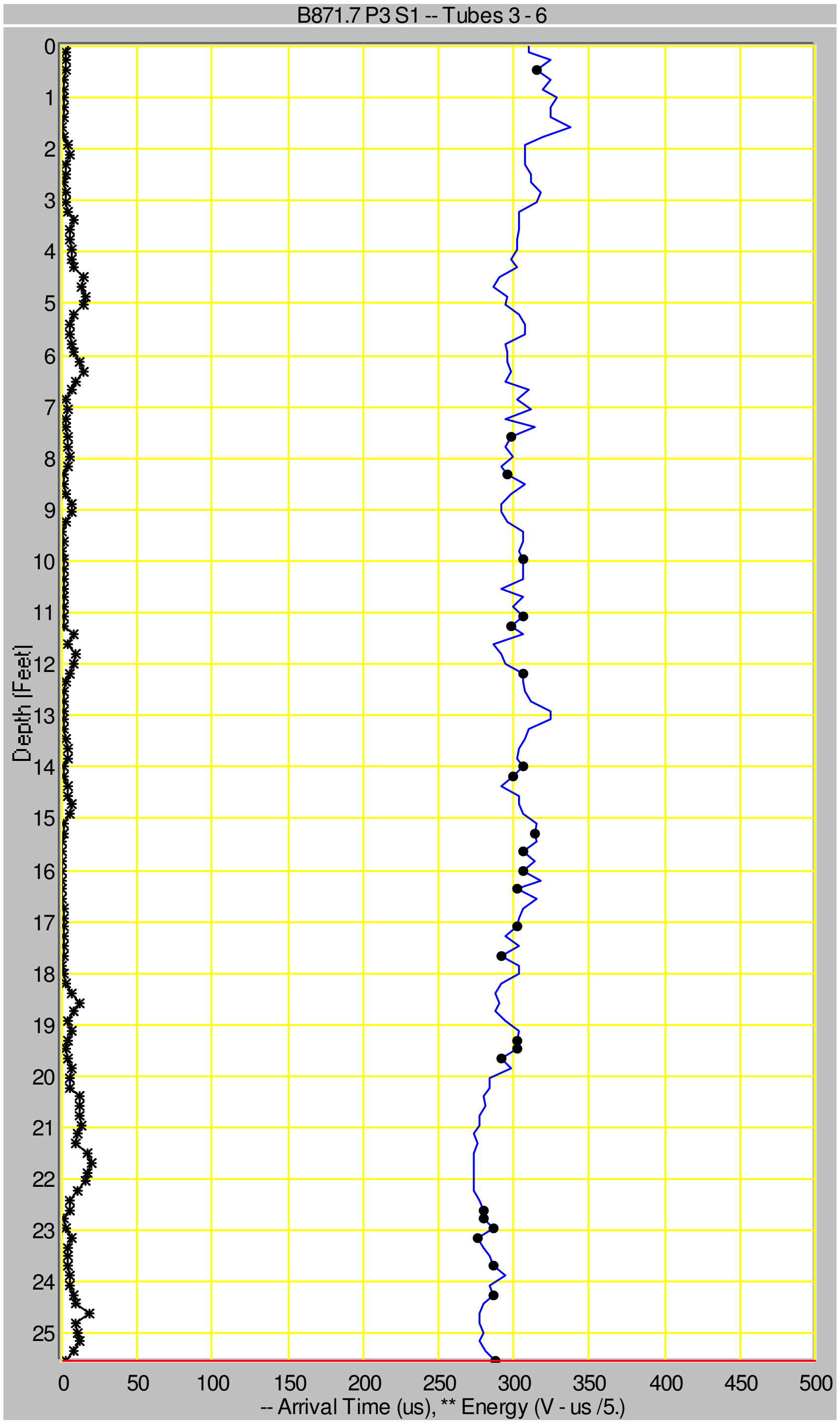


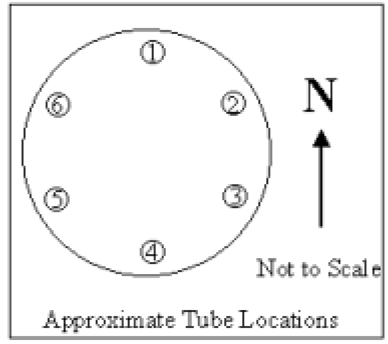


Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 46. inches
Cursor Depth: 25.523 ft
- Velocity = 11759 ft/sec
- First Arrival Time =

- Signal Energy = 10.23

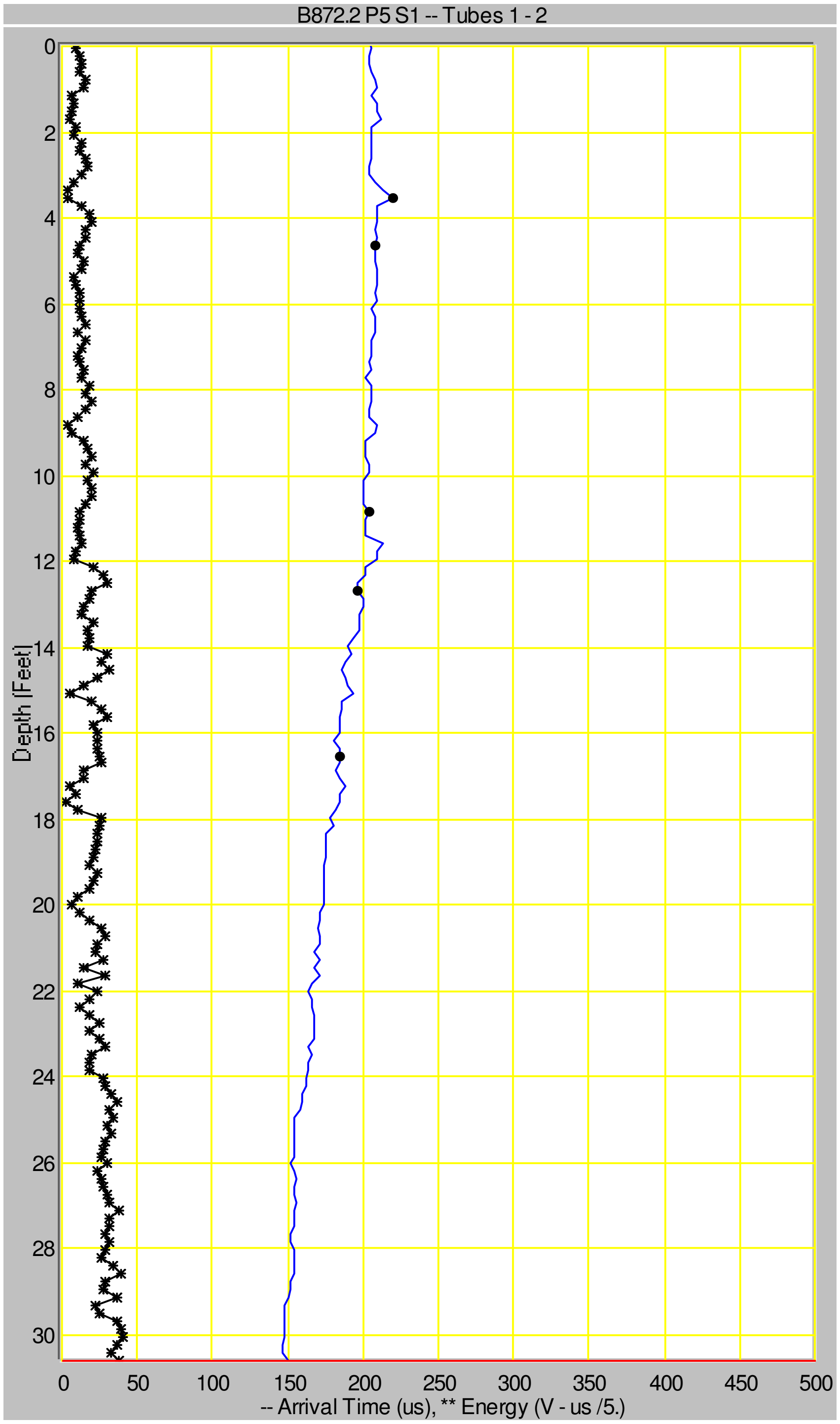


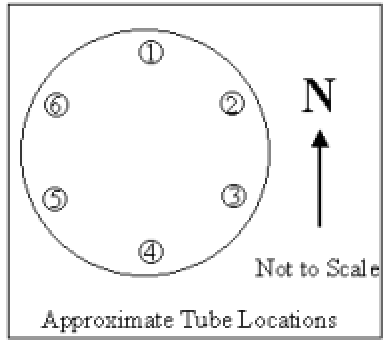


Project Name: 2804h
Shaft Name: B871.7 P3

Test Date: 5/24/2010
Tube Spacing: 46. inches
Cursor Depth: 25.523 ft
- Velocity = 13310 ft/sec
- First Arrival Time =

- Signal Energy = 9.769



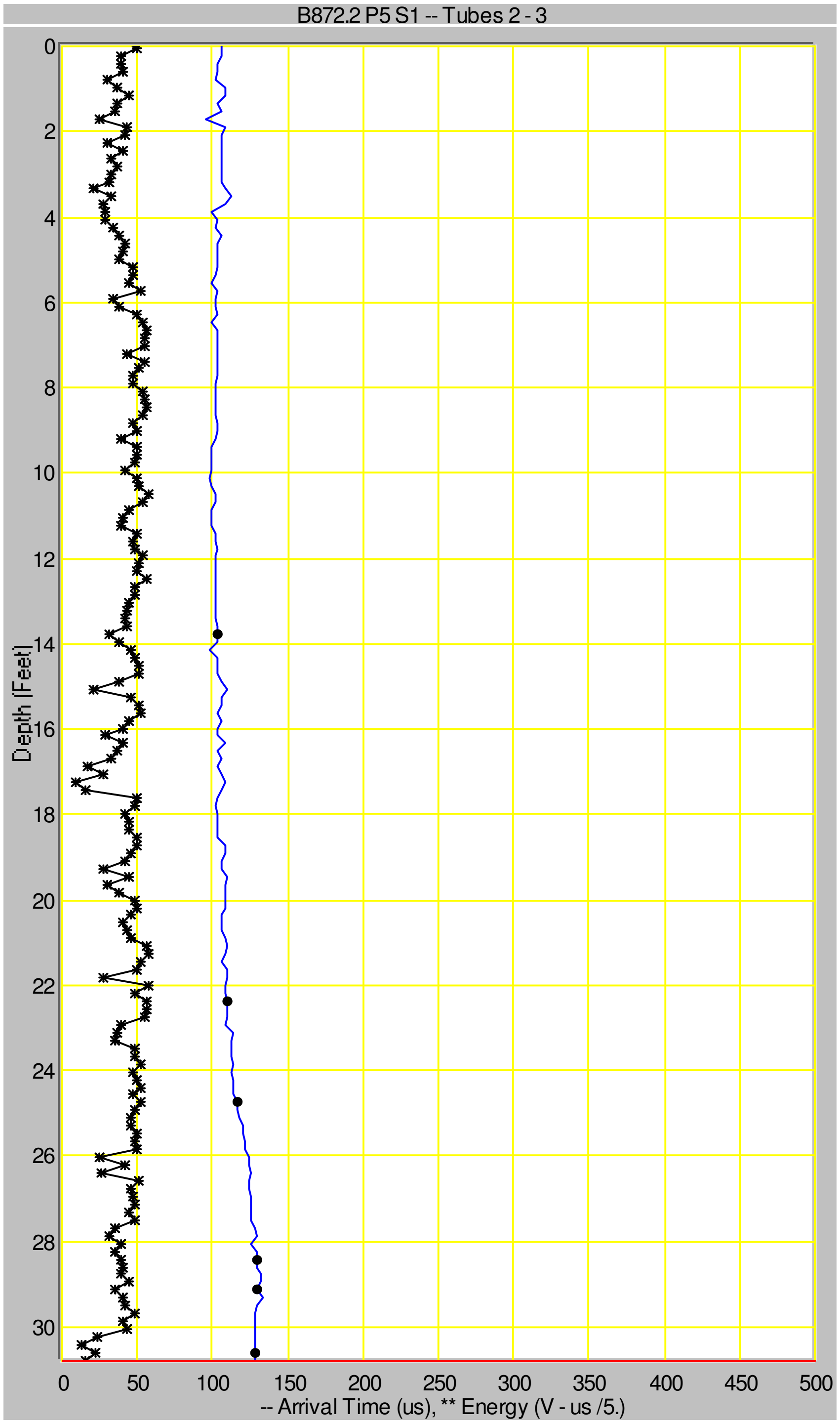


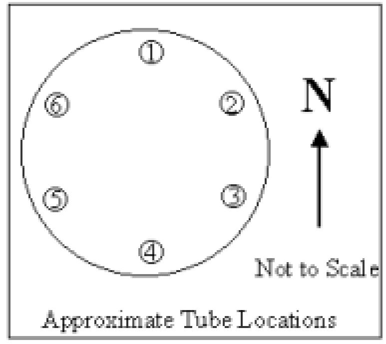
Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 34.5

Cursor Depth: 30.606 ft
- Velocity = 19167 ft/sec
- First Arrival Time =

- Signal Energy = 0.1933



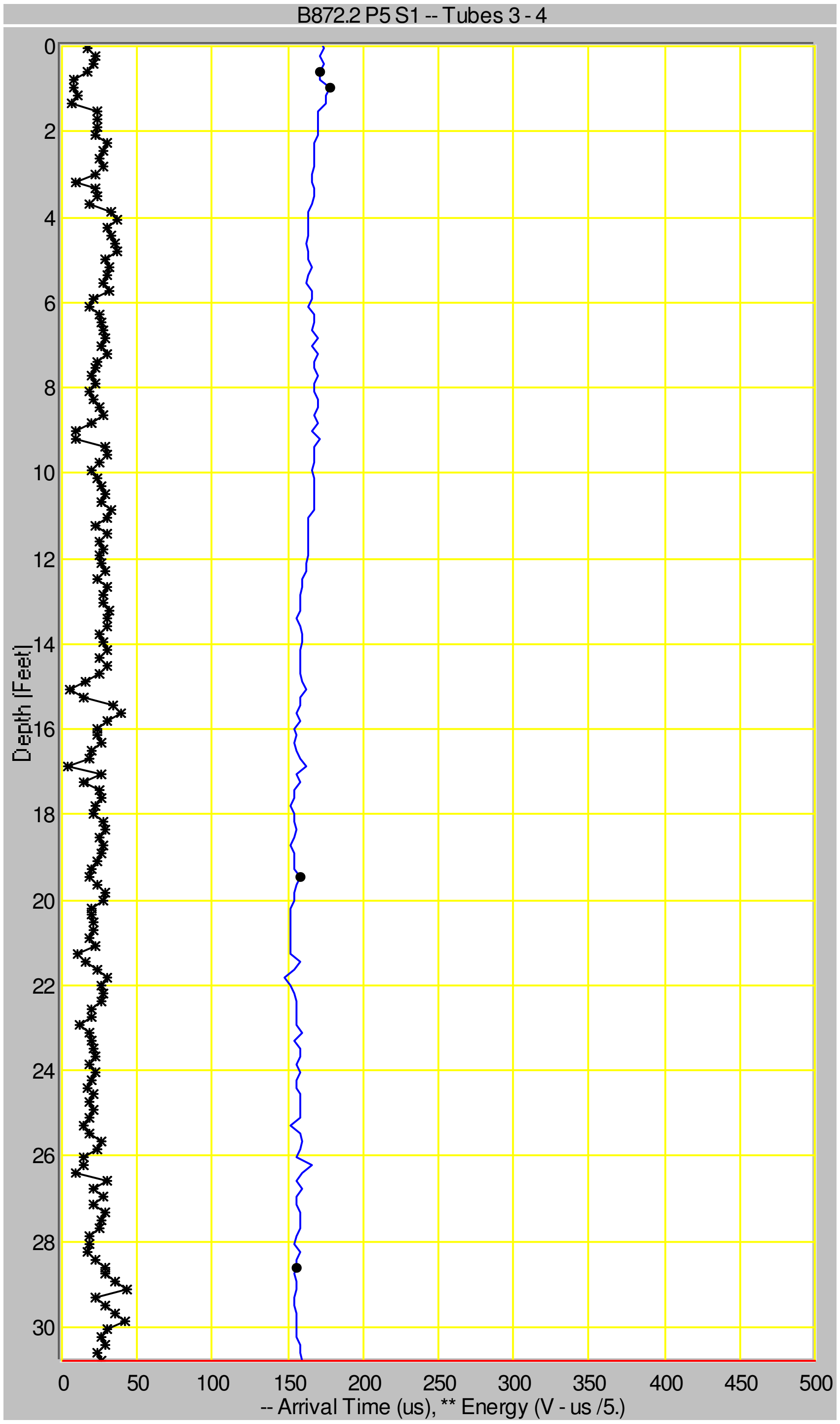


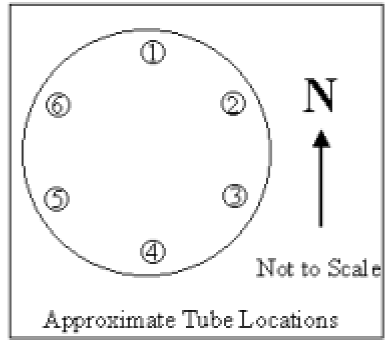
Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 16.5

Cursor Depth: 30.789 ft
- Velocity = 10742 ft/sec
- First Arrival Time =

- Signal Energy = 78.14

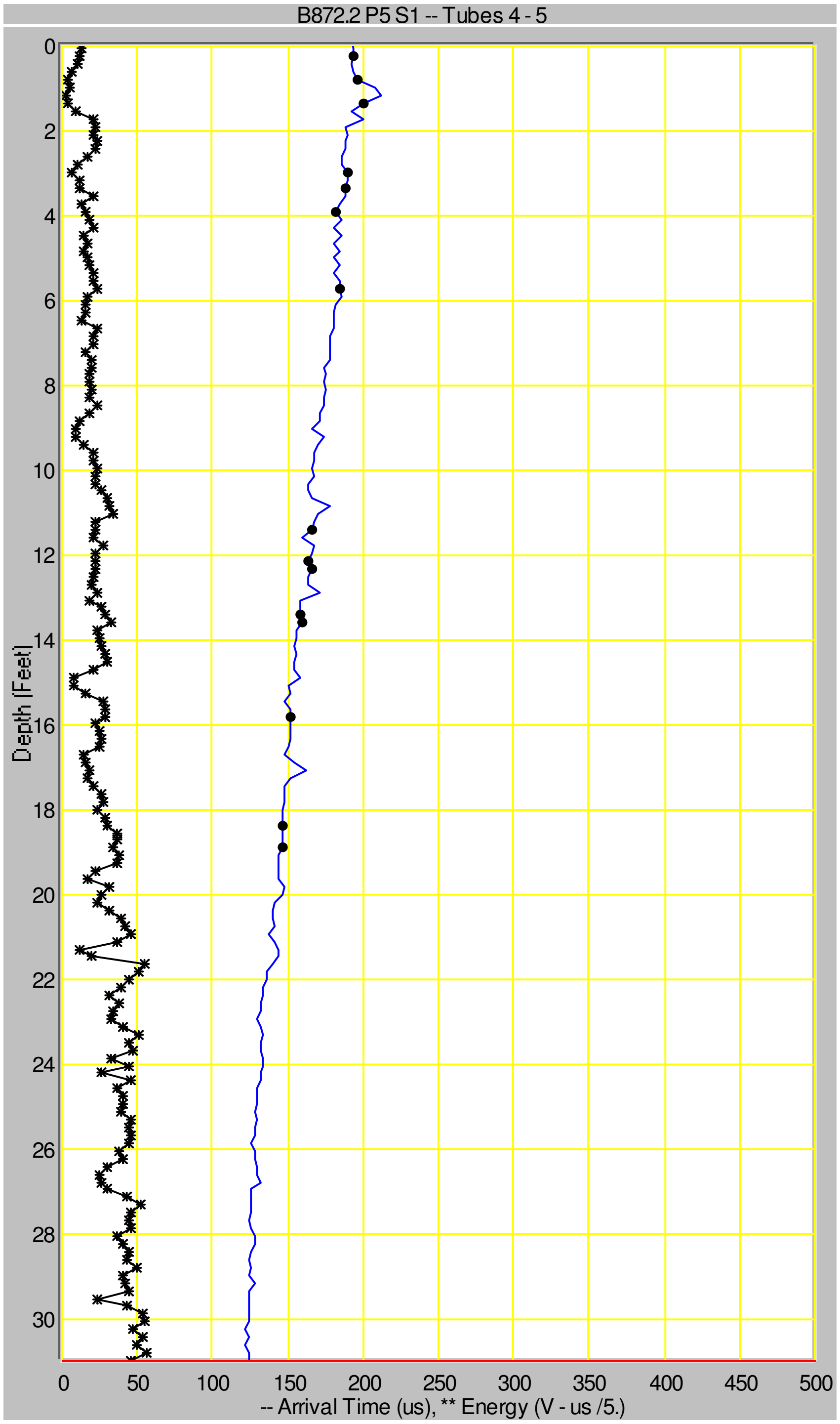


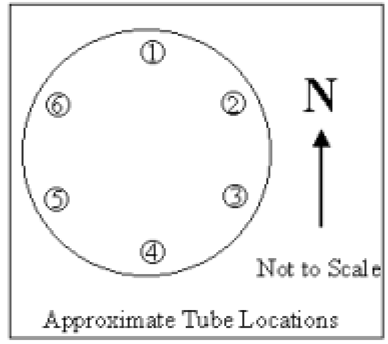


Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 28. inches
Cursor Depth: 30.789 ft
- Velocity = 14583 ft/sec
- First Arrival Time =

- Signal Energy = 126.5



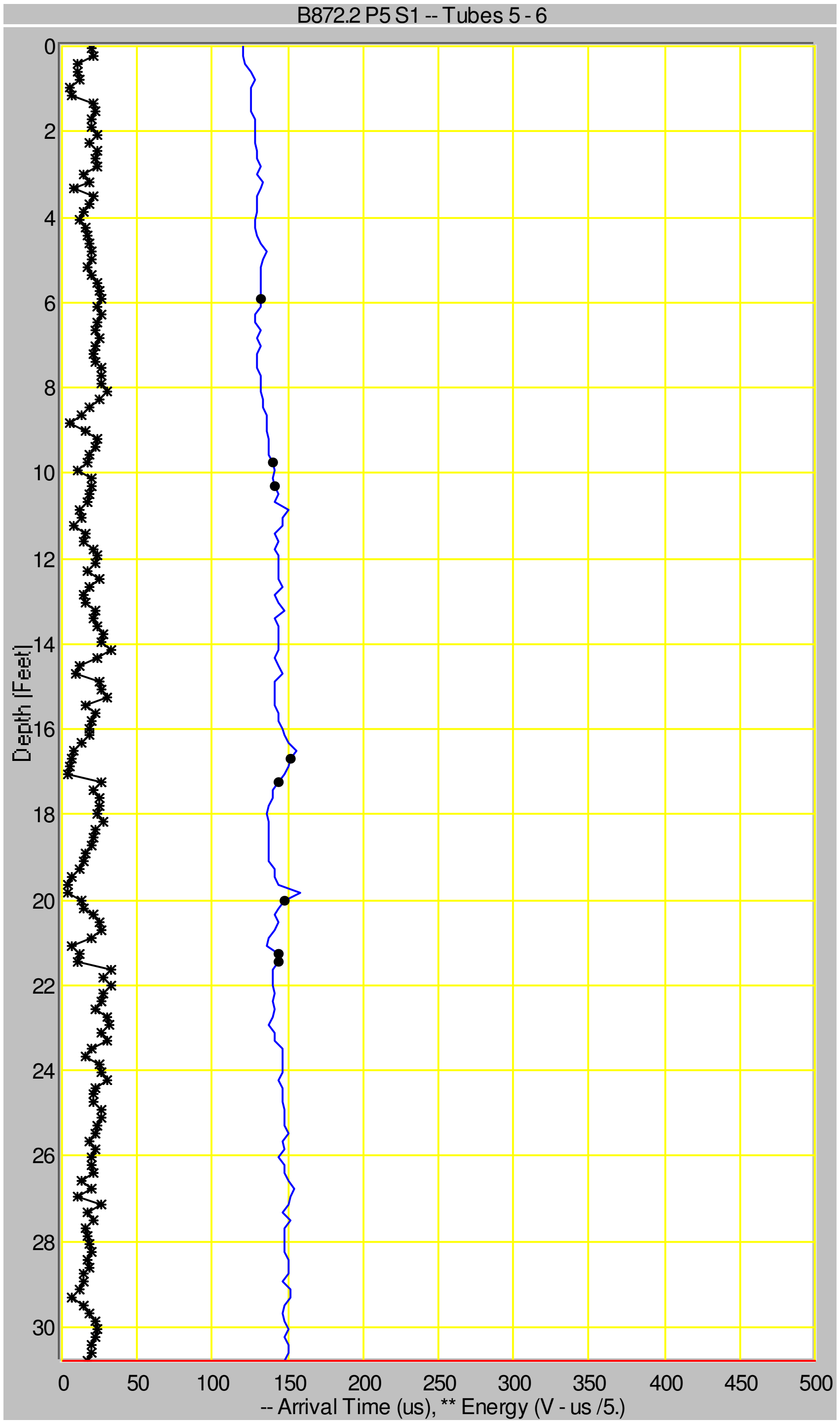


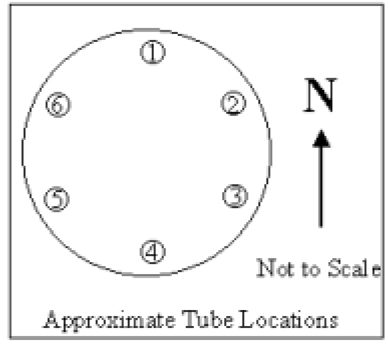
Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 31.5

Cursor Depth: 30.972 ft
- Velocity = 21169 ft/sec
- First Arrival Time =

- Signal Energy = 230.9



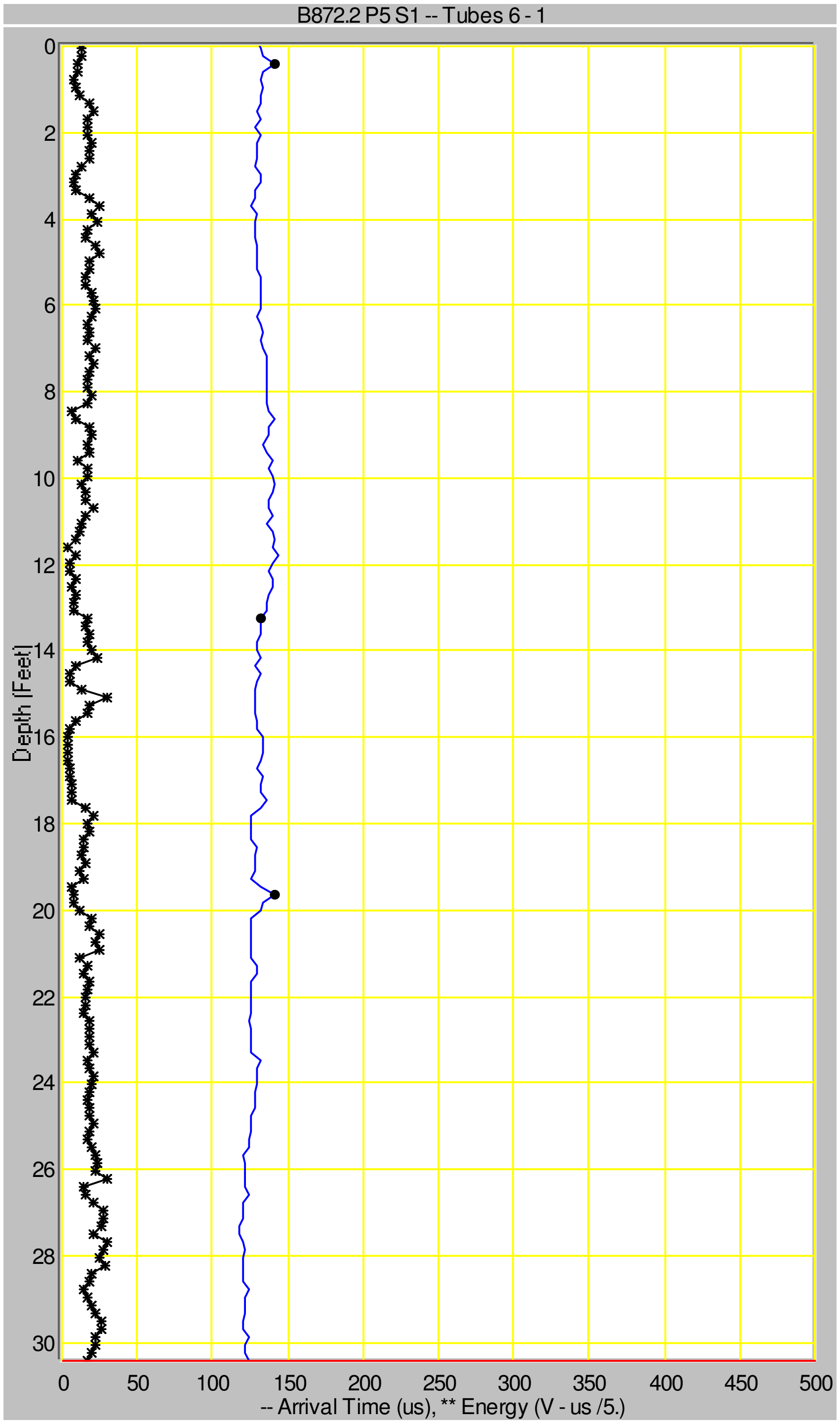


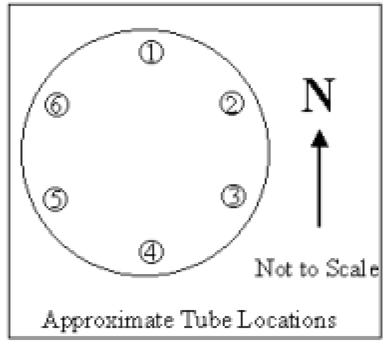
Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 19.5

Cursor Depth: 30.789 ft
- Velocity = 10980 ft/sec
- First Arrival Time =

- Signal Energy = 91.47



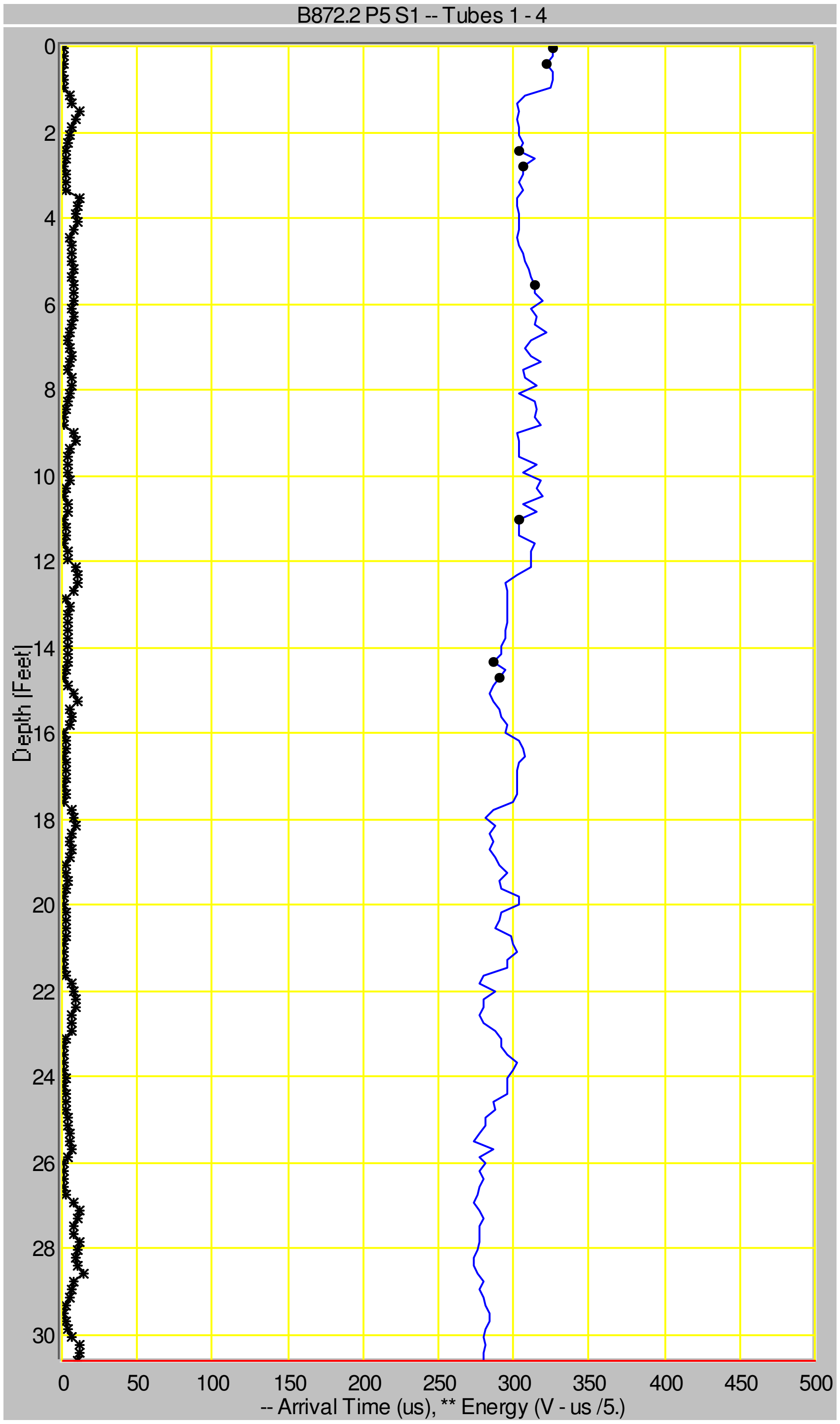


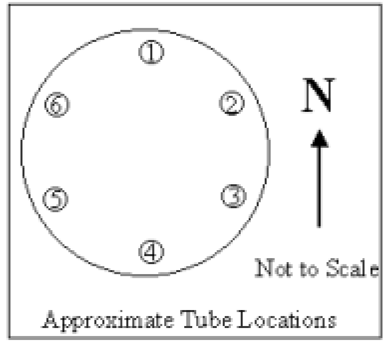
Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 20.5

Cursor Depth: 30.423 ft
- Velocity = 13777 ft/sec
- First Arrival Time =

- Signal Energy = 85.4 V-

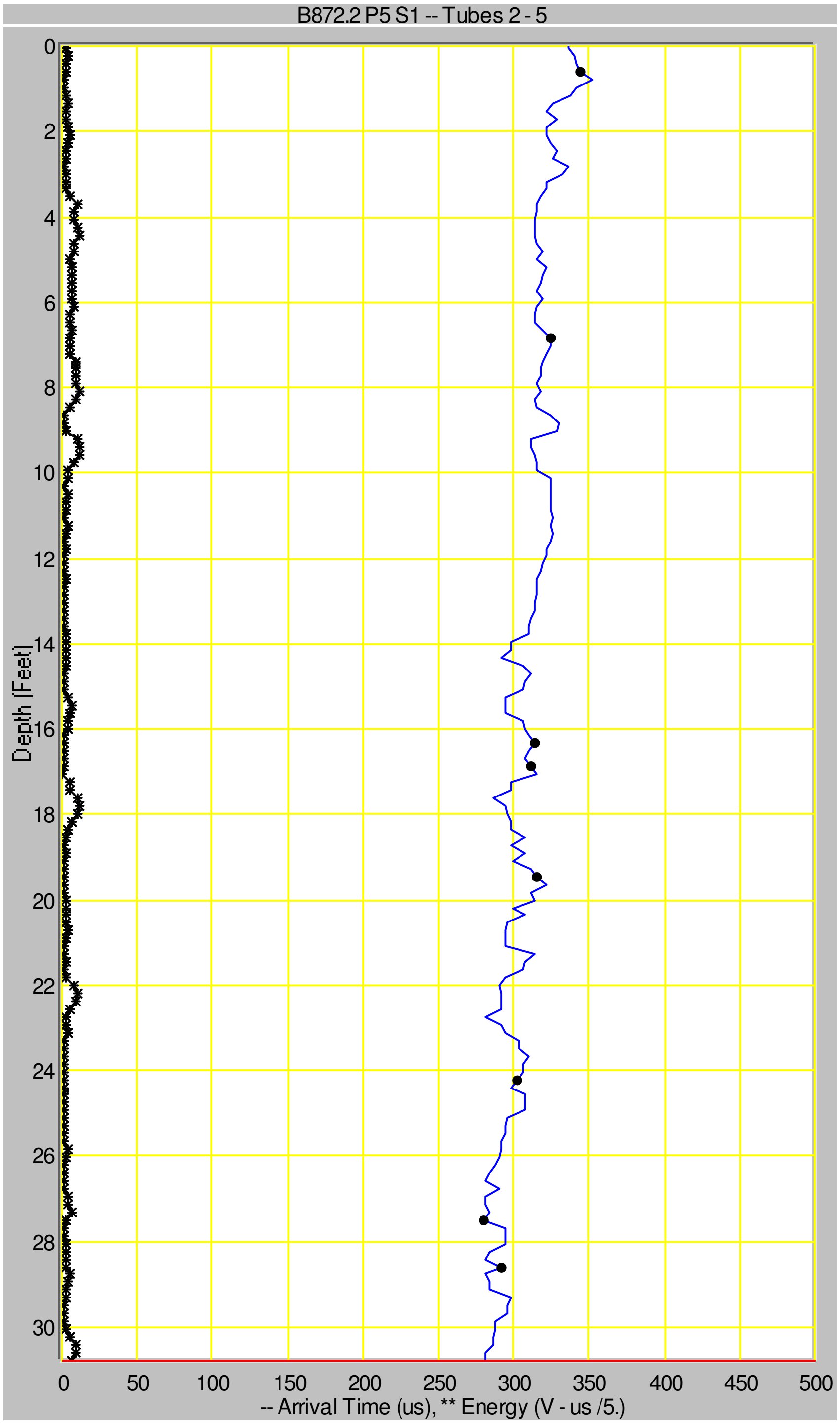


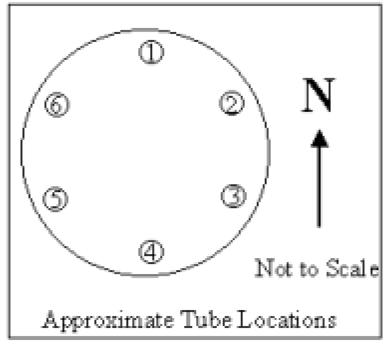


Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 49. inches
Cursor Depth: 30.606 ft
- Velocity = 14583 ft/sec
- First Arrival Time =

- Signal Energy = 49.67

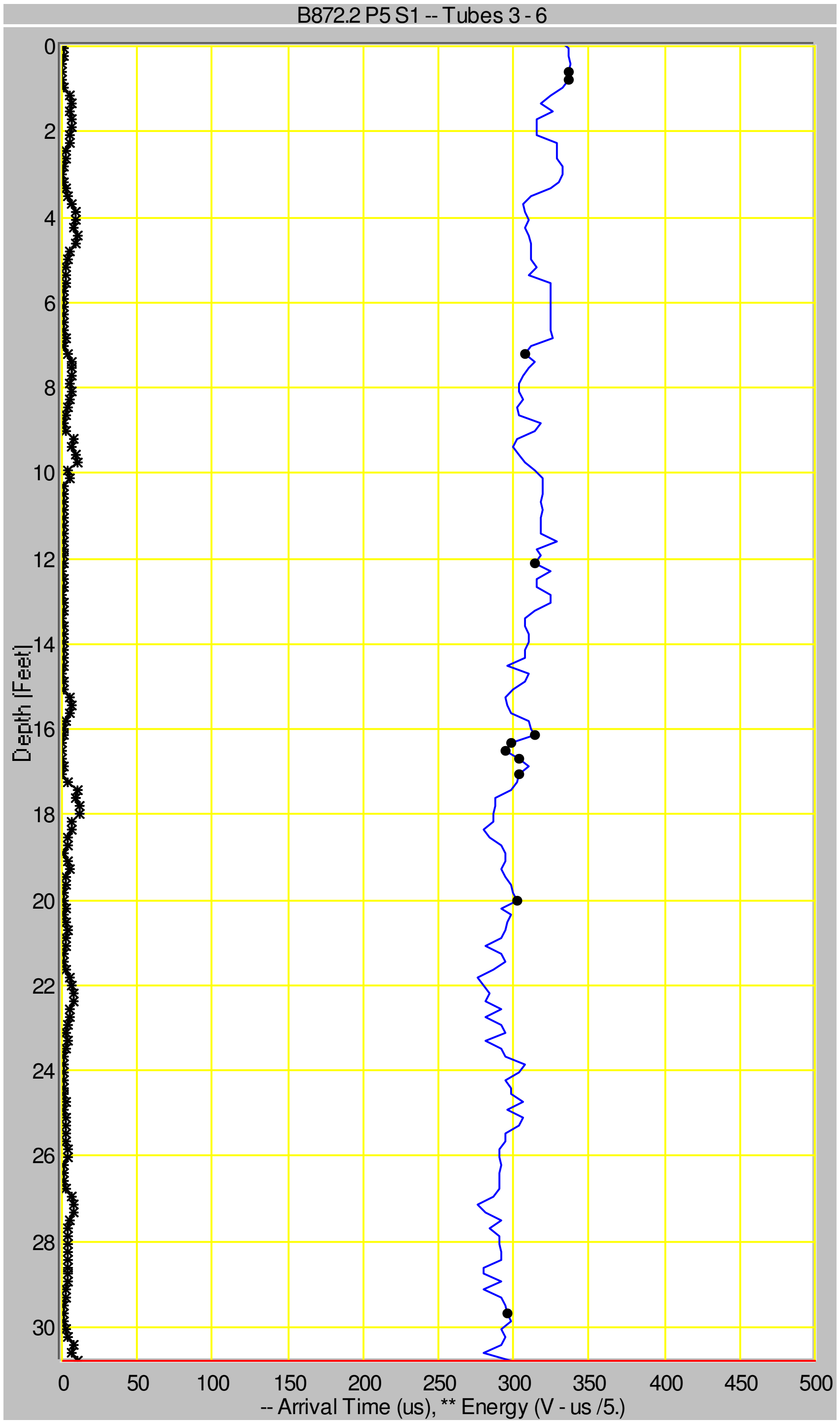




Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 51. inches
Cursor Depth: 30.789 ft
- Velocity = 15071 ft/sec
- First Arrival Time =

- Signal Energy = 33.86



Project Name: 2804h
Shaft Name: B872.2 P5

Test Date: 5/24/2010
Tube Spacing: 50. inches
Cursor Depth: 30.789 ft
- Velocity = 13982 ft/sec
- First Arrival Time =

298. us

- Signal Energy = 37.66

V-us

APPENDIX B

EXAMPLE CSL SPECIFICATIONS

B1.0 CROSSHOLE SONIC LOGGING (CSL) OF DRILLED SHAFT FOUNDATIONS

The completed drilled shaft foundations shall be tested with the nondestructive testing (NDT) method called Crosshole Sonic Logging (CSL) after at least 1 day (24 hours) of curing time has elapsed to allow the concrete to harden sufficiently. The Engineer may specify a longer minimum time if special retarders, mix designs, or other factors result in slower setting concrete. All CSL testing must be completed within 45 calendar days of concrete placement for steel access tubes, or 10 days for PVC access tubes (PVC tubes can debond from the concrete above the water table for larger shafts at more than 10 days of age). The choice of PVC versus steel tubes should be made in consultation with the CSL testing firm, and will depend on shaft size, testing schedule, and other factors. The CSL tests shall be undertaken by an experienced and approved independent testing organization. The CSL test measures the time it takes for an ultrasonic pulse to travel from a signal source in one access tube to a receiver in another access tube. In uniform, good quality concrete, the travel time between equi-distant tubes will be relatively constant and correspond to a reasonable concrete pulse velocity from the bottom to the top of the foundation. In uniform, good quality concrete, the CSL test will also produce records with good signal amplitude and energy. Longer travel times and lower amplitude/energy signals indicate the presence of irregularities such as poor quality concrete, void, honeycomb and soil intrusions. The signal will be completely lost by the receiver and CSL recording system for the more severe defects such as void and soil intrusions.

B1.1 DRILLED SHAFT FOUNDATION PREPARATION

A number of tubes, typically between 2 to 6, shall be installed in each shaft to permit access for CSL. The number of tubes installed will be as designated on the design drawings for each foundation. If the number and placement of the tubes are not specifically called out on the drawings, then the general guidelines in the table below should be followed.

Shaft Diameter	Recommended Number of Tubes	Tube Spacing
D < 2.5 ft	2 minimum	180°
2.5 < D < 3.5 ft	3 minimum	120°
3.5 < D < 5.0 ft	4 minimum	90°
5.0 < D < 8.0 ft	6 minimum	60°
D < 8.0 ft.	8 minimum	45°

The tubes shall be 1.5 to 2.0 inch inside diameter schedule 40 steel or PVC pipe. The pipes shall have a round, regular internal diameter free of defects or obstructions, including any at pipe joints, in order to permit the free, unobstructed passage of 1.35 inch or smaller diameter, typically 6 to 10 inches long, source and receiver probes. The tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes and to ensure a good bond between the concrete and the tubes.

The pipes shall each be fitted with a watertight shoe on the bottom and a removable cap on the top. The pipes shall be securely attached to the interior of the reinforcement cage with a minimum cover of 3 inches. The pipes may be attached to exterior of the cage if approved by the Engineer and if the minimum cover requirements are maintained. The tubes shall be installed in each shaft in a regular, symmetric pattern such that each tube is spaced the maximum distance possible from each adjacent tube, with a spacing in degrees around the perimeter of the cage to correspond to the design drawings or that called out in the table above for the selected number of tubes. The tubes are typically wire-tied to the reinforcing cage every 3 feet or otherwise secured such that the tubes stay in position during placement of the rebar cage and concrete placement. The Contractor shall submit to the Engineer his selection of tube material and size, along with his proposed method to install the tubes, prior to construction. The tubes shall be as near to vertical and parallel as possible. The tubes shall extend from the shaft bottoms to at least 3 feet above the shaft tops. Under no circumstance should the tubes be allowed to rest on the bottom of the drilled excavation. If the shaft top is subsurface, the tubes shall extend at least 2 feet above the ground surface. Any joints required to achieve full length tubes shall be made watertight. Care shall be taken during reinforcement installation operations in the drilled shaft hole not to damage the tubes. After placement of the reinforcement cage, the tubes shall be filled with clean water as soon as possible (immediately before or after concrete placement - no later than 4 hours after placement) and the tube tops capped or sealed to keep debris out of the tubes. Care shall be exercised in the removal of caps or plugs from the pipes after installation so as not to apply excess torque, hammering, or other stresses which could break the bond between the tubes and the concrete. Upon completion of the CSL testing, all water shall be removed from the access pipes and any other drilled holes. The pipes and holes shall then be completely filled with an approved grout.

B1.2 CSL TEST EQUIPMENT

The CSL equipment consists of the following components:

- A microprocessor based CSL system for display of individual CSL records, analog-digital conversion and recording of CSL data, analysis of receiver responses and printing of CSL logs
- Ultrasonic source and receiver probes for 1.5 or 2 inch I.D. pipe, as appropriate
- An ultrasonic voltage pulser to excite the source with a synchronized triggering system to start the recording system
- A depth measurement device to determine record depths
- Appropriate amplification and cable systems for CSL testing

B1.3 CSL LOGGING PROCEDURES

Information on the shaft bottom and top elevations and/or length, along with construction dates should be provided to the testing organization before or at the time of the CSL tests. CSL tests shall be conducted between pairs of tubes, with the determination of which pairs to be tested to be made as part of the testing contract. Typically, perimeter and/or major diagonal tube pairs are tested. Additional logs may be conducted in the event any anomalies are detected in the specified logs. The full depth of all pipes shall be used for conducting CSL tests unless approved otherwise by the engineer. Should an access tube be blocked, the Engineer shall determine what action should be taken in response. The CSL tests shall be carried out with the source and receiver probes in the same horizontal plane unless test results indicate potential anomalies/defects in which case the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes). CSL measurements shall be made at depth intervals of 0.2 feet or less, and shall be done from the bottom to the top of each shaft. The probes shall be pulled simultaneously, starting from the bottoms of the tubes, over the depth measuring device. Any slack shall be removed from the cables prior to pulling to provide for accurate depth measurements in the CSL records. Any anomalies/defects indicated by longer pulse arrival times and significantly lower amplitude/energy signals should be reported to the Engineer on-site and any further tests carried out as required to evaluate the extent of such anomalies defects. Additional NDT methods which could be used include Angled Crosshole Sonic Logging, Crosshole Tomography, Singlehole Sonic Logging, Gamma-Gamma Nuclear Density Logging, and/or Sonic Echo and Impulse Response tests.

B1.4 CSL RESULTS

The CSL results shall be presented in a report. The test results shall include CSL logs with analyses of:

- Initial pulse arrival time or compression wave velocity versus depth
- Pulse energy/amplitude versus depth

A CSL log shall be presented for each tube pair tested with any anomaly/defect zones discussed in the report as appropriate.

B1.5 ACCEPTANCE OF COMPLETED DRILLED SHAFT FOUNDATIONS

The acceptance of each drilled shaft shall be the decision of the Engineer, based on the results of the shaft integrity testing report(s) and other information on the shaft placement. Rejection of a shaft based on the shaft integrity testing shall require conclusive evidence that a defect exists in the shaft which will result in inadequate or unsafe performance under service loads. If the NDT records are complex or inconclusive, the Engineer may require coring or excavation of the shaft to verify shaft conditions. If a defect is confirmed, the Contractor shall pay for all coring or excavation costs. If no defect is encountered, the State shall pay for all coring or excavation costs, including grouting of all coreholes. In the case that any shaft is determined to be unacceptable, the contractor shall submit a plan for remedial action to the Engineer for approval. Any modifications to the foundation shafts and load transfer mechanisms caused by the remedial action will require calculations and working drawings stamped by a registered professional engineer for all foundation elements affected. All labor and materials required to perform remedial shaft action shall be provided at no cost to the State and with no extension of the contract time. In the event the equipment or software is functioning incorrectly these are some steps to use to identify why the problem is occurring or what is causing the problem, i.e. bad cable.