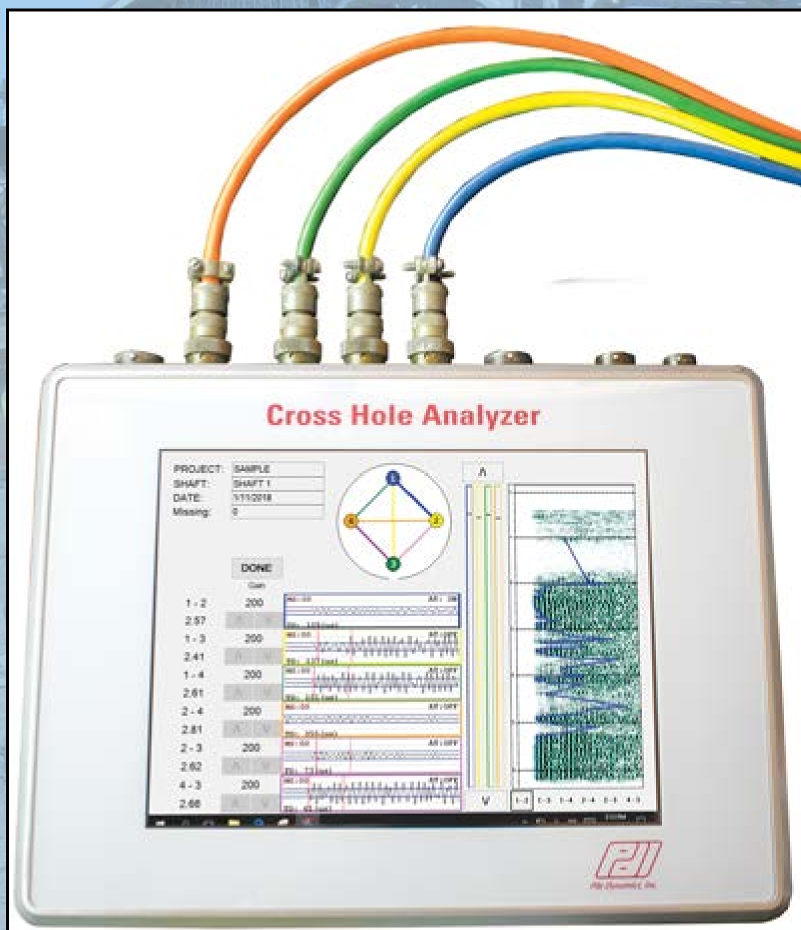
Manual for CHAMP-Q Cross-hole Sonic Logging System



Pile Dynamics, Inc.

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Chapter 1: Introduction

1.1 Overview

The Cross Hole Analyzer (CHAMP-Q) from Pile Dynamics is a very useful tool for determining the integrity of drilled shafts, also referred to as bored piles, which are equipped with at least two inspection tubes. The CHAMP is designed to measure pulse "first arrival time" (FAT) and the signal strength (Energy). Based on these and other on-site measurements, the wavespeed in concrete is calculated, which in combination with the signal strength then can be used to assess the concrete quality. The data acquired from the CHAMP should be transferred to a personal computer equipped with the CHA software, also provided by Pile Dynamics. The CHA-W program offers tools that help the user further analyze and interpret the data, as well as present a report quality output. Additional information on the CHA-W software can be found in PDI's CHA-W Manual. The results obtained are only as meaningful and reliable as the testing engineer's understanding of the physical principles involved. **The liability for the results obtained therefore rests solely on the persons testing, interpreting, and reporting the results; Pile Dynamics, Inc. (PDI) accepts no liability regarding the applicability or suitability of these tests to any particular situation.**

1.2 CSL Test Principle

By sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes), the CSL procedure inspects the drilled shaft's concrete homogeneity, and extent and location of defects, if any. At the receiving probe, pulse arrival time and signal strength are affected by the concrete, or lack thereof. For equidistant tubes, uniform concrete yields consistent arrival times with reasonable pulse wave speed and signal strengths. Non uniformities such as contamination, soft concrete, honeycombing, voids, or inclusions exhibit delayed arrival times with reduced signal strength.

1.3 CSL Access Tube Preparation

Install access tubes in each drilled shaft to be tested to permit possible inspection by CSL. Note that the actual number of tubes installed in each shaft is often selected as one tube for every 0.25m to 0.35m (10 to 14 inches) of drilled shaft diameter, with a minimum of three access tubes (our personal preference is for at least four tubes). Drilled shafts with different diameters at the same site may require a different number of access tubes. The most recent ASTM D6760 notes a maximum of 8 tubes as there is little benefit to exceed eight tubes in any shaft.

Note that it is advisable that every drilled shaft shall be equipped with access tubes, and this alone may inspire the installer into a more careful procedure. Certainly the cost of the access tubes is modest compared with the cost of the shaft and compared with the cost of a failed shaft. The best procedure and many job specifications require testing of every shaft to assure quality for every shaft.

In some cases, the actual number of drilled shafts to be tested by CSL may only be some percentage of all drilled shafts where the drilled shafts to be tested will be chosen after installation by the Engineer, either on a random basis or based on the installation records. If significant defects are detected, the number of drilled shafts tested may be increased by the Engineer. If access tubes are not installed at a relatively modest cost during installation, later inspection of a shaft (due to questions arising during construction from unusual or unplanned events) will be very difficult and very costly, or in some cases impossible. Every shaft might have some difficulty during installation (such as in extraction of the casing), so every shaft should be equipped with access tubes to permit the possible evaluation of any shaft having any installation difficulty.

The recommended access tubes are nominal 38 to 50 mm (1.5 to 2.0 inch) **inside** diameter. Tubes may be steel tubes (standard weight schedule 40), or PVC pipes (preferred schedule 80, although schedule 40 is satisfactory for shorter shafts), to allow access for the probes in each drilled shaft. **Steel tubes are usually preferred because the thermal expansion coefficient of steel and concrete are similar; the coefficient for PVC is not similar and often causes problems in CSL interpretation due to debonding**. If PVC tubes are specified and used, it is recommended to test the shaft soon after casting as debonding is likely to occur with continued curing time. Use round tubes that have a regular internal diameter free of defects and obstructions, including any tube joints, to permit free, unobstructed passage of the probes. Tubes should be watertight and free from corrosion with clean internal and external faces to ensure a good bond between the concrete and the tubes. Tubes may be extended with mechanical couplings. However, taping or other wrapping material to seal the joints and butt welding of joints are prohibited by ASTM D6760. Tubes should be installed by the Contractor such that the CSL probes will pass through the entire length of the tube without binding. The location of “joints”, if any, should be documented.

After placement of the reinforcement cage, fill the access tubes with clean fresh water as soon as possible but within at the latest one hour of concrete placement. (Note: The tubes should preferably be filled with water prior to concrete placement, but MUST be filled with water within at most 4 hours after placing concrete to prevent debonding of the access tubes due to differential temperatures.)

Cap the tube tops to prevent debris from entering the access tubes. Do not apply excessive torque, hammering or other stresses which could break the bond between the tube and concrete when removing caps from the tubes.

(Note: If an existing drilled shaft does not contain access tubes, access holes can be installed by coring a borehole in the concrete. Log core holes and include descriptions of any inclusions or voids. For drilled shafts with access tubes which do not allow the probe to pass through the entire length of the tube due to poor workmanship, replacement access holes may be provided by core drilling.)

1.4 Timing CSL Tests

Test the drilled shaft at a time specified by the construction documents or as the construction sequence allows. CSL testing can be performed any time after concrete installation although 2 days is usually the absolute minimum acceptable wait; ASTM D6760 requires a minimum of three days wait. Because the concrete strength and quality generally increases as the concrete cures, longer wait times are usually desirable, particularly if minimum pulse wave speeds are specified or to reduce result variability between drilled shafts or even as a function of depth in a single drilled shaft. However, long wait times increase the tube debonding which is detrimental to the test (reportedly particularly for PVC tubes). Production drilled shaft installation and subsequent construction influence the dates of CSL testing. The test should be performed preferably within 10 days after placement and prior to loading for test shafts, or within 45 days after placement on production drilled shafts. It might be noted that if the concrete shows weakness during a very early CSL test, additional time and a repeat CSL test may possibly show markedly better results due to a delayed concrete curing (delayed curing can result from various admixtures in the concrete – delays of curing have been reported as long as 56 days).

(Optional or as specified by the project documents: After all CSL testing has been completed, and after acceptance of the drilled shaft by the Engineer, remove the water from the tubes, place grout tubes extending to the bottom of the access tube, and fill all access tubes in the drilled shafts with grout.)

1.5 Measurements made before testing

Prior to CSL testing, the user should obtain a record of all drilled shaft lengths with elevations of the top and bottom, and installation dates of all drilled shafts. The access tubes should be clearly labeled for identification (e.g. 1, 2, 3…). Measuring the inside tube lengths using a weighted tape measure prior to testing helps assure the tube is free of obstructions and the probe can be lowered to the tube bottom. Measurement of tube lengths is proper procedure and information needed for test (to know the precise locations of the probes in the tubes at any time, for example, so they can be kept "level").

An alternate to measuring the tube lengths with a probe and tape rule is to use the CHAMP itself. Place ONE PROBE at the top of the tube, and "zero" the probe at the top (see Section 3.6.3.2). Slowly lower the probes from the top until it reaches the pile bottom, effectively measuring the access tube length. Repeat this for each tube using the same probe. Document each tube length. However, it is recommended that the user measure the inside tube lengths using a weighted tape measure instead of the CHAMP, in order to avoid potential damage to the probes caused by any obstructions present inside the access tubes. The user should also measure the tube stick-up lengths (the length of each tube extending above the top of the concrete) and the tube spacings, since he/she is expected to enter this information into the CHAMP unit.

1.6 CSL Test Procedure

CSL test procedure can be generally summarized as follows:

- Connect the transceiver probes to the cables.
- Lower the probes into the first set of tubes. (Typically Tube 1 and Tube 2, etc.)
- Set up the depth encoder assembly, either on the tripod or on individual tubes.
- Attach one end of the depth encoder cable to the data cable input port on the CHAMP and the other two split ends to the encoder assembly.
- Run the transceiver cables over the respective depth wheels and passing through the provided hooks (or roller plates). When using a tripod, thread the probe over the same color encoder wheel.
- Connect the other ends of the transceiver cables to the respective ports on the CHAMP-Q.
- Turn on the CHAMP-Q, enter all relevant information into the program (See "Basic Program Operation" on page 19.) until you get to the Data Collection Screen.
- After ensuring that the probes are touching the bottom of the tubes, after removing any slack in the cables, zero the depth encoders from tube bottom which is the preferred method. (Section 4.1.2.1)
- Pull the probes simultaneously, taking CSL measurements at intervals of 2 in (50 mm) (a user selected input) or less from the bottom to the top of the drilled shaft.
- After completing the first profile, lower the probes in the next set of tubes (Section 3.5.1) and continue data collection until all profiles are tested.

The CSL testing should initially be performed with the transeiver probes in the same horizontal plane in parallel tubes unless test results indicate potential defects, in which case the questionable zone may be further evaluated with offset tests (source and receiver vertically offset in the tubes). Using the labeling established for the tubes, perform CSL testing between all adjacent perimeter access tube pairs and across at least the major diagonals within the drilled shaft. In the event defects are detected in drilled shafts with more than four tubes, additional logs in other diagonal tube pairs may be required to estimate the extent of the defect. Offset tests are generally only helpful for the perimeter profiles.

Defects indicated by late pulse arrival times and significantly lower amplitude/energy signals should be immediately reported to the Engineer. Additional tests such as the offset elevation CSL testing may be required by the Engineer to further evaluate the extent of these defects.

In cases where abnormalities in the CSL results are detected, additional tests or analysis options may include CSL tomography, Gamma-gamma nuclear density logging, sonic echo or impact response tests, high strain dynamic pile testing, static load testing, or concrete coring. If the drilled shaft is cored, an accurate log of the cores which include depth and core recovery shall be kept, and core and coring logs shall be properly identified and given to the Engineer. Note that coring locations should be recorded and considered when comparing to CSL results. I coring results do not indicate a defect the defect may be in a different planar location. Additionally, bleed water channels may be present, which may inhibit signal transmission, especially in conditions where the pile is permanently cased.

The CSL test procedure is covered by ASTM D6760 (which can be downloaded from the ASTM website (www.astm.org). A suggested sample specification for application of the CSL method can be downloaded from the Pile Dynamics website (www.pile.com).

1.7 Your Safety

Caution! CSL field testing can be hazardous! It's YOUR RESPONSIBILITY to ensure safe working conditions. Use all suggested and required safety equipment. Typically CSL testing is performed during the drilled shaft construction phase. This means there could be constant movement of construction equipment, personnel, vehicles during the course of testing. Additionally CSL testing may require working close to open hole conditions that may require fall protection measures. THINK and BE PREPARED, especially with power (we suggest you use the internal CHAMP battery, or an external 12 volt D.C. battery during testing to avoid the risk of high voltage/line power). The CHAMP unit has self-contained battery power for nominally up to 4 hours operation. The battery is easily replaced in the field for an additional 4 hour cycle if longer test times are required.

Remember that **YOUR SAFETY IS YOUR FIRST PRIORITY**; avoid dangerous tasks or situations. It is particularly important to observe any drilling and concrete placement operations happening concurrently with your testing job (and plan your potential escape route in advance).

1.8 Your Responsibility

It is expected that you, the CHAMP operator, will become or are familiar with all aspects of data acquisition and analysis to assure that correct interpretations be made. This implies first that you begin by **thoroughly reading the CHAMP-Q and CHA-W MANUALS their entirety** and understanding the theory, principles, applications, and limitations as they apply to your situation. While data interpretation and application of your results are **entirely your responsibility**, after you have studied the manual, you should not hesitate to contact PDI for further information. We appreciate your input in making this document easier to read and understand. Furthermore, you should also seek advice and ask for the review of your work from those with more experience in your organization.

Chapter 2: Hardware

2.1 The CHAMP-Q Main Unit

Figure 2.1: CHAMP-Q Unit

The Cross Hole Analyzer (CHA) is the term used by Pile Dynamics for its Crosshole Sonic Logging (CSL) equipment. The specific hardware described in this manual is the "CHAMP-Q" which is a portable device that runs under Windows (version 10 and higher) for data acquisition. It has a replaceable and rechargeable battery that will each last for four hours of data acquisition. With Windows, CHAMP-Q integrates the convenience of touch screen operation with traditional windows formatting.

The CHAMP Unit has the following input/output ports

1 On-off switch (with embedded LED)
2 12 Volt DC input
3 Unit Charger input
4 Encoder Data Cable Input 1 (for Transceivers 1 and 2)
5 Transceiver Channel A
6 Transceiver Channel B
7 Transceiver Channel C
8 Transceiver Channel D
9 Encoder Data Cable Input 2 (for Transceivers 3 and 4)
10 USB ports (4)
11 Ethernet port
12 External Monitor VGA output
13 HDMI output

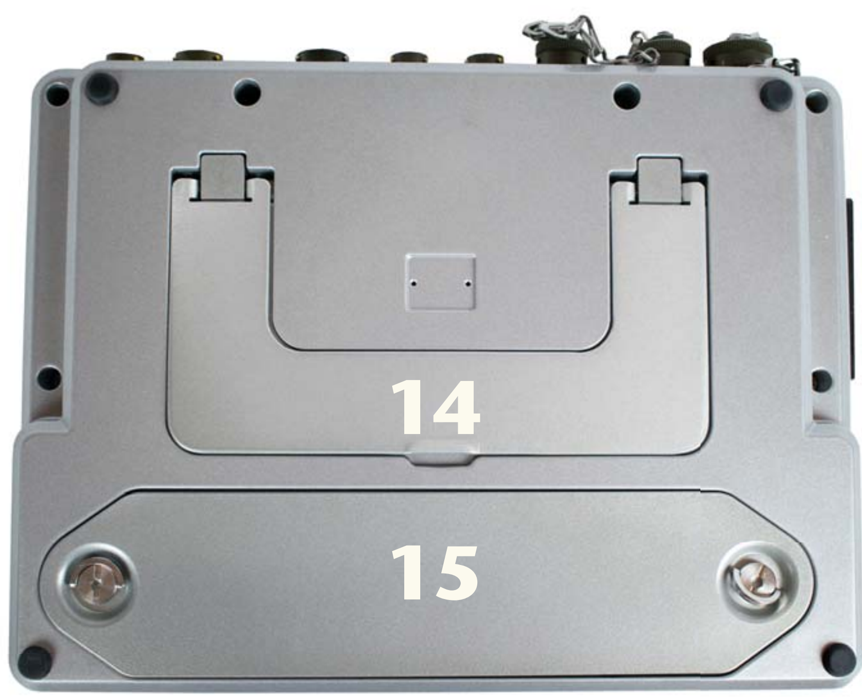


Figure 2.2: CHAMP unit rear view

14 Collapsing stand

15 Battery Compartment Access Cover

Figure 2.3: CHAMP-Q Unit with stand extended

2.1.1 Encoder Data Cable Inputs

The encoder data cables (Twist-lock quarter turn) connect here. Note: The same main cable that is used for Pile Driving Analyzer® can be used with CHAMP if an extension is required, such as when encoders are placed in the access tubes on the pile a considerable distance from the CHAMP-Q. In normal operation with encoders on a tripod, the data encoder cable plugs in directly here, and an extension cable is not required.

2.1.2 Transceiver Inputs

The four transceiver ports are used to connect the transceiver probes with a twist-lock connection. All probes have the same connection.

2.2 CHAMP-Q Power Accessories

2.2.1 Unit Charger

Figure 2.4: CHAMP-Q Unit Charger

The charger for the CHAMP-Q unit comes with an LED charging status indicator. When charging, the LED will glow orange-red and when charging is complete, the LED will switch to green. This connects to the charging input connector on the CHAMP-Q. The appropriate power cord should be used to connect the charger to the power supply outlet.

2.2.2 Internal Battery

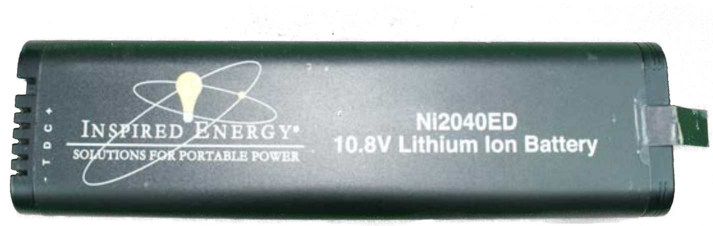


Figure 2.5: Replaceable Internal Battery

Internal Battery - 10.8V Lithium Ion Battery, provides 4 hours of use. Additional batteries are available. Each replaceable battery has an LCD display to show battery charge remaining.

2.2.3 External Battery Charger

Figure 2.6: External Battery Charger

Figure 2.7: Battery Charging in External Charger

Batteries to the CHAMP-Q Unit may be charged also using the external battery charger. This will allow a user to charge a battery that is not in use while operating the CHAMP-Q unit on a different battery or alternate power supply.

2.2.4 Depth Encoder Wheels

Depth measurement is performed by use of an optical encoder. The encoder measures the rotation of a pulley as the CSL probe wire is pulled up out of the shaft, which is then converted in to length based on the diameter of the pulley as well as the diameter of the probe cable. The encoder can be either placed at the top of the CSL access tubes or mounted on a tripod. Either method will work and each method provides slight advantages over the other. The tripod mounted encoders are manufactured for either a two probe system or four probe system.

2.2.5 Tripod Mounted Encoder Wheels

Figure 2.8: 4 probe tripod depth wheel encoder assembly.

A tripod mounted depth encoder allows guides for all probes wires and depth measurement at one location. each encoder wheel is painted a color that should correspond to the color of the probe wire as well as the encoder wire.

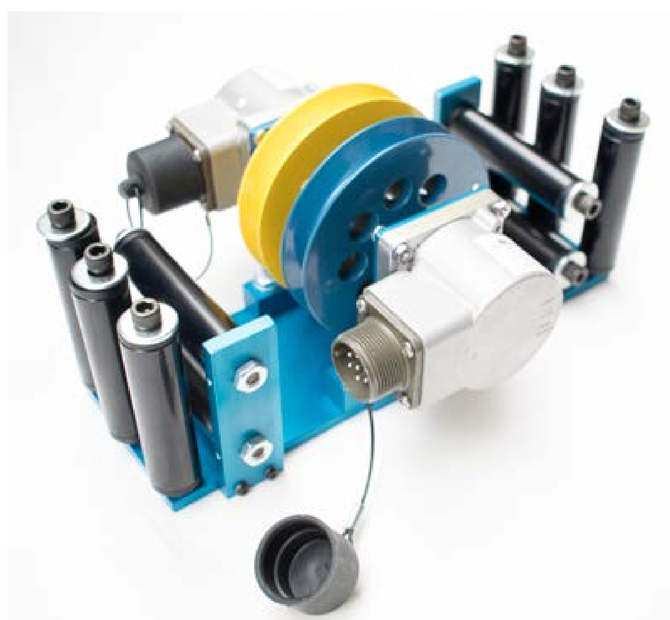


Figure 2.9: 2 probe tripod depth wheel encoder assembly.

2.2.6 Tripod

A tripod is included for systems with tripod mounted encoder wheels. Four probe systems include a heavy duty fiberglass tripod to withstand the additional pull force.

2.2.7 Nylon Cable Guides

Figure 2.10: Nylon insert cable guides.

Nylon cable guides are provided to keep the cables from being abraded by the edge of the tubes and should be used when using the tripod mounted encoders.

2.2.8 Roller Cable Guides

Figure 2.11:

Roller cable guides are provided to keep the cables from being abraded by the edge of the tubes and provide lower friction that the nylon cable guides which may prove useful for longer shafts.

2.2.9 Tube Top Mounted Encoders

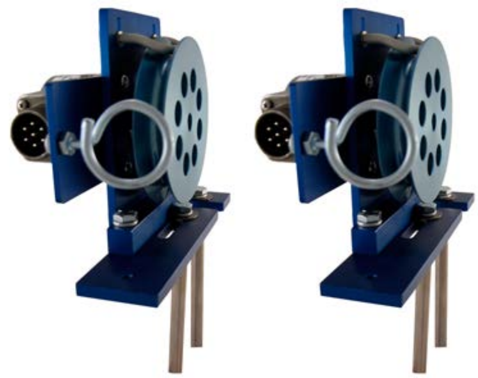


Figure 2.12: Separate Depth Encoders at the Shaft/Pile

Encoder assemblies can also be inserted at the tops of the access tubes (Figure 2.12) and are connected to the main unit with an encoder cable (Figure 2.13). A single 19-pin main cable then connects the encoders to the CHAMP-Q main unit. The encoder wheels are not color coded as any encoder can be used for any probe. It is important however to ensure that the color band on the encoder data cable matches the color of the probe cable.

2.2.10 Encoder Data Cable

Figure 2.13: Encoder Data Cable

The encoder data cable connect the encoder wheel to the CHAMP-Q main unit. The quarter turn twist-lock connector is connected to the CHAMP-Q main unit and the other threaded connector are connected to the encoder assemblies.

It is imperative that the color bands on the encoder data cable plug into encoder of the same color (and probe cable) for proper operation.

2.3 Transceiver Probes

Figure 2.14: Transceiver Probes.

The CHAMP-Q utilizes transceivers for data collection. Transceivers have the ability to both transmit a signal and record a signal. This gives several advantages to this system over a traditional 2 probe transmitter/receiver system. The first being that the system, supporting up four probes simultaneously, can collect up to six profiles at once reducing test time. The second is redundancy in the design allowing for backup in the field in the unlikely event a probe fails.

The transceiver connection to the cable spool is waterproof and any transceiver can be plugged into any color cable.

2.3.1 Probe Cable Spools

Figure 2.15: Four cable spool colors allow the user to differentiate one probe from another.

Probe cables are offered in various lengths to the user and, dependent on how many probes were included with the system, up to four colors. Cable length must exceed the length of the shafts being tested and the user should consider that an extra 3 to 6 meters (10 to 20 feet) of cable will be required to connect back to the main unit. A two probe system will include a blue and yellow cable. The four probe system will include blue, yellow, green and orange cables. All cables provide identical functionality and any transceiver can be plugged into any of the probe cables.

Cuts in the cable may make a probe inoperable due to electronic shorts, care in handling the cables is therefore imperative. Keep cables from abrading on the tubes or cage is recommended. Having spare cables (and even spare probes) is recommended so the testing can continue without delay in case of unexpected problems.

2.3.2 Probe Weights

Figure 2.16: Probe weight help lower the probe to the bottom of the shaft and keep the cable taught when pulling.

Probes should be fitted with a small weight (attached to the bottom of the probe) to allow them to sink naturally in the tubes. Three weight sizes and shapes are currently available. More weight allows the probes to self spool easier (although very fast deployment may allow the probe to "wedge" into a bent tube and thus may not be retrieved – controlled decent is therefore encouraged).

2.3.3 Probe Centralizers

Figure 2.17: Rubber centralizer.

Rubber "centralizers" (Figure 2.17) should be inserted between the probe and the bottom weights to keep the probe centered in the tube. The centralizers prevent incidental contact of the probe and the access tube wall which causes noise during data collection. These should be replaced if damaged or worn.

2.4 Charging the CHAMP

The batteries powering the CHAMP unit can be charged either with the battery attached inside the unit or with the battery removed from the unit and placed in the external charger. To charge the internal battery, the CHAMP unit charger should be plugged into an AC power source and twist locked into the plug noted by the lightning bolt. To charge batteries externally, plug the external battery charger into an AC power source and mount the battery in the battery bay.

When charging the internal battery, the CHAMP unit may be run at the same time. This will both power the system and charge the battery. When charging the system, the 12V power inputs can be used at the same time to power the system while the battery charges.

A fully discharged battery will take approximately three and a half hours to recharge fully. The LCD display on the battery will show the approximate remaining charge in the battery in increments of 20%. When charging, the next 20% "block" will blink on the LCD display. The charger also indicates the charging status of your battery. The LED on the AC converter will flash green when the battery is charging and will be solid green when charging is complete. If the LED is solid red, there is a charging error. The external battery charger also has an LCD charging status indicator.

It is always recommended to fully charge the CHAMP before testing using the provided battery charger.

2.5 CHAMP-Q Power Up Procedure

Press and briefly hold the on-off button. The green LED embedded in the button will turn green and the display screen will begin the booting process. The CHAMP comes equipped with an internal battery good for four hours of operation. If the battery runs low, you can run the CHAMP connected to a 12 Volt external power source (car battery) with the DC power adapter connected to the 12 Volt input. For office use, the CHAMP also comes with an external power supply that connects to an AC power source (100 to 250 Volts AC, 50 to 60 Hz). The output of this supply should be connected to the 12 Volt input. However, **in the field,** using the internal battery or an external DC power source is the recommended procedure.

2.6 External Inputs

2.6.1 External Keyboard and or mouse

An external keyboard and mouse can be plugged into the USB ports. Both touchscreen and external keyboard work in parallel, and can both be used simultaneously. The CHAMP-Q's touchscreen is designed for harsh field environments. However, an external keyboard and mouse provide backup flexibility if the touchscreen fails to operate properly.

2.6.2 External Monitor

The CHAMP can use an external monitor via the VGA connector or HDMI connection.

Chapter 3: File Setup

3.1 Starting the Program

After the CHAMP has been powered up, the unit will boot up to the desktop where the user may start the program by double clicking the CHA-S icon. This brings up the Main Menu(Figure 3.1)

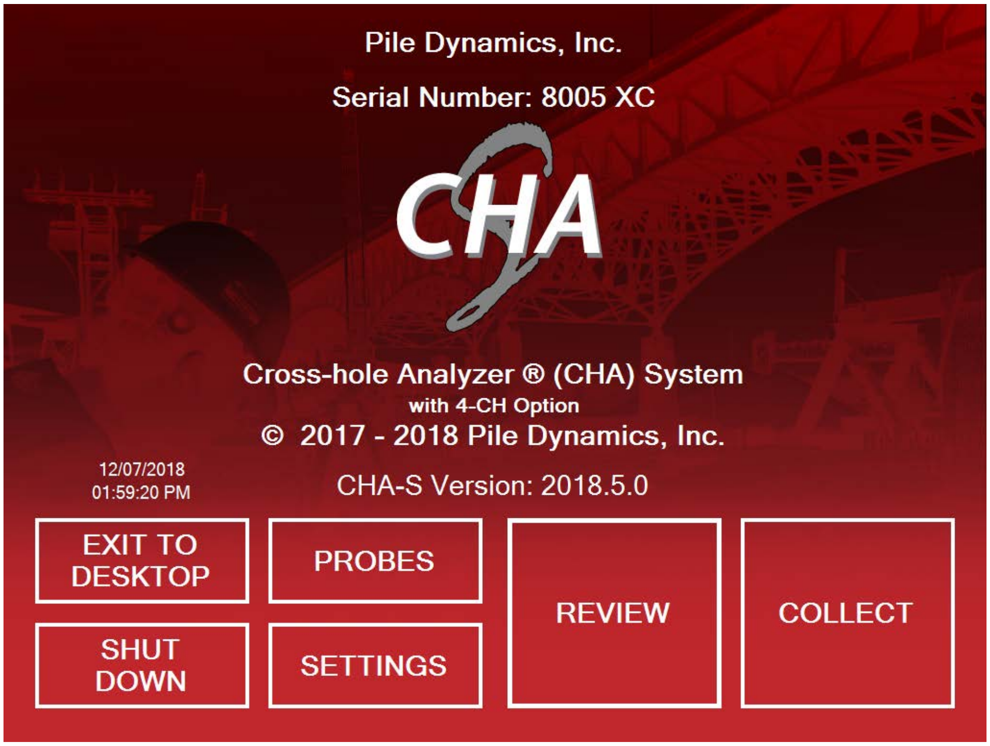


Figure 3.1: *Main Menu*

The file version of the CHAMP-Q software is displayed on this page. The SETTINGS button will take the user to the Settings menu where units can be changed. The REVIEW button will allow a user to review previously collected data. The 'EXIT TO DESKTOP' button terminates the program. The 'SHUT DOWN' button will close the program and shut down the unit. Alternatively, to turn off the CHAMP, follow normal Windows shut-down procedures.

3.2 Settings Menu

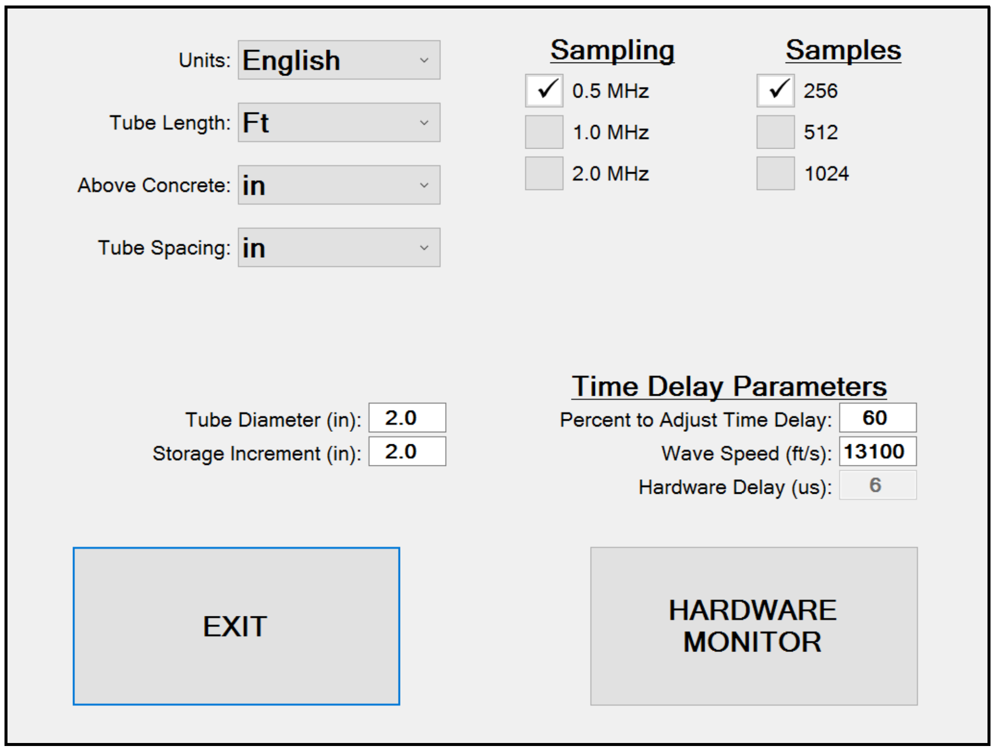


Figure 3.2: The settings menu.

The settings menu allows the user to adjust the units, set the sampling frequency and number of samples, adjust the time delay and enter the hardware monitor. It is recommended to collect data at the minimum values for both sampling (0.5 MHz) and samples (256) for standard data collection and analysis.

3.2.1 Adjusting Units

The system may be switched from SI to English units through the drop-down menu.

Once a unit system is selected the user may decide how to report each individual measurement.

3.2.2 Time Delay (TD)

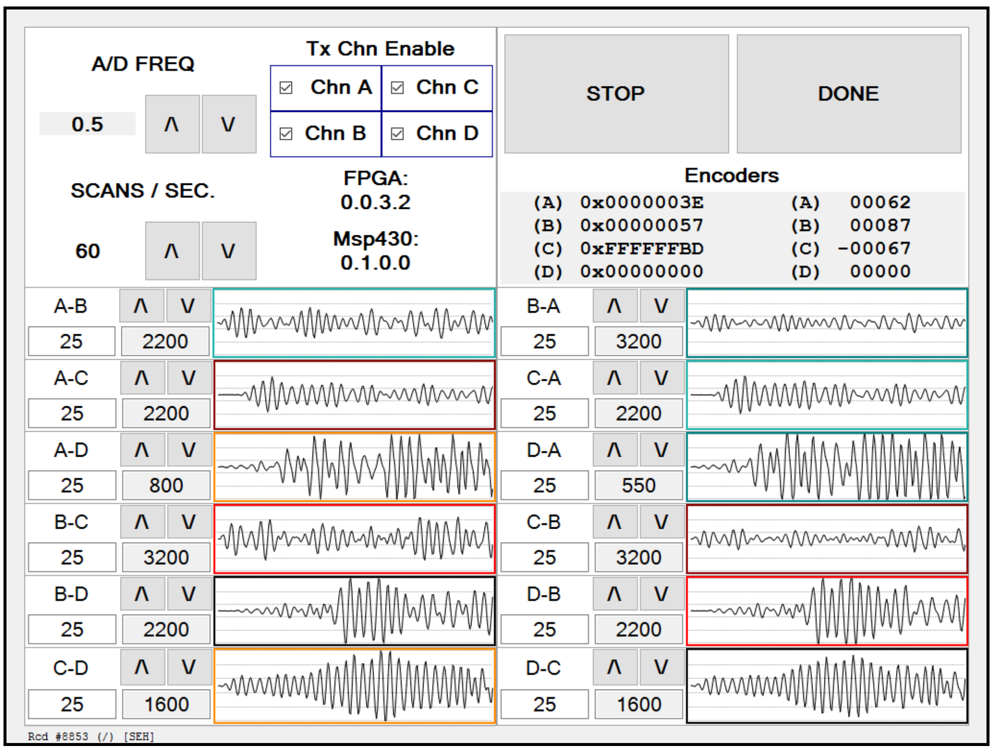
The **Time Delay** (TD) is the wait time between generating a sonic pulse and the start of data acquisition for detecting and capturing the received signal (needed because of the finite time window of data collection and variable distances between tubes). This allows for variation of "First Arrival Time" ("FAT" – left edge of the waterfall diagram) when tubes are not parallel (adequate margin to the left of, or prior to, the real first arrival), or allows for slower wavespeeds due to a defect. The CHAMP-Q automatically calculates a suggested value for TD (based on tube spacing and an assumed wavespeed of 4000 meters per second).

(TD [in "microseconds"] = 10^6 * (tube spacing / wave speed) – 100)

3.2.3 Time Delay Adjustments

Time delay calculations are performed automatically based on the entered distance between access tubes and an assumed wavespeed of 4000 meters per second. The user may allow additional time added to the calculation through the 'Percent to Adjust Time Delay' value. Ideally, time delay TD should be set so that the leading edge of the sonic pulse is about 20-30 percent from the left edge of the graph. Note that by increasing this value, the recorded time will shift later in the record and therefore less time before the arrival of the sonic pulse will be displayed.

3.2.4 Hardware Monitor



The hardware monitor allows the user to run the probes and view the signal from all probe combinations. This can be to verify that all transceiver probes are able to transmit and receive a signal. Additionally the user has the ability to adjust gain levels to determine the appropriate gain level for each profile.

3.3 Probes Screen

Before starting a test, it is important to make sure that the correct probes information has been entered. From the MAIN MENU (Section 3.1), pressing **PROBES** brings up the probe screen (Figure 3.3).

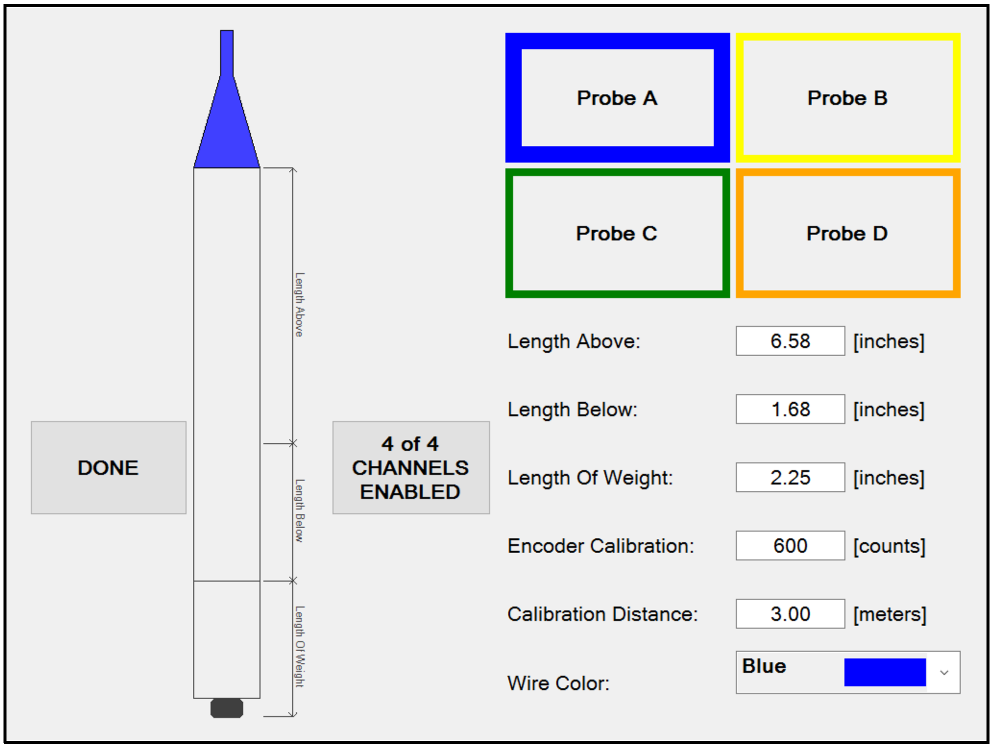


Figure 3.3: Probes Screen

3.3.1 Assigning Probes to Channels

It is imperative to accurately assign the probe wire color to the input channel. The system come pre-configured with the following assignments

- Channel A - Blue Cable
- Channel B - Yellow Cable
- Channel C - Green Cable
- Channel D - Orange Cable

While it is possible to reassign cable colors to different channels, Pile Dynamics strongly recommends that the user maintain these channel assignment to reduce the potential for errors occurring during data collection. It is equally important that the probe cable, encoder wheel and encoder cable colors all match.

3.3.2 Encoder Calibration

The current recommended value for the encoder calibration is 600 for the currently used encoders and a calibration distance value of 3 (meaning 3 meters equals 600 counts).

Note: In the CHA-W software for reporting final results, the REPORT feature allows direct determination of the calibration if and only if the probes are pulled the entire distance of the tubes and the probe dimensions and tube lengths are properly entered.

When using encoders on the PDI tripod, two of the four encoder calibrations will have opposite sign values (two positive and two negative). If the encoders are directly on the shaft tubes, all encoder calibrations will be negative (e.g. -600).

3.3.3 Probe Geometric Values

The total length of the probe should be measured and the sensor location considered and both **LENGTH ABOVE** and **LENGTH BELOW** the sensing element should be entered. The actual transmitting and sensing elements are about 25 mm above the bottom of the main probe (e.g. **LENGTH BELOW**). The currently offered entire probe length is about 210 mm, leaving 185 mm for the length above the sensing element.

The length of any optional add-on weight below the probe (if any) must be entered for the appropriate probe as the **LENGTH OF WEIGHT**. These weights are useful to help allow the probes to descend in the water and overcome friction effects. Larger or longer weights are generally helpful for longer tube lengths and are needed to hold the centralizer onto the probe. Enter a value of zero if no weight is used.

3.3.3.1 Switching Between 4 Probes, 3 and 2 Probes

The system can be adjusted to operate with 2, 3 or 4 probes. This is adjusted by selecting the button on the right hand side of the probe image so that it displays '2 of 4 channels enabled' (Figure 3.4), or '3 of 4 channels enabled'. When three channels are enabled, Probe 4 will be displayed with a red X the box to indicate that it is inactive. Selecting the right hand button again will disable channels three and four for a two channel system and once again will reset to the four channel system.

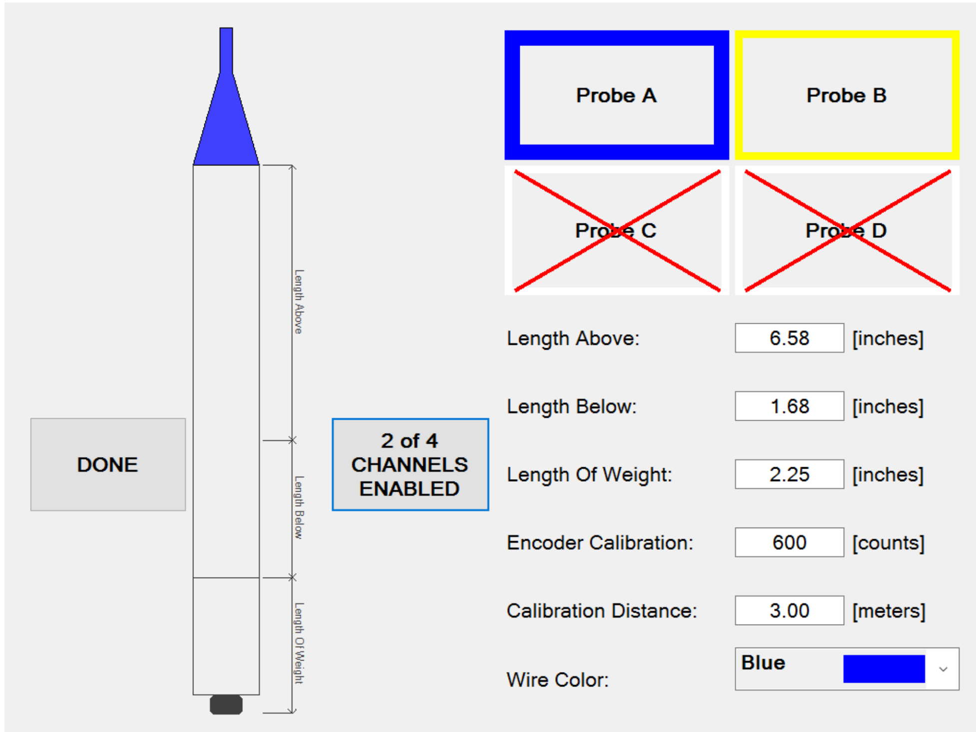


Figure 3.4: The system can toggle between four probes and two.

3.4 Collecting Data

Data collection begins by selecting the 'Collect' button from the main menu (Figure 3.1)

3.4.1 Create New Project

To create a new project or select an existing project, click **PROJECT** drop down menu (Figure 3.5). The user may select an existing project or select the **'Create New'** which will open the keyboard screen where the user can define the new project.

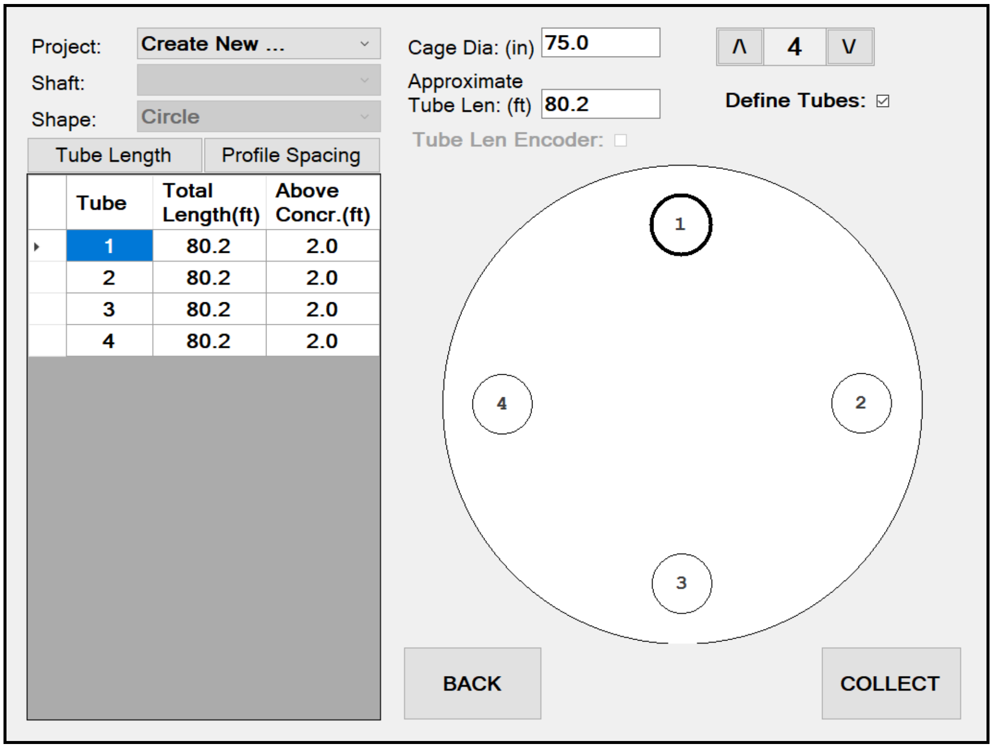


Figure 3.5: Creating a New Project or Selecting an Existing Project

NOTE: Once a project is selected or created, all new data files (.chx files) will be placed into that project folder. **All projects and (.chx files) will be saved automatically in the CHAMP-Q Projects Folder on the CHAMP-Q; no data is unintentionally erased or lost.** It should be mentioned that eventually, this project folder and the files it contains should be downloaded to the office computer (or network server) for permanent storage and this temporary CHAMP folder then deleted to provide room for new data to be acquired.

3.4.2 Create New Shaft

After selecting an existing project or creating a new project the user can create a new shaft by selecting the 'Create New' from the Shaft drop down menu. The keyboard screen will appear where the user can define the new shaft name (Figure 3.6).

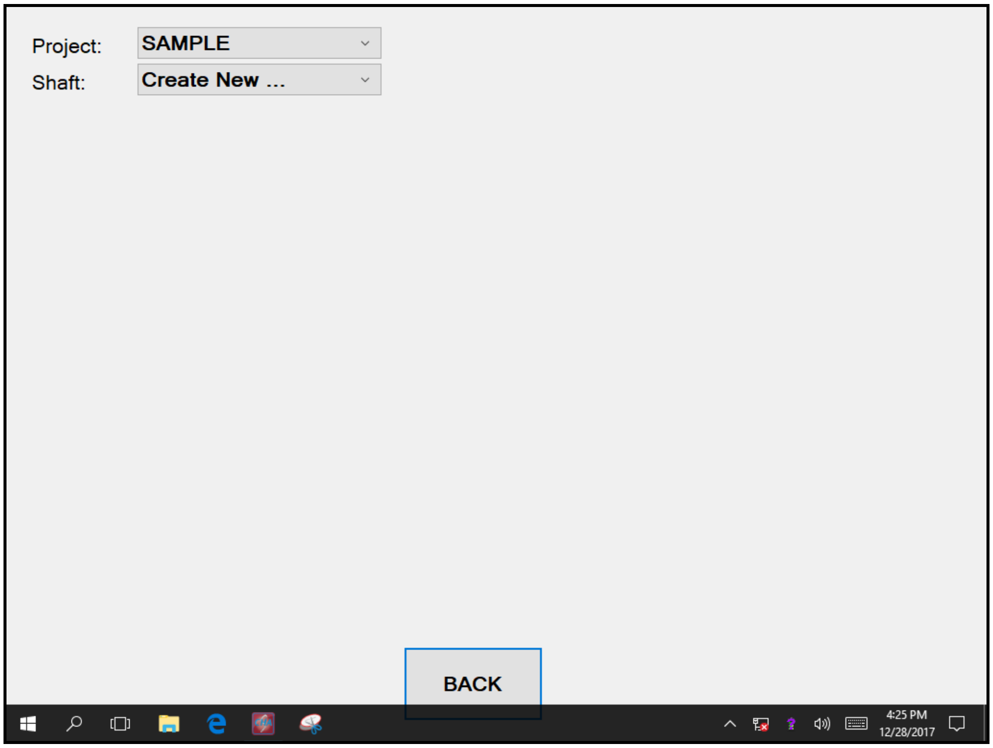


Figure 3.6: The Pile/Profile Menu.

3.4.3 Shape

Currently the CHAMP-Q allows for circular shapes only.

3.4.4 Tube Configuration

The tube configuration window will allow the user to nominally define the pile tube geometry. The user has the ability to either provide basic geometric measurements or provide further details before proceeding to data collection.

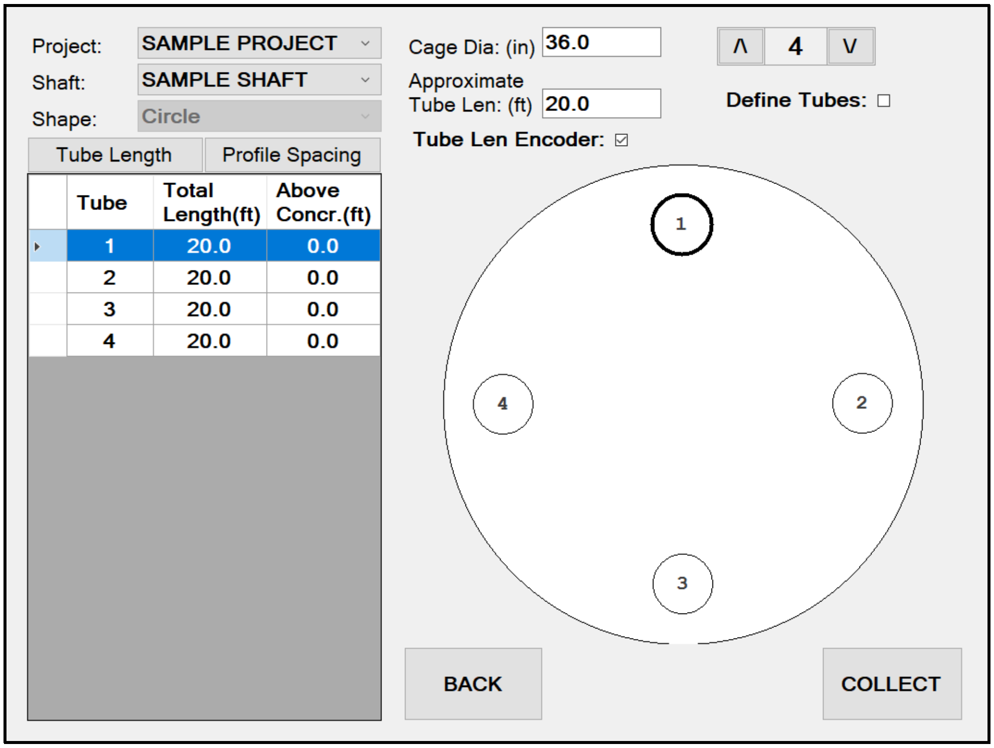


Figure 3.7: Tube Configuration

3.4.4.1 Adjusting Number of Tubes

Adjust the number to the appropriate number of access tubes for the shaft by pressing the up or down arrow in the upper right hand side of the screen until it reflects the number of tubes in the shaft. The graphic display of the shaft will reflect the number of tubes displayed.

3.4.4.2 Basic Shaft Definitions

The CHAMP-Q allows the user to enter in geometric measurements of tube lengths and tube distances as traditionally performed in previous systems or to simply enter a rebar cage diameter and approximate tube length and proceed to data collection. The advantage of measuring and entering these distances and lengths is for accuracy in reporting and wavespeed calculation. Entering only the cage diameter and approximate tube length will speed up the testing process in the field but will require editing after testing is performed to display the depth reference from the top of concrete properly as well as correct wavespeed calculation. The methods for correcting these values in CHA-W is discussed in Section 4.3.

The following entries are the “nominal” values:

- **Cage Diameter:** is the diameter of the reinforcement cage.

- **Approximate Tube Length:** is the nominal tube length (can change individually later if needed. Figure 3.7)

The **Cage Diameter** is used to calculate the nominal distance between all access tubes and assumes the tubes are spaced uniformly around the perimeter. This Spacing is the average distance between adjacent pairs of perimeter tube centers (affects calculated wavespeed). Usually the spacings are not uniform, and the correct individual spacings should be adjusted either before data collection or in post processing by ensuring the "Define Tubes" check box is checked).

Once the user has entered all appropriate values they may either proceed to data collection by selecting COLLECT or provide more accurate measurement details by clicking the DEFINE TUBES checkbox.

3.4.5 Tube Length Edits

For most shafts, tube lengths and tube pair spacings are all non-uniform, so the user must edit the parameters for each individual tube length and tube spacing.

The next request contains a listing for editing of the individual tubes (Figure 3.8). Generally the tubes are not identical, so the user selects a tube and then enters the correct value for each tube of the **TOTAL LENGTH, LENGTH ABOVE** CONCRETE.

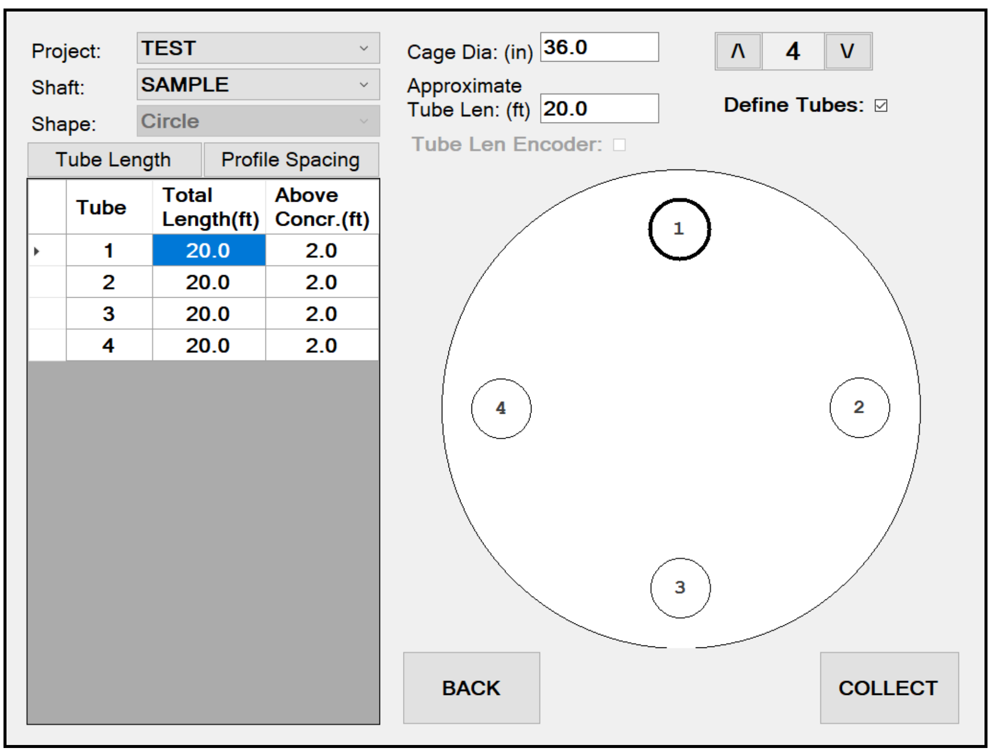


Figure 3.8: Tube lengths can be entered by selecting the Tube Length tab and changing the total length and length above concrete for each profile.

3.4.6 Tube Spacing Edits

Since the spacings between tube (center to center) are almost always different than the "nominal", enter each new measured spacing by clicking the **Profile SPACING** tab (Figure 3.9).

Enter each new measured spacing. The **Status** column notes the **Reference Tube** which is the major diagonal indicating two particular tubes (user selected) from which all other measurements are referenced. This minimizes the measurements required to define the tube geometry which is particularly helpful for shafts with many tubes.

The displayed table allows changes to the spacings between tubes. Only combinations of tubes that have one or the other reference tube included are contained in this list. For example, with the reference being 1-3, only spacings containing either tubes 1 or 3 will be required, as shown in Figure 3.9. Click to select the tube pair, and then click the value in the **SPACING** column to enter the new value. The geometry will be redrawn to reflect the data entry. Only these measurements need to be made and entered, and all other tube spacings which are not listed will be computed.

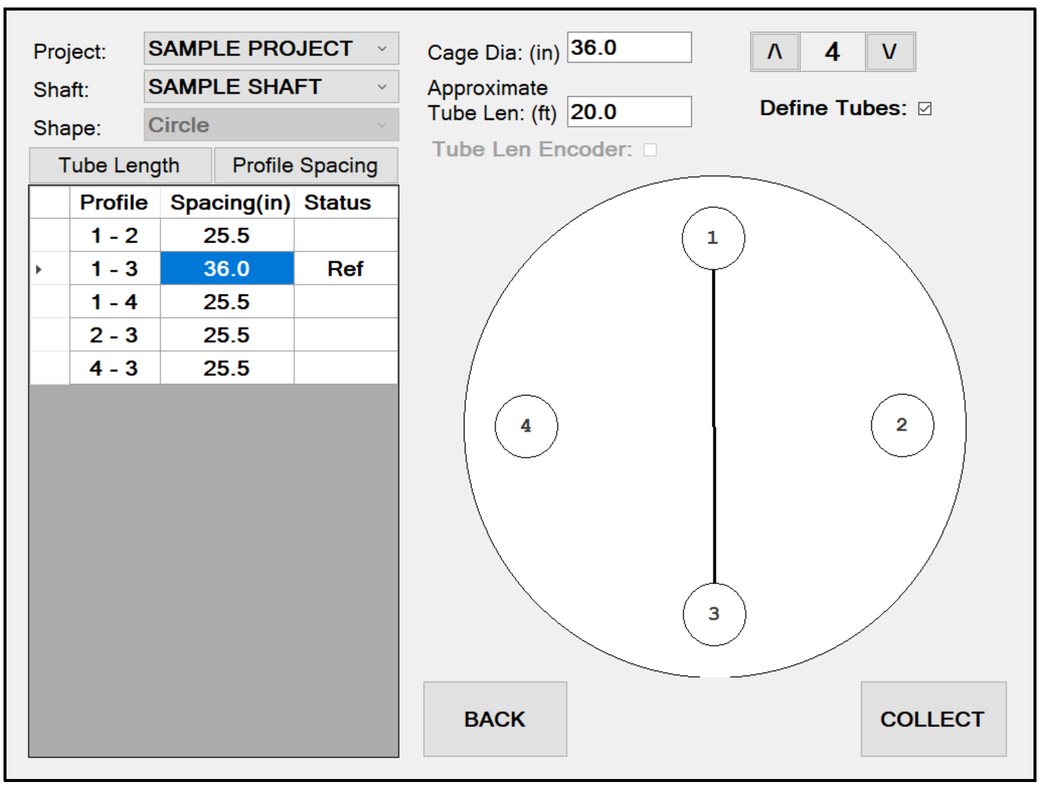


Figure 3.9: Profile spacing can be entered by selecting the profile spacing tab and changing the distance for each profile.

When all changes have been entered, click **COLLECT** to continue. If a physically impossible spacing is entered (relative to other entries) then the user will be notified and will require correction prior to continuing.

3.5 Profile Selection

Once the user completes inputting all the pile information (total tube length, length above concrete, tube spacings, etc.) click the **COLLECT** button to proceed to the profile selection screen

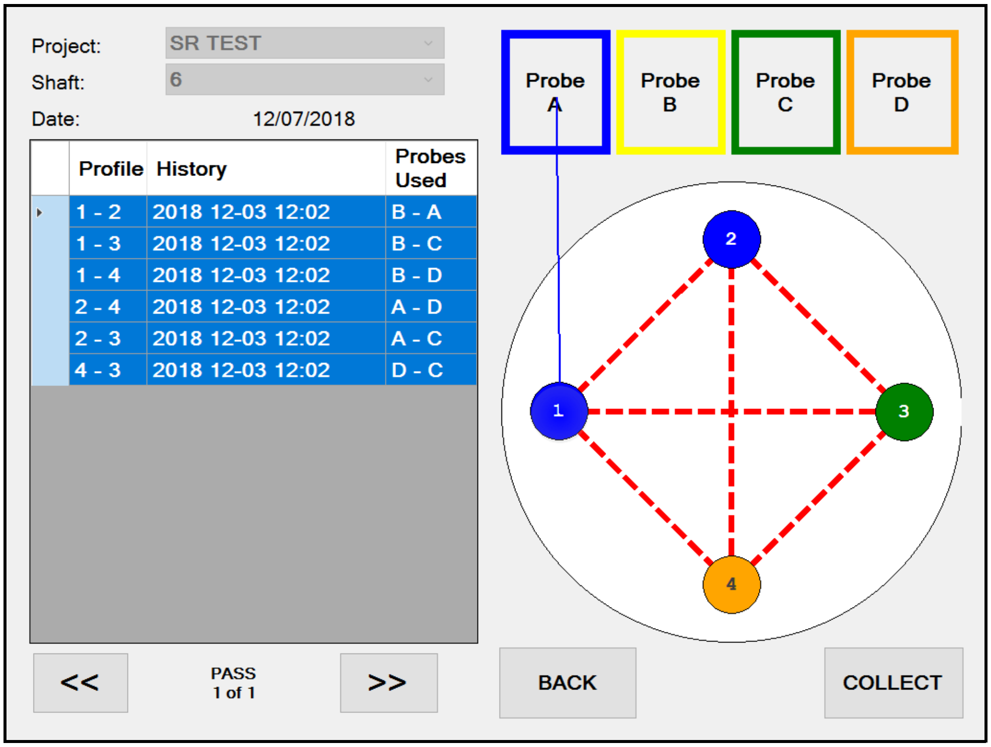


Figure 3.10: The Profile Selection Screen allows the user to choose which profiles will be tested by assigning probes to access tubes.

The program will automatically assign probes to each tube when entering the profile selection screen. In general it is recommended to follow the assigned configuration but the user is able to adjust which probe is assigned to which tube. **It is critically important that the displayed configuration match the actual placement of the probes**. Failure to follow these assigned tubes may result in inaccurate or unusable results, particularly when the tube lengths differ or when offset testing is performed.

If adjustments to the tube assignments are desired the user may simply select the probe and drag it to the tube it is placed in (Figure 3.10). Once done, the access tube color should reflect the color of the probe in that tube. For a four tube shaft with four transceivers this will on require one pull to complete all six profiles.

3.5.1 Probe Assignment for Multiple Passes

In situations where more that four tubes are installed in a shaft, data collection will require more than one pull to complete all profiles. In this situation the CHAMP-Q is pre-programmed to assign the probe placement for the minimum number of pulls (Figure 3.11)

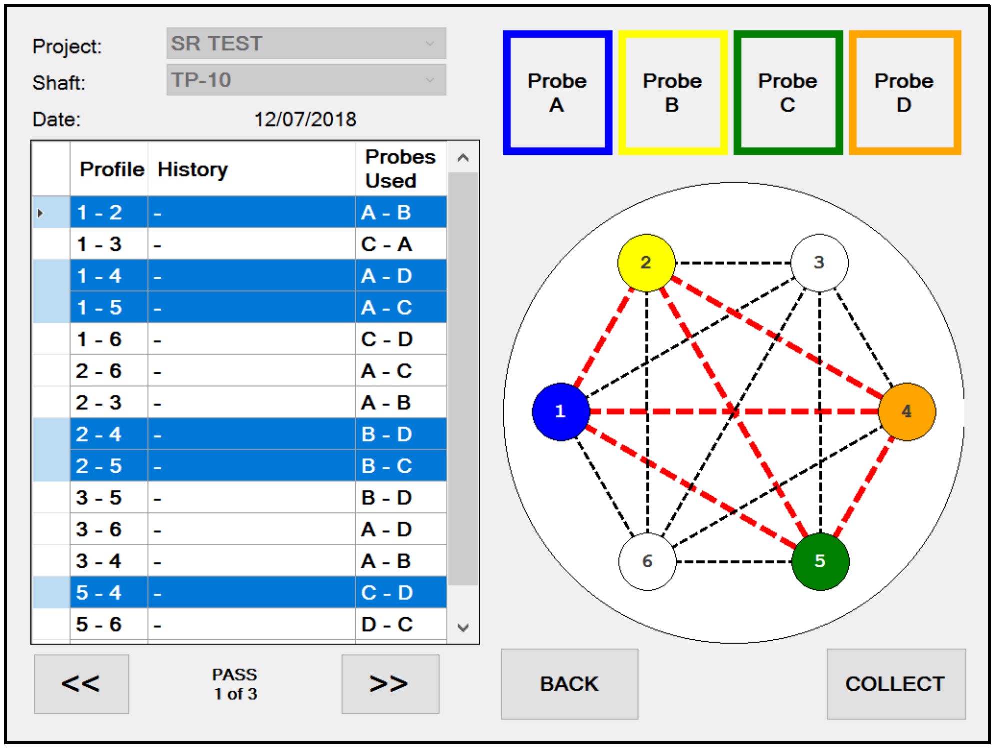


Figure 3.11: Probe assignment are pre-programed to minimize the number of passes required to complete a test.

Once a pull is completed the user can move to the next set of probe assignments by selecting the [>>] button. Please note that while the program minimizes the number of pulls required for a test, often multiple measurements for a given profile are collected. The CHAMP-Q will not save over a file but creates multiple files for the same profile, from which the user can choose for final reporting.

3.5.2 File History

If a profile has already been collected for a given profile it will be noted in the History column of the Profile Page. Profiles with a dash in the history column have yet to be collected.

Chapter 4: Data Collection

4.1 Proceeding to Data Collection

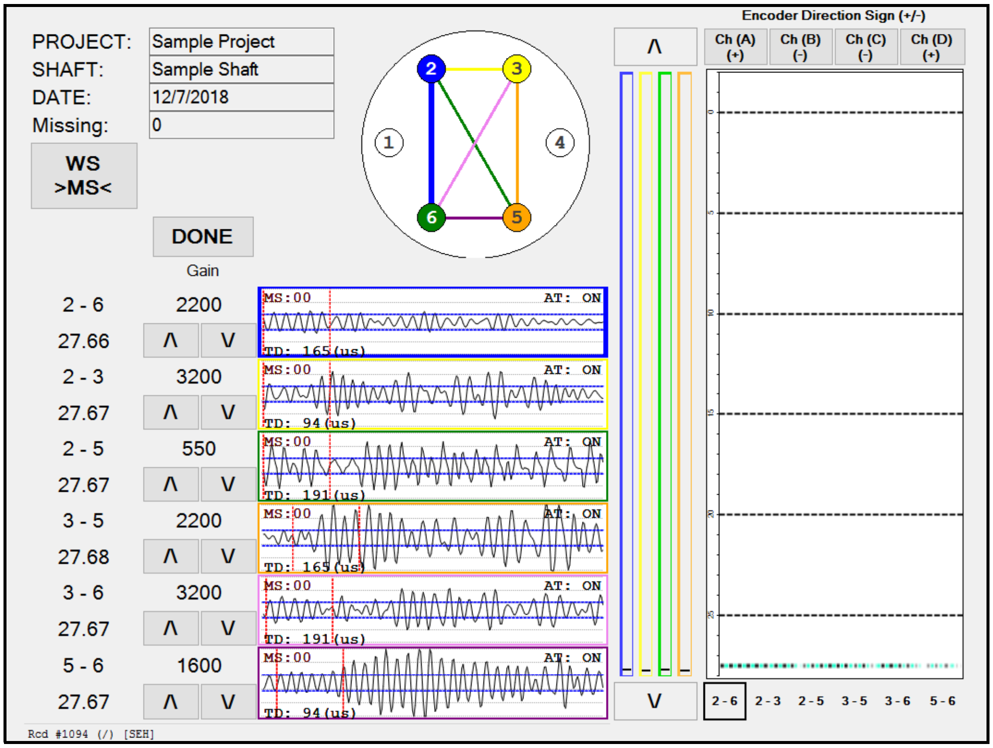


Figure 4.1: Data Collection Screen

4.1.1 Profile Monitor Windows (Raw Data Windows)

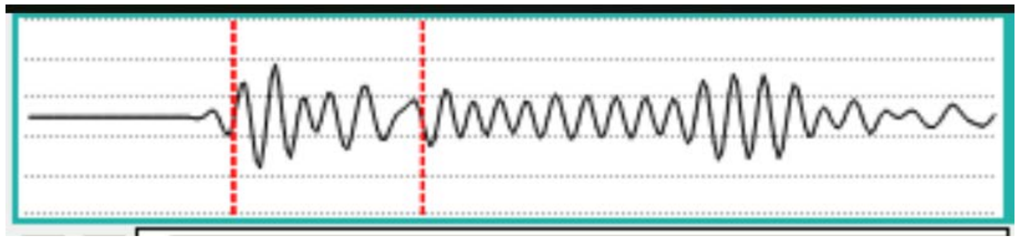


Figure 4.2: The Data Acquisition Signal

This left side of the data collection screen display all six of the actual data acquisition signal graphs simultaneously (250 data points, or 500 data points, or 1000 data points, either sampled at 500 kHz or 1 MHz or 2 MHz) at the current probe depths, and is offset by the trigger delay (TD). The graph represents a range of –10 to +10 volts (center is zero). This trace is nested (with color intensity reflecting amplitude) with others versus depth to comprise the “waterfall diagram” shown on the right half of the screen.

4.1.2 Zeroing The Depth Encoders

The CHAMP will allow data collection by either pulling the probes from the bottom of the access tubes (generally preferred) or lowering the probes from the top of the access tubes. Both of these methods effectively reference “zero” depth to nominally the top of the concrete, and show the current probe location referenced to the top of concrete (defined as zero depth). Accurate measurement of depths requires that carefully measured dimensions of each tube (such as: total tube length and length of tube above concrete) have been entered properly in the tube wizard, and that the probes are in the correct tubes indicated by the Tube Wizard.

Initially, the right half of the data acquisition screen is blank, because no data has yet been collected. For each profile the user must first define the current probe location to set the depth reference (or **ZERO**). There are basically two methods of referencing the probe depths: either to the top of the tubes, or to the bottom of the tubes.

4.1.2.1 From the Tube Bottom

The first (preferred) method of referencing is when probes are physically located at the bottom of their respective tubes. Once all slack has been removed from the probe cables, select the down arrow button (Figure 4.3) to set the current probe depth to the bottom of the access tubes. You should see one line of “waterfall” data (right half of screen) at the pile bottom (Figure 4.3). If the **MISSING** window shows any value but zero, press the down arrow button a second time.

If a profile contains access tubes with varying bottom tube elevations, (for example a tube was obstructed a partial distance from the bottom of the shaft), after zeroing the probes, the probe at the higher elevation should not be pulled until all probes are at the same elevation then pulling all probes in parallel.

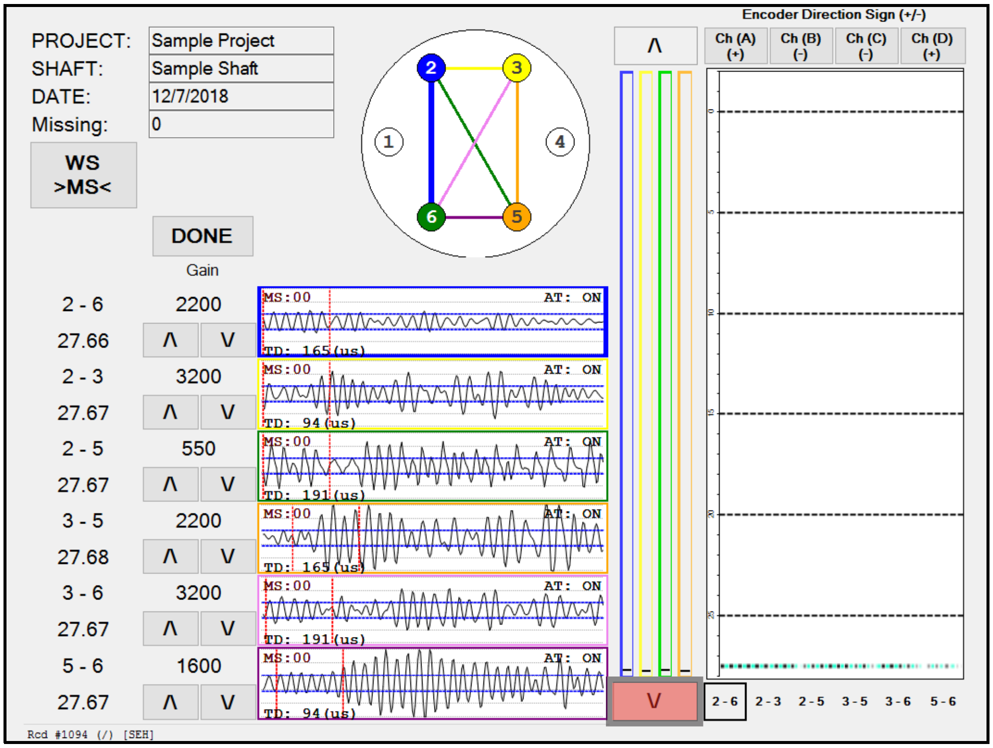


Figure 4.3: Zeroing the Depth Encoders at the bottom by selecting the down arrow (highlighted in red).

An additional minor adjustment for the probe depths occurs because the active transceiver probe elements are located near the bottom of the main probes. **Note: these values are set in the PROBES button of the MAIN MENU (Section 3.3), and remain unchanged unless new different probes are used, or if the lengths of bottom weights are changed.**

4.1.2.2 From the Tube Top

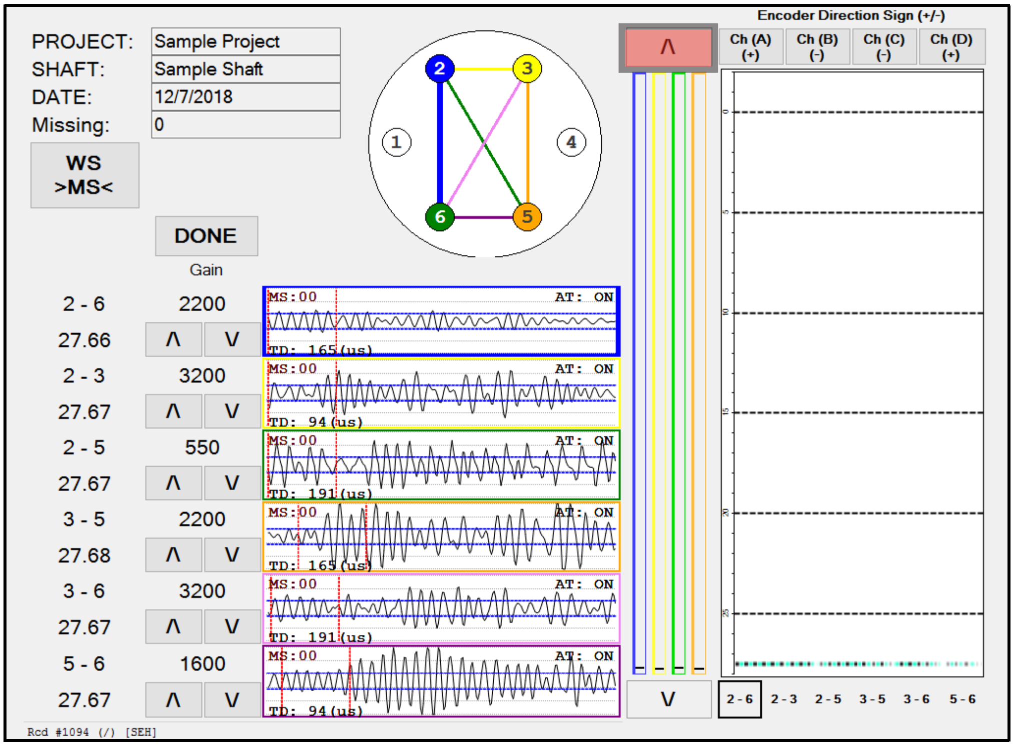


Figure 4.4: Zeroing the Depth Encoders at the top by selecting the up arrow (highlighted in red).

The other optional method (but only infrequently used) is when all probes are physically located at the TOP of their respective tubes. Pressing the up arrow button (Figure 4.4) sets the probe location to the top of the access tube. Again a small adjustment is made for probe length above the sensing element, which should also include the length of the nylon tube top inserts, if used.

4.1.3 Time Delay (TD)

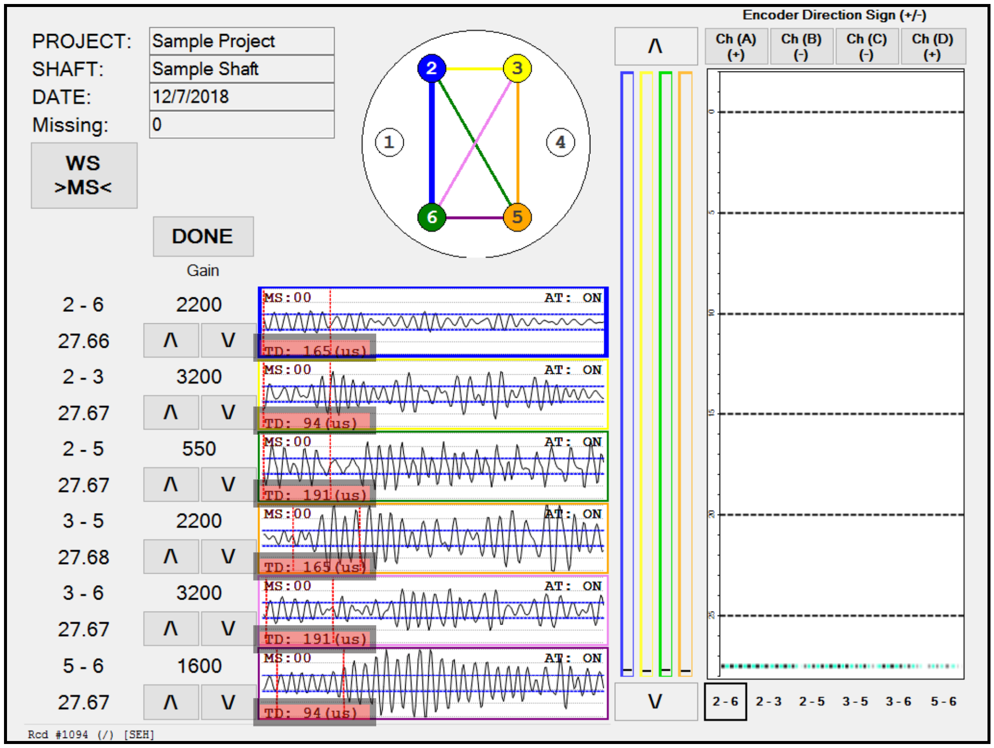


Figure 4.5: The Time Delay (TD) is noted in the red shaded area for each profile.

Tube spacing divided by wave speed is the theoretical travel time for a pulse between tubes. Subtracting 100 (micro-seconds) offsets the arrival time by 40% (of 250 points which is 0.5 milliseconds at a sampling frequency of 500,000 Hz), or 20% (of 500 data points which is 1 millisecond). **Note that the TD value can not be adjusted in the data collection screen so it is crucial that a reasonable distance be entered in set-up to allow TD to be set properly during data acquisition to display the left edge of the waterfall.** The signals must contain the desired ("left edge" of waterfall) First Arrival Time data during data collection. If you do not see the left edge of the data, the probe placement may not be agreement or the tube spacing at deeper depth is different than the entered value. TD should be adjusted (Section 3.2.3).

4.1.4 Signal Gain

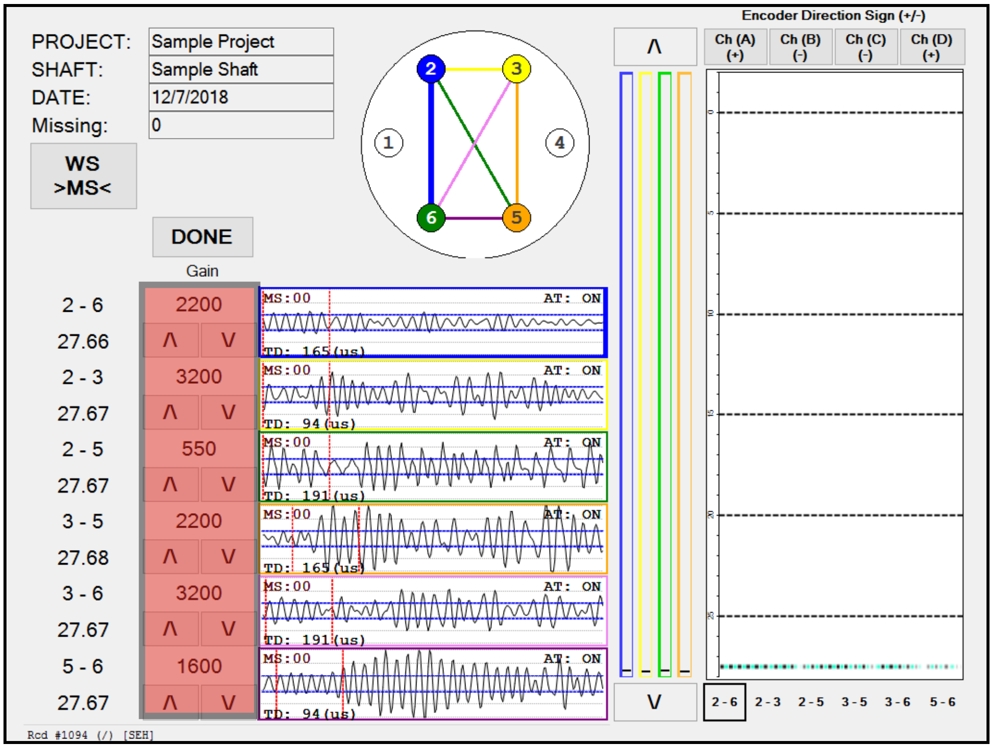


Figure 4.6: The Gain setting for each profile can be adjusted at the beginning of data collection by selecting the up or down arrow below each gain value (highlighted in red).

The **GAIN** of the signal processing circuitry can be adjusted up or down using the up or down arrows below each gain setting (Figure 4.5). This adjusts the strength of the signal data display graph (immediately to the right) for each respective profile. Ideally, the gain should be set high enough so that the signal is nominally at least 60% of full scale, yet low enough so that (most) larger peaks are less than full scale. Usually the same GAIN is used for all perimeter profiles. Larger tube spacings (such as the main diagonals) would likely require higher gain levels.

It is recommended practice to set the gain levels before testing the first pile in the Hardware Monitor (Section 3.2.4) after raising the probes roughly 2 ft (0.6m) off the bottom of the access tubes.

The entire profile (for one tube pair) must use the same gain. If the gain needs adjustment, the entire profile must be repeated (probes returned to tube bottoms, the "zero" reset, and probes re-pulled). It is often best to make all adjustments for **GAIN** when the probes are raised about one or 1.5 meters (3 or 5 ft) above the shaft toe where the shaft is likely to be more uniform, so that a potential "soft bottom" does not influence the input selection.The CHAMP-Q will prevent adjustments to the gain after the probes have been pulled 5 ft (1.5 m).

4.1.5 Tracking Depth

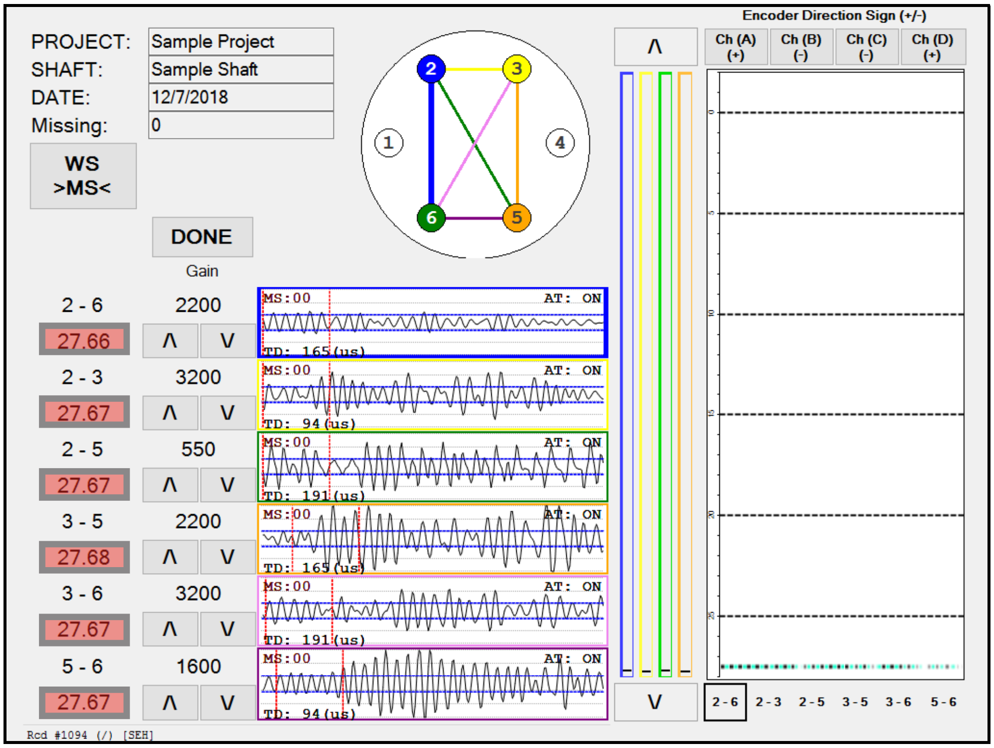


Figure 4.7: Depth for each profile is displayed below each profile name (noted by black square).

Depth locations are displayed below each profile. The depth displayed represents the average depth for the two probes. Additionally the bar graphs to the left of the waterfall diagram display the location of each probe.

4.1.5.1 Probe Depth Warning

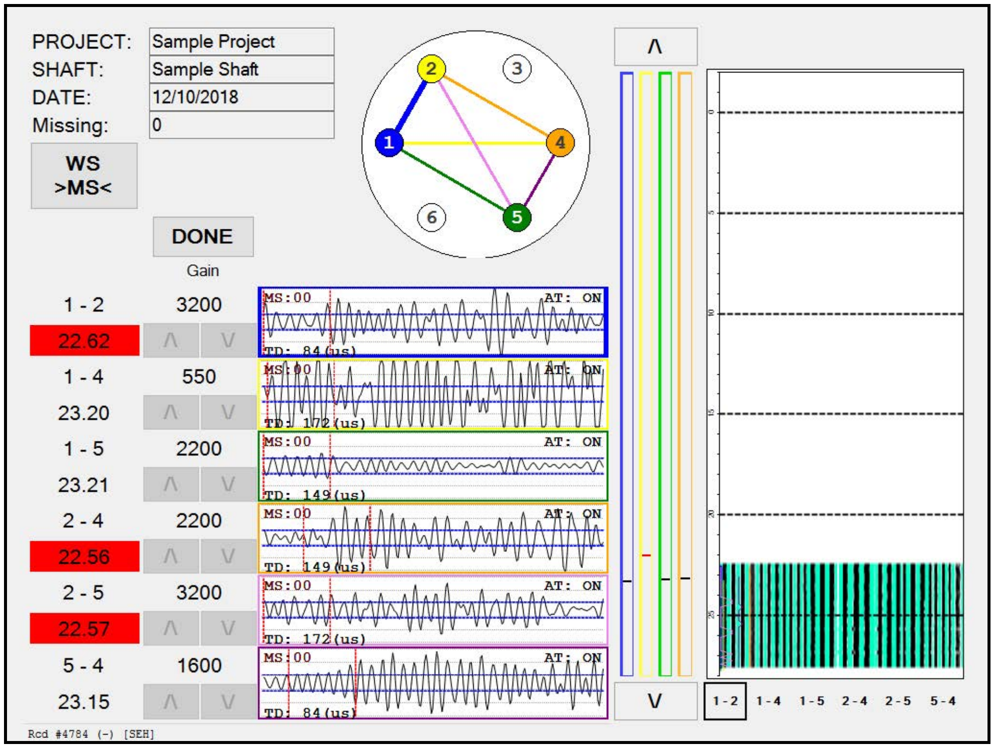


Figure 4.8: **Probes that have a depth greater than 6 inches (15 cm) from the lowest probe will be marked in red and the associated profiles with that probe will also be highlighted in red.**

If a probe indicates a depth difference of greater that 6 inches (150 mm) from the other probe, the probe will be highlighted in red on the depth display and all associated profiles will be highlighted in red.

4.1.5.2 Displaying Offset Values

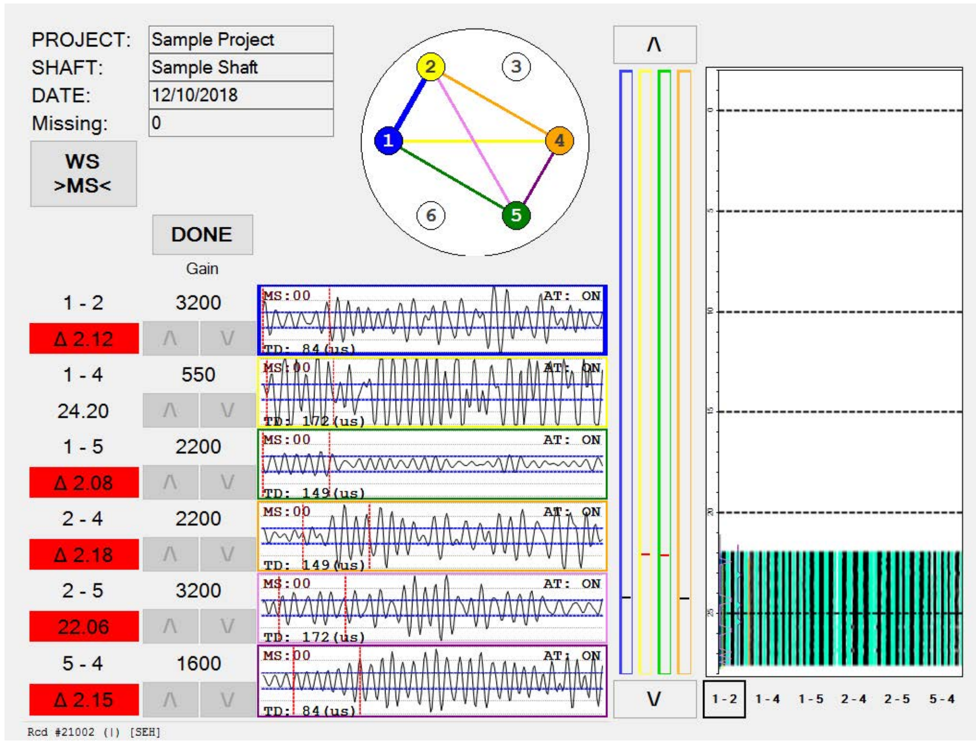


Figure 4.9: The depth display can be toggled to show the difference between the two probes by touch the depth value.

1 In some instances, offset testing may be specified for a project, where one probe is pulled to a higher elevation in an attempt to provide better resolution for a tomography analysis. The program can toggle between displaying the average depth for the profile and the offset value between the two probes for any collected profile by selecting the depth location. When a Delta (Δ) value is displayed before the number, this means the offset values is being displayed.

4.1.6 Missing Data Sets

The 'Missing' box located in the upper left hand side of the data collection screen reports the total number of missing data sets for all profiles. This occurs if the cable is pulled too fast for the scan/second rate and the signal is therefore skipped. If a data set is missing, the user may lower the probes until the data set is recovered ("Missing" value returns to zero), and then resume pulling the probes. Any missing profiles will also be noted by a red X on the bar graph to the left of the waterfall noting the depth of the missing data set.

4.1.7 Switching Waterfall View

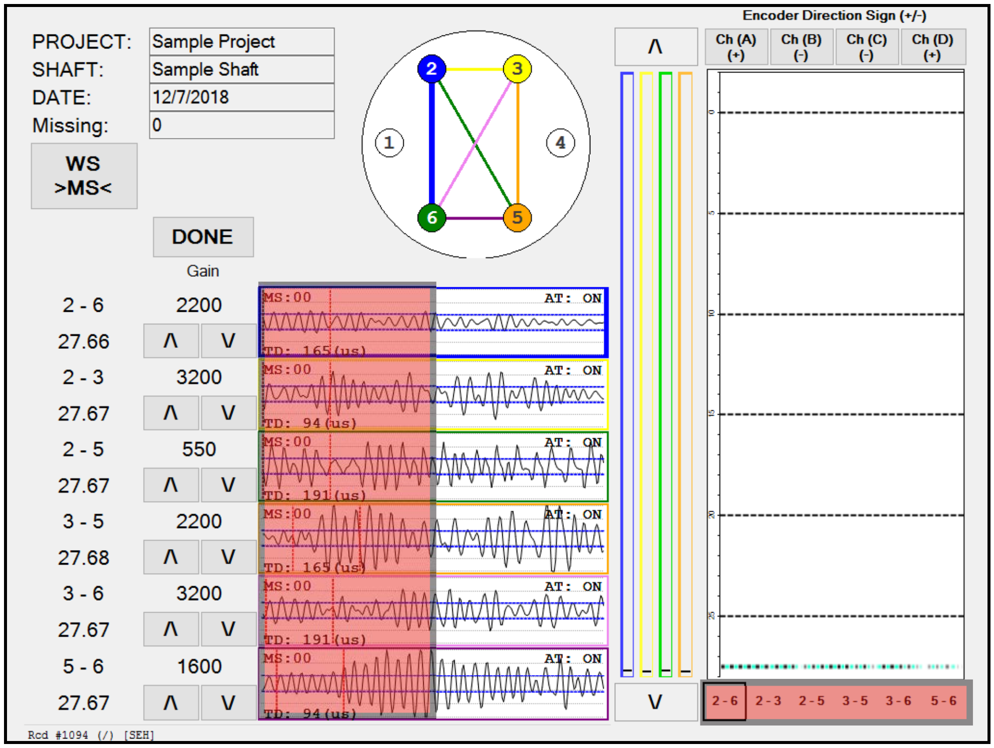


Figure 4.10: The displayed waterfall diagram may be changed during data collection.

The displayed waterfall diagram may be changed during data collection by either selecting the appropriate tab under the waterfall diagram or touching the left hand side of the data acquisition signal for the desired profile.The currently displayed waterfall graph is noted by the black box around the profile in the lower right-hand corner of the screen.

4.1.8 Turning On/Off Arrival Time (AT) Lines

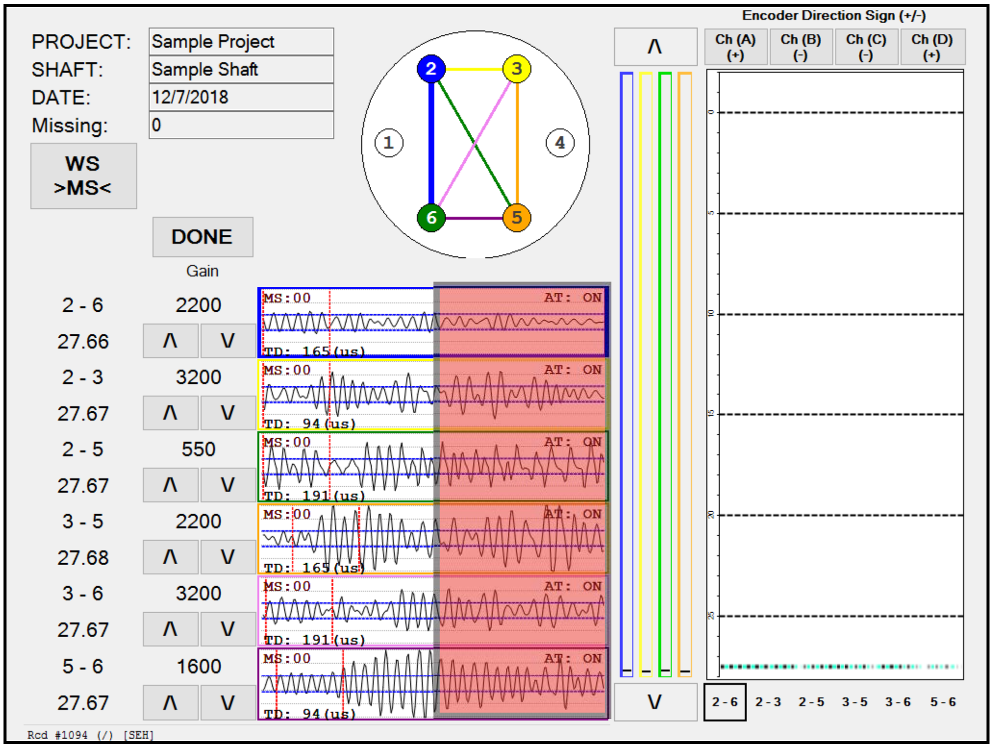


Figure 4.11: The AT lines for each profile may be toggles on or off.

The arrival time lines (AT) for each profile in the waterfall diagrams may be toggled on or off by clicking on the right hand side of each data acquisition signal.

4.1.9 Completing Data Collection

Press **DONE** to finish the data collection (the active tube pair is shown on this button). CHAMP-Q then proceeds to the data review screen where the waterfall for all six profiles may be view simultaneously.

4.2 Data Review

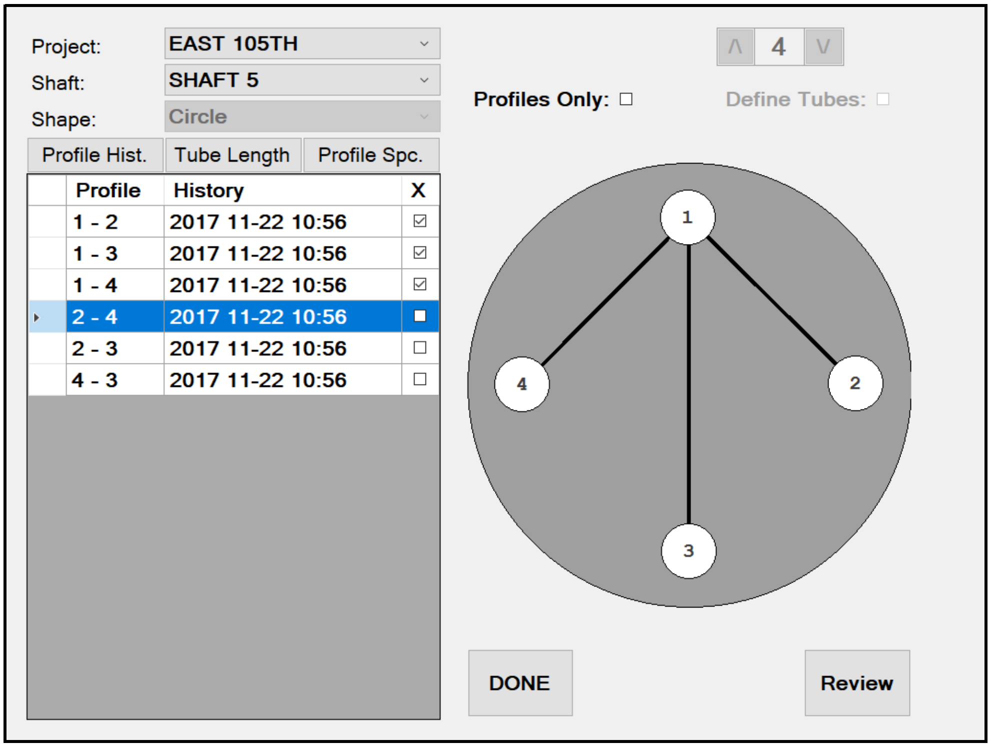


Figure 4.12: The user may choose up to 6 profiles to review simultaneously.

Selecting Review from the main menu will allow a user to review up to six profiles from one shaft. Note that as each profile is selected, a black line between each access tube will be drawn.

4.2.1 Data Review Screen

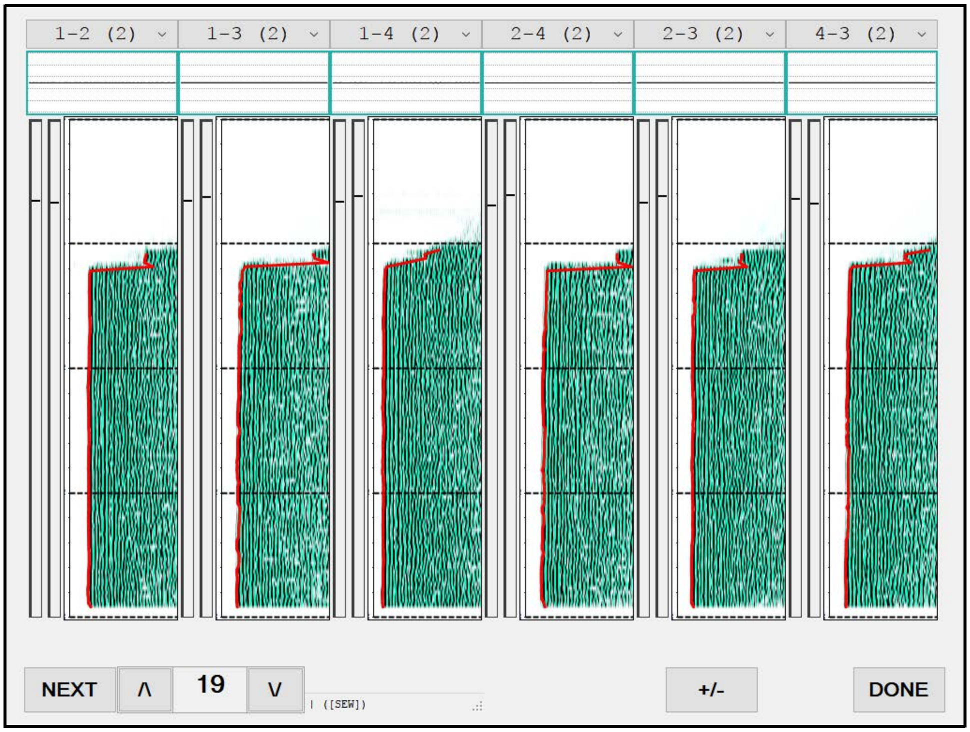


Figure 4.13: Data Review Screen

If the tube pair has more than one test, the user may select a different data set for that profile from the top drop down menu located at the top of the screen (Figure 4.13) for each profile. Multiple data sets for the same profile will display a name appended with additional characters (e.g. 1-2-1 indicates the second test of the tube pair 1-2, while 1-2-3 would indicate the fourth test of tube pair 1-2). When a new profile is selected the review screen will be redrawn with the new profile.

4.2.2 Scrolling Through Data Sets

The up and down arrow buttons in the lower left hand corner of the review screen allow the data to scroll the depth cursors up and down through the data. Continuously pressing the UP or DOWN arrow will cause continued movement until the desired shaft detail is in view..

4.3 Data Transfer and Analysis

When data collection is complete, return to the MAIN MENU and press EXIT. The collected data is stored in the CHA projects folder, which can be accessed from the Windows desktop.

Insert a USB drive into one of the USB ports of the CHAMP and copy the desired data files/project folder using one of the following operations:

1 Drag the desired data file/folder from the CHA Projects Folder to the drive corresponding to the USB port/memory stick.

2 Press and hold on the desired data file/folder to be copied and select **COPY**. Then press and hold on the drive corresponding to the USB port/memory stick and click **PASTE**. This operation is analogous with the right click feature available while using a mouse.

The data can be then transferred to a personal computer and accessed by the CHA-W software program for final data processing. That would include final selection of **FAT** by the **EDGE FINDER**, analysis for defects by the **DEFECT ANALYSIS** feature, and final report preparation. A separate Manual for the software program CHA-W, also provided by PDI, describes that program's operation.

4.3.1 Editing Geometry

Because the CHAMP-Q allows data collection without detailed entry of tube distances and lengths it will be necessary to perform this task if not entered in the field. Please note that any wavespeed calculation and subsequent analysis with the tomography program is dependent on the accuracy of the distance measurements between the access tubes as well as the vertical difference in elevation of the probes during data collection. Failure to enter accurate distance values based off of actual field measurements will likely result in incorrect data analysis and interpretation.

To perform the necessary edits to the pile geometry the user must do so by creating a report in the CHA-W program and then selecting the 'Profile I…' from the 'Edit menu (Figure 4.14)

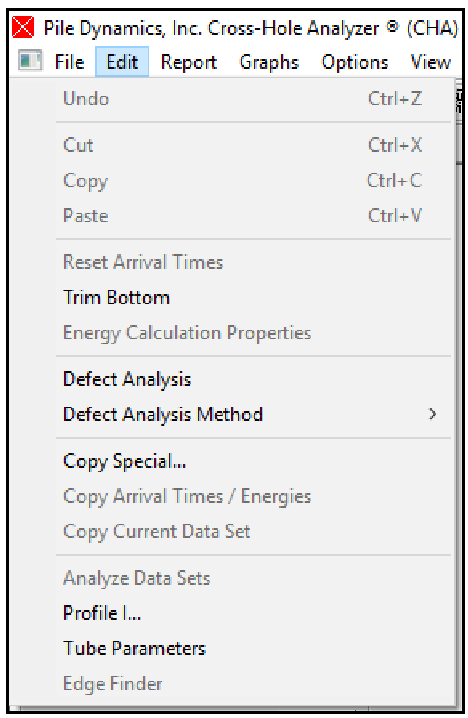


Figure 4.14: The Profile Editor can be accessed from the 'Edit' menu.

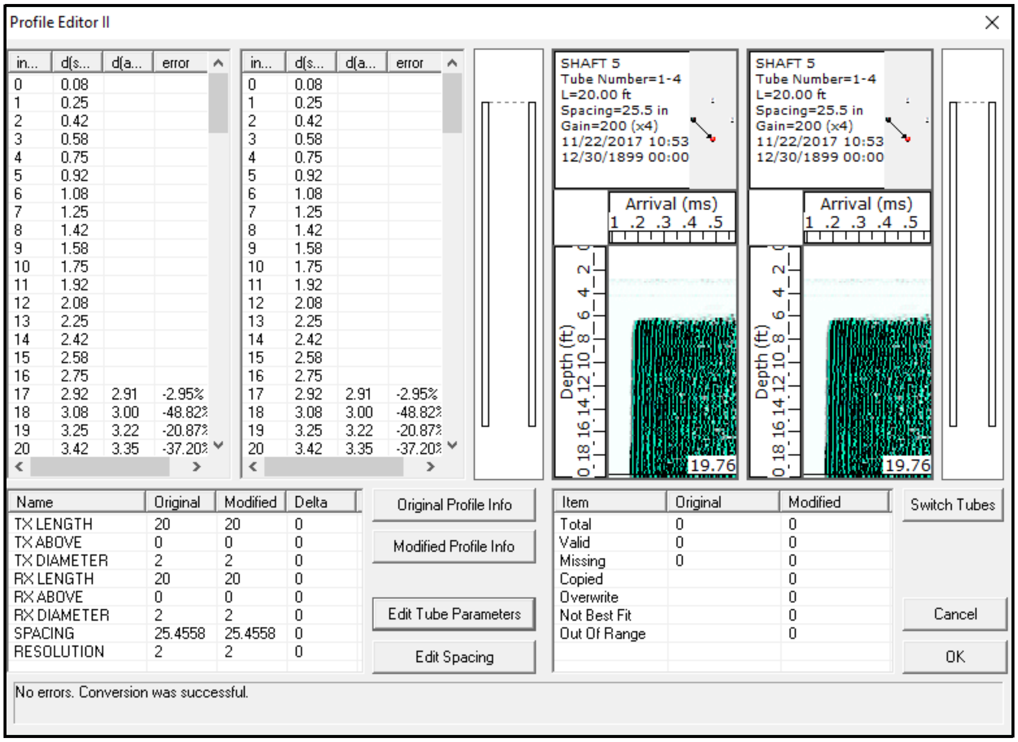


Figure 4.15: The Profile Editor.

The profile editor screen (Figure 4.15) will appear where the user may adjust the following options:

4.3.1.1 Edit Tube Spacing

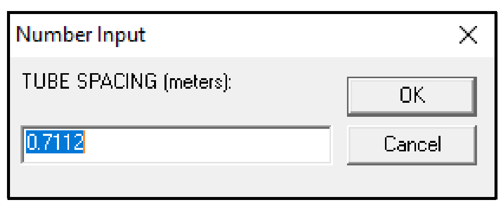


Figure 4.16: The Tube Spacing Window.

The horizontal tube spacing is adjusted by clicking on the 'Edit Spacing' button from the Profile Editor Screen. Once selected, the user may type in a different spacing and the changes will be accurately reflected in the displayed graphic at the top of the output.

Note the horizontal tube spacing may also be edited in the Properties window from the main screen in CHA-W however, this method does not adjust the csl.project file, resulting in the tube layout graphic disappearing from the output.

4.3.1.2 Tube Parameter Editor

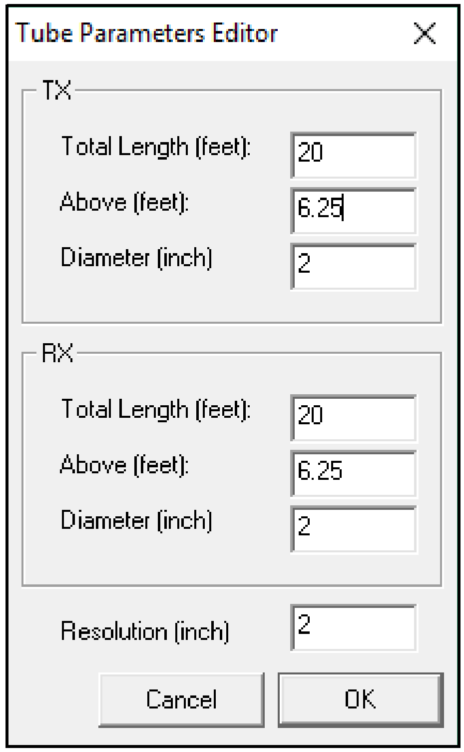


Figure 4.17: The Tube Parameters Editor.

The Tube Parameters Editor will allow the user to change the overall tube length, the tube length above concrete, as well as the diameter of the access tube. Note that length adjustments will only affect the scales. Collected data cannot be

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