FDOT
MANUAL FOR THE OPERATION OF THE SPT ANALYZER

Prepared by the University of Florida
for the Florida Department of Transportation
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1 INTRODUCTION

The Standard Penetration Test (SPT) is performed in accordance with ASTM D 1586 for the purpose of recovering a subsurface soil sample and making a measure of the soil's resistance to the sampler's penetrations. The measure of the resistance to penetration is the N-value, which is determined from the number of blows required to drive a sampler at the end of a drill string into the soil for three 6-inch increments using a 140-pound hammer dropped 30 inches. The sum of the number of hammer blows required to drive the sampler the last two six-inch increments is the N-value, or blow count. Although in accordance with the ASTM all hammers must be 140 pounds and dropped 30 inches, all hammers do not consistently deliver the same amount of energy to the drill string. Variations in the energy delivered to the drill string can cause different N-values to be reported for identical soil conditions. This presents a problem for design based on N-values.

The SPT Analyzer™ (the "Analyzer") provides a means of measuring the energy transferred from a SPT hammer to the drill string. Being able to measure this energy allows engineers using the SPT N-values to assess their reasonableness, adjust them to a standard N_{60}, and assess the general performance characteristics of an SPT hammer system. Additionally, measuring the energy transfer of an SPT hammer system may be beneficial for training drill crews or spotting problems with SPT equipment.

The purpose of this *FDOT Manual for the Operation of the SPT Analyzer* is to provide Florida Department of Transportation (FDOT) personnel with a suggested operating procedure for using the Analyzer in the field to gather energy transfer data for an SPT hammer/drill rig system. The goal of the manual is to provide sufficient information to guide a person (field technician or engineer) through the process of: 1) operating the SPT Analyzer to gather the desired field data, and 2) downloading and saving the field data onto the SPT-PC program which is loaded on a personal computer (PC).

The Manual does not address the theory behind the testing, nor does it discuss methods to evaluate the data once they are downloaded to the SPT-PC program. It does present a procedure and recommendations for recovery of field data and recording information so that an engineer using the data should have the necessary information for his evaluation. However, an engineer directing the performance of an energy measurement test with the SPT Analyzer™ may wish to direct that more, or less, information and data be recorded by the field technician using the Analyzer.

Pile Dynamics, Inc. (PDI), the manufacturer of the SPT Analyzer™, has prepared an *SPT Analyzer Users Manual, September 1995.* The PDI manual is included as Appendix A. The FDOT manual has taken much of its information from the PDI manual, often verbatim, but does not address all issues presented in the PDI manual; if the FDOT manual does not suitably answer an operator's questions, the PDI manual should be consulted.

Safety must always be considered when working around activities such as SPT sampling. Adhere to FDOT Safety standards.

2 EQUIPMENT

Equipment and information necessary for performing energy measurements with the SPT Analyzer are described below and are pictured in the accompanying figures.

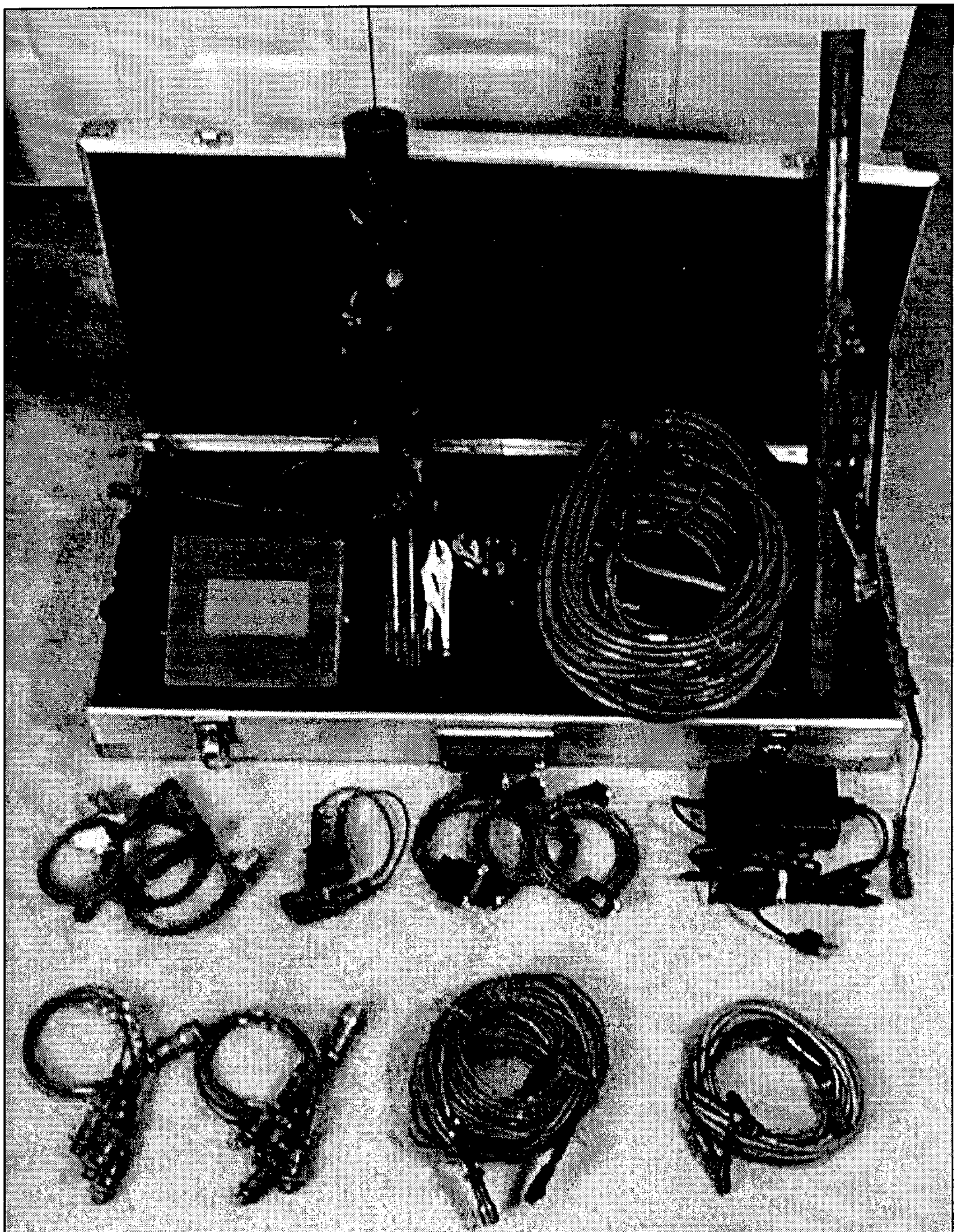

Figure 2-1. SPT Analyzer Components with Carrying Case.

1. **Instrumented SPT drill rod section.** Two foil strain gages are permanently affixed to the approximate 2-foot long drill rod with a short cable attached to each strain gage. One NW and one AW rod are included with the FDOT-owned analyzer.

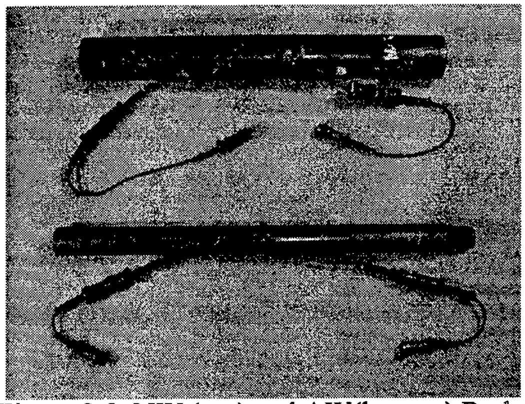

Figure 2-2. NW (top) and AW(bottom) Rods.

2. **Bolt-mounted piezoresistive accelerometers.** Two accelerometers are required and must be bolted to the side of the instrumented drill rod section. For the FDOT-owned analyzer, piezoresistive accelerometers are used. Piezoelectric accelerometers may be used for SPT energy testing, but would require different cabling and configuration of the SPT Analyzer data processing unit.

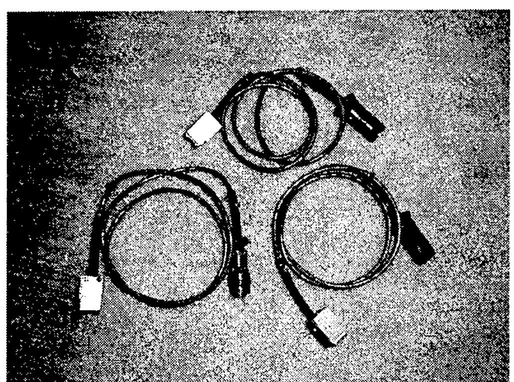

Figure 2-3. Accelerometers (three pictured).

3. **Calibration values for the Gages to be used.** The calibration sheets for the accelerometers and strain gages are included in Appendix B. However, if new gages are used or old gages are recalibrated, then the new calibration values must be recorded and used. Calibrations for the accelerometers, the "PAK (*5000)" numbers, are typically from about 350 to 450. For the strain gages, the "Calibration Factor" for Bridges 1 and 2 are typically around 220 ME/V.

4. **SPT Analyzer data processing unit.** The "Analyzer" is a small orange "box" with touch screen and is used to collect and process the signals from the strain gages and accelerometers.

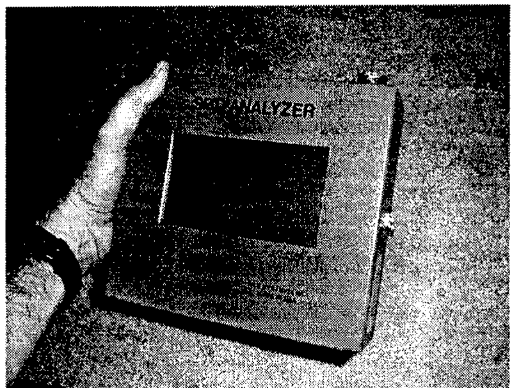

Figure 2-4. Data Processing Unit – the "Analyzer."

5. **Cables for the "field."** The "pigtail" cable connects to each of the four gages and consolidates these four cables into one. The main cable connects the pigtail cable to the Analyzer. The field 12-volt battery power cable connects the analyzer to a standard car battery.

Figure 2-5. Pigtail Connection Cable.

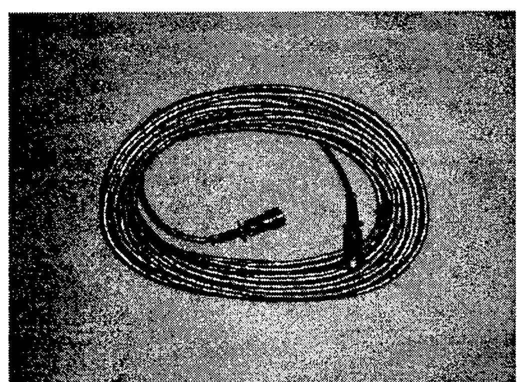

Figure 2-6. Main Cable.

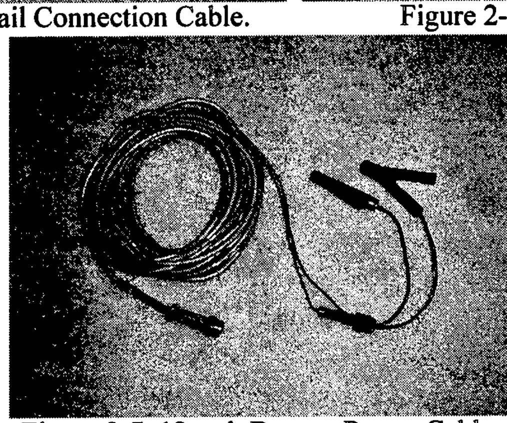

Figure 2-7. 12-volt Battery Power Cable.

Also shown in Figure 2-1, but not pictured individually, are a remote increment trigger, extra cables for converting threaded cable ends to quick disconnect, and a few tools such as screwdrivers, vise grip and adjustable pliers.

6. **Cables for the "office."** A power cable, with adapter, for 120/240 volt power supply is used to power the analyzer indoors. Also, two cables are available for connecting the analyzer to a printer or plotter. Another cable, labeled with "PC," is required to download data from the analyzer to a PC.

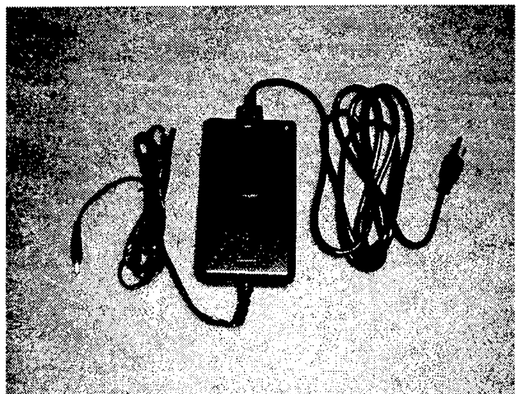

Figure 2-8. 120/240-volt Power Supply.

7. **PC with SPT-PC program and "Key."** A computer must be available to which the Analyzer data can be downloaded. This requires the SPT-PC program be loaded and a "Key" attached to the PC's parallel port.

8. **Forms.** Suggested forms for use in recording field information are included in Appendix C.

3 SUGGESTED OPERATING PROCEDURE

The following SPT Analyzer operating procedure is presented as a suggested guide for recovering SPT energy transfer data. The procedure is presented in three sections: Prepare Work Area and Equipment, Acquire Data, and Download Data.

3.1 Prepare Work Area and Equipment

3.1.1 Initial Site Setup

1. **Locate the work area for the SPT Analyzer.** It is best to keep the analyzer in the shade unless in use. Also, locate such that cables can reach both the power supply and the SPT hammer/drill string. Working off of a truck tailgate is often suitable.

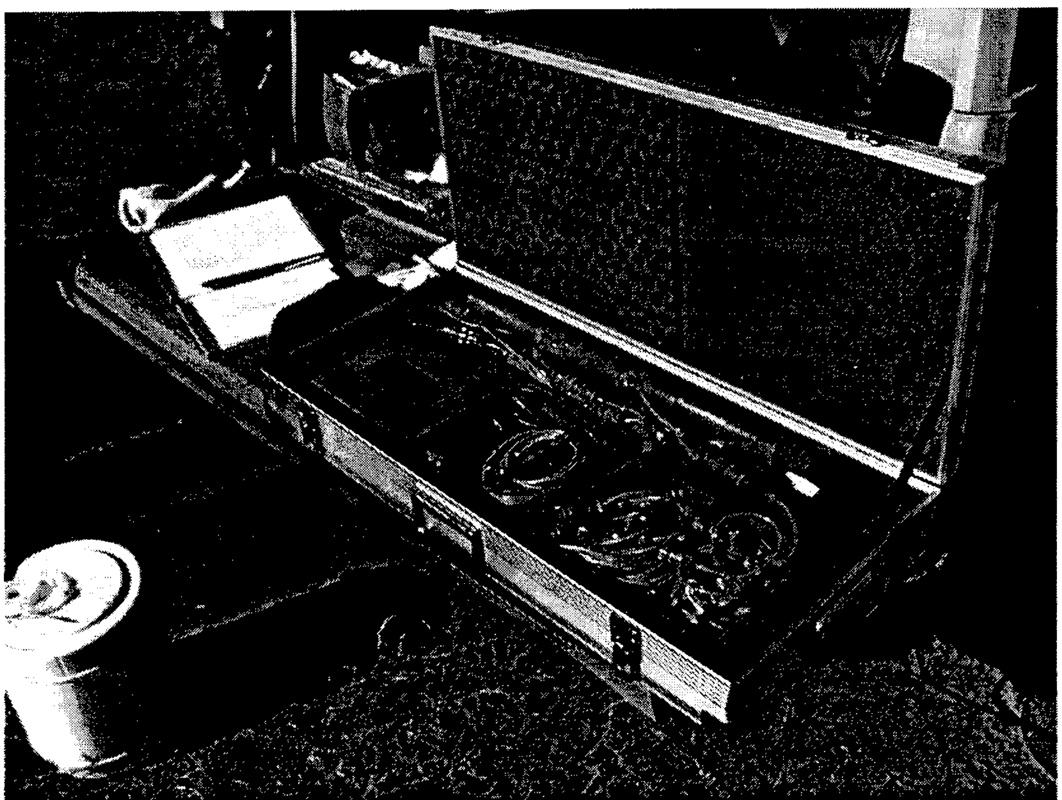

Figure 3-1. Equipment Placed on Truck Tailgate.

2. **Record information about the SPT System (hammer, rig, driller, etc.).** Two forms for recording general information about the SPT system are included in Appendix C along with examples. Other forms may be generated and used as needed to meet the requirements of the project.

3. **Measure/mark safety hammer drop height.** If a safety hammer is being used and the hammer drop height is to be noted during testing, mark the hammer stem at 28", 30", and 32" above the point where the bottom of the hammer barrel rests in the down position. By doing this, when the hammer operator raises the hammer during testing, the approximate height of the hammer pull can be noted by observing where the bottom of the hammer barrel rises relative to the markings on the hammer stem. A heavy-duty marker, wax crayon, or paint can be used to make the circular marking around the hammer stem.

Figure 3-2. Measuring and Marking Drop Height on Safety Hammer Stem.

4. **Direct the drill crew to perform at least two SPT drives prior to taking energy measurements if they have not previously conducted testing that day.** This serves the purpose of warming up the system and operators to bring them closer to normal working order. For safety hammer systems, the rope and cathead are also given a chance to dry, warm up, and stretch out.

5. **Connect one end of the power cable to the analyzer and the other to the vehicle battery.** Ensure that the cables are attached to the appropriate battery terminals, with the red clamp on the positive terminal. Wrap the cable coming off of the battery around the vehicle mirror or other fixed object. This will help keep the cables from inadvertently being pulled off the battery during testing. The red LED beside the Analyzer's power switch should light up when connected.

6. **Select the appropriate instrumented drill rod, AW or NW.** Note that one end of the rod is denoted as #1 and one as #2. This is important since the strain gage calibration is referenced to the end of the rod from which its cable emits.

7. **Attach two accelerometers to the instrumented drill rod by bolting them to the predrilled holes.** The accelerometers must be vertically aligned, with cables downward, and should be wrench tightened. Two to three washers should be placed between the accelerometer and the bolt head.

8. **Connect the gage cables to the pigtail and make note of the cable channel.** The four pigtail cables are labeled with channel notations of F1, F2, A1, and A2. The cables are also marked with either one or two yellow bands to correspond with their 1 or 2 notation (i.e. the F1 cable will have one yellow band, while the F2 cable will have two). The strain gages should be connected to the F1 and F2 cables and the accelerometers to the A1 and A2 cables. Make note of which gage is connected to which channel. For simplicity and to limit possible confusion, it is good practice to always connect strain gage #1 to F1 and #2 to F2.

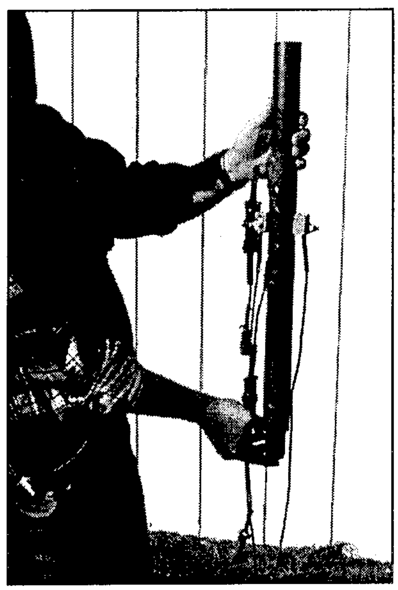

Figure 3-3. Instrumented Rod with Accelerometers and Pigtail Cable Attached.

9. **Connect the Analyzer to the pigtail cable using the main cable.**

3.1.2 Prepare the Analyzer – Input Information

Prior to inputting information into the Analyzer, ensure that sufficient memory is available in the Analyzer to record the anticipated number of blows. This can be checked as described in Section 3.2.2 (Step 30) by observing the save location of the last blow recorded. Remember that the Analyzer can store data from a total of 179 blows, and the save location of the final blow is ID179. To observe this follow the REVIEW and then LIST DATA boxes. If enough memory is not available, then download data and clear the memory as described in Section 3.3.

Several pieces of information must be entered into the Analyzer to prepare for testing. This is accomplished using the procedures and touch screens.

10. **Turn on Analyzer.** The touch screen should become visible. Adjust the screen contrast, if required, using the thumbnail screw mounted on the left side of the analyzer unit.

11. **Introductory (Start-up) Screen.** This first screen (Figure 3-4) is displayed when the SPT Analyzer is turned on. At this screen touch either a) the owner name if a change is desired, b) the units box to toggle back and forth from English to Metric, c) the review box to access data review options, or if none of these options is desired press d) anywhere else on the screen to continue the Project Description Screen.

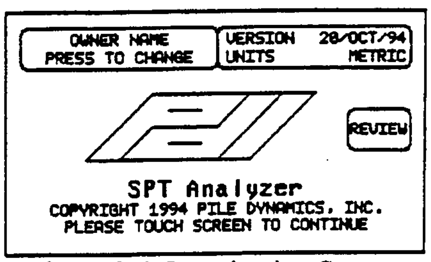

Figure 3-4. Introduction Screen.

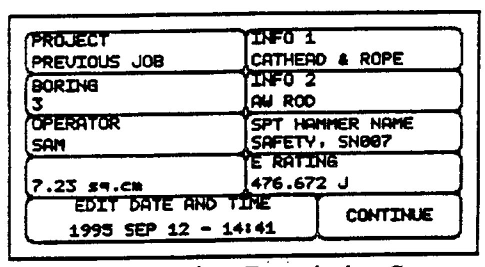

Figure 3-5. Project Description Screen.

12. **Project Description Screen.** On this screen (Figure 3-5) the basic information about the project is entered. These descriptive labels are attached to the data. To change one of the labels, touch that box and the screen will change to an alphabetic input screen. Page 11 of the *SPT Users Manual* in Appendix A discusses the use of the touch screens for inputting alphabetic and numeric characters. As discussed in Appendix A, the labels include:

- PROJECT -- May be the overall job identifier or company name.
- BORING -- the bore hole number or identifier. This entry is what is used to form the file name of the output .x01 file. For instance if this is entered as "42-2" then the

output .x01 file will be 42-2.x01. Therefore, this entry should be unique from entries for other test borings.

- OPERATOR -- Name of the person using the drilling equipment or rig supervisor.
- INFO 1 – Additional information of user's choice, such as drill rig type (e.g. CME 45).
- INFO 2 – Additional information of user's choice, such as drill rig serial number.
- SPT HAMMER NAME – description of the hammer, serial number, etc. (i.e. Safety or Automatic).
- AREA – This should be the area of the instrumented drill rod. Based on the EA factor measured during rod calibration and considering the steel to have an E = 30,000ksi, the area of the FDOT owned AW rod (#54) is 1.17in^2 (7.55cm^2) and the NW rod (#50) is 2.30in^2 (14.84cm^2). These are not the same as the suggested default values and must be entered using the numeric keypad screen. The current calibration values should be consulted if new rods are obtained, or the existing rods are modified or recalibrated.
- E RATING – This value is the rated hammer energy. For a 140 lb hammer dropped a nominal 30 inches this value should be 350 lb-ft (476 N-m).

Once all of these entries have been satisfactorily made, press CONTINUE.

13. **Confirmation Screen.** If all entries have not been revised, then the Confirmation Screen will appear asking the user to confirm that all entry changes desired have been made. If not, touch RETURN TO INFO SCREEN. Otherwise, touch ACCEPT DATA AND CONTINUE.

14. **Rod Length Screen.** Use the numeric keypad to input the rod length. This value should be the length from the center of the gage cluster on the instrumented rod to the tip of the split spoon sampler.

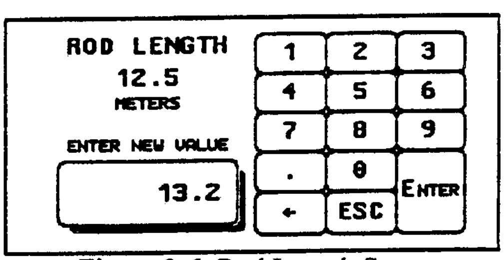

Figure 3-6. Rod Length Screen.

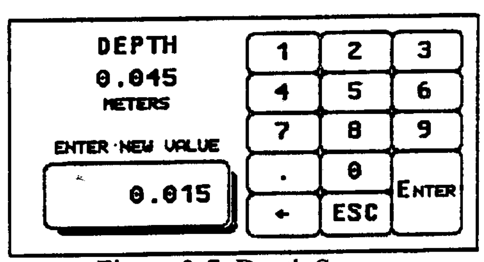

Figure 3-7. Depth Screen.

15. **Depth Screen.** Use the numeric keypad to input the depth. This is the depth from the reference point, often the ground surface or top of mud tub, to the bottom of the sampler. This is usually a little shorter than the Rod Length.

16. **Transducer Screen.** This screen, Figure 3-8, presents information on the four transducers used to take data. These four transducers are identified in the **TRANS** column as A1, A2, F1, and F2. This numbering corresponds to the numbering on the pigtail cable.

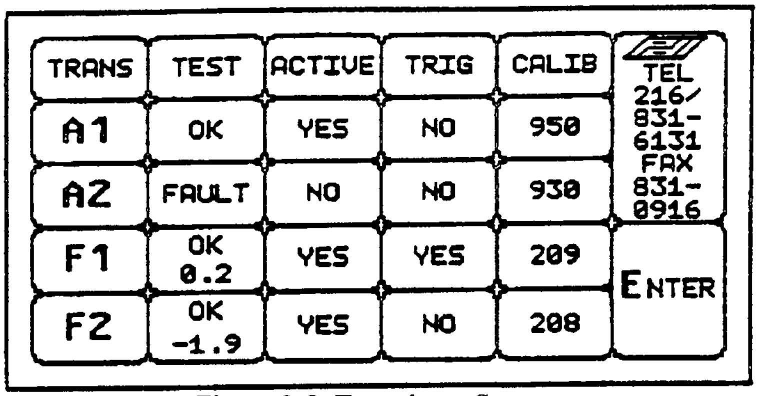

Figure 3-8. Transducer Screen.

The TEST column lists the status of the transducers as OK, FAULT, or NO GAGE. If the gages are connected properly and operational, then all entries should show OK. If not, then check the gages and wiring. The **ACTIVE** column toggles from NO to YES when touched. Only data from gages that are active will be used to display and calculate energies during the conduct of the test. If all gages are working properly, then these entries should be YES. If one of the gages appears to have problems or FAULT, it can be designated as NO. Data from all four channels will be recorded whether or not the gages are identified as active, but making a faulty gage not active may assist in evaluating the quality of the data from the other gages. In the **TRIG** column, one of the four sensors is identified to serve as the trigger for detecting and recording data. Only one may be selected. It is suggested that the F1 or F2 force sensor be used. In the **CALIB** column, the gage calibration values are displayed. If the calibrations do not agree with the gages connected to that particular transducer channel, then change these by pressing the value to be changed and using the numeric keypad that appears. When all of these data are satisfactory, touch the ENTER box.

17. **Confirmation Screen.** If there is a fault with one of the gages, or a problem with the trigger channel, then a confirmation screen will appear notifying the user of the "problem" and asking whether to continue or return to the transducer screen. If satisfied, press the ACCEPT DATA AND CONTINUE box.

18. **Set-up Screen.** The set-up screen, Figure 3-9, summarizes the information inputs. Review this information to ensure that the information is correct. If any needs correcting,

press the box that contains the incorrect information to return to the corresponding entry screen. Seven boxes are shown on the screen.

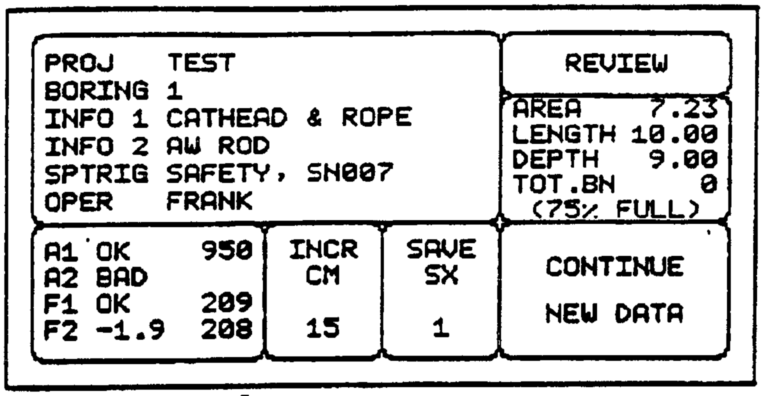

Figure 3-9. Setup Screen.

The **TITLES** box at the upper left part of the screen is self-explanatory. The **SENSORS** box at the lower left show the four sensors (A1, A2, F1, and F2) along with their status (OK, BAD, or value if force offset is more than one volt), and calibration. The **INCR** box at the bottom of the screen is used to specify the increment depth used during testing. Since the SPT blow count is recorded in three 6-inch increments, the INCR may be set to 6 inches so that during testing, when a special button is pressed, the current DEPTH value will be increased by the INCR value. This does not have to be done during testing if a record of the blow count is written down, but may assist in evaluating the results. This value may be reduced if more precision is required. The number in the **SAVE SX** box specifies the frequency of blows to be saved. In low N-value soils the SAVE value should be low (1 or 2). High N-value soil may require a higher value (like 5 or more) since once the 179 blow Analyzer memory is full, the Analyzer must be downloaded and the memory cleared prior to collecting more data. The **REVIEW** box at the upper right allows the user to look at previous data. The **AREA** box displays the area of the rod and the rod lengths and sample depth. Additionally, the current total number of blows and percentage of Analyzer memory used is displayed. If all of this information is satisfactory, press the CONTINUE NEW DATA box to advance to the Collect screen.

3.1.3 Connect the Instrument to the Drill String

19. **Connect the instrument to the drill string.** Once the bore hole has been drilled to the desired depth for sampling and the drillers have lowered the sampler and drill string into

the bore hole, screw the instrumented drill rod to the top of the drill string. Use connectors/ adapters as required when the instrument threads are not the same as the drill rod. In general, use as few connectors as possible. The main cable should be disconnected from the pigtail cable when screwing the rods together. Wrench-tighten these joints. Reattach the main cable to the pigtail cable. Use caution to ensure that the gages are not struck, particularly the accelerometers. The accelerometers have not proven to be durable, particularly when subjected to impacts that are not along their vertical axis. Ensure the cables are not grabbed and damaged by wrenches.

Figure 3-10. Connecting Instrument to Drill String.

20. **Attach the hammer and anvil.** Attach the safety hammer's stem or the automatic hammer's anvil directly to the top of the instrumented rod section. Again, ensure the hammer stem or wrenches do not strike the gages.

3.2 Acquire Data

3.2.1 Record the SPT Energy Data

21. **Collect Screen.** The Collect screen, Figure 3-11, contains both control options (generally in boxes) and information (generally not in boxes). The Analyzer will be at this screen while the SPT is being performed and data are being collected. At this point some of the input data can be reviewed and checked again such as project title information, LENGTH, DEPTH, INCR. These can be changed by pressing their respective box or by pressing the SETUP box to return to the set-up screen. If no changes are needed, the Analyzer is prepared for receiving data.

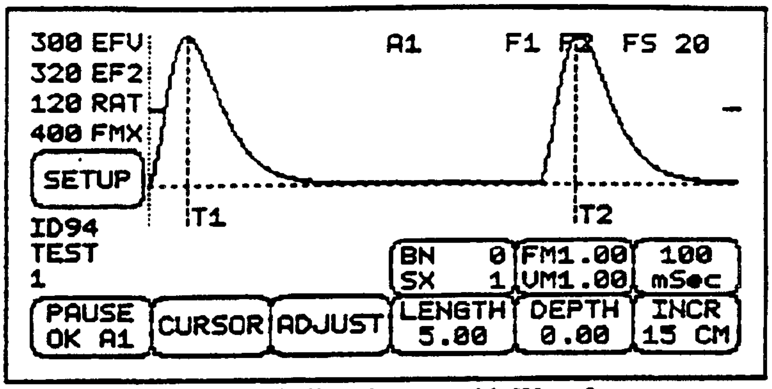

Figure 3-11. Collect Screen with Waveform.

22. **Check Sensors in the PAUSE Box and toggle to ACCEPT.** At this point the Analyzer is showing the Collect screen. Observe the PAUSE box at the bottom left of the screen. The sensor status is displayed below the word PAUSE, alternating through all four sensors. Press this box to toggle the word PAUSE to ACCEPT. When ACCEPT is showing the analyzer is then ready to record signals sent by the sensors. (If a temporary halt during testing is needed, it is a good idea to PAUSE the Analyzer. Otherwise, the Analyzer may record unwanted signals from the sensors as hammer blows, using up its limited memory.)

23. **Direct the drillers to perform the SPT.** During the performance of the test someone should be directed to keep the cables from being damaged or dropping into the drilling mud. Also, someone should observe the approximated hammer drop height.

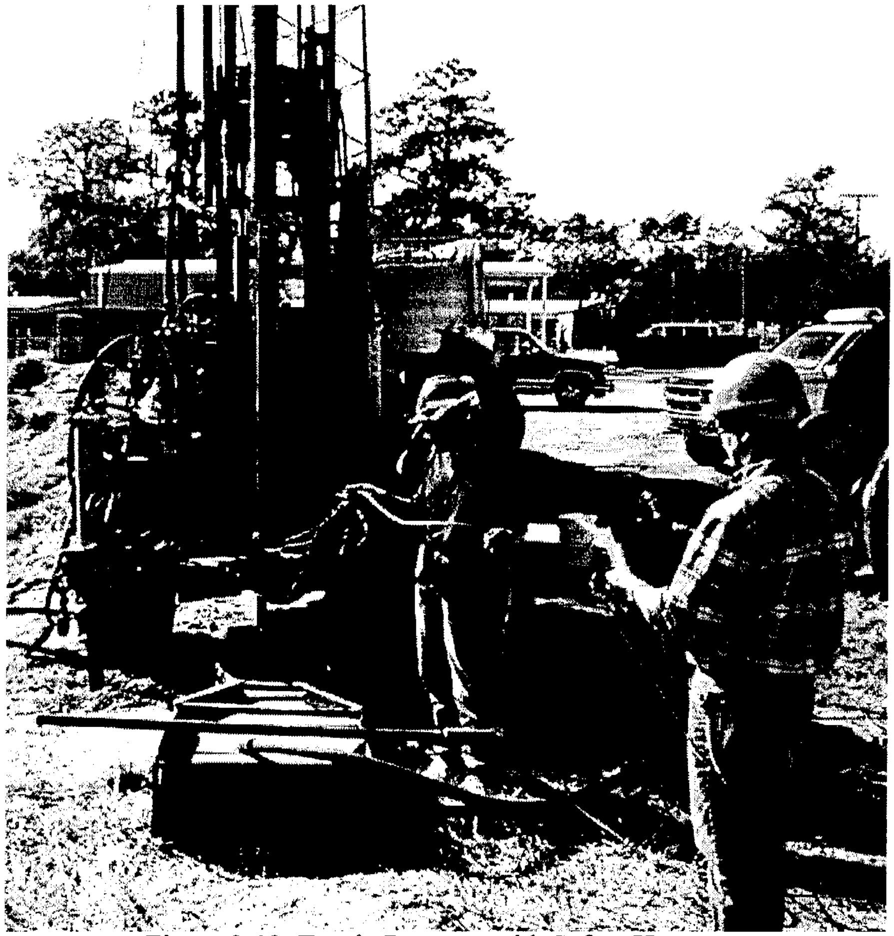

Figure 3-12. Test in Progress with Safety Hammer.

24. **Observe/monitor the incoming data**. Two waveforms, or traces, will show on the Collect screen for each hammer blow: a solid line that shows the force measured in the strain gages, and a dashed line that shows the (velocity) x (rod impedance) which is calculated from accelerometer data. Both traces are based on the data measured in the gages during the hammer impact and are plotted versus time. The time scale may require adjusting to "spread out" or "compress" the view. This is accomplished by pressing the mSec (millisecond) box on the lower portion of the right screen edge and selecting the desired time scale. For short rod lengths, a time scale of 10mSec is useful for viewing the trace of the first compression wave. Longer rod lengths will require a longer time scale. A longer time scale may also be needed to view the full length of the record (100mSec).

Other items to observe and note are the following:

- The hammer impact causes an initial compression wave to travel down the drill string. This is seen on the Analyzer's screen as a sharp rise in the force and velocity trace at the beginning of the record. As the wave travels down the drill rod, the traces show that the force and velocity measured at the top of the rod decrease. A thick bar beneath the waveforms represents the length of the rod. The end of the rod on the display corresponds to the time required for a wave to travel to the tip of the sampler and back up to the gages (time = 2L'/c). After the wave has reflected from the sampler, the wave will likely change form and may become a tension wave where the force becomes negative and the velocity increases.
- The force and velocity traces should be proportional during the initial compression wave (until time 2L'/c). This means they should have a similar maximum peak value at the initial impact and then should generally share the same waveform until after the first compression wave. If the traces are not proportional, then corrective actions may be required – gages may not be connected properly, may be malfunctioning, drill rods may not be securely connected, etc. If one of the gages is not functioning properly, replace it with one that is. **Be sure to change the calibration numbers in the Analyzer**. If a replacement is not available, the malfunctioning gage can be made inactive for display purposes. This may be accomplished while testing is in progress by pressing at the top of the screen where A1 and A2 are displayed. Pressing in this area will toggle the display to use a velocity trace based on A1, A2, No A, or A1 A2 (the average). Toggling through this sequence is a good way to determine which of the two accelerometers is malfunctioning.
- The blow number (BN) will increase with each hammer blow. Also, the ID of the save location of each blow saved (which number out of the 179 blow locations) is displayed just above the project name. In Figure 3-11 the location shown is ID94.
- Four numbers are displayed at the upper left of the screen. These values are calculated from the recorded wave traces. EFV and EF2 represent energy transfer (ft-lbs) by the EFV and EF2 methods and should be on the order of 175 to 315 for a hammer operating at from 50 to 90% efficiency. The RAT value is the ratio of the time to force zero to the calculated 2L'/c. This should be between 0.9 and 1.2 (90 and 120 on the display) for the EF2 calculation to be valid. The FMX box shows the maximum force in the drill rod measured during the blow and will generally not exceed about 27 kips (270 on the display).

25. **Press INCR box each time the sampler advances the designated increment.** This box is located at the bottom right of the Collect screen. For example, if the increment is set to 6 inches, pressing the INCR box each time the spoon penetrates 6 inches will increase the recorded DEPTH by 6 inches. Pressing the remote trigger attached to the Analyzer by cable will do the same as pressing the INCR box. This step is not critical as long as each of the 6-inch blow count increments is recorded on the Form.

26. **Press ACCEPT box to toggle it to PAUSE at end of test.**

27. **Note/Record the appropriate information on the test form.** This includes observed hammer drop, number of wraps of rope around the cathead, rpm of the automatic hammer or cathead, and any other pertinent comments such as poor or good rope throw, rod joint very loose, borehole not vertical/skewed, analyzer stopped recording/memory full after first 30 blows, etc.

28. **Recover the split spoon sample, visually classify the soil, and record this on the form.** If desired, a sample may be collected in an air tight sample jar for later testing.

3.2.2 Prepare for Next Test

After the performance of one test series, several actions may be taken before the next series, to include reviewing existing data and assessing the need to download.

29. **Determine if downloading is required before next test.** Observe the save location of the last blow recorded. This can be seen as the ID number along the left edge of the Collect screen. Consider the likely number of hammer blows to be recorded on the next test, and if there is not enough memory in the Analyzer to accommodate those blows, then download as discussed in Section 3.3. Remember that the Analyzer can store about 179 blows and a selected portion of the memory can not be cleared. The entire memory must be downloaded and cleared before new data may be recorded. The memory status may also be observed by using the "Review screen."

30. **Use the Review screen to observe previously recorded data, if desired.** Reviewing the data, either their waveform or tabular format of quantities may be desired. This may be useful in assessing whether or not the recorded data are reasonable and if any gages are not performing satisfactorily. The Review screen, Figure 3-13, may be reached from the Collect screen by either pressing the SETUP box and then the REVIEW box, or by turning the Analyzer off and then on again to display the Introductory screen and then pressing the REVIEW box.

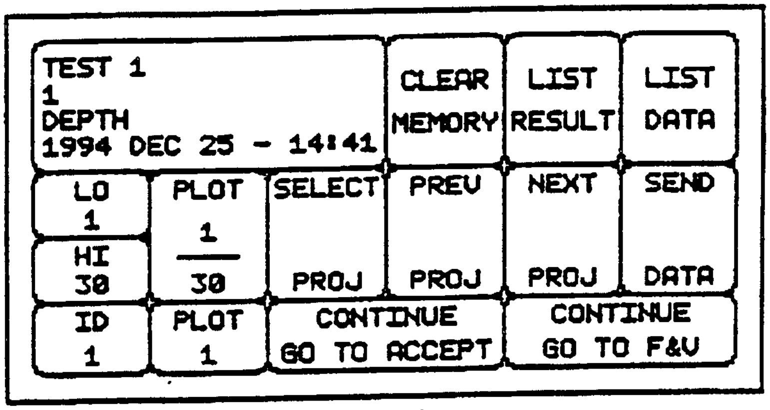

Figure 3-13. Review Screen.

- To review the waveform data press the LIST DATA box to view a listing of the files saved on the Analyzer. On the List data screen, the left column provides command boxes. The middle column shows the save locations for the files described in the adjacent third column. Select the set of data to be reviewed by pressing and highlighting the save location in the middle column. Then press the GO TO DATA box. The first blow of that file is displayed on a screen that is much like the Collect screen. The NEXT ID and PREV ID boxes may be pressed to advance forward and back through the recorded blows. Just as on the Collect screen, the sensors can be made active or inactive by pressing along the top of the screen where "A1 A2 F1 F2" is displayed. The time scale can also be changed. Return to the Review screen by pressing the OUTPUT REVIEW box.
- To review the tabular data press the LIST RESULTS box. A table lists results by blow number with the data file name shown at the bottom of the screen. Pressing the SWITCH RESULTS box will switch the column headings to show additional information. Other boxes along the right of the screen can be used to view results from other borings or projects.

31. **Recheck the gages to ensure that connections are secure and the accelerometer bolts tight.**

32. **Turn the Analyzer off and then back on to begin entering data for the next test.** Follow the same process as previously outlined for inputting data. The information from the last test will still show up in the information fields. These need not be re-entered if they have not changed.

3.3 Download Data to PC

Downloading is required when either the Analyzer's memory is full or when project testing is completed. Once the data are downloaded to the PC, the Analyzer's memory can be cleared to allow more test data to be recorded. Note that it is not possible to clear particular portions of the Analyzer data – the memory can only be cleared in its entirety, so all data must be downloaded prior to clearing.

The SPT-PC program has memory for 3440 hammer blows. The hammer blows are saved at save locations numbered 1 through 3440. When downloading Analyzer data to SPT-PC, caution must be taken to ensure that the Analyzer data do not overwrite needed SPT-PC data. If data from the SPT-PC program have been saved to a file on disk, then it may be okay to overwrite these data. SPT-PC data saved to file remain in the SPT-PC's 3440-blow memory. The data remain there until overwritten.

In general, downloading can be time consuming. Once the preliminary commands have been given and downloading has commenced, each hammer blow requires about 20 seconds to download. An Analyzer with its memory full with 179 blows will require at least one hour to download.

The following steps outline the procedure for downloading the Analyzer data to the SPT-PC program on a PC.

33. **Connect the Analyzer to the PC with the serial port cable, install the key to the PC, and turn on the Analyzer.** The Analyzer can be powered by either the same DC battery cable connection or by the AC power adapter plugged into a standard wall outlet. Insert the SPT-PC key into the PC's parallel port. Figure 3-14 shows a setup using the AC power adapter with the key installed.

34. **Start the computer (PC) and the SPT-PC program.** Start the SPT-PC program by double-clicking either the SPT-PC shortcut on the desktop or the Sptpc.exe file located as follows: C:\SPT\Sptpc.exe. The screen shown in Figure 3-15 (or similar) will appear.

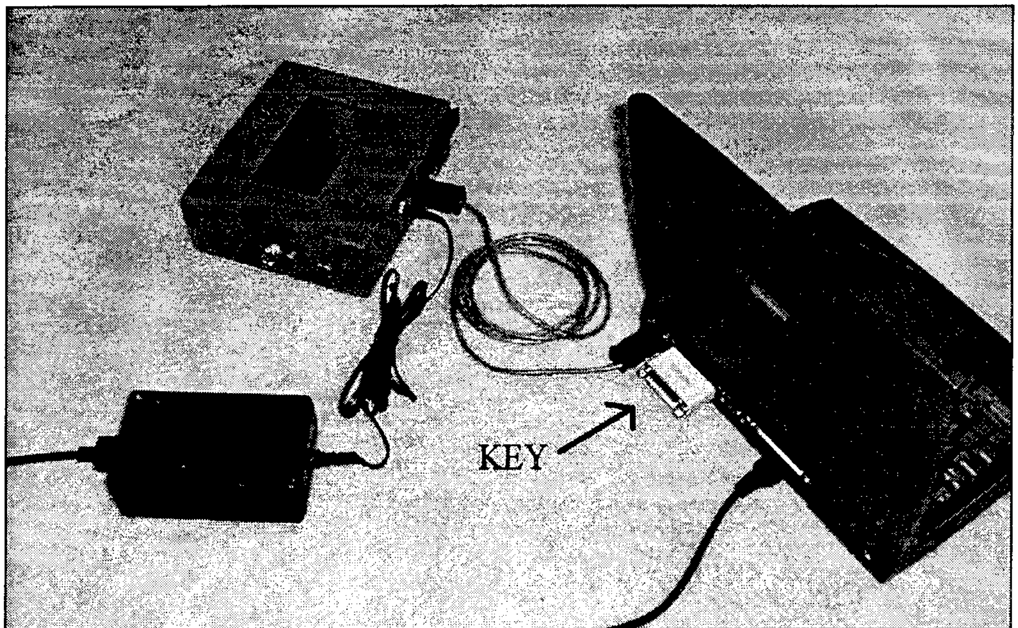

Figure 3-14. PC Connected to Analyzer with Key Installed.

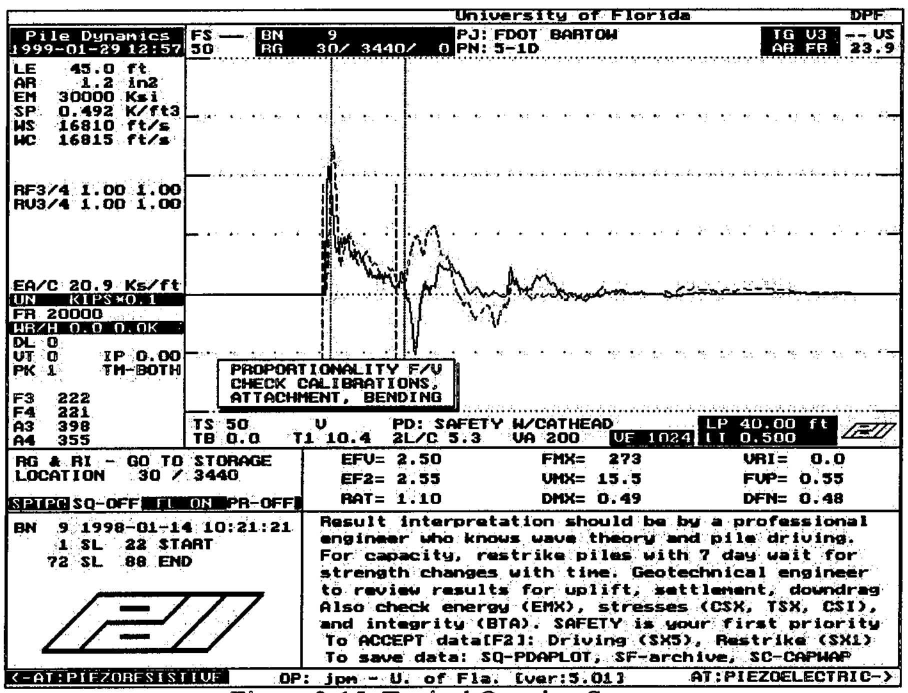

Figure 3-15. Typical Opening Screen.

35. **Determine to which SPT-PC save locations the Analyzer data will be saved.** If this is not already known, then review the SPT-PC table of contents (TC) of save locations (SL) to determine which SLs can be overwritten.

- Typed entries always appear in the box above the PDI logo at the lower left. Errors in typed entries can be corrected using the backspace key or escape key.

- Enter/type the command "TC" and press enter. A Table of Contents box will appear on top of the screen showing the save location (SL#) for the first blow, the number of blows saved (MANY), the blow numbers (BL#), the project name (PJ), the boring number or identification name (PN). Figure 3-16 shows this screen. Use the page down key to view higher SL#s. Reviewing these data should allow the operator to determine what save locations are okay to overwrite. Use the escape key to quit the TC view.

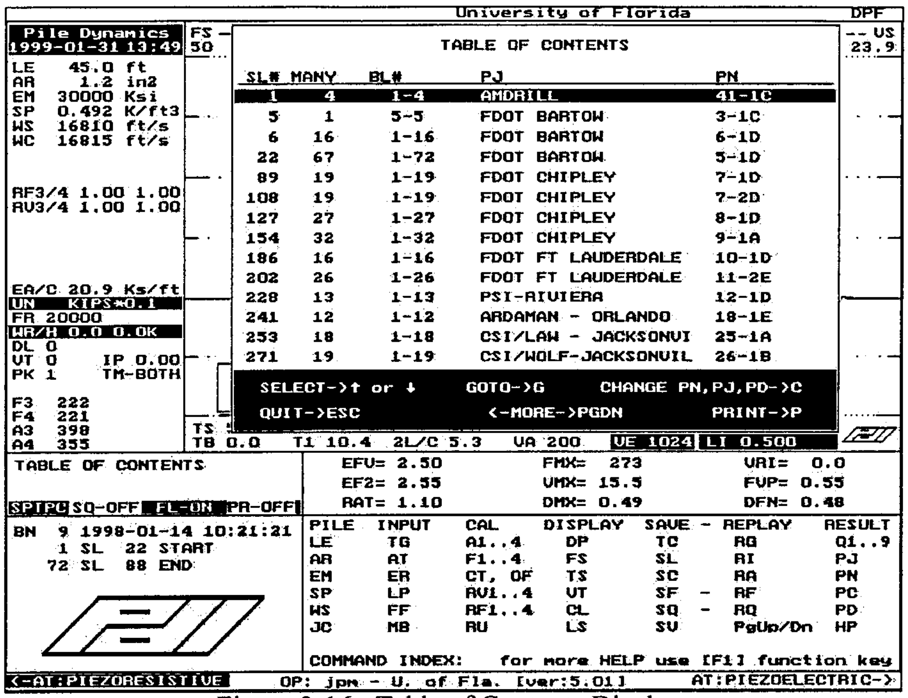

Figure 3-16. Table of Contents Display.

36. **Instruct the Analyzer to send data to the PC**. To do this, press the REVIEW box on the Analyzer's Introduction screen (see Figure 3-4). Then from the Review screen press the SEND DATA box (see Figure 3-13). The Analyzer will then display the screen shown in Figure 3-17.

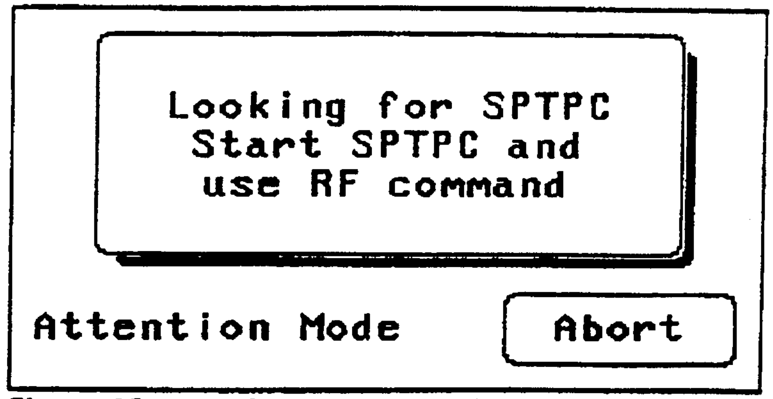

Figure 3-17. Looking for SPTPC Screen.

37. **Instruct the PC to read the Analyzer files**. To do this, start the SPT-PC read file command by typing RF and pressing the enter key. Once this is done, the SPT-PC program begins RECEIVING SPT INFO for each hammer blow as indicated in the entry box and shown in Figure 3-18. After the program has read the basic information, the screen will appear as shown in Figure 3-19 where the files to download and the download location may be specified. The Analyzer screen will appear as shown in Figure 3-20.

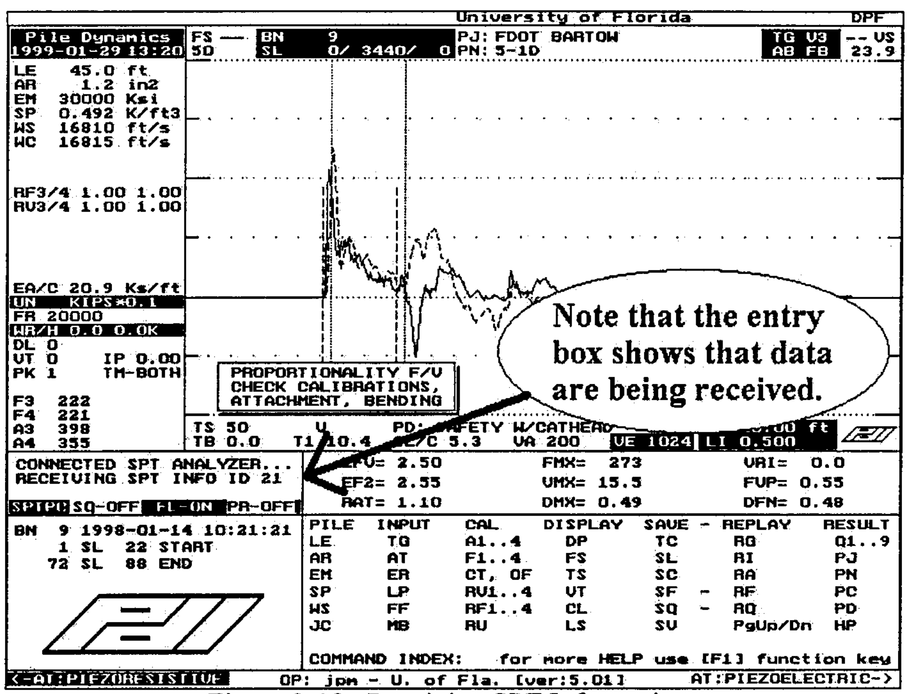

Figure 3-18. Receiving SPT Information.

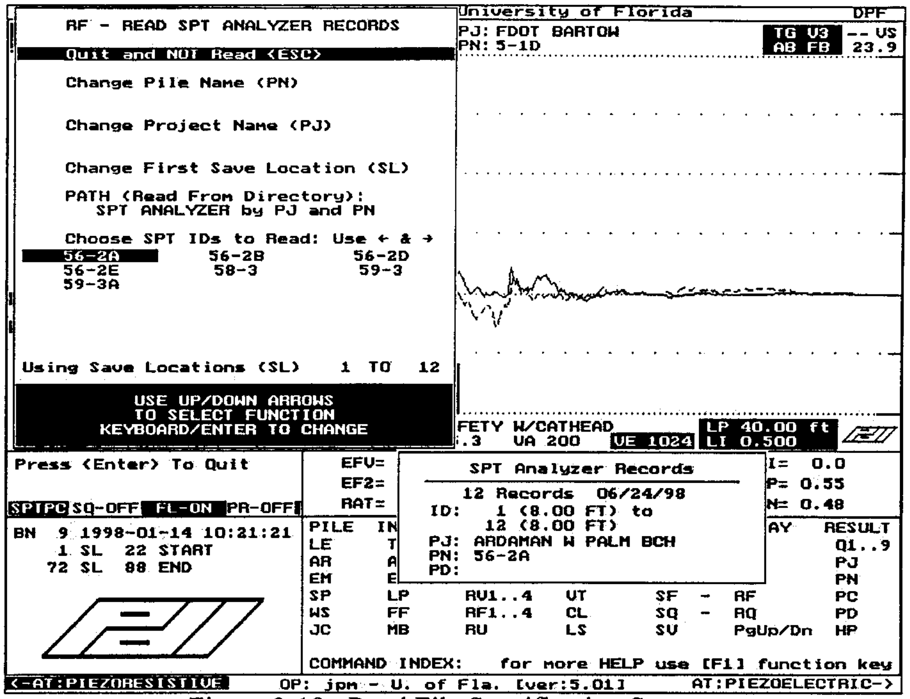

Figure 3-19. Read File Specification Screen.

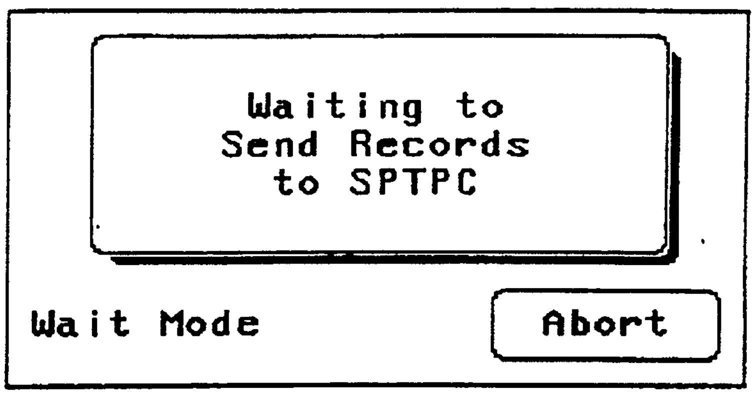

Figure 3-20. Analyzer Waiting to Send Records.

38. **Use the keyboard's left and right arrow keys to select the SPT ID to read**. Figure 3-19 shows there are seven sets of data that are on the Analyzer and may be read. ID 56-2A is currently selected (highlighted). Note that the details on the selected data set are shown in the box near the lower right. This box shows the number of records, date, hammer blow ID numbers, PJ, PN and PD. Once the desired SPT ID (or file) has been selected (highlighted), then proceed.

39. **Confirm or modify the specified "Using Save Locations (SL)"**. The locations to which the blow will be saved are shown. There are 3440 save locations in the SPT-PC program and the contents of these can be viewed as previously discussed using the TC (Table of Contents) command. To specify a save location to which it is okay to write the

data, use the up and down arrow keys to highlight "Change First Save Location (SL)." Once this is highlighted, type the first save location number desired and entered. The "Using Save Locations" entry will change to reflect the entry.

40. **Execute the command to read file by highlighting and selecting the "RF-Read SPT Analyzer Records" option.** Once this is done, the analyzer commences downloading the specified data to the PC. The Analyzer will display the progress as shown on Figure 3-21. Similarly, SPT-PC will show the progress on its screen. Once completed, the Analyzer's screen will return to the Review screen (Figure 3-13).

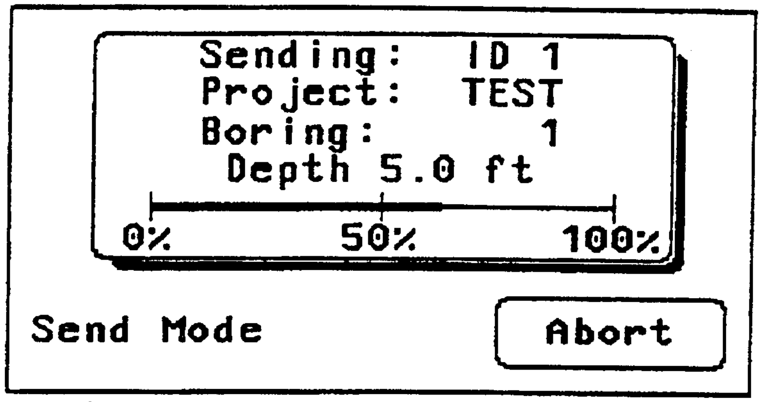

Figure 3-21. Screen while Analyzer is Sending Data.

If the PC's screen goes into the screen saver mode while the data are downloading, do not press any keys to restore the screen until all data have been downloaded. Doing so may halt the downloading process. Again, the end of downloading can be noted when the Analyzer screen reverts to the Review screen.

41. **To download additional data sets, go back and repeat the steps beginning at step 35.** Note that once the next data set is identified, the default SPT-PC save locations will be immediately after the previously saved data.

42. **If all data have been downloaded, the Analyzer's memory may be cleared.** This is done from the Review screen by pressing the CLEAR MEMORY box. Once pressed a confirmation screen will appear as shown in Figure 3-22. Press the CONFIRM box to delete all data (specific parts of the data cannot be deleted). Now, the Analyzer may be used to recover new data.

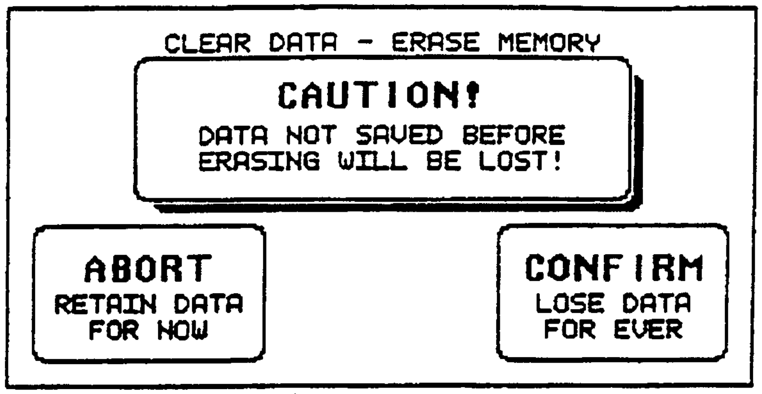

Figure 3-22. Confirmation Screen for Clearing Memory.

4 TIPS / TROUBLESHOOTING

The following comments provide a few tips and troubleshooting suggestions.

A suggested numbering system is as follows: each system (Rig-Hammer-Driller combination) should have a unique "SPT System ID #" that will be used to identify all testing performed with that system. This may facilitate compilation and evaluation of data in the future.

The Analyzer does not sense the hammer blows and does not record the blow data on occasion. The collect screen does not show any activity. If this happens, and the analyzer does not begin recording after a few blows. Stop the SPT. PAUSE the Analyzer. Check cables connections. Consider changing the trigger sensor to another channel (F1 or F2 preferably, else A1 or A2). Press PAUSE to toggle the Analyzer back to ACCEPT and resume the SPT. Sometimes simply toggling the Analyzer from ACCEPT to PAUSE and back to ACCEPT will get the Analyzer to begin triggering.

Additional suggested equipment to have on hand includes the following: wrenches for accelerometer bolts; extra bolts and washers for bolting accelerometers to the rod; pipe wrenches for affixing instrument and connectors to the drill string; paint, marker, or wax crayon for marking hammer stem; and connectors for connecting the AW and NW instrumented rods to the possible J threads or to N3 rod.

The hammer blow rate can be determined from the data recorded on the Analyzer so timing the hammer blow series is not necessary.

The SPT-PC program will not run if the key is not installed (attached) to the PC's parallel port.

The SPT-PC program may be installed on another PC using the Pile Dynamics, Inc. update disk. Execute the "install.bat" file.

The SPT-PC program should work when executed from Windows. If problems arise, however, exit Windows and execute the program from the DOS prompt as "C:\spt\sptpc.exe".

Keep the Analyzer from being exposed to direct hot sunlight for extended periods. This may affect the LCD display. When not in use and in between SPT samples, place the Analyzer in the shade or cover it with a towel.

Take care of the Analyzer's touch screen. The touch screen need not be pressed hard. Pressing hard will not help since the screen's touch mechanism is located in the soft membrane on the top. If initially pressing the desired box does not work, press again. Often the the corners of the box areas are most sensitive. Also do not use sharp or abrasive objects such as pens, keys, erasers, or dirty fingers. If the screen is punctured it will not work.

Take care of the accelerometers. Although they are designed to take a strong impact in the direction of their vertical axis, they are sensitive to blows in other directions. Also, during hot weather testing, it is suggested to keep the gages from overheating in the sun.

Take care of the instrumented rods. Take care not to grab the glued-on strain gages or the cables with wrenches. Also inspect the cables near their juncture with the "goop" (the glue which affixes the gages to the rods). The top cable (the one closest to the hammer) often tends to pull away from the goop and become damaged. The use of a band with padding or strong tape may be useful in keeping the cable from pulling away from the goop.

APPENDIX A

PDI's *SPT Analyzer Users Manual, September 1995*

S P T

SPT Analyzer

SPT Users Manual

September 1995

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List of Figures

The SPT ANALYZER
by Pile Dynamics, Inc.

1 Introduction

The Standard Penetration Test (SPT) is a widely used soil exploration method, generally performed according to ASTM D1586. The procedure includes obtaining the N-value, which is a relative indicator of soil strength, and retrieving a sample of the disturbed soil for classification purposes.

SPT results are commonly used for pile foundation design and many other geotechnical evaluations. The completeness and reliability of the SPT data are very important to the engineer's design. With low confidence the design must be very conservative with high safety factors to reduce risk and uncertainty. With better data and greater confidence, the design can have lower safety factors, and thus be more economical, while having similar or less risk. Thus, the design engineer should strive to obtain quality soil explorations.

SPT sampling involves driving a split barrel sampler on the bottom of a drill string to recover disturbed soil samples. The sampler is driven into the soil by a standard 64-kg (140-pound) SPT hammer falling a distance of 760 mm (30 inches). It is advanced in three 150-mm (6-inch) increments to a total depth of 450 mm (18 inches); the number of blows required to advance the sampler is observed for each of the three increments. The N-value is the sum of the numbers of blows required to advance the sampler through the second and third increments. The N-value provides an indication of soil density or consistency and shear strength. Unfortunately, the N-value is also affected by the variability of the actual impact energy transmitted from the hammer through the drill string and sampler.

ASTM D1586 allows a diversity of equipment. It has been clearly demonstrated that the type and operational characteristics of the SPT hammer can have a significant influence on the resulting SPT N-value; Finno (1989) demonstrated in a uniform sand deposit that the N-values from one SPT hammer type were about 2 to 3 times higher than those of a second SPT hammer of different type. It should be apparent that any design based on empirical use of N-values will be better if the SPT hammer performance can be properly evaluated. Because of the known wide variability of performance in SPT hammers, a separate specification for measuring energy in the SPT was developed (ASTM D4633).

Similar to pile driving, the SPT installation procedure is governed by stress wave propagation. One dimensional wave mechanics can be used to analyze these measurements and evaluate energy transfer. The energy transmitted can be determined from the work done from the expression

$$E(t) = \int F du = \int F V dt \doteq EFV \tag{1}$$

which is called EFV, and implies that both force F and velocity V measurements are available. This expression is theoretically exact (needs no corrections as imposed by ASTM

D4633), and applies to any drill rod even with loose connectors and even to rods of non uniform cross section. It only requires accurate measurement of force and velocity. Force is best measured by gluing strain gages to the drill rod. Velocity can be measured by integrating acceleration. At the time ASTM D4633 was developed, the measurement of acceleration for steel to steel impacts in the SPT did not produce satisfactory results. As a result, researchers took advantage of wave propagation theory for waves travelling in one (downward) direction

$$V(t) = \frac{F(t)}{(\frac{EA}{c})} \quad (2)$$

where E is the elastic modulus, A the cross sectional area, and c the speed of wave propagation in the drill rod. Substituting Equation (2) into Equation (1) leads to

$$E(t) = \frac{c}{EA}\int F^2 dt = EF2 \quad (3)$$

where this energy is called EF2. ASTM D4633 uses EF2, and several correction factors and conditions, to evaluate energy transfer. This equation holds only in the absence of upward travelling waves and thus for completely uniform rods since non-uniformities cause reflections and upward travelling waves. Unfortunately, the drill rod is not uniform as different cross sections can be connected together using subs, rod tolerances only assure area within 20 percent and different wear on different sections further compounds this variability, and joints are clearly a violation and are particularly distressing when loose, as they frequently are.

Current technology has recently developed accelerometers which can handle the steel to steel impact and velocity measurements can now be reliably made. Thus, both the EFV and ASTM D4633 EF2 can be calculated. A task group reviewing the ASTM D1586 specification has suggested that the N-value be modified to a standard N_{60} using the following equation

$$N_{60}E_{60} = N_{field}E_{measured} \quad (4)$$

where E_{60} is 60 percent of the theoretical potential energy (.476 kJ, 350 ft-pounds) or .285 kJ (210 ft-pounds), N_{field} is the field observed N-value, and $E_{measured}$ is the measured energy. The 60 percent energy transfer value was selected as the historical average that many empirical relations have been based upon. This approach seems justified and should lead to more uniform results delivered by the various SPT hammer manufacturers and SPT hammer types (donut or safety hammers using cathead and rope or various automatic trip hammers). The diameter of the cathead and number of turns affect the transfer efficiency as they affect the friction on the lift/drop system. Even donut or safety hammers, which are otherwise identical, can have different efficiency due to the skill of the operator using a cathead and rope system. Different automatic trip hammers have different impact velocities due to the differences in the lifting and dropping mechanisms. The SPT ANALYZER can measure the energy (EFV and/or EF2) and thus rate any SPT hammer, allowing the design engineer to compute the N_{60} value from the observed field N-value.

REFERENCES.

ASTM Standard D1586, "Standard Method for Penetration Test and Split-Barrel Sampling of Soils"

ASTM Standard D4633, "Standard Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems"

Finno R.J. 1989. Subsurface Conditions and Pile Installation Data, Predicted and Observed Behavior of Piles. Results of a Pile Prediction Symposium, ASCE Geotechnical Special Publication No. 23. R.J. Finno, Editor. 1-74.

Abou-matar, Hasan, and Goble, G.G., 1994, "Measurements on the Standard Penetration Test" ASCE Geotechnical Journal.

2 The SPT ANALYZER, Hardware Description

Pile Dynamics Inc. has used its vast experience in adapting modern electronics to the measurements of pile driving and dynamic testing to develop a simple system which can be applied to the SPT. Sensor systems to measure both force and velocity are now available. The specially instrumented rod section is inserted into the drill string during SPT hammer operation. A short cable connects the instrumented rod with the main SPT ANALYZER signal conditioning and processing unit. The signal conditioning has been miniaturized and combined with special purpose A/D convertors and microprocessors into the dedicated SPT ANALYZER (which is the size of PDI's P.I.T. Collector: 65 × 150 × 200 mm, 2.5 × 6 × 8 inches). The SPT ANALYZER is powered by 12-volt DC, either from a vehicle battery or from a power supply connected to 120/240-V AC mains.

SPT ANALYZER data entry uses the convenient and proven easy to use touch-screen (like the P.I.T. Collector). Entries for rod area and length, for documenting project/boring descriptions and names, for user comments, and data control and review are all through several programmed menus for the LCD touch-screen. The SPT ANALYZER control unit features a graphic LCD screen for data and result display. The quality of measurement is continuously displayed during data collection. Results of full force and velocity versus time measurements for a user selected blow frequency are retained in memory. Data for any blow can be plotted on HP plotters or serial laser printers for inclusion in a report. The energy results for every blow are also stored in memory.

Both raw data and results can be downloaded to a PC for further evaluation and report preparation. A PC program called SPTPC accepts data and stores results in a format like that used by the Pile Driving Analyzer® (PDA). The SPTPC program has the look and feel of the PDA (or PDA-PC program). Output results are in an ASCII format and can be conveniently printed, plotted, and summarized by the PDAPLOT program.

Features of SPT ANALYZER

Very compact with no moving parts for harsh field conditions.

Touch-screen with high resolution intelligent graphics and very user friendly menu environment simplifies data collection.

Measures both force and velocity on an instrumented SPT rod section. Selected records are stored in memory for later inspection and analysis with the SPTPC software.

Calculates transferred energy from both EFV and ASTM D4633 EF2 methods. Results, including time ratio and maximum force, for every blow stored in memory for later automatic processing of results with the PDAPLOT software.

SPT ANALYZER delivered in transit case. One year warranty.

Lightweight (1.6 kg or 4 lb.), small size (65 x 150 x 200 mm; 2.5 x 6 x 8 inches), wide operating temperature range (0°C to 40°C).

Operates on 12 volt DC car battery (jumper cable included) with low power consumption, or on standard AC line power.

3 SPT Rods

The SPT ANALYZER can be used to evaluate many different rod sizes. As explained in the INTRODUCTION (§1), the rod should ideally be uniform. In practice it is seldom truly uniform, although the non-uniformity may be small when the rod string is all of the same nominal size (e.g. AW) and the joints are securely tightened. Uniformity for measurement purposes is achieved when the instrumented section is nominally of the same type and dimension as all rod sections below it. There may be a difference in cross sectional area between the instrumented rod and the hammer/anvil section. The anvil is often solid while the rod is usually hollow. Any non-uniformity will reduce the actual energy transfer past the instrumented rod due to reflections at the non-uniformity. In some cases, rods of different types (e.g. AW and NW) may be connected into a single string using subs; this should be avoided whenever possible as the theory is then grossly violated, particularly for the EF2 result. The user may send any rod size or rod length to PDI to be instrumented.

4 Sensors

4.1 Strain

The SPT ANALYZER requires measurement of strain, which is converted to force using the cross sectional area and elastic modulus of the SPT rod. The force is required for the calculation of energy. It is sufficient for the calculation of EF2. Foil strain gages (350 ohm) will be glued directly onto the rod in a full Wheatstone bridge arrangement. They many be attached to measure axial response (normal recommendation) or torsional response for special application. PDI recommends using a 2 ft (0.6 m) section and that two strain gage bridges be applied. Each strain bridge is terminated in a short cable with quick disconnect plug.

4.2 Accelerometers

The SPT ANALYZER also has the capability of measuring acceleration which is then immediately integrated into velocity. Both force and velocity are required for the calculation of EFV. All PDI accelerometers are mounted on a rigid aluminum block and are terminated in a short cable with a quick disconnect plug. Accelerometers mounted on plastic blocks do not have sufficient frequency response and should never be used. The aluminum block is bolted to the instrumented rod section, with the cable oriented axially with the rod in the down position.

The type of accelerometer can be either piezoresistive (PR) or shear piezoelectric (PE) only, and the type selected and used must match the type needed for the SPT ANALYZER. The SPT ANALYZER can be made or ordered for either type accelerometer, although piezoresistive is currently preferred.

4.3 Connection of Sensors to SPT ANALYZER

All sensors (strain gages and optionally also accelerometers) are connected by the quick connector plugs to a short connection cable which accepts up to four individual sensors and combines them into a single main cable, much the same as in the normal PDA operation. The main cable is then connected to the SPT ANALYZER.

The accelerometers should first be attached to the SPT rod, and all accelerometers and strain bridges should be connected to the connection cables. Next the SPT instrumented rod should be placed at the top of the drill string at the appropriate time when measurements are desired. Finally the main cable should be attached to the connection cable; this connection at the last minute prevents the cables from becoming tangles as the rod is spun and joints tightened. After the test, the main cable is disconnected at the connection cable prior to removal of the instrumented section, another non-instrumented section is inserted as the soil boring investigation advances to the next depth, and the instrumented section is attached again and cable connected. This procedure is repeated until the hole is completed and testing concluded.

The SPT ANALYZER is capable of sensing the status of each sensor (see §5.6, Figure 1.1). The user must assure that all sensors are functional and that the data acquired are of good quality. Good quality data are generally:

a) consistent: the data from sequential blows are similar

b) proportional: the initial peaks of force and velocity (times pile impedance E×A/c) should have similar magnitudes for a uniform rod.

c) reasonable: results (stresses and energy) should be reasonable.

If data quality is not satisfactory, user should change sensors, or cables, until good quality is achieved. If data are of suspect quality, then results are also suspect.

5 Operation of SPT ANALYZER—Data Acquisition

5.1 Power

Connect the SPT ANALYZER to a 12-volt power source. In the field this will be a 12 volt DC battery or vehicle electrical system. Use the power connector supplied with the SPT ANALYZER; make sure that the polarity of the power connection is properly observed (red to positive; black to negative).

At the desk-top, power is provided by the 12 volt DC power supply, which in turn is powered by 110-220 volt 50-60 Hz AC. The power supply is not for use outdoors or in construction environments. AC power is hazardous. Pile Dynamics, Inc. is not responsible for misfortunes involving improper use of this equipment.

When proper power is supplied the red LED on the SPT ANALYZER glows brightly, and the power switch may be turned on.

5.2 Start-up Screen

After turning on the power, the SPT ANALYZER will first display the screen depicted in Figure 1. This start-up screen has information and some options.

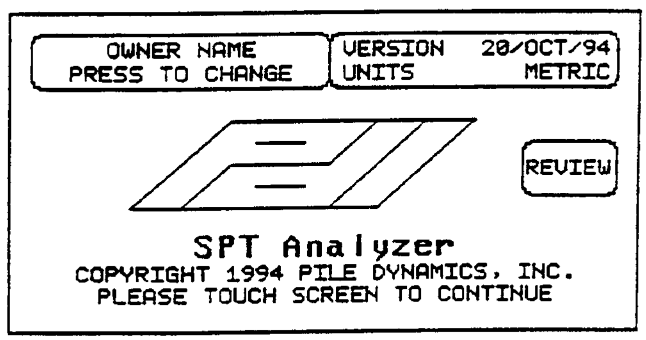


Figure 1 Introductory screen

a) In the box in the upper left corner of the display, the current owner name is shown. If changes to this name are desired, press anywhere in the box. A data entry facility, described further in §5.4, appears to let the user type a new owner name.

b) In the upper right corner, the version number of the current software (stored on EPROM) is displayed. Metric or English (U.S. Customary) units of measurement may be selected by pressing anywhere in this box. The selected system of measurement will be used throughout subsequent operation and thus is very important; select the correct units before proceeding.

c) In the center right is a REVIEW key, for reprocessing data already in memory. See §5.9.

d) The remaining portion of the screen contains the PDI logo and copyright notice. To proceed to data collection, press anywhere in this area. Unlike the REVIEW response, a short series of screens will appear and lead the user through required data entries.

5.3 Date and Time

The SPT ANALYZER contains a digital clock, used for marking records and plots with the current time and date. The screen in Figure 2 is used to set the time and date, and is accessible at various times during operation. Occasionally this screen is displayed at start-up, meaning that the clock contained an illogical value and the user must provide the correct date and time before proceeding. There are five boxes for making individual corrections to the YEAR, MONTH, DAY, HOUR, and MINUTE. Each box works similarly. By pressing the right half of the box (+), the current value is increased, while pressing the left half of the box (-) decreases the value. To retain the current value, press the lower left box. To use the new modified value, press the lower right box.

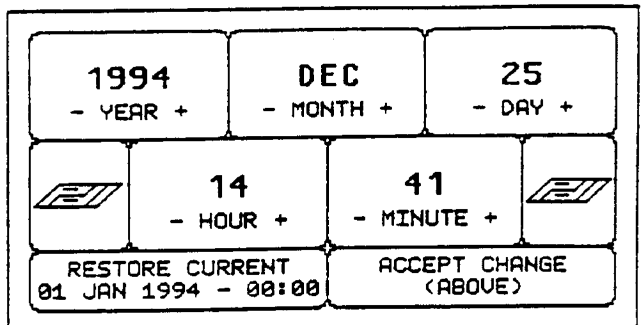


Figure 2 Screen for setting date and time

5.4 Project Description

The first screen is shown in Figure 3. Several descriptive labels can be attached to the data and will be used for data identification. These include:

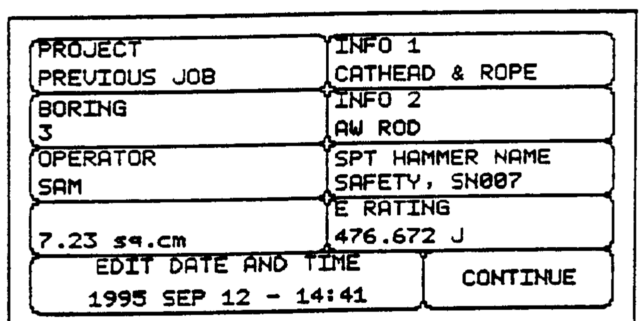


Figure 3 Project description screen

a) **PROJECT** - generally overall site identifier

b) **BORING** - the specific location/hole identifier

c) **OPERATOR** - the name of the person using the equipment or rig supervisor

d) **INFO 1** - additional information of user's choice

e) **INFO 2** - additional information of user's choice

f) **SPT HAMMER NAME** - description of hammer, serial number, rig type, etc.

In general, the previous labels (if any) will be the defaults first displayed. Each label can be modified by pressing anywhere inside the box in which it is displayed.

The screen will change to a 5 x 6 array (Figure 4) containing 26 letters (English alphabet), plus one key each for 1) space, 2) backspace (←) for corrections, 3) 0-9 for switching to numbers and punctuation (Figure 5), and 4) ENTER (finish typing and accept new label). Each key press will result in an addition to the new label displayed between the first and second rows. Each label can contain a maximum of 19 characters. When acceptable, press ENTER. If any label has been changed, then it will be highlighted (reverse color). The **BORING** label in particular will probably change every time, but many of the other labels may be the same and need not be changed.

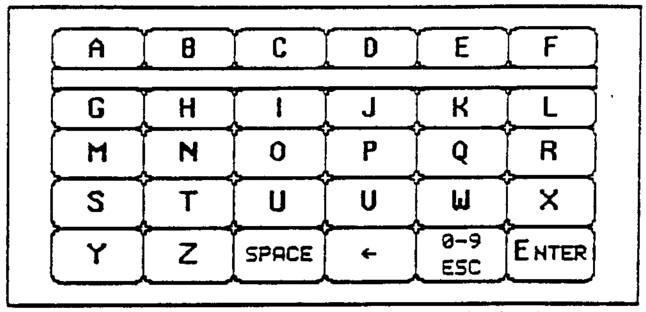


Figure 4 Screen for entering alphabetic characters

The **AREA** and **E RATING** keys are used for entering the cross sectional area (cm² or in²) and Energy Rating (e.g. .476 kN-m or 350 lb-ft) respectively. The drill rod is assumed to be steel, with an assumed density of 78.5 kN/m³ (.492 k/ft³), an assumed modulus of elasticity of 210,000 MPa (30,000 ksi), and an assumed wave speed of 5,120 m/sec (16,810 ft/sec).

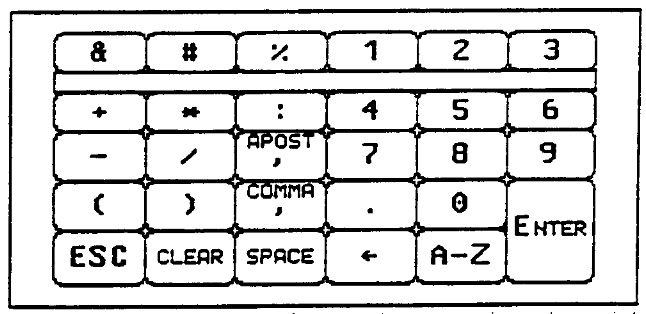


Figure 5 Screen for entering numeric and special characters

It is very important to enter the proper cross sectional **AREA.** If this key is pressed, four choices are given as shown in Figure 6 (AREA corresponding to AW rods, to NW rods, enter a different value on a numeric keypad, or retain the current value). Press the appropriate choice.

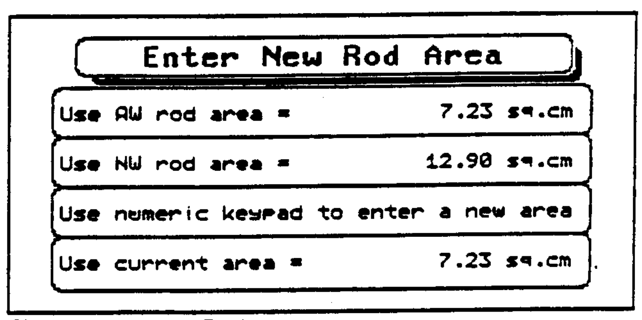


Figure 6 Rod area

The last entry possibility from this screen is for the date and time, which are described separately in §5.3.

When all is completed, press CONTINUE. See §5.5.

5.5 Confirmation Screens

After leaving the PROJECT DESCRIPTION screen (Figure 3), if all entries have not been changed or reviewed, the user is asked in Figure 7 whether to go back and make more changes or to continue and use present values. Press lower left box to return, or the lower right box to continue.

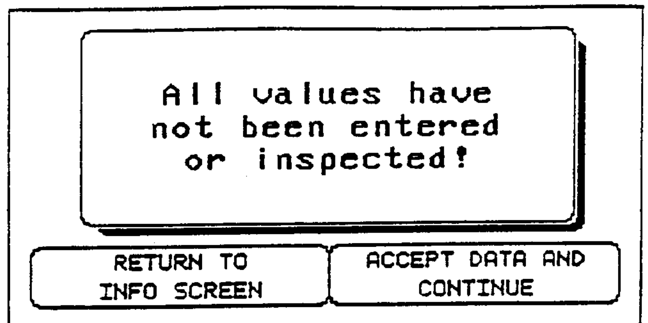


Figure 7 Some entries have not been reviewed

The second request is to enter the **rod length** in a screen shown as Figure 8. The length requested is the length from the sensors to the toe of the drill rod string.

This keypad is a standard way to enter all numerical values. The variable name (ROD LENGTH), current value (12.5), and unit of measurement (Meters) are shown in the upper right for user reference. As the new numerical value is entered, it is displayed in the lower left window. Corrections can be made using the backspace key (←). Where negative values are allowed, a minus (-) replaces the backspace when applicable. Decimal points can be entered. When the correct length is displayed in the entry window at the lower left, press ENTER to continue.

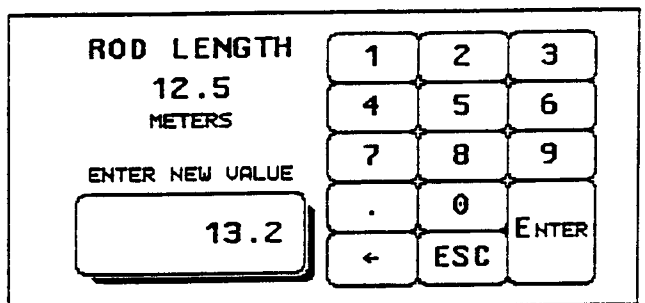


Figure 8 Numeric keypad: rod length

Numbers less than 1.0 are not accepted for rod length.

The next request is to enter the **depth** using the numeric keypad (Figure 9). The depth requested is the length from the reference to the toe of the drill rod string. The depth is usually slightly less than the rod length (typically 1.5 ft or .45 meters less).

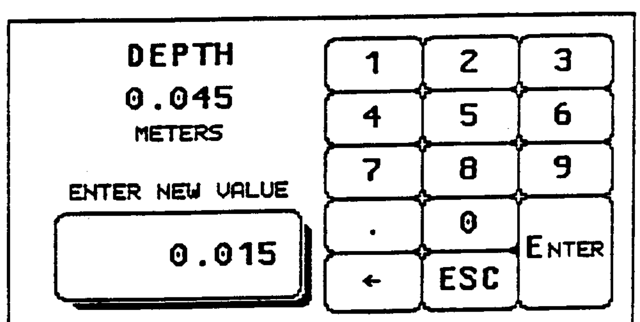


Figure 9 Numeric keypad: depth

5.6 Sensor Selection and Calibration

Figure 10 demonstrates the selection / calibration screen when no sensors are attached. The screen is a matrix in which the left column and the top row are labels. The left-most column, headed TRANS, contains the labels designating the four sensors: A1 and A2 are for the two accelerometers; F1 and F2 are for the two force-sensing strain gages. The top row contains four other labels, TEST, ACTIVE, TRIG and CALIB, designating sensor parameters as described below.

TRANS	TEST	ACTIVE	TRIG	CALIB	TEL 216/ 831- 6131 FAX 831- 0916
A1	FAULT	YES	NO	950	
A2	FAULT	YES	NO	930	
F1	FAULT	YES	NO	209	ENTER
F2	FAULT	YES	NO	209	

Figure 10 Transducer status screen, no transducers attached

TEST The SPT ANALYZER automatically checks the status of all four sensors. If no sensor is connected, or the sensor is out of specification tolerance and is not likely to work, the status will be listed as **FAULT**. If a sensor is detected which is within tolerance and is therefore likely to work, the status is listed as **OK**. The accelerometers are listed as only OK, while the strain gages list OK and a number (which is the offset voltage; values within plus or minus 4 volts should give acceptable data). These are information only and pressing the key will not cause any action to be taken.

ACTIVE
This function selects which sensors' signals will be used to obtain results. While the SPT ANALYZER records all four sensors independently and keeps the individual records separate in memory, the main computation and data display uses a single velocity and a single force. The single records may be one individual accelerometer (or force) or the average of two accelerometers (or forces), depending upon this selection. If **YES** is selected, that particular sensor will be used. If **NO** is selected then that particular sensor will not be used. Pressing any key in this column will change a YES to a NO, or a NO to a YES. The user should select NO for all sensors with FAULT status. Later, during reprocessing, different signals can be selected if corresponding sensors were active during data collection.

TRIG This function selects which sensor will be the primary device used to detect data. Only one sensor will be labeled YES while all others will be labeled NO. Pressing any key in this column will change that key to a YES and all others to a NO. It is suggested that either of the force sensors (F1 or F2) be used as the trigger sensor.

CALIB
This function sets the calibration sensitivity of the individual sensors. Each sensor is supplied with a PDI calibration. Pressing the key in this column for each sensor allows the used to enter this calibration value with the numerical keypad.

In Figure 10, all sensors have the same status (FAULT) under the TEST column because no sensors are connected. In practice, sensors will be connected as described in §4.3. If the

TEST column shows FAULT, something is wrong with the respective sensor or cable attachment. Check connections and replace sensors or cables until the TEST status changes.

If sensors and cables have been properly attached, then the selection calibration screen should look more like Figure 11. In this case, three sensors are detected and active. A2 is a FAULT and ACTIVE is therefore set by the user to NO. F1 is the selected trigger sensor, and calibrations have been entered for each sensor.

TRANS	TEST	ACTIVE	TRIG	CALIB	TEL 216/ 831-6131 FAX 831-0916
A1	OK	YES	NO	950	
A2	FAULT	NO	NO	930	
F1	OK 0.2	YES	YES	209	ENTER
F2	OK -1.9	YES	NO	208	

Figure 11 Transducer status screen, transducers attached

Pressing the large box, with the PDI logo and telephone numbers, gives the user more contact information and another opportunity (Figure 12) to change the owner name.

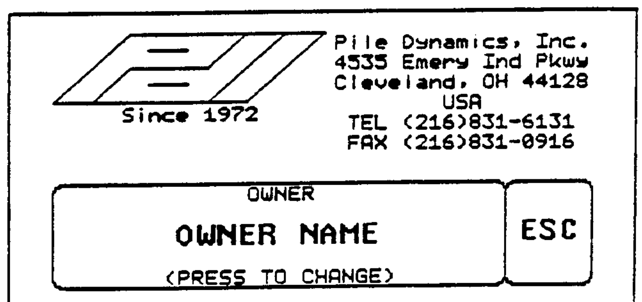


Figure 12 Pile Dynamics logo and contact information

When all sensors have been tested by the ANALYZER and determined to be satisfactory, and active, trigger, and calibrations have been reviewed/changed as appropriate, press ENTER to continue.

If a problem is detected with the trigger channel (bad sensor, no sensor connection to ANALYZER, or trigger channel not ACTIVE), then a warning message is given suggesting the user return to the selection / calibration screen.

5.7 Setup

The next screen is a review of all previous data entries (see Figure 13). Each entry should be reviewed. If changes are necessary with any entry, press the block that contains the incorrect entry and the ANALYZER will return to the appropriate entry screen described above.

TITLES Project descriptions are shown in the upper left box (see §5.4 for instructions on changing). If a change is requested, then a temporary caution screen is shown suggesting that the PROJECT label be the first label that is changed.

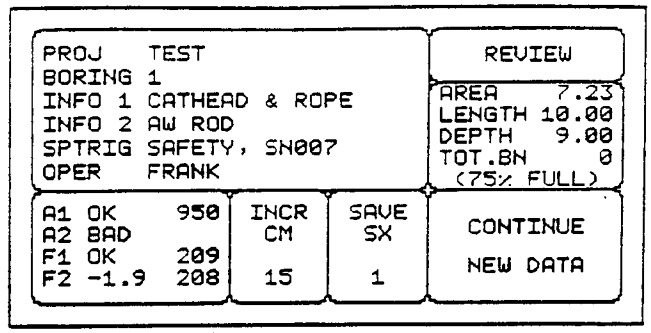


Figure 13 Set-up screen

SENSORS In the lower left box, the four sensor possibilities (A1, A2, F1, F2) are shown along with their status (OK, BAD, or value if force offset is more than one volt), and calibration input. The channel selected as the trigger sensor is highlighted.

AREA.. Rod descriptions of AREA, LENGTH, and DEPTH are displayed in the right center box. If change is requested, a series of three screens (see §5.4 for AREA, or §5.5 for ROD LENGTH and DEPTH) requiring entry for each (or ENTER for no change) are given. Additional information of current total number of blows (TOT.BN) and memory allocation (percent of memory full) are shown for user reference.

INCR In §1, the SPT operation was described. The blow count is normally taken in three increments of 150 mm (15 cm, 6 inches) and the N-value is the sum of the values for the last two increments. Thus, normally the value for INCR will be set to 15 cm (or 6 inches), but INCR may be changed (key on bottom row) if more precision is required. The INCR value will be added to the current DEPTH value every time a special key is pressed during data collection under actual SPT sampling.

SAVE This variable (key on bottom row) selects the frequency of blows to be saved in memory. The memory will hold about 175 blows. In low N-value soils, the SAVE value should be a low number (like 1 or 2), while in high N-value soils, a higher value (like 5 or 10) may be more suitable since once the 175 blow storage is full, the ANALYZER data must be downloaded and the memory then cleared prior to collecting more data.

Signals are collected through a 12-bit analog-to-digital converter. Sampling frequency is 20,000 Hz. Each record has four separate signals (A1, A2, F1, F2) each with 2048 samples each. The total time for each signal collected is therefore 102.4 msec.

REVIEW Pressing this key (upper right corner) will allow the user to look at previous data or collect new data. See full description in §5.9.

CONTINUE Pressing this key (lower right corner) will continue to new data collection as described in §5.8.

5.8 Data Collection

After selecting to collect new data, the screen looks like Figure 14. This screen contains control options (generally in boxes) and information (generally not in boxes).

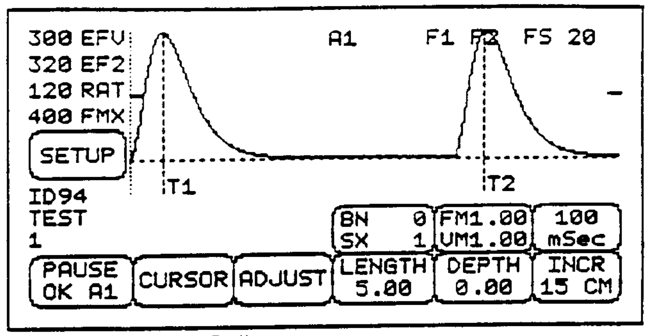


Figure 14 Collect screen

5.8.1 Data Collection—Control Options

SETUP This will return operation to the SETUP screen (Figure 13, §5.7), to adjust titles, for example.

PAUSE The sensor status is shown below the word PAUSE, alternating automatically through all four sensor possibilities. Pressing this key will place the ANALYZER in a stand-by condition where no data will be accepted, and cables or sensors may be changed without causing false signal detection. In this condition the PAUSE key is replaced by the ACCEPT key.

ACCEPT In order for data collection to proceed, press this key. This terminates the stand-by condition, allowing signals to be detected. The ACCEPT key is replaced by the PAUSE key.

CURSOR Two cursor lines are provided (T1, T2) which correspond nominally to the input time and 2×L/c later. Pressing this key will change the bottom row of keys to those shown in Figure 15. Both lines may be moved **LEFT** or **RIGHT** in time (by pressing the appropriate key) at either a **FAST** or **SLOW** rate (one or other will be highlight; to change press this key) using the provided keys. The force and velocity values for both T1 and T2 are shown in the two left boxes; the time indicators are shown in the LEFT and RIGHT boxes and are in 50 microsecond units. Press **ESC** to exit this routine.

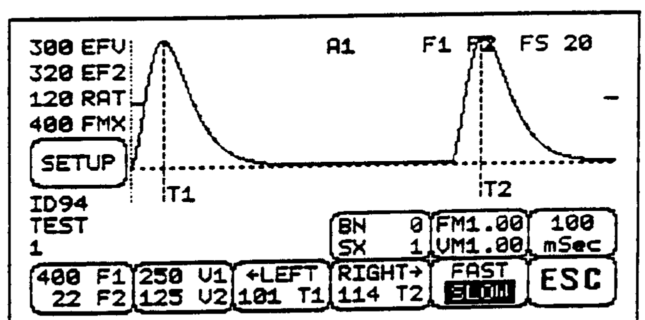


Figure 15 Collect screen, after pressing CURSOR

ADJUST The velocity may be moved left or right relative to the force curve, to account for data phase shifts, using the **T.SHFT** (time shift) key (Figure 16); shifting by more than a couple time increments should not be necessary (shifting by more

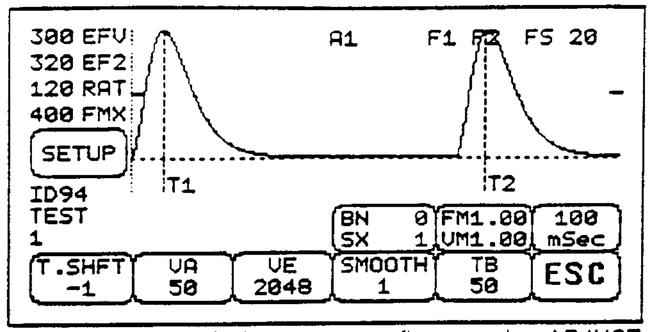


Figure 16 Collect screen, after pressing ADJUST

than a couple units probably is an indication of data problems). Changing VA (Velocity Adjust) affects the starting time increment and **VE** (Velocity End) defines the ending time increment used to adjust velocity curve.

No adjustment is made before VA, and the velocity adjustment starts at VA, rotating the base line such that at time VE the velocity is defined as zero. The default values of VA and VE are the trigger time and end of record respectively.

SMOOTH is used to filter the high frequency content of the curve by averaging over a number of points (1 is average of 1 and thus no smooth, 3 is average of 3,... Do not use a value higher than 9). **TB** is the Time Beginning of the displayed record.

LENGTH Allows the user to change the LENGTH below sensors.

DEPTH Allows the user to change the current penetration depth.

INCR Pressing this key increments the current depth by the value indicated in INCR. This key should be pressed each time the visually observed INCR value has been achieved. This helps in reprocessing in determination of the N-value.

BN/SX Pressing allows user to change the SAVE Frequency of blows (see §5.7).

FM/VM Scale factor multipliers for force and velocity respectively. Normally these will always be unity (1.0). Entry will be by the numeric keypad method.

TIME The time scale for display is shown. Pressing this key will bring up a menu similar to Figure 17. Press to highlight the desired scale and then press the lower right box to accept (or the lower left box to retain the current scale).

FS The current force scale is displayed in the upper right corner. Although there is no box, pressing this corner will ask (numeric keypad) for a new maximum force scale (for display and plotting).

A1/A2 The active accelerometers can be selected by pressing the upper row screen displaying the current active-accelerometer names: A1, A2, A1 A2, or NO A.

F1/F2 The active force (strain) selection is made in a manner similar to the accelerometers as described immediately above.

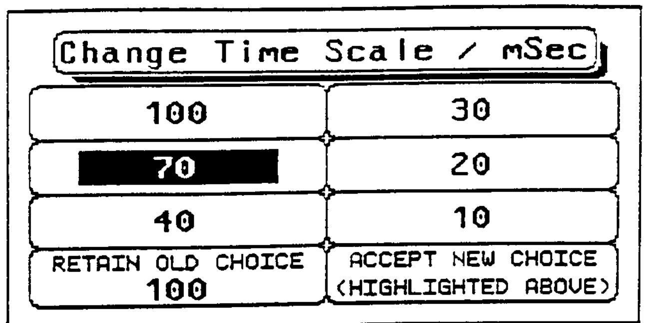


Figure 17 Time scale selection screen

5.8.2 Data Collection—Information

Referring again to Figure 14, in the upper left hand corner are four calculated output results. See §1 for further background information. These results will be stored and may later be transmitted to the PC for further review and/or processing (see §5.9.2).

EFV is the energy calculated from the integral of the product of force and velocity.

EF2 is the energy calculated according to ASTM D4633 as the integral of the force squared.

RAT is the time ratio of the time of force zero (EF2 end time) to 2×L/c.

FMX is the maximum force.

In the area just below the SETUP key are shown the current ID number and the PROJECT and BORING labels for the current test. If they need correction, press the SETUP key.

5.9 Data Review

After data are collected, selected force and velocity records are held in memory. The results EFV, EF2, RAT, and FMX are also retained separately for each blow. Both time records and results are accessible. The main control screen for this function is shown in Figure 18. The functions of the keys shown are described below.

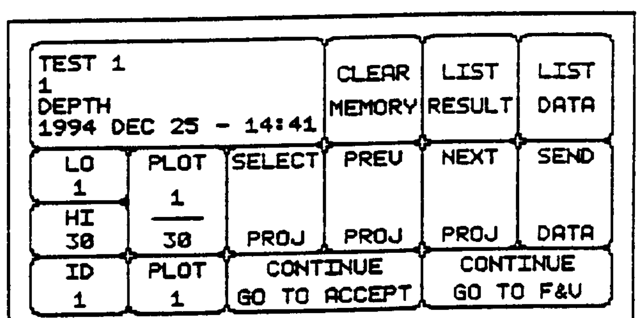


Figure 18 Review screen

TITLES The PROJECT, BORING, and DEPTH with associated date and time of acquisition for the current ID (see ID description below) are displayed. Pressing anywhere in this square allows these TITLES to be edited as described in §5.4 (see also Figure 3).

After completing edits and pressing CONTINUE, a confirmation screen (Figure 19) asks whether to retain the previous titles (KEEP OLD - lower left) or update to the changed titles (SAVE NEW - lower right). Changing any title (PROJECT, BORING, OPERATOR, INFO 1, INFO 2, or HAMMER NAME) will update all records, consecutively adjacent to the current ID and containing the original titles, to the new titles.

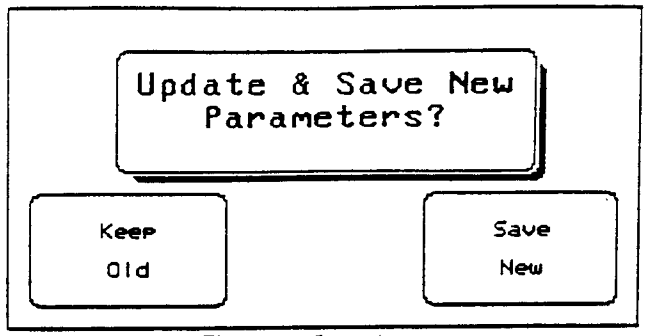


Figure 19 Titles confirmation screen

CLEAR MEMORY

The user should be completely finished analyzing, plotting, and transferring data to the PC before accessing this function. Pressing this key will request a confirmation screen (Figure 20). If the lower right box (CONFIRM) is pressed, all data will be erased completely from memory. Pressing the lower left box (ABORT) will retain the current data.

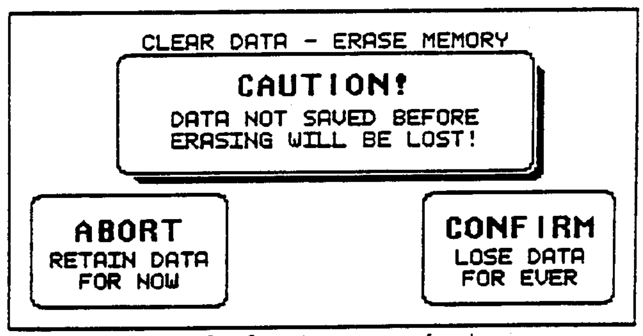


Figure 20 Confirmation screen for clearing memory

LIST RESULT

The results may be reviewed. Pressing this screen will display Figure 21. A short title for the current data set is shown at the bottom of the screen. Use the DATA/BORING/PROJ key to select the selection criteria and then page though the data (if DATA is selected and both columns are full), or change to different data sets if BORING/PROJ are selected. Pressing MAIN MENU will change the right hand function boxes and allow for data transfer before returning to the MAIN MENU (see §5.9.2 for further instructions).

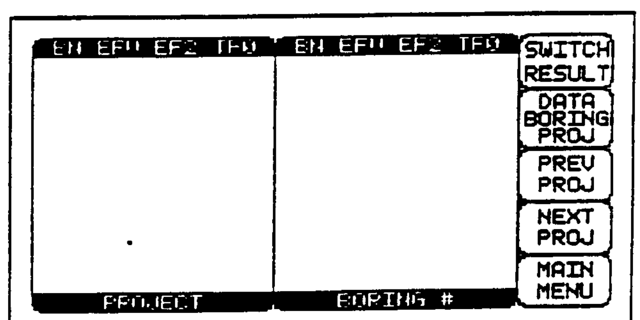


Figure 21 List result screen

LIST DATA

Pressing this screen will display Figure 22. The right boxes show partial title information for the data groups. The middle column shows the LO and HI storage locations (ID numbers) for data with identical titles. The highlight square can be changed by pressing the new choice. The left column shows the control functions described below:

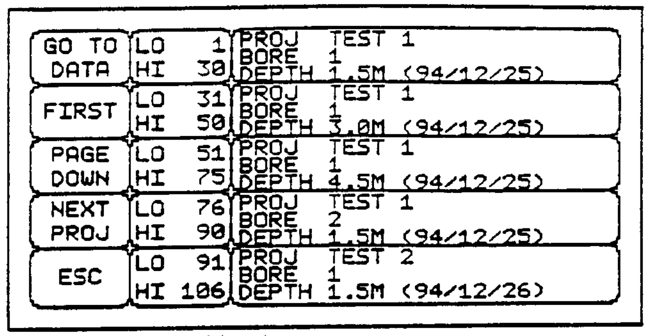


Figure 22 List data screen

GO TO DATA - displays the first force velocity time record of the group selected by the highlight.

FIRST - this is information only which means that the current page is the beginning of the list.

LAST - this information informs that the current page shows the end of the list.

PAGE UP (PAGE DOWN) - will change the information shown to the next (previous) page of information allowing the user to browse through the memory.

NEXT PROJ (BORING, DEPTH) - skips to the next PROJECT (or next BORING, or next DEPTH). This may be faster than going through each page.

ESC - Returns to the main review screen with no action.

LO

This is the lowest ID of the current data group (by PROJECT, BORING or DEPTH as defined by SELECT), or user may enter a value with the numeric keypad.

HI

This is the highest ID of the current data group (by PROJECT, BORING or DEPTH defined by SELECT), or user may enter a value with the numeric keypad.

ID

This shows the current ID. Changing this value with the numeric keypad allows the user to go to that specific ID, or selects it to be plotted (see PLOT below).

PLOT

Plots can be requested either for a) the current ID only, or b) for a <u>block</u> of ID's specified by the LO and HI values. Selecting either will bring up the PLOT screen shown in Figure 23 which has several new choices. Pressing **ESC** allows the user to exit with no plotting.

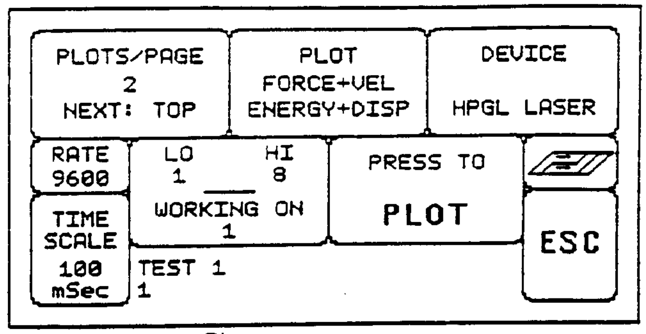


Figure 23 Plot screen

PLOTS/PAGE (upper left box) selects how many axes will be included and their locations on the page. The force and velocity data curves as functions of time are always plotted, regardless of whether one or two axes are requested, and optionally the derived time function curves of displacement and energy are plotted on a second axis if requested.

The upper middle box is for information purposes only. Another information only box includes the Project and Boring titles in the lower center box of the screen. Pressing the box with PDI logo will present more contact information and allow the owner name to be changed.

DEVICE (upper right box) selects between HP Laser printers or HP pen plotters; both devices must be connected to the SPT Analyzer with their serial port.

RATE (second row left) allows the serial bit rate[1] to be selected from among several commonly-used values. The SPT ANALYZER will use this frequency to transmit information to the receiving device. Both devices must be set for the same bit rate. See Figure 24. Press the box containing the desired value; this causes the value to be highlighted. Press the ACCEPT box to accept the new choice indicated by the highlight, or press the RETAIN box to keep the previous choice in effect.

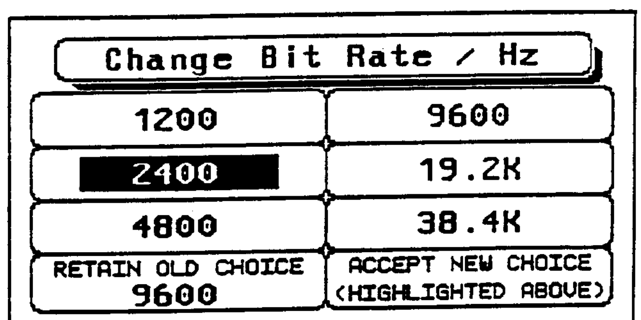


Figure 24 Bit rate for serial data transfer

[1]Bit rate is often mistakenly called baud rate. Baud rate is a parameter of modem telemetry, and is not applicable here, nor is it necessarily equal to the bit rate.

TIME SCALE (lower left box) is used the change the plot's horizontal length. (See Figure 17).

PRESS TO PLOT (center right box) will activate the plotting sequence and should be pressed only after all other boxes have been reviewed and approved. The companion (center left) information box shows the LO and HI limits selected and which data are currently plotting. Only the data with a STATUS of YES will be plotted.

> After plotting is activated, the PRESS TO PLOT box is changed to **PRESS TO ABORT**, which allows user to halt the plotting if needed.

SELECT This allows the user to choose the criteria for the LO and HI ID values. Selection is based on project (PROJ), BORING, or DEPTH. Alternatively, if LO or HI has been user selected, SELECT will display USER. This, along with the companion PREV and NEXT keys, described below, allow the user to conveniently select groups of blows for PLOT or SEND, saving keystrokes in office replay.

PREV The LO and HI ID values will be changed to the next lowest values.

NEXT The LO and HI ID values will be changed to the next highest values.

SEND DATA Data can be transferred to any PC using the SPTPC program's RF function. If this function is requested, the SPT ANALYZER first shows a message (Figure 25) which gives instructions to connect the SPT ANALYZER to the PC and start the SPTPC program. If the proper serial port connection is made and the SPTPC program is running, then enter "RF" in the SPTPC program and the SPT ANALYZER screen should change to Figure 26.

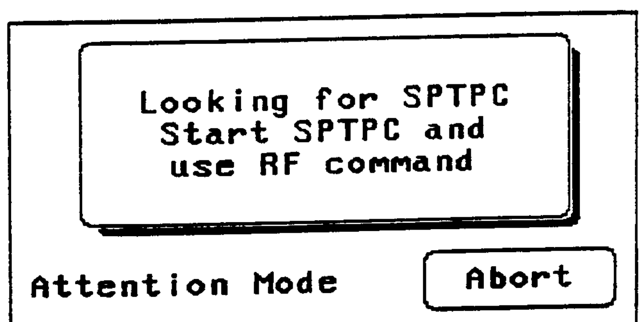


Figure 25 Send data, attention mode

At this point, select the desired data set on the PC in the SPTPC program ("Choose SPT ID's to Read"; use the left and right arrow keys) and then use the up arrow to highlight the option "RF - READ SPT ANALYZER RECORDS" and enter (accept by OVERWRITE if the SL is acceptable or change SL).

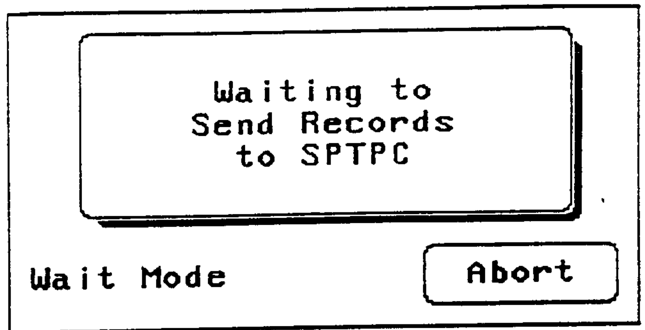


Figure 26 Send data, wait mode

The data will be transferred automatically (screen will look like Figure 27 and show the transfer progress). The SPTPC program also shows the transfer progress. The other functions in the SPTPC program are described in the SPTPC manual and are not repeated here.

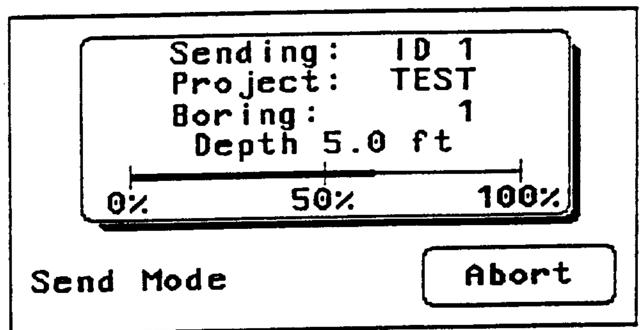


Figure 27 Send data, send mode

GO TO ACCEPT
Will lead to Figure 13 Summary screen. Press the lower right box labeled "CONTINUE - NEW DATA" to collect additional data, or press REVIEW to return to the Review control screen (Figure 18).

GO TO F&V Will lead directly to the force velocity data of the current ID as shown in Figure 28 and as described in §5.9.1 below.

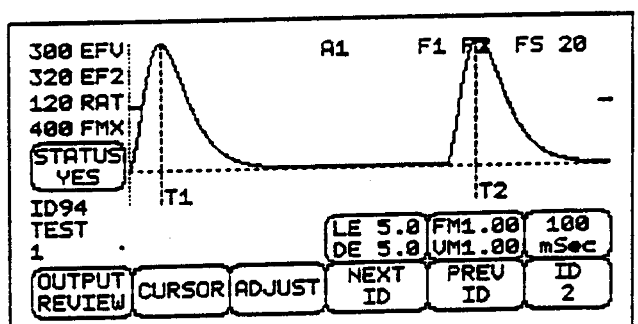


Figure 28 Force-and-velocity display

5.9.1 Data Review—Time Records

The screen (Figure 28) shows again the force and velocity time records. Many functions are similar to those described in §5.8 above and shown in Figure 14 so the descriptions of those functions are not repeated here. Other functions include:

STATUS The STATUS will be either YES or NO. If YES, the data are considered good and will be plotted if a plot is requested. If NO, the data will be ignored if a block plot is requested. The default is YES. If the data are poor, press the square to change the STATUS to NO.

OUTPUT/REVIEW
Press to return to the REVIEW CONTROL screen (Figure 18).

NEXT ID Press to change the data display to the next higher ID.

PREV ID Press to change the data display to the next lower ID.

ID Press to go to the numeric keypad to enter the ID location to go to directly.

5.9.2 Data Review—Result Files and File Transfer

The data results may be reviewed. Pressing the LIST RESULT key will display a screen like Figure 21. A short title for the current data set is shown at the bottom of the screen. Use the DATA/BORING/PROJ key to select the selection criteria and then page though the data if DATA is selected and both columns are full, or change to different data sets if BORING/PROJ are selected. If FIRST and LAST are both shown then all data are displayed; if "PREV ..." or "NEXT ..." is shown, then pressing that key will scroll through the data.

Pressing MAIN MENU will change the right hand function boxes (see Figure 29) and allow for data transfer before returning to the main menu. If data transfer is not desired press the MAIN MENU key (lower right box) to go directly to the REVIEW screen (Figure 18).

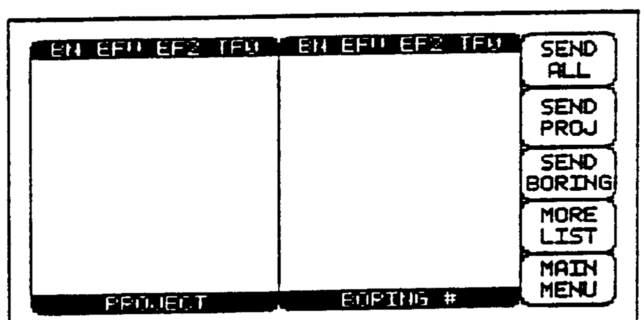


Figure 29 **List more results**

In order to transfer data, the SPT ANALYZER must be connected to the serial port of the target PC, and the PC must be running some communication software such as CROSSTALK®.[2] The user must set certain serial communications parameters in the PC software. The CROSSTALK commands that set the necessary parameters are:

SPeed	9600	DAta	8
PArity	None	STop	1

[2]CROSSTALK® is a registered trademark of Digital Communications Associates, Inc.

The user then can select what data to send:

SEND ALL will send all data.

SEND PROJ will send all data matching the current PROJECT name.

SEND BORING will send all data matching the current BORING name.

After selection of any of the above the SPT ANALYZER will transmit the data to the PC, through the serial connection and PC communication software, and return to the main Review screen (Figure 18). Depending upon PC software, the data may be seen on the PC screen.

If the PC software has been commanded to receive the data as a file, using the ASCII file transfer protocol, it will store the data in a file from which they can be directly read by the PDAPLOT program. See the PDAPLOT manual for instructions on use of this program for further processing and presentation.

5.9.3 Data Review—Data Transfer

The SPT ANALYZER collects data and stores them in memory. Data should be transferred to a PC for a more permanent storage on floppy disk or other removable medium. Data can be transferred using the SEND DATA command in the DATA REVIEW screen as described below.

SEND DATA Data can be transferred to any PC using the SPTPC program (and the RF function). If this function is requested, the SPT ANALYZER first shows a message (Figure 25) which gives instructions to connect the SPT ANALYZER to the PC and start the SPTPC program. If the proper serial port connection is made and the SPTPC program is running, then enter "RF" in the SPTPC program and the SPT ANALYZER screen should change to Figure 26. At this point, select the desired data set on the PC in the SPTPC program ("Choose SPT ID's to Read"; use the left and right arrow keys) and then use the up arrow to highlight the option "RF - READ SPT ANALYZER RECORDS" and enter (accept by OVERWRITE if the SL is acceptable or change SL). The data will be transferred automatically (screen will look like Figure 27 and show the transfer progress). The SPTPC program also shows the transfer progress. The other functions in the SPTPC program are described in the SPTPC manual and are not repeated here.

6 Maintenance

The SPT ANALYZER has been designed for minimum required maintenance. However, you should always try to protect the SPT ANALYZER as best as possible. The SPT ANALYZER is NOT WATERPROOF; gaskets are provided around the screen and the bottom covers but water or mud could still potentially enter the unit there or around the power switch or input or serial connectors. The SPT ANALYZER is light, but is not designed to float.

6.1 Display Screen

The liquid-crystal display is sensitive to temperature. It may be operated at temperatures ranging 0—40 •C (32—104 •F), with some variation in color. Images on the screen might not be visible outside of this operating temperature range. The screen may be stored without permanent damage at temperatures ranging -20—60 •C (-4—140 •F), but should not be exposed to condensing moisture. No problems are anticipated during normal operation, but don't leave the SPT ANALYZER exposed in the sun or in a hot parked car; keep it in its case when not in use.

6.2 Touch Screen

The touch screen surface is a soft membrane, and should be treated with care. If punctured the membrane will be electronically compromised. If scratched or abraded, it will obscure the display. Therefore do not violate it with sharp or abrasive objects, such as pens, keys, erasers, or dirt. Operate the touch screen with a reasonably clean finger or soft glove. As necessary, clean the membrane with a soft cloth moistened with water or mild window cleaner, never with abrasive substances.

6.3 Changing the Fuse

The fuse is located inside the SPT ANALYZER on the *digital* circuit board. Changing it requires the services of an electronics technician. If the fuse is suspect, return the SPT analyzer to Pile Dynamics, Inc. If possible please provide a description of the circumstances of its failure, as this will assist in repairing the SPT ANALYZER.

6.4 Memory Back-up Batteries

An auxiliary battery, located on the power board, enables the SPT ANALYZER to retain the contents of its memory even when turned OFF. This battery is not rechargeable; it should last at least two years but probably less than ten years. When the charge on this battery becomes low you will be alerted on the display screen. In this condition the SPT ANALYZER may lose data from memory. You should immediately copy all current data which you would like to retain to a permanent form of storage (§5.9.2, §5.9.3). After transferring your data to a durable medium, send the SPT ANALYZER back to Pile Dynamics or take it to a local electronics or computer repair facility to have the memory back-up battery replaced by a qualified technician.

6.5 Changing the EPROM

Occasionally there will be program updates for the SPT ANALYZER. The program is stored in EPROM (Erasable & Programmable Read-Only Memory), which is housed in a pair of removable integrated circuit chips. When these updates occur, we recommend that you send the SPT ANALYZER back to Pile Dynamics, Inc. to have the new chips installed. If you are unable to return the SPT ANALYZER, PDI can send you a replacement EPROM containing the new program. We strongly recommend that you go to a local electronics or computer repair facility to have the EPROM installed by a qualified technician.

6.6 Further Information

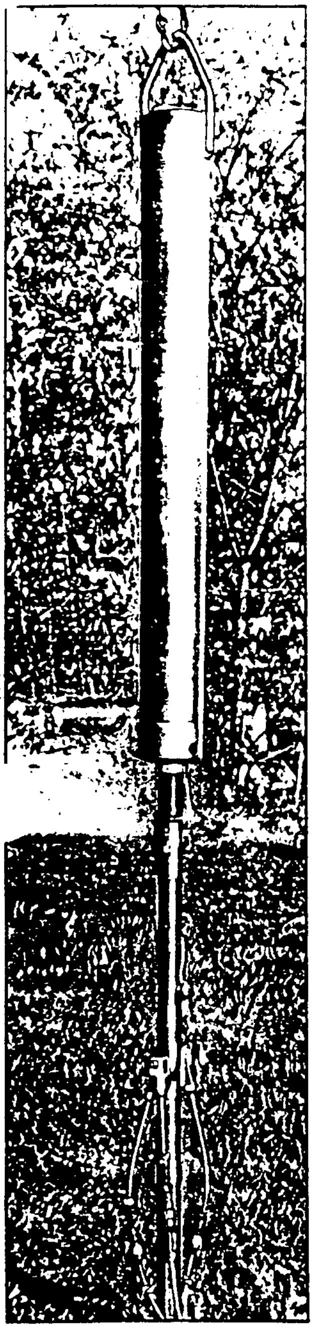
For further information contact Pile Dynamics, Inc., 4535 Emery Industrial Parkway, Cleveland OH 44128-5701, USA, Telephone (216)831-6131, FAX (216)831-0916.

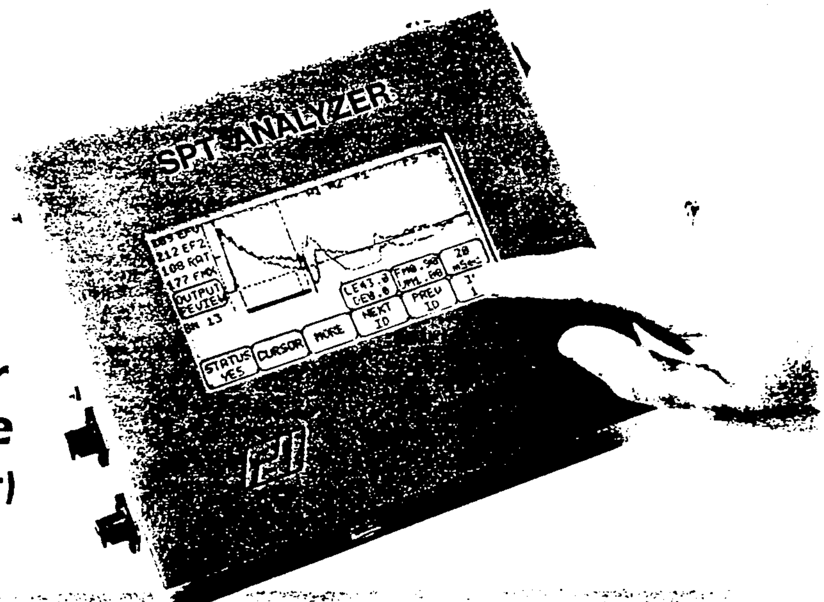
APPENDIX B

Manufacturer's Information and Gauge Calibrations

SPT ANALYZER™

For Improved Reliability of SPT N-values





Measures and Checks SPT Hammer Performance (Energy Transfer)

- Immediate results for each hammer blow
- Conforms to ASTM D4633 specification for SPT energy measurement
- Measures energy transfer; results used to normalize measured SPT N-value to N_{60}
- Provides definitive answers as to consistency of operation, operator performance, or efficiencies of specific rig or rig type
- Measurements also indicate static strength during test and dynamic soil response for future pile driving predictions or static pile performance

The Standard Penetration Test (SPT) is a widely used soil exploration tool (ASTM D1586) which involves driving a split barrel sampler at the bottom of a drill string to recover disturbed soil samples. The number of blows required to drive the last 300 mm (one foot) is the "N-value" and indicates soil strength. The SPT N-value and retrieved soil sample are used for many geotechnical evaluations. The SPT N-value data influences the engineer's design. With low reliability, the design must be very conservative to reduce risk. Reliable N-values result in lower and more economical safety factors. However, the N-value depends also upon SPT hammer energy input.

ASTM D1586 allows a wide diversity of equipment for sampling and N-value measurement. It has been clearly demonstrated that the type and operational characteristics of the SPT hammer significantly influence the energy transfer and resulting SPT N-value. Donut or safety hammers which are otherwise identical can have different efficiencies due to the skill of the operator using a cathead and rope system. Different automatic trip hammers have different impact velocities due to the differences in the lifting and dropping mechanisms. Because of the known extreme variability of SPT hammers, a separate specification for measuring SPT energy was developed (ASTM D4633). A task group reviewing ASTM D1586 has suggested that the N-value be modified to a standard "N_{60}"

$$N_{60}\, E_{60} = N_{field}\, E_{measured}$$

where N_{field} is the field observed N-value, $E_{measured}$ is the measured energy, and E_{60} is 60 percent of the theoretical potential energy (60 percent represents the historical average that many empirical relations have been based upon). This approach provides a more rational approach to geotechnical design. The SPT Analyzer measures the energy for any manufacturer or type of SPT hammer, allowing the design engineer to compute the rational N_{60} value from the observed field N-value. Optional software can extract static and dynamic soil response for direct determination of "wave equation" parameters for pile driving analysis.

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PDI designs all its equipment to be rugged and to endure harsh construction conditions. Reliability is proven by hundreds of PDI units in the field and our strong commitment to quality products and support. The SPT Analyzer is designed for the professional engineer or researcher and comes with a full one year warranty for normal use. PDI's solid international reputation is the result of quality products, decades of dedicated engineering research, and commitment to technical support of its clients, including suggestions and advice on unusual applications and data interpretation for dynamic pile testing. Training is available as requested, as are continuing education courses on dynamic testing on a regular basis at various locations around the world.

SPT Analyzer™

Pile Dynamics, Inc. has used its extensive experience in measurements of pile driving to develop a simple system which can be applied to the SPT. The SPT Analyzer is very compact and cost effective, and at a moment's notice can be transported (by plane as carry-on luggage) to remote sites. A specially instrumented rod section inserted into the drill string during SPT hammer operation measures strain (force) and acceleration (acceleration is integrated to velocity). A short cable connects the reusable instrumented rod with the SPT Analyzer which is operational in minutes.

User friendly operation

- Easy-to-learn "touchscreen" entries through intuitive menus are available for:
  - Rod area and length
  - Documenting project/boring descriptions and names
  - User comments
  - Data control and review
- The SPT Analyzer features a graphic LCD screen for data and result display
- Force and velocity versus time measurements and computed results are retained in memory
- Data collected is stored automatically and can be transmitted to a PC for later further review
- Data can be plotted on HP plotters or serial laser printers for inclusion in a report
- Data can be used for further optional analysis to obtain a more detailed soil model for dynamic wave equation pile driving analysis.
- Inputs and results can be selected in either SI or English units.

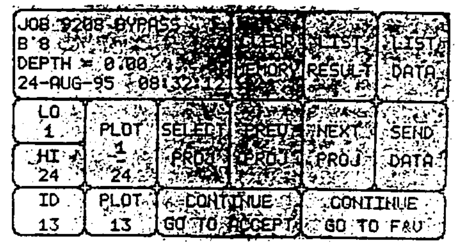
Field equipment

- Two strain channels (instrumented drill rods)
- Two acceleration channels (user choice of piezoresistive or piezoelectric type accelerometers)
- Automatic balancing of all signals
- Rugged transducers quickly attached to drill string and connected by single cable to SPT Analyzer
- Single component data acquisition unit, set-up and ready to use in minutes

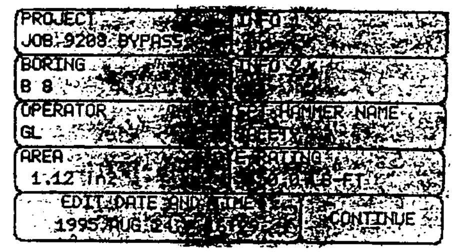
Hardware

- Rugged sealed aluminum housing for harsh field conditions; no moving parts
- Small size (65 x 175 x 200 mm)
- Light weight (1.3 kg; 3 lb.)
- Temp: 0° to 40° C, operating; -20° to 65° C, storage
- Power: external 12 V DC car battery, or 100 - 240 V AC to 12 V DC convertor
- Comes with equipment transit case for checked baggage
- High contrast, user friendly, graphics LCD "touchscreen" simplifies data entry and data collection
- Serial port for data output and data transfer
- Data storage in battery-backed RAM at user selected frequency
- Technical manuals and support by the industry leader
- Full one year warranty

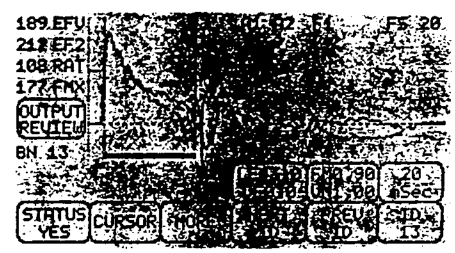
The "touchscreen" can display many different menus for data entry and inspection. Requests are made by pressing the "box" with the name of the desired function. The display changes to a new screen with the appropriate requests.



The SPT Analyzer provides for user input titles and descriptions, drill string descriptive input (area, length, embedment), transducer checks and calibration setting, data acquisition or data review, direct plotting, and serial data transfer to PC's with the Send function.



For example, project descriptions are displayed as above, and if changes are required simply press the appropriate box and a numeric keypad is then shown which requests the new value. Titles and other user input comments are changed with an alphanumeric screen. Data collected is displayed with calculated results (in upper left for screen below); the force and velocity are displayed graphically (force and time scales are user selectable) to evaluate data quality. Data collected and stored can be output or reviewed.



Pile Dynamics, Inc.

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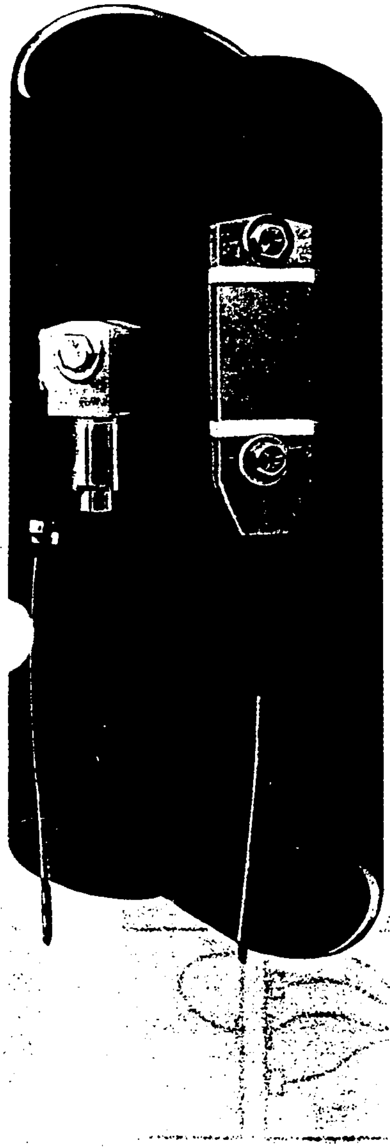
Strain and Motion Sensors from Pile Dynamics



Pile Dynamics, Inc. (PDI) has provided Pile Driving Analyzer® equipment since 1972. Measurements require axially accurate strain and acceleration signals at high microstrain (με) and high "g" levels which are converted to force and velocity for further analysis. PDI has continually updated and refined this capability resulting in accurate calibrations to NIST (U.S.A. national bureau of standards) and repeatable measurements using an economic system of reusable sensors which are quickly attached to any pile with minimal preparation. Systems with extra cable length and/or full waterproofing for deep depth underwater testing are available on request.

Strain Transducer Specifications:

Effective Gage Length:	3 inch (76 mm); 2 inch (50 mm) version as option
Size:	4.5 x 1.4 x .4 inch (115 x 35 x 11 mm)
Material:	Aluminum (optional: steel transducer for structural or static testing)
Circuit:	Full bridge; 2 pair shielded cable (standard length: 3 ft; 900 mm)
Sensitivity:	380 με/mV/V typical (individual calibration included)
Strain Range:	Nominally 2,000 με when firmly attached (limit 8,000 με)
Shock Range:	Nominally 5000 g's
Temperature Range:	-50° to 120°C Operating
Options:	Full waterproofing, extra cable length, quick connectors
Attachment Method:	Bolts to quickly attach to pile (see reverse page)
Optional:	C-clamps or mounting tabs and adhesive for structural testing

PDI Strain Transducers are also used in static load monitoring and/or structural monitoring such as for measurements on highway bridges, lock gates and other civil structures.

Piezoelectric Accelerometer Specifications:

Mounting:	To special aluminum block (1 x 1 x 1 inch: 25 x 25 x 25 mm)
Circuit:	Integral impedance converting electronics; shielded cable (3 ft; 900 mm)
Sensitivity:	Nominally 1.0 mV/g with 10 V.D.C. bias voltage input
Range:	5,000 g's (Limit 10,000g's)
Frequency Range:	0.25 to 7000 Hz (Resonant Frequency: > 40 kHz for accelerometer)
Temperature Range:	-50 to 120°C Operating
Time Constant:	Nominally 3 s
Options:	Full waterproofing, extra cable length, quick connectors
Attachment Method:	Bolts to quickly attach to pile (see reverse page)

Piezoresistive Accelerometer Specifications:

Mounting:	Inside special aluminum block (1.25 x 1 x 0.75 inch: 30 x 25 x 20 mm)
Circuit:	Full bridge, 2 pair shielded cable (3 ft; 900 mm)
Sensitivity:	Nominally 0.07 mV/g with 6.4 V.D.C. input
Range:	10,000 g's (Limit 15,000g's)
Frequency Range:	DC to 3 kHz (accelerometer resonant Freq: 5 kHz critically damped))
Temperature Range:	-50 to 90°C Operating
Options:	Extra cable length, quick connectors
Attachment Method:	Bolts to quickly attach to pile (see reverse page)

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veland, Ohio 44128, U.S.A.
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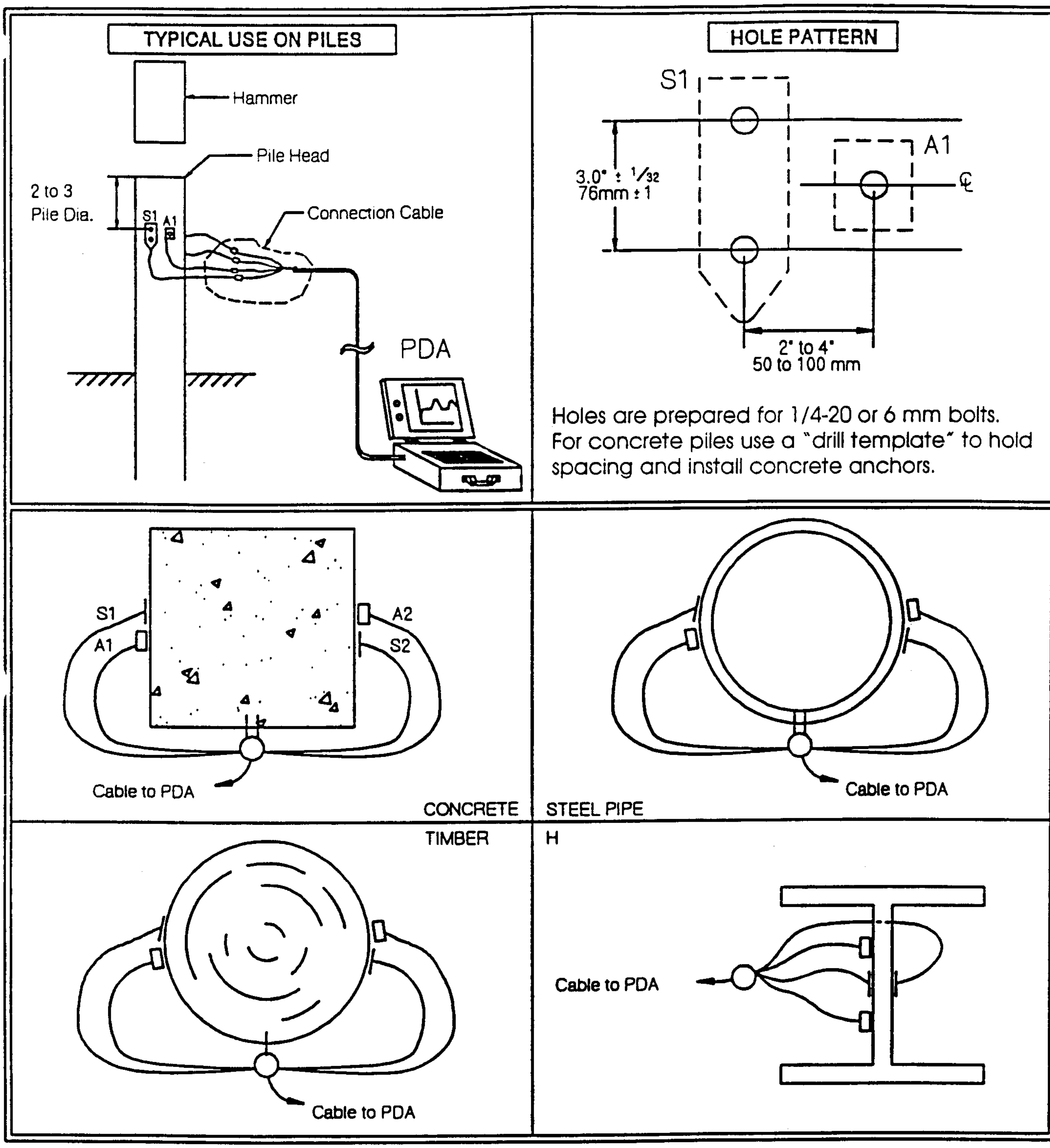
Email: info@pile.com
http://www.pile.com

Sensor Installation for Dynamic Pile Testing



Pile Dynamics, Inc.

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Fax: (216) 831-0916
Email: info@pile.com
http://www.pile.com

Sensors are quickly bolted to any pile type, usually about 2 to 3 pile diameters below the pile top. Strain transducers are attached symmetrically on the pile to account for bending effects. Accelerometers should be attached near the strain transducers. Attachment is typically with drilled and tapped holes for steel pipe piles, clearance holes with bolt/nut for steel H piles, lag bolts for timber piles, or by installing embedded anchors for concrete piles.

Information Concerning Acceleration Calibration

With this shipment of accelerometers, we are including calibration sheets from PDI.

PDI tests each accelerometer we receive on our Hopkinson Bar calibrator. These calibrations are traceable to National Institute of Standards and Technology (NIST). The method of calibration uses a comparison of velocity to the strain measured in the rod. We determine the accelerometer's calibration by making the velocity (integral of accelerometer then multiplied by the impedance) equal to the strain as theory demands.

Sometimes the PDI value and the manufacturer's value vary by a few percent. Entran uses a shaker table for low G calibration and frequency response using a reference accelerometer. PCB uses a shock calibration with comparison to a reference accelerometer. Any comparison evaluation has a basic accuracy of about ±2%. The two graphs on the reverse side of this page show the results of PDI recalibration of PCB and Entran accelerometers. The graphs show the serial number versus the ratio of the PDI calibration to the original manufacturer's calibration (a ratio of 1.0 is perfect agreement). In general, PCB calibrations have less scatter. Entran calibrations have improved, but still have more scatter to the data points and thus the Entran calibration is less reliable.

Our PDI Hopkinson Bar test more closely matches real pile driving data, so we have good confidence in our PDI calibration value (if there are significant differences between the two values then we trust our PDI value; this is particularly true for Entran calibrations from their low G shaker table calibration). Also, remember that each calibration process is accurate only to within about 2 percent, so having a 4% difference between methods is possible and is considered the basic accuracy attainable.

By the way, PDI only charges $35 for calibration of each strain transducer or each accelerometer. Re-calibration of accelerometers by the factory would cost about $170 due to the work involved for PDI to disassemble and reassemble the accelerometer and its block and a reasonably high cost for the calibration by the factory. Note the initial "new" PDI calibration is given at no charge as part of our commitment to providing quality equipment.

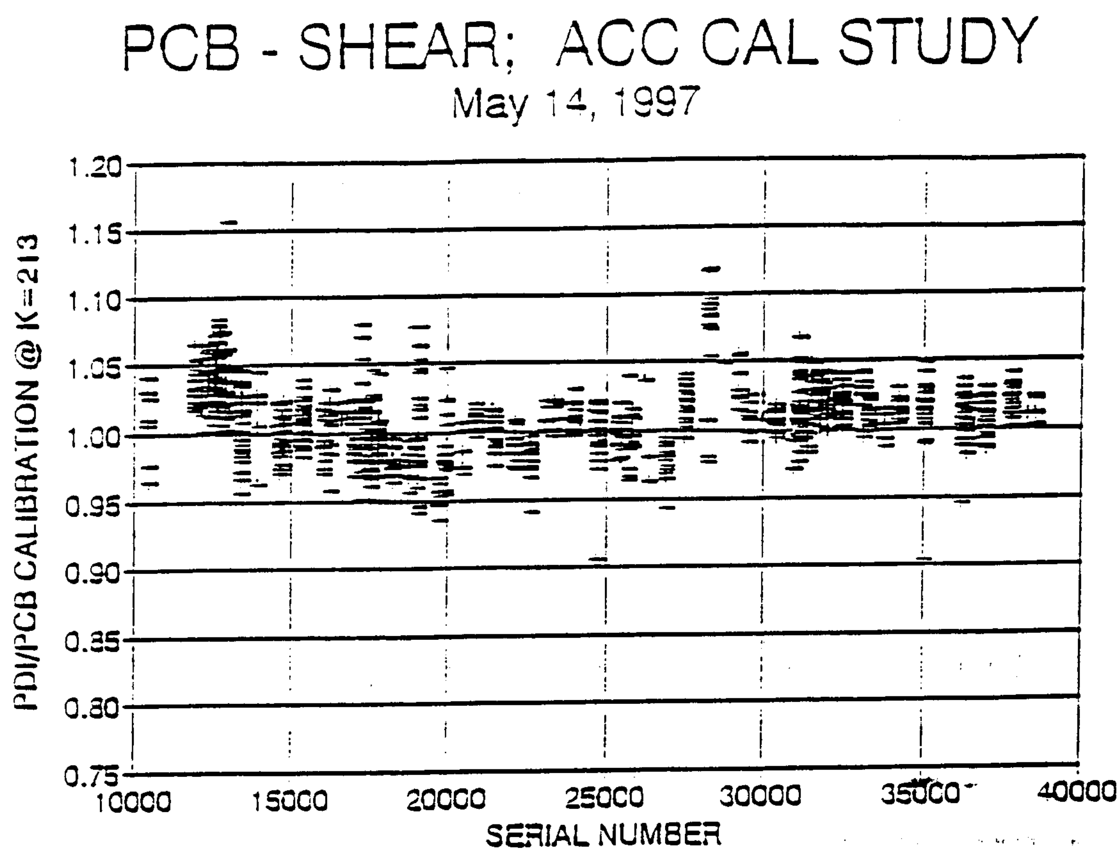
PDI calibration also reduces turn around time! We are not dependent on the original manufacturer's busy calibration lab schedule and we don't have to spend time taking the units apart before sending them in for a manufacturer's recalibration, then rebuilding them when returned. In-house accelerometer calibration can be done usually in less than a week. Total time is usually more dependent upon shipping time and customs clearance, if required.

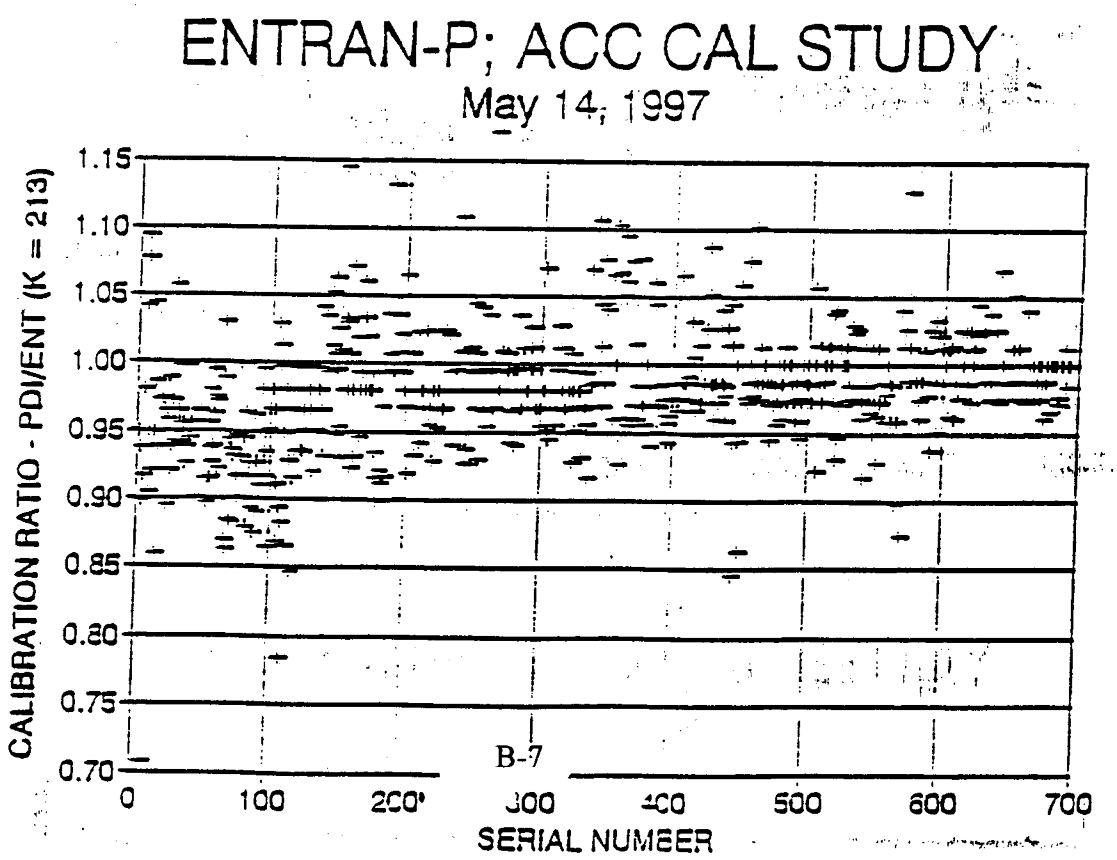
Handle With Care

Please handle the sensors with care. Strain transducers and accelerometers will last longer if they are handled carefully. Most people probably feel that the transducers are very durable since they are made to be bolted to the pile. And really they are! Problems may occur more often when the transducers are not on the pile! Strain transducers should not be carelessly hit against objects, stepped on, bent, or dropped. Accelerometer manufacturers (particularly Entran) have warned us that careless hitting objects, especially in off axis and cross axis directions, could cause a <u>non-warranty failure</u> of a sensor. And you should always use a new flat washer on the mounting bolts of all sensors.

If you have any questions or comments, please give us a call or fax.

November 13, 1996
Pile Dynamics, Inc.


PCB - SHEAR; ACC CAL STUDY
May 14, 1997
PDI/PCB CALIBRATION @ K=213
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
10000
15000
20000
25000
30000
35000
40000
SERIAL NUMBER


ENTRAN-P; ACC CAL STUDY
May 14, 1997
CALIBRATION RATIO - PDI/ENT (K = 213)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
100
200
300
400
500
600
700
SERIAL NUMBER

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. TG F1 DPF

Pile Dynamics 08-May-98 11:50 | FS — 10 | BN 969 SL 855/ 3440/ 2 | PJ: calibration PN: HOPBAR | A 4 F 2 | -- US 3.3

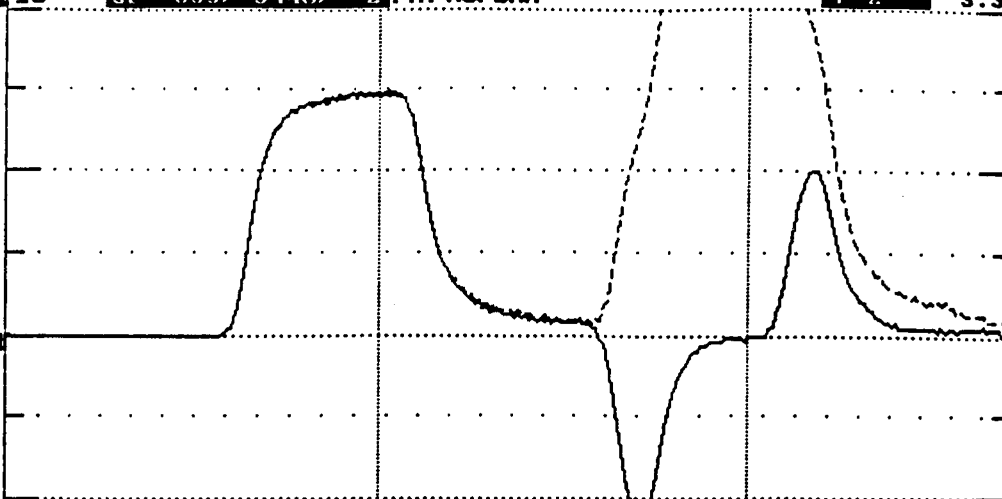
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 16862 ft/s

JC 0.50
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL 0
UT -1
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 360



TS 12 E B PD: P495 LP 0.00 ft
TB 7.0 T1 11.7 2L/C 4.7 VA 1000 VE 1024 LI 1.0

VMX= 4.8 FMX= 74 AMX= 199
VT1= 2.5 MEX= 145 FUP= 0.99

ACCEPT SQ-OFF FL-OFF PR-OFF

contact Pile Dynamics USA
with your questions
tel USA - 216 - 831- 6131
fax USA - 216 - 831- 0916

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: P495

CALIBRATION FACTOR: 0.072 mV/G

PAK (*5000): 360 DATE: 14-MAY-98

PDA OPERATOR: [signature]

<-AT:PIEZORESISTIVE OP: RCA DC [ver:4.05] AT:PIEZOELECTRIC->

#495

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. TG F1 DPF

Pile Dynamics 24-Mar-98 11:57 | FS — 10 | BN 20 SL 316/ 3440/ 99 | PJ: calibration PN: HOPBAR | A 4 F 2 | -- VS 3.3

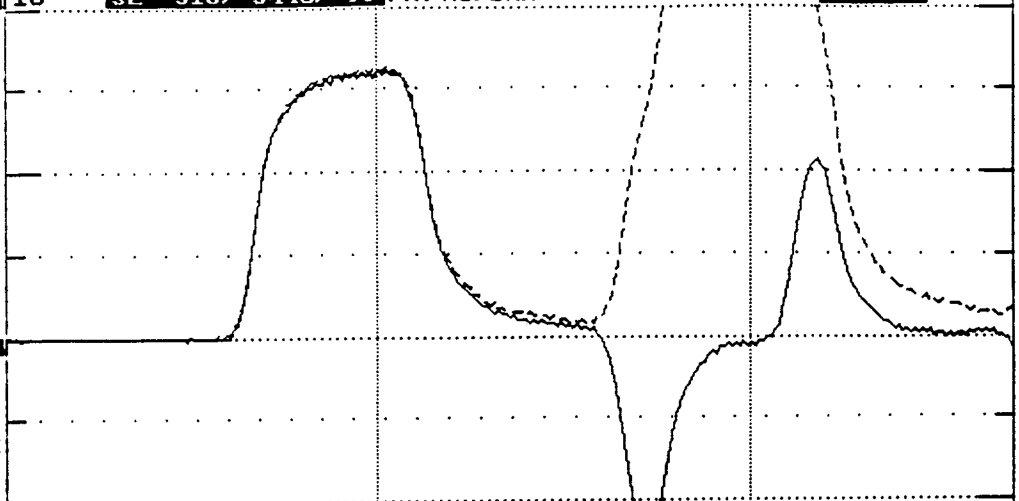
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 16862 ft/s

JC 0.50
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL 0
VT -1
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 397



TS 12 E B PD: P549 LP 0.00 ft
TB 7.0 T1 11.7 2L/C 4.7 VA 1000 VE 1024 LI 1.0

VMX= 5.3 FMX= 81 AMX= 199
VT1= 2.7 MEX= 158 FVP= 1.00

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: P549

CALIBRATION FACTOR: 0.0794 mV/G

PAK (*5000): 397 DATE: 24-MAR-98

PDA OPERATOR: R.C.A.

contact Pile Dynamics USA
with your questions
tel USA - 216 - 831- 6131
fax USA - 216 - 831- 0916

<-AT:PIEZORESISTIVE OP: Ryan C. Allin [ver:4.05] AT:PIEZOELECTRIC->

#549

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. IG F1 DPF

Pile Dynamics
08-Apr-98 11:03

FS — 10

BN 379
SL 655/ 3440/ 99

PJ: calibration
PN: HOPBAR

A 4
F 2

-- VS 3.3

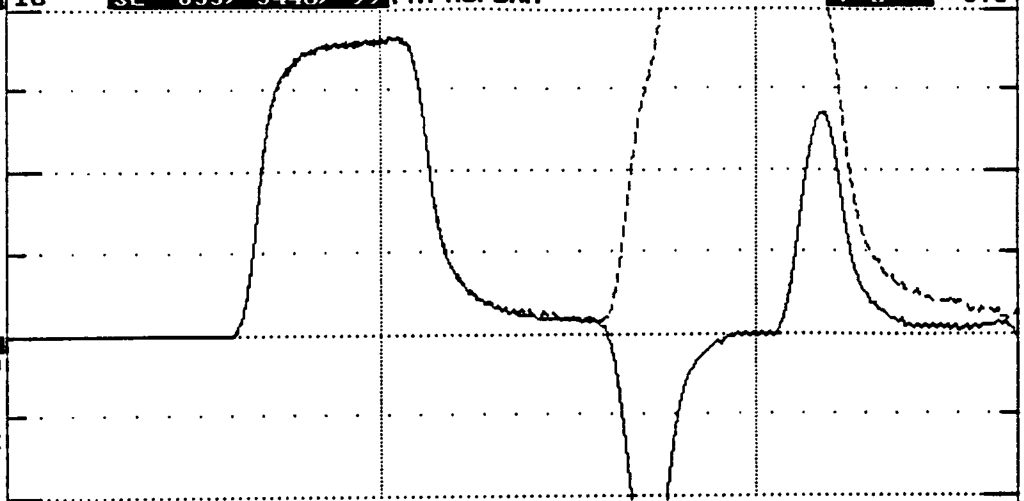
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 16862 ft/s

JC 0.50
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
VN KIPS*0.1
FR 20000 MB 90

DL -3
VT -1
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 435



TS 12 E B PD: P577 VA 1000 VE 1024 LP 0.00 ft
TB 7.0 T1 11.7 2L/C 4.7 LI 1.0

VMX= 5.9 FMX= 91 AMX= 249
VT1= 3.0 MEX= 178 FVP= 0.99

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: P577

CALIBRATION FACTOR: 0.087 mV/G

PAK (*5000): 435 DATE: 8-Apr-98

PDA OPERATOR: [signature]

contact Pile Dynamics USA
with your questions
tel USA - 216 - 831- 6131
fax USA - 216 - 831- 0916

<-AT:PIEZORESISTIVE OP: Ryan C. Allin [ver:4.05] AT:PIEZOELECTRIC->

#577

Replaces #779
no charge

QBTA: ON [ALT-F1/BB=60] Pile Dynamics, Inc. TG F1 DPF

Pile Dynamics 17-Sep-97 13:47 | FS — 10 | BN 93 SL 3059/ 3440/ 99 | PJ: RECAL PN: HOPBAR RESTRIKE | A 4 F 2 | -- VS 3.3

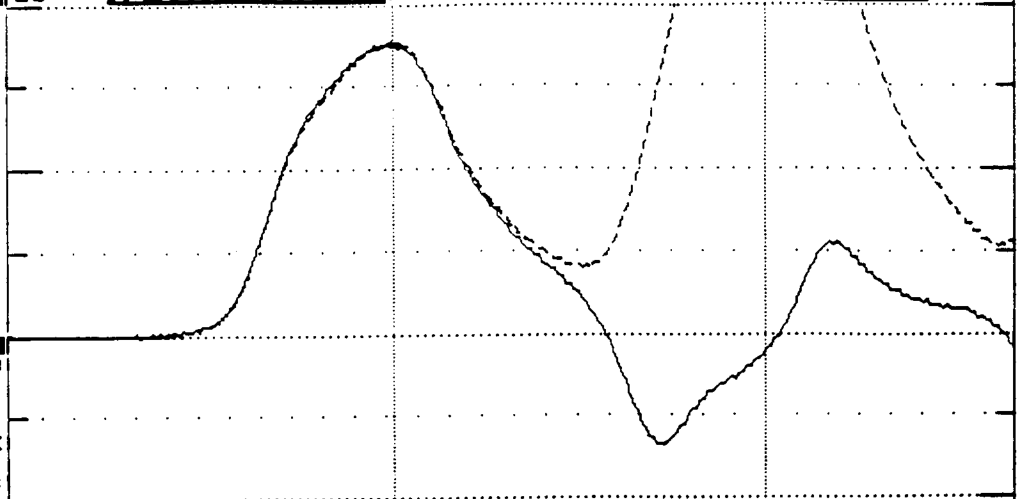
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 16851 ft/s

JC 0.50
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL 0
VT -1
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 398



TS 12 TB 7.0 E B T1 11.9 PD: P801 2L/C 4.7 VA 1000 VE 1024 LP 0.00 ft LI 1.0

EFV= 0.51	E2M= 0	ETR= 0.00
EF2= 0.51	E2L= 0	EMX= 0.5
RAT= 1.02	BPM= 0.0	DFN= 1.45

ACCEPT SQ-OFF FL-OFF PR-OFF

contact Pile Dynamics USA with your questions
tel USA - 216 - 831- 6131
fax USA - 216 - 831- 0916

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: P801

CALIBRATION FACTOR: 0.0796 mV/G

PAK (*5000): 398 DATE: 17-SEPT-97

PDA OPERATOR: [signature]

<-AT:PIEZORESISTIVE OP: Garland Likins [ver:4.05] AT:PIEZOELECTRIC->

801

#54 AW Rod

Cycle No. 1

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	-4.98	.00	.00	.00
2	1140.89	32.25	.12	.14
3	2179.90	61.67	.25	.27
4	3064.63	87.88	.38	.39
5	4068.22	115.51	.50	.52
6	5057.46	143.20	.63	.65
7	6072.47	171.23	.76	.78
8	7013.69	198.35	.88	.90
9	8138.19	230.29	1.02	1.05
10	9091.13	256.76	1.14	1.16
11	10031.78	284.01	1.27	1.29

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	7829.71 lbs/V	222.54 ME/V		7774.24 lbs/V	220.96
Offset	132.05	4.02		22.77	.91
Corr Coe	.999879	.999883		.999982	.999988

Force Strain Calibration
EA Factor 35183.23 Kips
Offset -9.35
Corr Coe .999989

Cycle No. 2

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	31.33	-.03	.00	.00
2	1399.29	39.21	.17	.17
3	2239.63	63.76	.28	.28
4	3356.37	95.13	.42	.43
5	4097.15	115.51	.52	.52
6	5201.30	147.67	.67	.67
7	6054.82	171.36	.77	.78
8	7099.24	201.40	.91	.91
9	8052.01	227.86	1.03	1.03
10	9159.38	259.15	1.17	1.17
11	10162.51	287.67	1.30	1.30

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	7756.55 lbs/V	221.33 ME/V		7764.79 lbs/V	221.56
Offset	55.71	1.22		44.06	.88
Corr Coe	.999980	.999975		.999982	.999988

Force Strain Calibration
EA Factor 35045.17 Kips
Offset 13.17
Corr Coe .999992

Cycle No. 3

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	45.68	.02	.00	.00
2	1035.23	28.75	.11	.12
3	2191.40	60.85	.25	.26
4	3075.81	86.39	.37	.38
5	4082.33	115.10	.50	.51
6	5151.53	145.30	.64	.65
7	6067.86	171.46	.76	.77
8	7078.49	199.81	.89	.90
9	8198.64	230.84	1.03	1.04
10	9125.22	257.61	1.15	1.16
11	10220.77	287.58	1.29	1.30

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	7800.66 lbs/V	221.87 ME/V		7774.99 lbs/V	221.14
Offset	148.49	3.53		93.85	1.97
Corr Coe	.999892	.999870		.999965	.999964

Force Strain Calibration
EA Factor 35157.58 Kips
Offset 24.63
Corr Coe .999989

Bridge Excitation: 6.4 Volts
A 60.4K Ohm shunt resistor produces 5.0 Volts output.

	Bridge 1	Bridge 2
Calibration Factor:	221.91 ME/V	221.22 ME/V
EA Factor	: 35128.66 Kips	

$$A = \frac{EA}{E} = \frac{35128.66}{30,000} = 1.17 \text{ in}^2$$

Calibrated by: Paul T Kicher
Paul T. Kicher

Calibrated on: 28-Jul-97
Traceable to N.I.S.T.

Thomas P. Kicher & Co.
2920 Canterbury Court
Willoughby Hills, OH 44092
Phone (216) 944-9371

Calibration Data Sheet for SPT rod #:54 AW
Calibrated: July 28, 1997

The calibration data furnished herein (the "Calibration Data") was obtained using load cells that were calibrated according to traceable N.I.S.T. standards. Thomas P. Kicher & Co. makes no representations and gives no advice as to the use of the Calibration Data or the use of any equipment calibrated using the Calibration Data. Thomas P. Kicher & Co. is providing no professional, engineering or other advice or services other than obtaining the Calibration Data.

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Calibration Data Sheet for SPT rod #:50 NW
Calibrated: 25-Jul-97

#50 NW Rod

Cycle No. 1

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	-19.90	-.01	.00	.00
2	1015.32	13.13	.06	.07
3	2623.32	36.72	.17	.17
4	3301.76	46.54	.21	.22
5	4065.66	57.87	.26	.27
6	5357.56	76.81	.35	.35
7	6000.00	86.35	.39	.40
8	7364.78	106.61	.48	.49
9	8464.98	122.46	.56	.56
10	9529.76	137.71	.63	.63
11	10023.52	145.32	.66	.67

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	15070.31 lbs/V	218.59 ME/V		15034.36 lbs/V	218.05
Offset	83.71	.11		25.09	-.74
Corr Coe	.999933	.999994		.999978	.999980

Force Strain Calibration
EA Factor 68944.27 Kips
Offset 76.18
Corr Coe .999937

Cycle No. 2

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	8.49	.17	.00	.00
2	1149.81	15.90	.06	.07
3	2174.04	30.97	.13	.14
4	3025.86	43.39	.18	.20
5	4101.32	59.34	.26	.27
6	5282.16	76.46	.33	.34
7	6114.37	88.79	.39	.40
8	7066.88	102.81	.45	.46
9	8089.94	117.72	.52	.53
10	9131.74	133.06	.59	.60
11	10074.89	146.70	.65	.66

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	15121.74 lbs/V	219.89 ME/V		15085.27 lbs/V	219.35
Offset	203.88	2.38		56.04	.23
Corr Coe	.999799	.999886		.999953	.999978

Force Strain Calibration
EA Factor 68774.24 Kips
Offset 40.15
Corr Coe .999987

Calibration Data Sheet for SPT rod #:50 NW
Calibrated: 25-Jul-97

Cycle No. 3

Sample No.	lbs	ME	Bridge 1 Volts	Bridge 2 Volts
1	-15.51	.00	.00	.00
2	1635.47	22.43	.10	.11
3	2295.04	32.24	.15	.16
4	3192.80	45.14	.21	.21
5	4257.95	60.68	.28	.29
6	5081.68	72.92	.34	.34
7	6091.52	87.34	.40	.41
8	7150.23	103.20	.47	.48
9	8050.33	115.88	.53	.54
10	9169.61	132.43	.61	.61
11	10476.76	151.41	.70	.70

Bridge 1	Force Cal	Strain Cal	Bridge 2	Force Cal	Strain Ca
Cal Factor	15017.48 lbs/V	216.76 ME/V		14984.46 lbs/V	216.27
Offset	50.13	-.08		-24.90	-1.15
Corr Coe	.999968	.999998		.999992	.999956

Force Strain Calibration
EA Factor 69281.86 Kips
Offset 55.49
Corr Coe .999962

Bridge Excitation: 6.4 Volts
A 60.4K Ohm shunt resistor produces 5.0 Volts output.

	Bridge 1	Bridge 2
Calibration Factor:	218.41 ME/V	217.89 ME/V
EA Factor :	69000.13 Kips	

$A = \frac{EA}{E} = \frac{69000}{30000} = 2.3 in^2$

Calibrated by: Paul T Kicher
Paul T. Kicher

Calibrated on: 25-Jul-97
Traceable to N.I.S.T.

Thomas P. Kicher & Co.
2920 Canterbury Court
Willoughby Hills, OH 44092
Phone (216) 944-9371

Calibration Data Sheet for SPT rod #:50 NW
Calibrated: July 25, 1997

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APPENDIX C

Suggested Forms

SPT System ID #: 59 **Boring No.:** 3

Company & office location: FDOT Lake City

Test Location: Lake City FDOT Maint. Yard

Date: 1/25/99 11:55am

Driller name (yrs exper.): E. Jordan (25)

Method of Drilling: Rot. Wash Drilling Fluid: Bentonite

Rod Type: AW (instrumented rod area, in² = 1.17)

SPT Analyzer Operator: J.P.M.

Accelerometer 1 (A1): 577 / 435 (number/calibration)

Accelerometer 2 (A2): 549 / 395 (number/calibration)

Force 1(F1) / Force 2(F2): 221.91 / 221.22 (calibrations)

Rig Make & year: CME 45B, 1984, ATV rig

Rig Serial No.: 163544 Company Rig ID: FDOT #8352

Hammer Type & ID#: Safety Condition: good

Lifting Mechanism: rope & cathead

Diam. & Cond. Of Rope: 3/4" good, slightly worn Circumf. Of Cathead: 25 in

Reference Datum: ground surface Test Units: English

Weather: Sunny, about 70°

Notes:

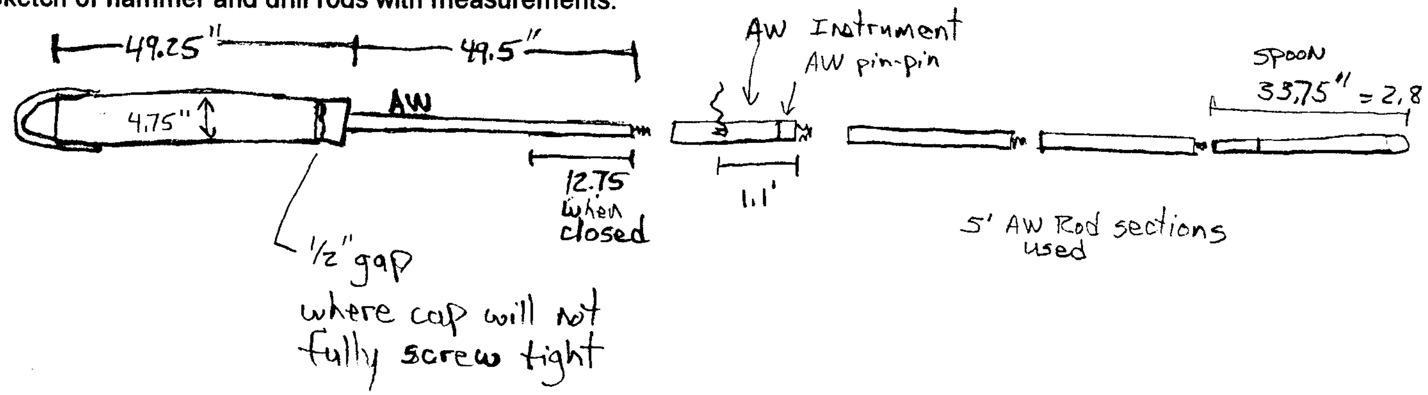
Analyzer file name	Rod Length (ft)	Depth at start of run (ft)	Faulty Sensors	Trigger Sensor	SX	Observed Hammer drop ht (in)	Number of wraps or RPM	Visual soil class-ification	Blows	Incre-ment	Misc. Comments
59-3a	13.9	10.0	A2	F2	1	32" +/-	2 1/4	tan-brown sand with silt (SP-SM)	2	6-in	A1 not functioning properly
									4	12-in	A2 looks okay
									4	18-in	
59-3b	18.9	15.0	A2	F2	1	31.5"	2 1/4	brown silty fine sand (SM)	7	6-in	A2 okay, A1 bad
									8	12-in	good rope throw
									12	18-in	
59-3c	23.9	20.0	–	F2	1	30.5"	2 1/4	brown clayey fine sand (SC)	4	6-in	hammer drop ranged from 30"
									7	12-in	to 32"
									11	18-in	
										6-in	
										12-in	
										18-in	
										6-in	
										12-in	
										18-in	

Note: Analyzer file names should correspond to the BORING entry on the Project Description Screen (see Figure 3.5)

Rod Length: measured from gages to tip of sampler
Depth: measured from point of reference to tip of sampler

Additional System/Test Information for System # 58

Sketch of hammer and drill rods with measurements:



Other Notes:

This hammer is seldom used. It is a back-up on the rig normally using an automatic hammer.

SPT System ID #: ____________ ***Boring No.:*** ________

Company & office location: ____________

Test Location: ____________

Date: ____________

Driller name (yrs exper.): ____________

Method of Drilling: ________ Drilling Fluid: ________

Rod Type: ____________ *(instrumented rod area, in^2 =)*

SPT Analyzer Operator: ____________

Accelerometer 1 (A1): ____________ (number/calibration)

Accelerometer 2 (A2): ____________ (number/calibration)

Force 1(F1) / Force 2(F2): ____________ (calibrations)

Rig Make & year: ____________

Rig Serial No.: ____________ Company Rig ID: ________

Hammer Type & ID#: ____________ Condition: ________

Lifting Mechanism: ____________

Diam. & Cond. Of Rope: ____________ Circumf. Of Cathead: ________

Reference Datum: ____________ Test Units: ________

Weather: ____________

Notes: ____________

Analyzer file name	Rod Length (ft)	Depth at start of run (ft)	Faulty Sensors	Trigger Sensor	SX	Observed Hammer drop ht (in)	Number of wraps or RPM	Visual soil class-ification	Blows	Incre-ment	Misc. Comments
										6-in	
										12-in	
										18-in	
										6-in	
										12-in	
										18-in	
										6-in	
										12-in	
										18-in	
										6-in	
										12-in	
										18-in	
										6-in	
										12-in	
										18-in	

Rod Length: measured from gages to tip of sampler
Depth: measured from point of reference to tip of sampler

Additional System/Test Information for System # ________

Sketch of hammer and drill rods with measurements:

Other Notes:

APPENDIX D

Summary Steps for Test Procedures

SUMMARY STEPS FOR TEST PROCEDURE
(from Chapter 3)

3.1 Prepare Work Area and Equipment

3.1.1 Initial Site Setup

1. Locate the work area for the SPT Analyzer.
2. Record information about the SPT System (hammer, rig, driller, etc.). Use forms in Appendix B.
3. Measure/mark safety hammer drop height.
4. Direct the drill crew to perform at least two SPT samples prior to taking energy measurements if they have not previously conducted testing that day.
5. Connect one end of the power cable to the analyzer and the other to the vehicle battery.
6. Select the appropriate instrumented drill rod, AW or NW.
7. Attach two accelerometers to the instrumented drill rod by bolting them to the predrilled holes.
8. Connect the gauge cables to the pigtail and make note of the cable channel.
9. Connect the Analyzer to the pigtail cable using the main cable.

3.1.2 Prepare the Analyzer – Input Information

10. Turn on Analyzer.
11. Introductory (Start-up) Screen.
12. Project Description Screen.
13. Confirmation Screen.
14. Rod Length Screen.
15. Depth Screen.
16. Transducer Screen.
17. Confirmation Screen.
18. Confirmation Screen.

3.1.3 Connect the Instrument to the Drill String

19. Connect the instrument to the drill string.
20. Attach the hammer and anvil.

3.2 Acquire Data

3.2.1 Record the SPT Energy Data

21. Collect Screen.
22. Check Sensors in the PAUSE Box and toggle to ACCEPT.
23. Direct the drillers to perform the SPT.
24. Observe/monitor the incoming data.
25. Press INCR box each time the sampler advances the designated increment.
26. Press ACCEPT box to toggle it to PAUSE at end of test.
27. Note/Record the appropriate information on the test form.
28. Recover the split spoon sample, visually classify the soil, and record this on the form.

3.2.2 Prepare for Next Test

29. Determine if downloading is required before next test.
30. Use the Review screen to observe previously recorded data, if desired.
31. Recheck the gages to ensure the connections are secure and the accelerometer bolts tight.
32. Turn the Analyzer off and then back on to begin entering data for the next test.

3.3 Download Data to PC

33. Connect the Analyzer to the PC with the serial port cable, install the key to the PC, and turn on the Analyzer.
34. Start the computer (PC) and the SPT-PC program.
35. Determine to which SPT-PC save locations the Analyzer data will be saved.
36. Instruct the Analyzer to send data to the PC.
37. Instruct the PC to read the Analyzer files.
38. Use the keyboard's left and right arrow keys to select the SPT ID to read.
39. Confirm or modify the specified "Using Save Locations (SL)".
40. Execute the command to read file by highlighting and selecting the "RF-Read SPT Analyzer Records" option.
41. To download additional data sets, go back and repeat the steps beginning at step 35.
42. If all data has been downloaded, the Analyzer's memory may be cleared.