



***Viking 6.0 Software Instruction Manual***  
*for*  
***DOCTer Impact-Echo Test System***

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## 1. Introduction

The Viking 6.0 software is as of July 1<sup>st</sup>, 2003, used for Germann Instruments DOCTer impact-echo test systems.

The software requires only one PCMCIA card installed in a laptop. The card is the 2 channel NI 5102 card, 20 MS/s and 8-bit Digitizer.

The same card is also used for s'MASH Impulse Response testing.

In this manner the DOCTer impact-echo systems can be supplied separately, or as an integral part together with the s'MASH Impulse Response system in the same laptop.

With the one-channel DOC-500 system, regular Impact-Echo testing can be performed for thickness measurement or flaw detection once the P-wave speed has been estimated by calibration over a solid portion of the member where the thickness is known. This calibration procedure usually requires drilling out of a core or drilling of a hole, unless testing can be made close to an edge where the thickness can be measured. Performed in this manner the best accuracy of the estimates of the thickness measurements or depth of flaw is +/-1.5%.

The two-channel DOC-1000 (comes without Laptop) and DOC-2000 (comes with Laptop) allow non-destructively the P-wave speed to be estimated on the surface of the member as stated in the ASTM C 1383-98 standard prior to thickness measurement or detection of flaws. The best accuracy of the thickness estimates or depth of flaws based on this procedure is +/-3%. In practice, this accuracy can be reduced to +/-1.5% by calibration in parallel of the P-wave speed at locations where the thickness of the member tested is known.

The depth of surface opening cracks can also be measured with the two channel DOC-1000 or DOC-2000 systems.

The DOC-500 and the DOC-1000 require ones own laptop installed with the PCMCIA card and the Viking 6.0 software.

The DOC-2000 has the same setup as the DOC-1000 but is including a Pentium Laptop with installed PCMCIA card and the Viking 6.0 software, ready to use.

On the following pages the Viking 6.0 software is outlined in detail.

The hardware is described in separate manuals, the "Operation and Maintenance Manual for the DOCTer Impact-Echo Systems".

To perform the testing the theory of impact-echo testing has to be read and understood. For this purpose the NOTES are supplied.

Testing cases are, furthermore, supplied in a separate manual from Germann Instruments. This manual also contains a recommended testing procedure.

A two-day course is offered separately in impact-echo testing by Germann Instruments.

## 1.1 About the Viking 6.0 software

The VIKING software, Version 6.0, allow testing for thickness of concrete plates or plate-like structures with the DOCTer Impact-Echo Test System according to the ASTM C 1383-98: "Standard Test Method for Measuring the P-wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method" Appendix D.

The software can also be used for testing of flaws in plates or other structural elements like layered plates, columns, beams and ring structures, once the solid and flaw frequencies have been calculated and identified for the actual frequencies to be compared to.

In addition, the depth of surface opening cracks can be estimated with the software.

In this manual the operation of the VIKING 6.0 software is described step-by-step. An example from testing the thickness of a slab, outlines the procedure for making a file, calibration of the wave speed, testing for thickness of plates, examining the data, changing records and printing of a report.

Once the general flow through the software is understood and the single steps have been practiced, the VIKING software should be fairly easy to handle.

The software allows a quick evaluation of the measured frequency in relation to the calibrated one. This feature can be used for speedy evaluation if thickness measurements are within pre-set limits or for flaw detection.

The test results are stored in a grid and special operations like clipping of the R-wave, or analyzing a portion of the transducer displacement waveform, can be done automatically during testing. These special features of the VIKING software makes it possible to test a structure in an organized and quick manner, at the same time that the efforts spend afterwards at the office for analysis of the test results and printing of a report are minimized.

However, such speedy testing requires that the proper homework be done. It is important to carefully plan the testing before going on-site. The testing problem needs to be specified, drawings and other relevant information collected, calculations made of the expected frequencies for the actual ones to be compared to, the testing grid decided upon and the correct hardware selected. Based on the expected frequency to be measured and the needed accuracy, the transducer displacement parameters the time between samples (points) and the number of samples (points) are decided about.

**NOTE:** Once the time between samples has been selected in the setup no change can be made during testing. Only the number of samples (points) can be changed (512, 1024 or 2048 points).

Testing on-site requires the same kind of skills. Pre-testing has to be made to make sure the testing problem can in fact be solved. Estimation of the P-wave speed is required if accurate results are needed. During or after testing, on-site, it is important to confirm the test results, e.g. by coring.

## **2. Installing and uninstalling the PCMCIA card, the card driver and the Viking software**

### ***2.1 Installing the PCMCIA card, card driver and the Viking 6.0 Impact-Echo software from the VIKING 6.0 CD-ROM in a Laptop***

Computer requirements: Windows 95 and up, Pentium 300 MHz and above, min. 32 MB RAM, with CD-Drive and Floppy Disk Drive. **The following instructions are for Windows XP.**

**Insert the PCMCIA card loosely in one of the laptop slot, but do not connect it until instructed.**

#### **INSTALLING THE PMCIA CARD AND CARD DRIVER**

- 2.1.1 Turn on the computer
- 2.1.2 Insert the Viking 6.0 CD in the CD drive
- 2.1.3 Wait until National Instruments Scope Software CD is on the desktop
- 2.1.4 Click Install Software
- 2.1.5 Click Next in the Welcome screen
- 2.1.6 Click Accept in License Agreement
- 2.1.7 In Select Installation Type highlight Interactive Support Only and click Next
- 2.1.8 In Start Installation click Next
- 2.1.9 Wait until Installation Completed is on the screen. It takes several minutes
- 2.1.10 Click the View Readme File button so it is unchecked. A checkmark has to be in the Restart Windows button
- 2.1.11 Click Finish
- 2.1.12 In Install click the OK button to restart the computer
- 2.1.13 When the computer is off, connect the PCMCIA card in one of the slots
- 2.1.14 "Found new Hardware" will come up for first time installation
- 2.1.15 Complete the "Found new Hardware Wizard", press "Finish"
- 2.1.16 Found new Hardware – your hardware is ready for use
- 2.1.17 Double click the icon on the desktop "Measurement and Automation". Updating configuration data will take place automatically. In User Preference click OK, and close the Measurement and Automation Explorer screen

#### **INSTALLING THE VIKING 6.0 IMPACT-ECHO SOFTWARE**

- 2.1.18 The Viking CD-Rom is still in the D-drive. Go from Start to Run
- 2.1.19 In Run type D:\viking\setup.exe and press OK
- 2.1.20 In Viking 6.0 Setup click OK
- 2.1.21 In Viking 6.0 Setup click the setup button icon
- 2.1.22 In Viking 6.0 – Choose Program Group, the Program Group highlighted has to be Viking 6.0 and in Existing Groups also the Viking 6.0. Press Continue
- 2.1.22 Press OK in Viking 6.0 Setup confirming that Viking 6.0 Setup was completed successfully
- 2.1.23 In Start and All Programs selecting the Viking 6.0. Make a right mouse click on the icon. Select Send To Desktop and click. The Viking 6.0 icon will be on the desktop
- 2.1.24 Double click the Viking 6.0 icon on the desktop
- 2.1.25 The Viking – Unlocking screen comes up. Fill in the registration, connect the laptop to a printer and print.
- 2.1.26 The following page illustrates such a printout with Software ID #1 and ID #2. Upon receipt by Germann Instruments the Unlock Key number will be returned by fax or by e-mail.



## Viking Software v. 6.0

### Request for Unlock key

Company: NDT #1, Ltd.  
2284 Flaw Street  
Test Town  
USA

Contact Person: Mr. A. Wright

Telephone number: (667) 453 7656

Fax number: (667) 453 7657

email address: NDT#1@adm.org

Program Serial number #: 4064

**Software ID #1: 315787573**

**Software ID #2: 839180**

**Unlock Key:** \_\_\_\_\_

**Send this page by fax to: GERMANN INSTRUMENTS A/S, Denmark**

*FAX: +45 - 3967 3167*

**or e-mail the information to: [germann@post6.tele.dk](mailto:germann@post6.tele.dk)**

The unlock key number will be returned from Germann Instruments A/S between GMT 09.00 to 16.00 on normal working days

- 2.1.27 Double click Viking 6.0 icon on the desktop. Click Apply unlock key. For the two ID numbers in question, type in the Unlock Key number given by Germann Instruments, and click Unlock.
- 2.1.28 A confirmation stating that the Viking software is Unlocked is given. Click OK.
- 2.1.29 The Viking software is now operational. Double click the Viking 6.0 icon on the desktop. The VIKING MAIN MENU page 12 will turn up.
- 2.1.30 Proceed after connection of the testing unit to the computer as outlined on page 12 and onwards.

**Two installations can be made with the Viking software, one for the computer to be tested with and one for an office laptop for analyzing the test results and making a test report. Each installation of the Viking software needs a separate unlocking key number.**

**NOTE:** The procedure for installing the extra installation is identical to the procedure in section 2.1. To perform the installation the PCMCIA card is needed. To release the card from the field computer unthread first the two screws on the top lid of the two channel connector box, then turn the computer upside-down and unthread the other two screws. Gently disconnect the jack from the card. Be careful not to break the cords connected to the jacks. Release the card. After installation of the software in the office laptop, remove the PCMCIA card, reinsert it in the field laptop and reassemble the parts in the reverse order.

The office laptop without PCMCIA card will not be able to conduct testing, but will be able to examine records and print and to use the file utilities once test data has been transferred to the office laptop from the field laptop. .

**NOTE:** More than two installations of the Viking software will only be given after an installation charge has been paid to Germann Instruments.

## ***2.2 Uninstalling the PCMCIA card, card driver and Viking 6.0 Impact-Echo software***

Unless the card and card driver are shared by other software and in use, e.g. for the s'MASH Impulse Response Test, the uninstalling takes place as follows:

The card is connected to the laptop in one of the slots

### **UNINSTALLING THE PCMCIA CARD AND THE CARD DRIVER**

- 2.2.1 Turn on the computer
- 2.2.2 Go from Start to Control panel
- 2.2.3 Click Add or Remove programs
- 2.2.4 Click NI Measurement and Explorer 2.2.0
- 2.2.5 Click Remove
- 2.2.6 Click Yes in the National Instruments Installer
- 2.2.7 NI Scope 2.1.2 is highlighted in Add or Remove Programs
- 2.2.8 Click the Change/Remove button
- 2.2.9 Choose Automatic and click Next in Select Uninstall Method

- 2.2.10 In Perform Uninstall click Finish
- 2.2.11 NI-DAQ 6.9.2 is highlighted in Add or Remove Programs
- 2.2.12 Press the Remove button
- 2.2.13 Press Yes as answer to the question “Are you sure you wish to uninstall the application”
- 2.2.14 Wait until the uninstalling is completed
- 2.2.15 NI-Scope Soft Front Panel 1.5f6 is highlighted. Press the Change/Remove button
- 2.2.16 Choose Automatic and press Next in Select Uninstall Method
- 2.2.17 In Perform Uninstall click Finish
- 2.2.18 NI-VISA 2.5.2 is highlighted in Add or Remove Programs, click Change
- 2.2.19 In NI-VISA 2.5.2. Setup click Remove All
- 2.2.20 In NI-VISA Uninstall click Next
- 2.2.21 In NI-VISA 2.5.2. Setup the message NI-VISA 2.5.2. has been successfully uninstalled is shown. Click the Finish button
- 2.2.22 Remove the card from the slot

### **UNINSTALLING THE VIKING 6.0 SOFTWARE**

- 2.2.23 In Add or Remove Programs highlight Viking 6.0.
- 2.2.24 Click the Change/Remove button
- 2.2.25 Click Yes in Application Removal
- 2.2.26 Click OK in Application Removal
- 2.2.27 Exit Add or Removal Programs
- 2.2.28 Exit Control Panel
- 2.2.29 Delete the Viking 6.0 icon on the desktop
- 2.2.30 Restart the computer

### 3. The Viking Flow Chart

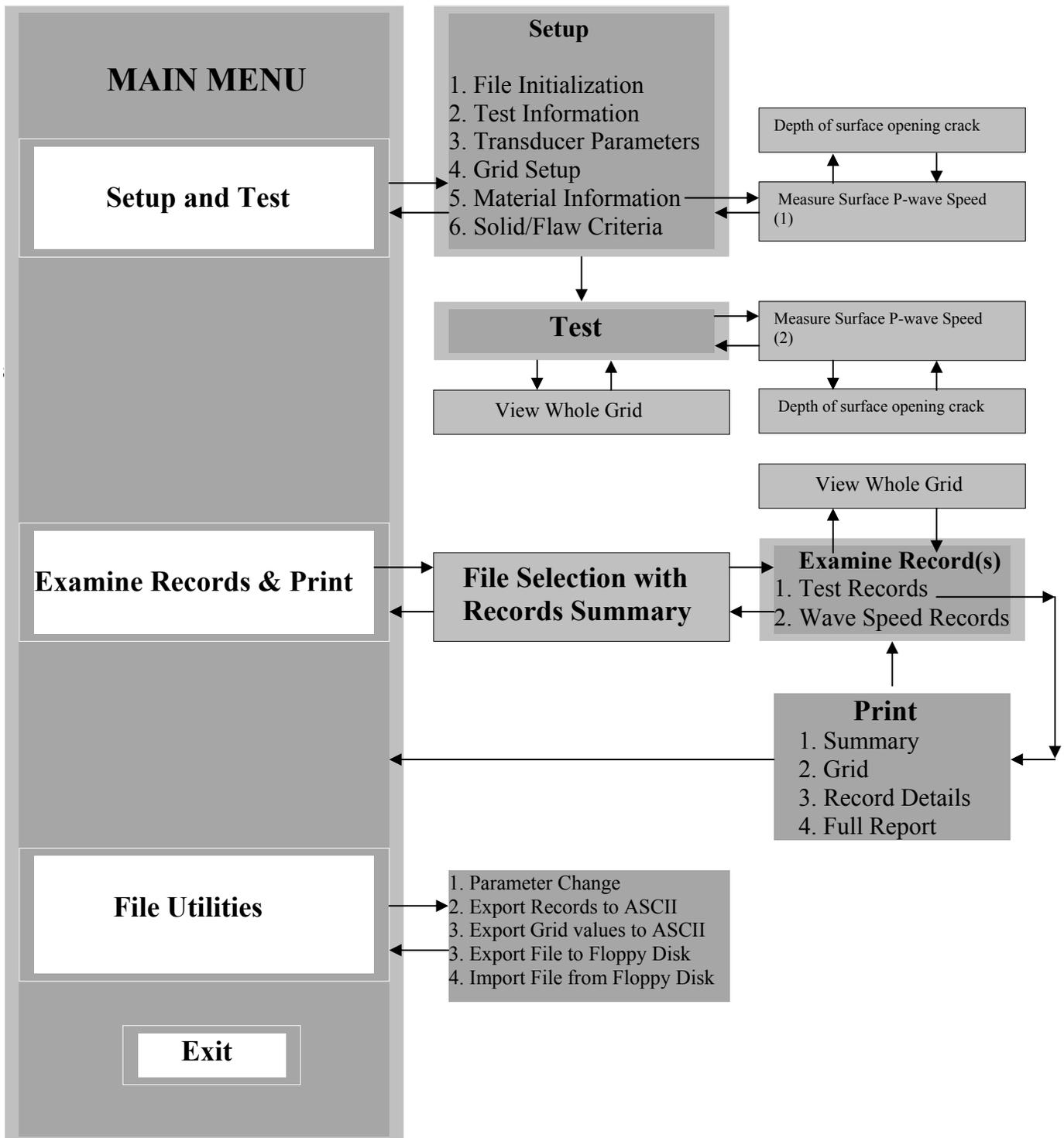


Fig.1. The Viking Flow Chart

Connect the transducer unit(s) to the channel(s), and turn the transducers on. Follow the instructions in the Operation and Maintenance Manual.

Turn on the computer. Wait until the VIKING icon is on the screen. Double click the icon. The Viking Main Menu will be shown.

#### 4. The Viking Main Menu



*Fig.2. The Viking Main Menu*

The main menu has four options: “Setup and Test”, “Examine Records and Print”, “File Utilities” and “Exit”.

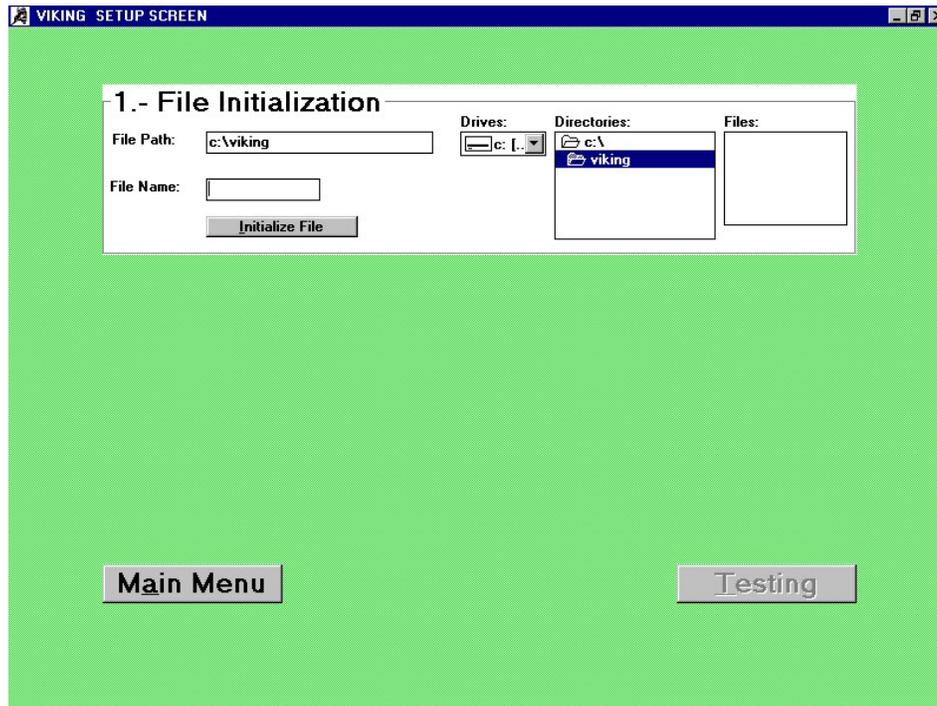
One click on a button will produce the screens in a sequence as shown in the Viking Software Flow Chart, fig.1, page 11. Alternatively, the “Alt”-key can be pressed on the keyboard followed by pressing the underlined letter in the button. This procedure is constant throughout the VIKING.

During on-site testing, only the “Setup and Test” option is normally used. The “Examine Records and Print” and “File Utilities” are for final analysis of the test results and printing of the report at the office.

## 4.1 Setup and Test

Clicking the “Setup and Test” button will produce the Viking Setup Screen with the File Initialization dialog box as shown in fig. 3.

### 4.1.1 VIKING SETUP SCREEN (File Initialization Dialog Box)



*Fig.3. The Viking Setup Screen (file initialization dialog box)*

The file path is shown ("c:\viking"), the drive ("c:"), the directory ("c:\viking", with the folders opened), the files, the file name with a cursor blinking in the box and a button named "Initialize File".

Directions for choosing another drive are given in Appendix A.

#### 4.1.1.1 File Name

To make a file, type the file name (max. 8 characters) in the file name box after the blinking cursor. Make sure the file name is correct. Otherwise, adjust it. Press the Enter-key or click on the "Initialize File" button.

The "Initialize File" button will change to "File Initialized" and the remaining part of the Viking Setup Screen will be exhibited, fig. 4.

#### 4.1.2 VIKING SETUP SCREEN (the complete screen)

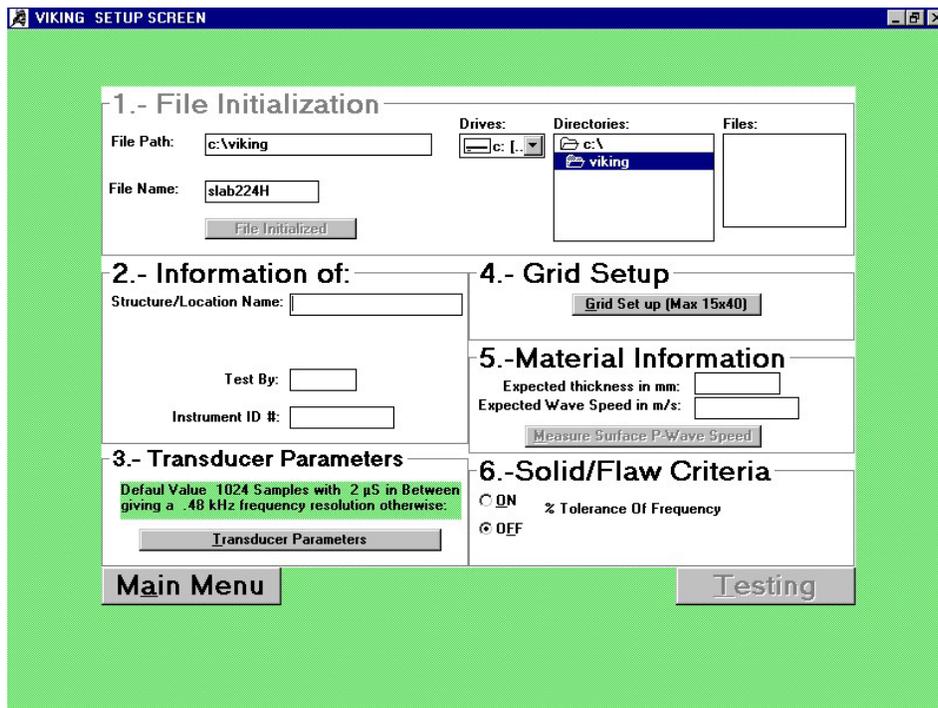


Fig.4. The Viking Setup Screen (the complete screen) after a file has been initialized

The cursor is blinking in the Structure/Location Name box, ready for the information to be typed in.

#### ***Slab example:***

*The testing example used in the following for illustration of the software is from testing the thickness of a slab. The slab has been cast on a compacted sand/gravel bed with a sheet in-between the slab and the substrate. The design thickness is 200 mm with a required minimum of 185 mm. The size of the slab section to be tested is 10 x 40 meters. It is decided to make 600 test points by dividing the slab into a grid of 15 columns and 40 rows (spacing between test points will be 0.6 meter by 1 meter).*

## 4.1.2.1 Information of

### 4.1.2.1.1 Structure/Location Name

The information is typed in, maximum twenty (20) characters. Press the Enter-key. The cursor moves to the next box.

### 4.1.2.1.2 Test by

The initials of the technician/engineer in charge of the testing are typed in, maximum five (5) characters. Press the Enter-key. The cursor moves to the next box.

### 4.1.2.1.3 Instrument ID #

Type in the identification number of the DOCTer Impact-Echo test equipment used, maximum ten (10) characters. Press the Enter-key. The “Transducer Parameters” dialog box is highlighted.

## 4.1.2.2 Transducer Parameters

The transducer parameters are the number of samples and the time between samples forming the transducer displacement curve in the time domain, as well as the trigger voltage that makes the card(s) trigger.

Press the Enter-key once more and the Transducer Parameters screen will turn up, fig. 5.

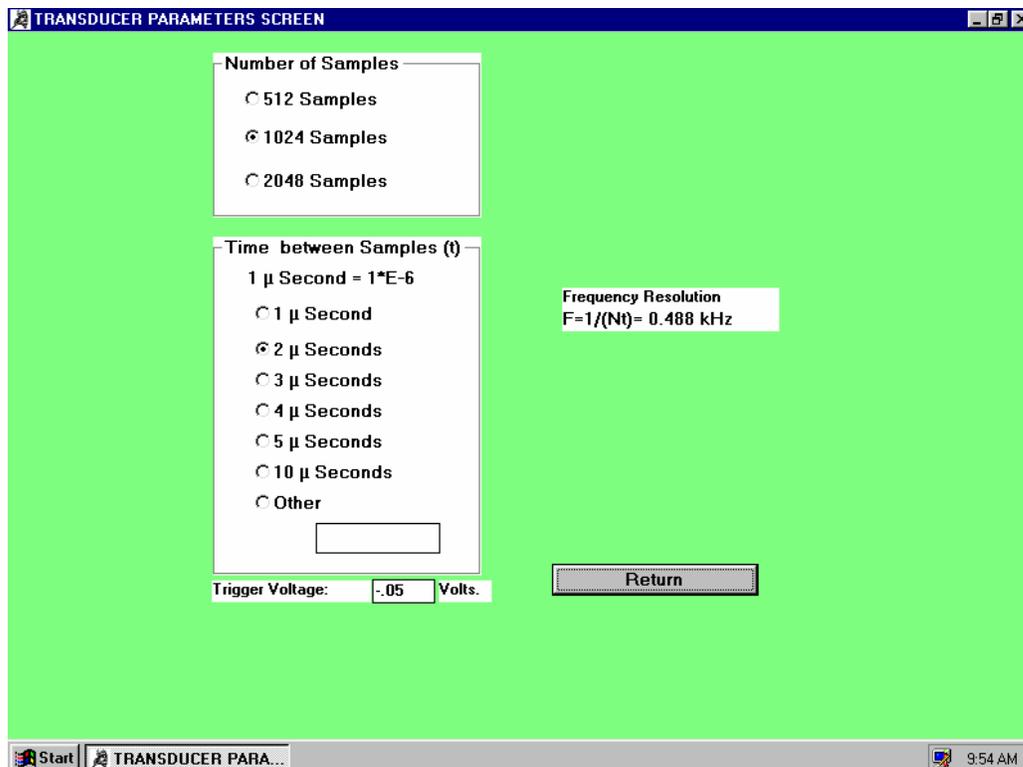


Fig. 5. The Transducer Parameter Screen

#### ***4.1.2.2.1 Number of samples and time between samples***

The default values of the transducer parameters are 1024 samples (points analyzed) and 2 microseconds between the sample points, to form the transducer displacement curve in the time domain. This produces a 0.488 kHz resolution in the frequency spectrum as illustrated in fig.5. These settings are the recommended ones for testing concrete plates with a thickness between, about, 50 mm to 200 mm (frequency range of about 40 kHz to 10 kHz, for a wavespeed of 4000 m/s).

Should a higher resolution on the frequency spectrum be required, e.g. when testing thicker structures or materials with lower wavespeeds, or if a higher accuracy of the thickness estimate is needed, 2048 samples can be chosen with a longer time between samples. To select other settings, click once on the relevant settings.

2048 samples are always collected in a test. The number of samples analyzed can be changed to 512, 1024 or 2048 samples at any time during testing, but, once selected, the time between samples cannot be changed.

#### ***4.1.2.2.2 Trigger voltage***

The trigger voltage default value is -0.05 Volts. Maintain this value for all types of normal testing. A more negative value, -0.10 Volts to -0.20 Volts may be used should the transducer unit pre-trigger. Such pre-triggering may happen in moist conditions or when electrical or mechanical noises are present at the testing location. A lower trigger value than -0.30 Volts may not make the card(s) trigger, unless a powerful impact is made.

Make sure the transducer parameter settings are as required. Click the “Return” button and proceed to the “Viking Grid Setup” screen by pressing the Enter-key once more.

NOTE: Once the Grid Setup has been entered, the “Structure/Location Name”, “Tested by” and “Instrument ID #” can only be changed by means of the File Utilities. The “Transducer Parameters” box is disabled when entering the Grid Setup, and the time between samples as well as the trigger voltage cannot be changed, unless a new file is created.

#### ***Slab example, continued***

*The Structure/Location Name, Test by, Instrument ID # is typed in. The transducer parameters are set at 2048 samples, 2 microseconds in-between the samples and the default value of the trigger level at -0.05 Volts.*

*The 2048 samples with 2 microseconds in-between produce a 0.244 kHz frequency resolution, equivalent to a maximum systemic error, all other factors being constant, from the frequency measurement of  $e_f = \pm \Delta f / 2f = \pm 0.244 / 2 \cdot 10 = \pm 0.012 = \pm 1.2\%$  (see ASTM C 1383-98), with the frequency  $f$  of 10 kHz (4000 m/s divided by 2 times the thickness 200 mm).*

### 4.1.2.3 Grid Setup

The Viking Grid Setup screen is illustrated in fig.6.

#### 4.1.2.3.1 Grid Identification

Enter a identification of the grid - maximum four (4) characters - in the “Grid Identification” box after the blinking cursor. Press the Enter-key. The “Columns” box will become highlighted and active.

As shown in fig. 15 a maximum of 15 columns and 40 rows can be selected (max. 600 test points) in one grid or any smaller combination thereof. All 600 test results can be printed out on one page.

The columns can be chosen between A-O (15) and the rows between 1-40. Larger grids than 15 x 40 grid points have to be subdivided into smaller, appropriate-sized grids.

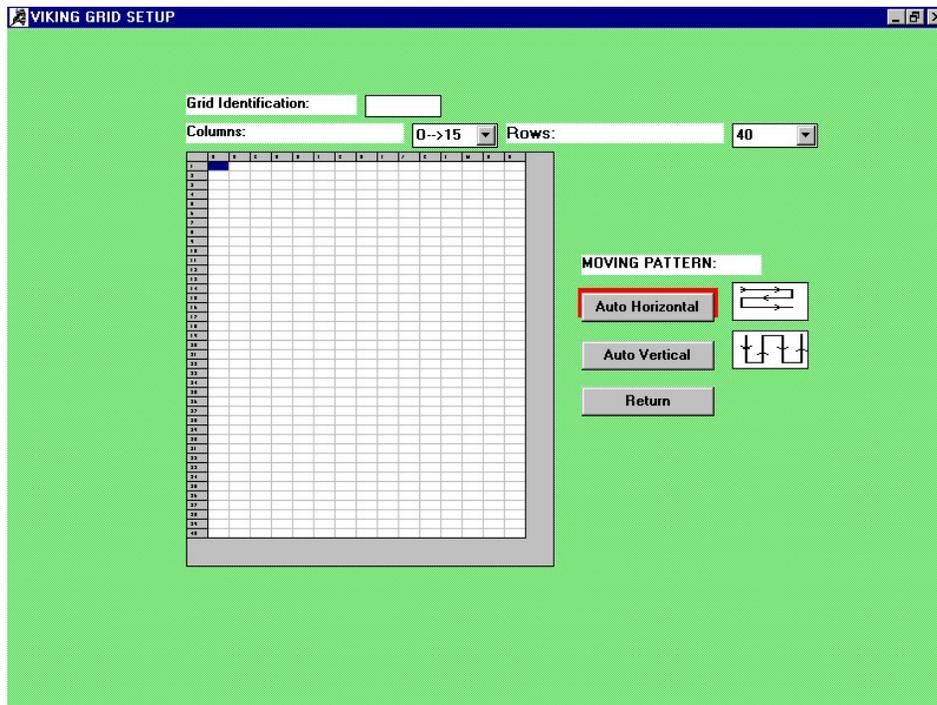


Fig 6. The Viking Grid Setup screen

Lay out the test grid on the surface to be tested, in columns and rows.

Using water-resistant chalk, clearly mark the columns with capital letters, starting with “A” and the rows with numbers starting with “1”.

Make absolutely sure every test point can be retrieved at a later stage, e.g. for re-testing, or for verification of the test results by coring, e.g. in relation to a fixed point.

Set the grid layout on the computer screen accordingly.

#### ***4.1.2.3.2 Number of columns in the grid***

Click once in the scroll button adjacent to the active column box. A pull-down menu is shown. Select the number of columns by one click on the capital letter followed by an arrow and the number of columns.

The number of selected columns is now illustrated in the grid layout on the screen. Make sure the number of columns is as required, otherwise correct. The number of rows is highlighted, ready to be specified.

#### ***4.1.2.3.3 Number of rows in the grid***

Activate the pull-down menu with one click on the adjacent scroll button. Select the number of rows by clicking on the desired number. The number of rows is illustrated in the grid layout.

NOTE: At this stage make sure the number of columns and rows are correct and matching the grid layout on the concrete surface. Upon returning to the setup screen, the Grid Setup is disabled, and no further corrections can be made except in File Utilities, section 4.3, where only the Grid Identification can be changed.

#### ***4.1.2.3.4 Moving pattern in the grid***

The general moving pattern during testing can be selected between “Auto Horizontal” and “Auto Vertical” as illustrated in fig. 6. Once the moving pattern has been decided upon, it has to be adhered to during testing. However, during testing, records can be jumped over, re-testing can be made at a location earlier tested at, and several records can be stored at the same test location.

The default value of the moving pattern is “Auto Horizontal”, indicated by the flashing red border. Should this pattern be the desired one, press the Enter-key for returning to the setup screen, or click the “Return” button.

If the “Auto Vertical” moving pattern is required, click once in the “Auto Vertical” button. The flashing red border highlights the window. Press the Enter-key for returning to the setup screen, or click once the “Return” button.

Upon returning to the Viking Setup Screen, the Grid ID is shown below the “Structure/Location Name” box. The number of columns and rows of the grid are stated in the Grid Setup dialog box below the “Grid Setup (Max 15x40)” button. This button is now disabled.

### ***Slab example, continued***

*The Grid ID number is entered. The grid of 15 columns and 40 rows, 0.6 m by 1 m between test points totaling 600 test points, is laid out quickly on the slab using elastic color strings for marking. Each test point is clearly labeled. The “Auto Horizontal” moving pattern is chosen.*

#### **4.1.2.4 Material Information**

##### ***4.1.2.4.1 Expected thickness in mm***

Upon returning to the Setup Screen, the cursor is blinking in the “Expected thickness in mm” box. Fill in the expected thickness in mm and press the Enter-key. The blinking cursor will move to the “Expected Wave Speed in m/s” box.

##### ***4.1.2.4.2 Expected Wave Speed in m/s***

###### ***4.1.2.4.2.1 Best-guess wave speed***

A wave speed known from earlier testing of a similar material can be used. Should the wave speed not be known, 4000 m/s could be used as the first, best guess for concrete. This first, best-guess wave speed will be supplanted if another wave speed is entered in the first test record (found by calibration against thickness) or if surface speed measurements have been recorded.

Once the first record has been stored, the wave speed value will not be altered.

###### ***4.1.2.4.2.2 Calibrating the wave speed for a known thickness***

The best-guess wave speed of 4000 m/s can, when testing starts out, be calibrated at a solid location of the plate where the thickness is known, using the equation  $C_p = 2 \cdot T \cdot f$  (the thickness “T” in mm, the frequency “f” in kHz and the apparent wave speed “C<sub>p</sub>” in m/s). This calibration is typically done initially, before storing of the first record takes place in the grid.

This procedure is the recommended one. The procedure is illustrated in figs. 10-12, p. 25-26.

###### ***4.1.2.4.2.3 Measure Surface P-wave Speed***

Alternatively, the wave speed can be estimated by measuring the P-wave speed on the surface with the Longship, provided the elastic properties of the surface are not different from the interior. This requires two transducers set at an internal distance of 300 mm with a 5 mm diameter impactor placed 150 mm from the first transducer on the line of the transducers, as with the Longship.

The obtained wave speed is the "true" wave speed, which in comparison to the "apparent" wave speed measured by Impact-Echo testing on a plate, is 4% higher.

The surface P-wave speed measurement procedure is outlined in Appendix B.

#### 4.1.2.4.2.4 Estimation of the depth of surface opening crack

From the "Measure Surface P-wave Speed" screen access can be made to estimate the depth of surface opening crack by clicking the screens "Crack Depth Measurement" button. The procedure is outlined in Appendix C.

#### 4.1.2.5 Solid/Flaw Criteria

The criteria can be used for thickness evaluation to indicate if the frequency (or the thickness) measured is within a pre-set tolerance of the calibrated. This application requires the plate to be solid.

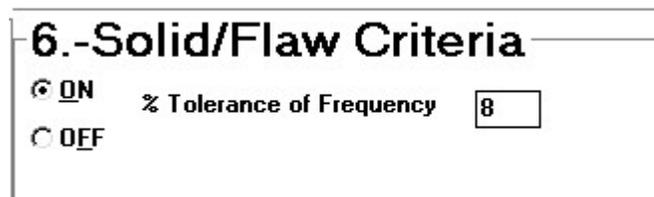
Alternatively, the criteria can be used for flaw detection provided the thickness of the plate is constant. Should a flaw be present, the measured frequency will be different from the calibrated one, all other factors being constant. The relative magnitude of this difference is used for evaluation.

The default value of the "Solid/Flaw Criteria" is "OFF".

Activation of the criteria takes place by clicking the "ON" button.

An additional box will appear to specify the tolerance percentage the measured frequency can deviate from the calibrated one.

The default value is  $\pm 6\%$ . Should another tolerance percentage be required, click in the box and type in the new value, fig. 7. The minimum value is  $\pm 2.1\%$ .



*Fig.7. The Solid/Flaw Criteria activated. An 8% tolerance level has been entered. If the measured frequency (or thickness) is outside  $\pm 8\%$  of the calibrated one, a highlighted "FLAW" is indicated on the testing screen. Otherwise, an "S" is shown ("S" for Solid).*

The grid has an option for illustrating the "F" and the "S". The "F's will be shown as "Flaw".

In setting the percentage tolerance, the inherent variation of the thickness estimate with the DOCTer has been taken into account. The ASTM C 1383-98 standard explains in details these systemic errors. Examples in Appendix B.

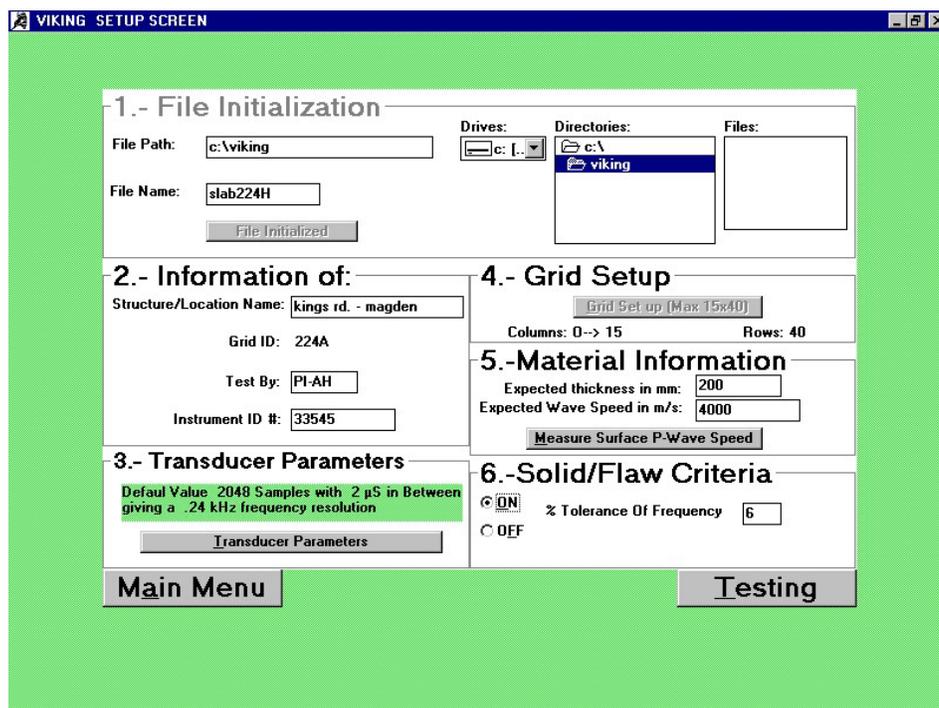
The Viking Setup Screen has been completed.

### *Slab example, continued*

*In the slab example, the expected thickness of 200 mm and a best-guess wave speed of 4000 m/s are entered.*

*The Solid/Flaw Criteria is activated and the tolerance level set at the default value,  $\pm 6\%$ . This means, that if the actual thickness measure is outside 188 mm and 212 mm, a "Flaw" will be indicated. Inside this tolerance, an "S" for "Solid" will be shown.*

The completed Viking Setup Screen is illustrated in fig. 8.



*Fig. 8. The Viking Setup Screen completed*

Clicking the "Testing" button in fig. 8 will produce the Viking Test Screen.

NOTE: The "Measure Surface P-wave Speed" window can be activated but only used with the Longship. .

### 4.1.3 Viking Test Screen

The Viking Test Screen is illustrated in fig. 9. The slab example is used for illustration.

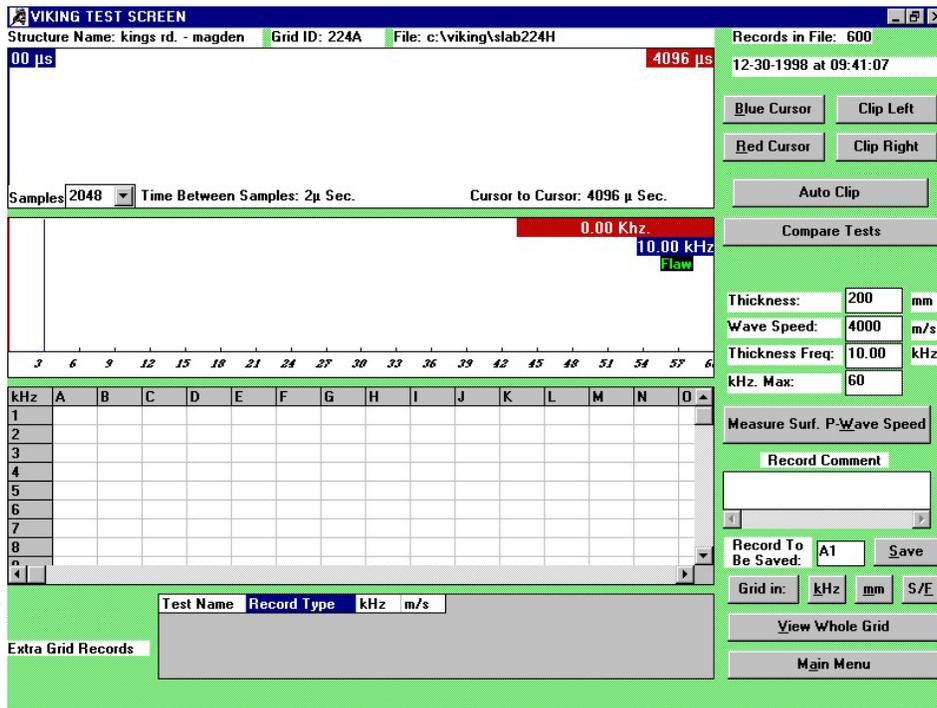


Fig.9. The Viking Test Screen

Below the information bar, containing the Structure Name, the Grid ID, the File, and the Records in Files, are, on the left side, the frames for the waveform, followed by the frequency spectrum frame, the frame with Grid Records and a frame with Extra Grid Records.

On the right side of the screen are buttons for clipping options, auto clipping and comparing tests.

Adjacent to the frequency spectrum frame are the thickness (expected), the wave speed used, and thickness frequency (the calibrated frequency) boxes.

A window for changing the maximum scale for the frequency spectrum is followed by buttons for measuring the surface P-wave speed and boxes for record comment, saving of the record, buttons for grid units and a button for viewing the whole grid.

The particulars of the frames, the boxes, and the buttons are given in the following.

#### 4.1.3.1 The waveform spectrum

In this frame, the transducer displacement in the time domain (volts on the vertical axis versus microseconds on the horizontal) will be plotted after a test is made.

The frame also contains two cursors (hidden in fig. 9) with a red flag and a blue flag. The flags of the cursors indicate the position of the cursors on the time axis. The cursors are used for clipping of, e.g. a

disturbing R-wave, or for cutting out a part of the waveform, if needed, or for measuring the contact time (the width of the R-wave).

Furthermore, the number of samples is indicated in this frame (2048 samples, optionally 1024 and 512 samples from the pull-down menu), the Time Between Samples, and the Cursor to Cursor value in microseconds. The cursor to cursor value is used, e.g. for measuring the width of the R-wave, or the time between two arrivals of the P-wave to the surface.

#### **4.1.3.2 Clipping options**

The blue cursor is activated by one click on the "Blue Cursor" button and the red cursor by one click on the "Red Cursor" button.

##### ***4.1.3.2.1 The "Clip Left" and the "Clip Right" buttons***

The main application of clipping is to remove the influence of the R-wave on the waveform in the frequency spectrum, or to select a certain part of the waveform for analysis.

After activation, the cursor is moved with the arrow keys "←" and "→" on the keyboard. For speed moving, the "Shift" key is pressed first, then the arrow keys. After the cursor has been positioned in the waveform spectrum as required, clipping can be made left of the cursor by clicking the button "Clip Left". The button name changes to "Restore Left". Another click on this button will remove the clipping and restore the "Clip Left" name.

Similarly, after clicking the "Red Cursor" button the cursor can be moved with the arrow keys and clipping of the waveform to the right by clicking the "Clip Right" button.

An example of clipping left and right is shown in fig. 13, p. 27.

##### ***4.1.3.2.2 The "Auto Clip" button***

Once a test result is on the screen and the blue and the red cursors have been positioned in the waveform spectrum as required, e.g. to remove the influence of the R-wave on the frequency spectrum or to analyze a certain portion of the waveform, auto clipping can be activated.

During testing, only the waveform between the cursors will be automatically analyzed into frequency, saving time later for analysis in the office. This is done by one click on the "Auto Clip" box. A red rectangle will start flashing around the button, which will change its name to "Stop Auto Clip". One click in the button will stop the auto clipping.

#### 4.1.3.2.3 The "Compare Tests" button

Clicking the "Compare Tests" button will produce a pop-up screen asking to enter the record name to be compared to. Enter the record name to be compared and click the "OK" window. When the next test result is on the screen the frequency spectrum of the chosen record will be exhibited as a green curve for the actual frequency spectrum to be compared to, see fig. 14, page 27. The "Compare Tests" button has been changed to "Remove Comparison". Clicking this button once will remove the comparison.

#### 4.1.3.3 The frequency spectrum (the amplitude spectrum)

Below the waveform frame is the frequency spectrum. This frame contains a frequency scale and a red and a blue box at the upper right corner.

The frequency scale can be changed between 5.1 kHz and 150 kHz by clicking in the box adjacent to the "kHz. Max." box. The default value is 60 kHz.

The **red box** in the frequency spectrum frame indicates the actual position of the movable, red cursor on the frequency scale in kHz, and, for the wave speed used, the related travel path in mm of the P-wave.

***Note that for flexural vibration (bending) the depth measure is not related to the travel path.***

In general, the red cursor will be placed automatically at the highest frequency peak in a 70% band around the calibrated frequency (the blue cursor frequency).

If needed, the red cursor is moved by first clicking somewhere in the frequency spectrum frame and then pressing the arrow keys, "←" & "→". By first activating the "Shift"-key and then one of the arrow keys, the red cursor will move from peak to peak in the frequency spectrum. When activating only the arrow keys, the red cursor will move in steps equivalent to the frequency resolution.

The **blue box** contains the calibrated frequency, the "bench-mark" frequency. This frequency is also shown in the adjacent "Thickness Freq." box. In the frequency spectrum, the blue "bench-mark" cursor is always positioned at the related kHz value. The position of this cursor can only be changed by altering either the thickness or the wave speed in boxes above the "Thickness Freq." box.

#### 4.1.3.4 Thickness, wave speed and thickness frequency

Adjacent to the frequency spectrum are boxes showing the expected thickness in mm and the wave speed in m/s as entered in the setup screen or as measured before the first record is stored. The related thickness frequency is also stated, calculated in fig. 10 as:

$$f = C_p / 2T = 4000 \text{ m/s} / 2 \cdot 200 \text{ mm} = 10.00 \text{ kHz}$$

**Calibration of the wave speed** is made at a solid location with known thickness. Fig. 10 show a test made at the A1 location of the slab where a thickness of 185 mm ( $\pm 2$ mm) was measured.

The exhibited frequency is 11.47 kHz. The calibrated wave speed is then:

$$C_p = f \cdot 2T = 11.47 \text{ kHz} \cdot 2 \cdot 185 \text{ mm} = 4244 \text{ m/s}$$

Fig. 11 and 12 illustrate the changing of the wave speed. First, the 4244 m/s is entered in the wave speed box and the "Enter"-key activated. Then, the parameter to be changed is chosen in the pop-out screen and the "Calculate" button is clicked on. The calibrated parameters are exhibited in fig. 12 as 200 mm for thickness, 4244 m/s as wave speed and the 10.61 kHz as the calibrated frequency. The blue cursor in the frequency spectrum is positioned accordingly, and the 10.61 kHz is exhibited in the frame's blue box.

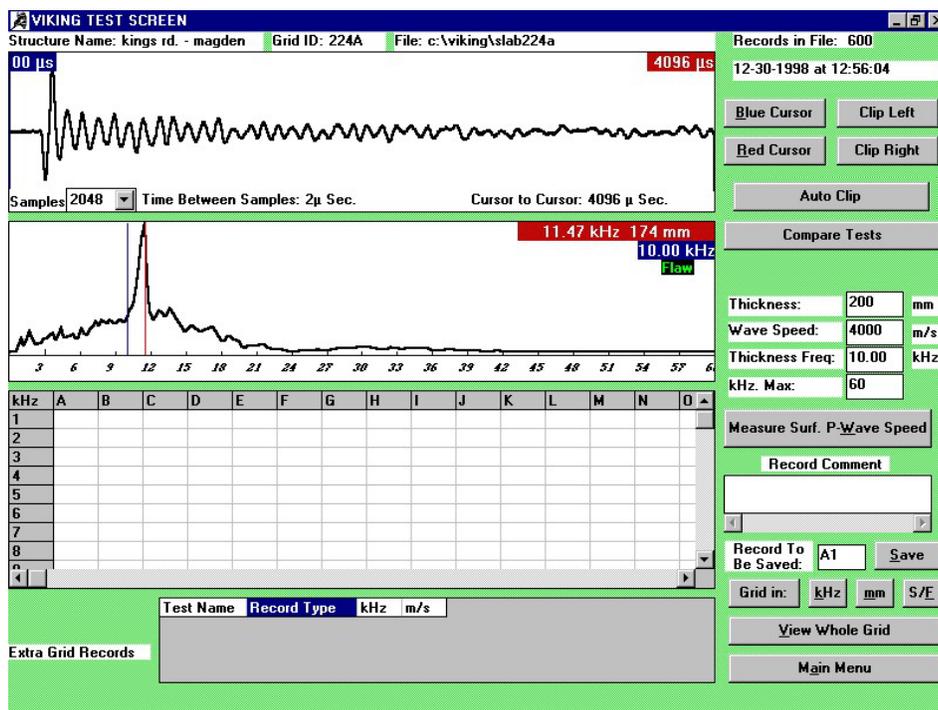


Fig.10. The Viking Test Screen with a test result for calibration of the wave speed. The frequency measured is 11.47 kHz. As the actual thickness measured is 185 mm, the calibrated wave speed is  $C_p = 11.47 \text{ kHz} \cdot 2 \cdot 185 \text{ mm} = 4244 \text{ m/s}$ . This wave speed is entered in the "Wave Speed" window. Press the Enter-key. The pop-out screen in fig.11 will appear.

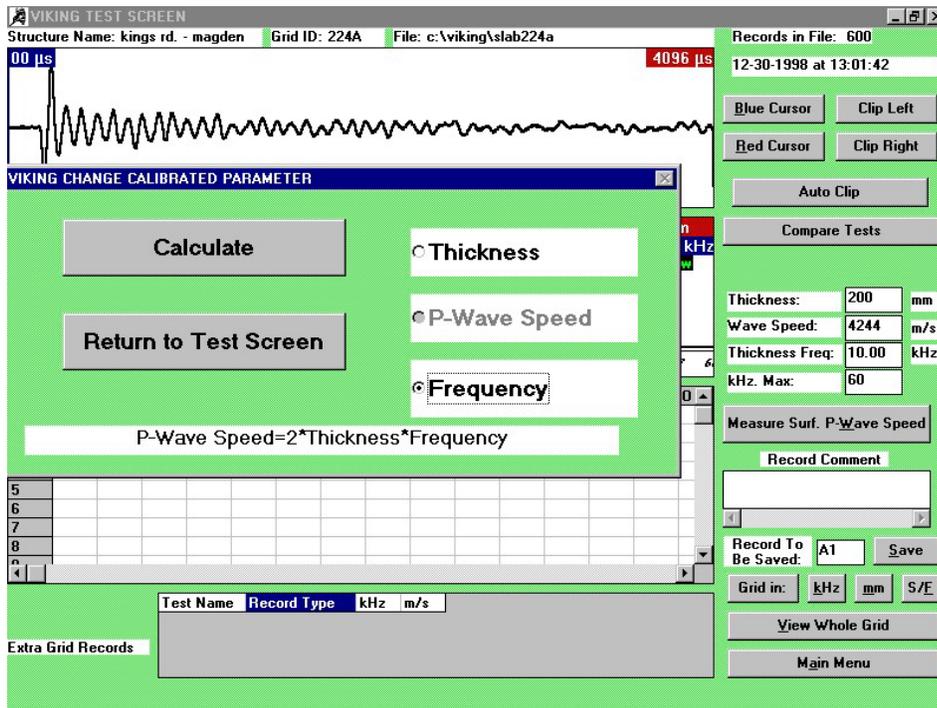


Fig.11. The pop-out Viking Change Calibrated Parameter screen. The parameter to be changed is clicked in, followed by one click in the "Calculate" button. In the case in question, the frequency button is clicked for the calibrated frequency to be re-calculated as  $f = C_p/2T = (4244 \text{ m/s})/(2 \cdot 200 \text{ mm}) = 10.61 \text{ kHz}$ , see fig.12.

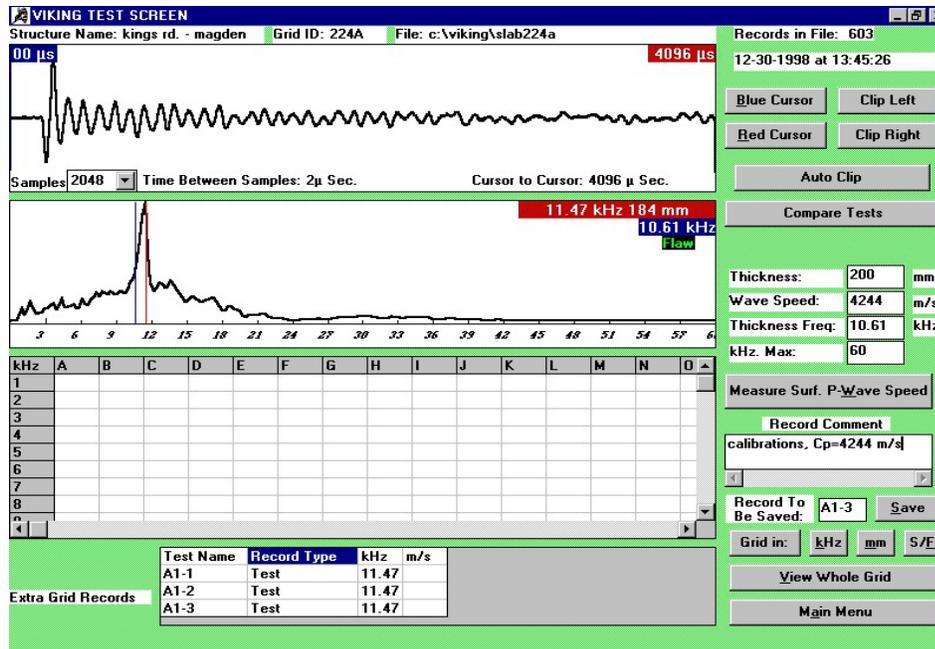


Fig.12. Upon returning to the test screen the design thickness (200 mm), the calibrated wave speed (4244 m/s) and the calibrated frequency (10.61 kHz) are stated adjacent to the frequency spectrum. The blue cursor in the frequency spectrum is positioned at 10.61 kHz, also indicated in the blue box in the frequency window. The red cursor is positioned at the frequency peak measured, and the related values, 11.47 kHz and 184 mm (for 4244 m/s wave speed) are illustrated in the red box. A "Flaw" indication is shown since the 184 mm measured thickness is less than 186 mm (200 mm less 6% entered as the Solid/Flaw Criteria).

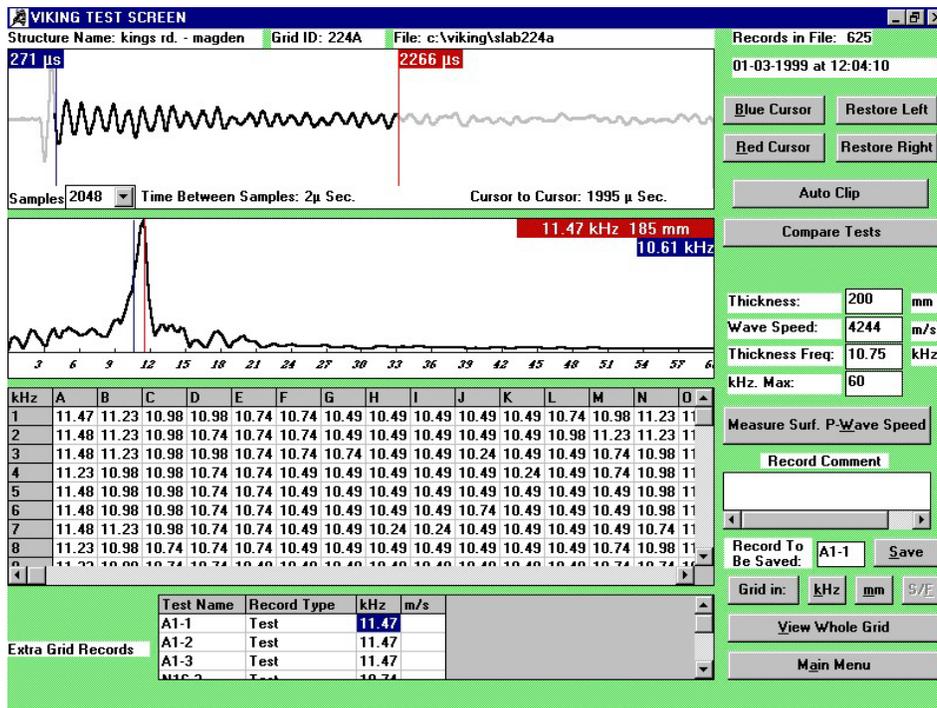


Fig. 13. Clipping of the R-wave and the last part of the waveform. As will be seen the clipping is not affecting the position of the measured frequency (the red cursor) for this thickness. Therefore, clipping was not used in the testing. The grid is filled out with test results

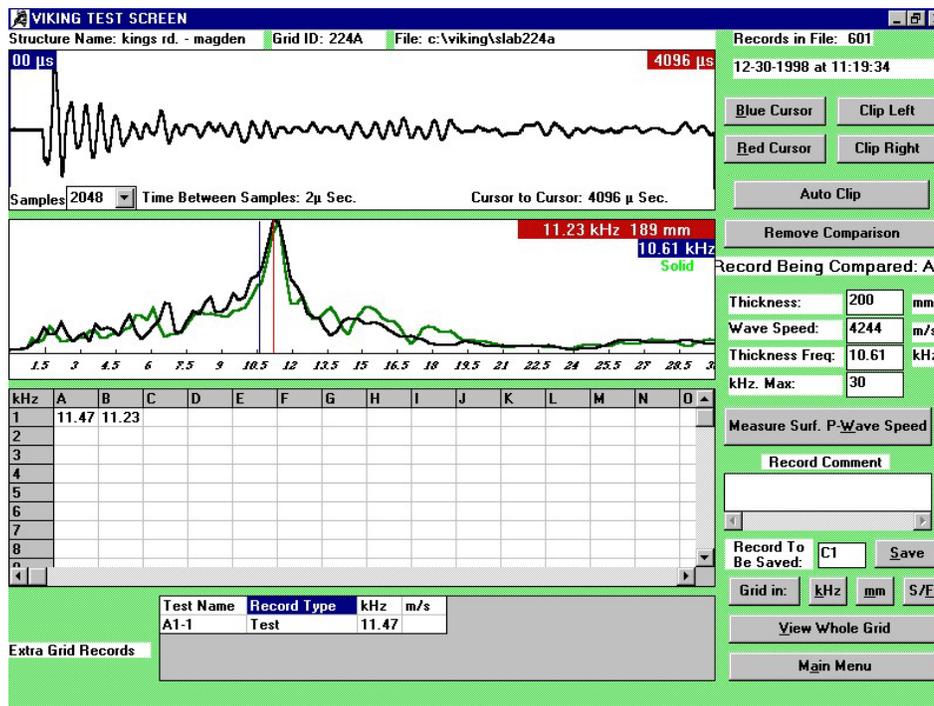


Fig 14. Illustration of record B1 compared to record A1 (the green frequency curve). The frequency scale has been changed to max. 30 kHz. The red cursor position at 11.23 kHz relates to a 189 mm thickness for a wave speed of 4244 m/s. "Solid" is indicated below the blue box containing the calibrated 10.61 kHz frequency. The "Solid" indication is obtained since the measured thickness 189 mm is greater than 200 mm less 6% (188 mm).

#### **4.1.3.5 Measure Surface P-Wave Speed with the DOC-1000 / DOC-2000 systems**

One click on the "Measure Surf. P-wave Speed" button will produce the Viking Surface P-wave Screen, see Appendix B. After testing for P-wave speed and returning to the Viking Test Screen, the average of the P-wave speeds measured will be used in the further testing. The thickness will be as earlier specified and the calibrated frequency will be re-calculated according to the equation  $f = C_p/2T$ .

All surface measurements of the wave speed will be stored in the extra grid records at the bottom of the Viking Test Screen and can be retrieved by double clicking on either of the boxes with the information.

From the "Surface P-wave Screen" access can be made to the "Depth of Surface Opening Crack" screen for testing as outlined in Appendix C.

#### **4.1.3.6 Record Comment**

Clicking in the window will make the window active and comments (max 50 characters) can be entered.

#### **4.1.3.7 The Grid and saving of records**

Below the frequency spectrum frame is illustrated the grid, as selected.

When starting out storing records in a grid, the first record to be saved is "A1". After a test result is on the screen, and it is made sure the red cursor is properly positioned, the value of the red cursor is stored in the grid by clicking the "Save" window, or by pressing the "Alt"-key and the "S"-key.

The red cursor in the frequency spectrum may be repositioned in steps equivalent to the frequency resolution by clicking somewhere in the frequency spectrum frame and activating the arrow keys " $\leftarrow$ " or " $\rightarrow$ ". By pressing the "Shift" key first and then one of the arrow keys the red cursor will move from peak to peak in the frequency spectrum.

The position of the next record to be saved is illustrated in the "Record To Be Saved" box. Saving of record(s) will be made automatically in the pattern decided upon in section 4.1.2.3.4, Moving Pattern in the Grid.

The grid records can be shown as frequency in "kHz", in "mm", or as "S/F", if the Solid/Flaw Criterion has been activated. Toggling between the options is made by clicking the "kHz", the "mm" or the "S/F" buttons adjacent to the "Grid in:" box.

The grid will automatically be re-positioned as testing proceeds throughout the grid. Alternatively, the grid can be moved manually, vertically or horizontally, by clicking the adjacent scroll buttons.

Previous test result can be brought to the screen by double clicking the record in the grid. The test name is illustrated in the "Record To Be Saved" box, once the double click has been performed.

#### **4.1.3.7.1 Extra Grid Records file**

Should extra records need to be saved at a particular grid location, e.g. at “C23”, the “Record To Be Saved” box is clicked behind the record number. The cursor is blinking behind the “C23” record name.

Delete the designation with the “←BS” key. Enter the new designation, e.g. “C23-1”, perform the extra test and click the “Save” button.

A pop-out screen, “VIKING EXTRA GRID RECORDS WARNING” will emerge with the message/question:

“This record does not belong to the grid. Do you want to save it as an extra grid record?”

If accepted, the record will be saved in the “Extra Grid Records” file at the bottom of the Viking Test Screen.

A third record can then be stored, e.g. as “C23-2”, after the designation has been entered, etc., etc.

If an earlier used extra record name is typed into the “Record To Be Saved” box, the new test record on the screen will overwrite the old one, after the “Save” button has been activated and after confirmation has been made in the “VIKING CHANGE RECORD WARNING” pop-out screen:

A record has already been saved in the Grid at this position. Do you want to overwrite this record with the one on the screen?

Any of the extra records can be brought to the screen by double clicking in one of the information windows in the Extra Grid Record table.

#### **4.1.3.7.2 Jumping over grid records during testing**

The record name to be jumped to is entered in the “Record To Be Saved” box (click once behind the number, press the “←BS” key to delete the previous record name and enter the record name to be jumped to). The cursor is blinking after the record number.

Upon bringing the test to the screen the blinking cursor will disappear. Click the “Save” button. The record is saved at the required position in the grid and the next record name in the moving pattern is shown in the “Record To Be Saved” box.

Records that have been jumped over will, in the grid presentation, be blank (empty).

#### **4.1.3.7.3 Changing an existing record**

Records in a grid cannot be deleted once they have been saved, but they can be over-written.

Click in the “Record To Be Saved” box behind the number part of the record name and delete the designation using the “←BS” key. Enter the name of the record to be changed (a capital letter followed by a number). The cursor is blinking after the record name.

Perform the test. The blinking cursor behind the record name has disappeared. Click the “Save” button. The “VIKING CHANGE RECORD WARNING” pop-out screen will appear with the following message/question:

”A record has already been saved in the Grid at this position. Do you want to overwrite this record with the one on the screen?”

If affirmative, the new record is saved at the required grid location and the subsequent record in the moving pattern is shown in the “Record To Be Saved” box.

#### 4.1.3.8 View Whole Grid

The whole grid is shown on a separate screen by clicking the “View Whole Grid” button. The grid can be illustrated in “kHz”, in “mm” or in “S/F”, as outlined on the following pages for the slab example.

VIKING VIEW WHOLE GRID SCREEN

VIKING GRID VIEW, Measurements are given in kHz.

Structure Name: kings rd. - magden  
 Grid ID: 224A  
 File: c:\viking\slab224a  
 Records in File: 603  
 Date: 12-30-1998

Thickness in mm: 200  
 Wave Speed in m/s: 4244  
 Thickn. Freq: 10.61  
 Instrument ID: 33545  
 Tested By: PI-AH

	kHz					mm					Solid/Flaw	Return To Testing Screen			
kHz	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	11.47	11.23	10.98	10.98	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.74	10.98	11.23	11.48
2	11.48	11.23	10.98	10.74	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.98	11.23	11.23	11.48
3	11.48	11.23	10.98	10.98	10.74	10.74	10.74	10.49	10.49	10.24	10.49	10.49	10.74	10.98	11.23
4	11.23	10.98	10.98	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.24	10.49	10.74	10.98	11.23
5	11.48	10.98	10.98	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.49	10.49	10.49	10.98	11.48
6	11.48	10.98	10.98	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.74	10.49	10.49	10.98	11.48
7	11.48	11.23	10.98	10.74	10.74	10.49	10.49	10.24	10.24	10.49	10.49	10.49	10.49	10.74	11.23
8	11.23	10.98	10.74	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.49	10.49	10.74	10.98	11.23
9	11.23	10.98	10.74	10.74	10.49	10.49	10.49	10.49	10.49	10.49	10.49	10.49	10.74	10.74	10.98
10	11.47	10.97	10.72	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.74	11.23
11	11.71	10.97	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.72	10.97
12	11.71	11.22	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.23	10.23	10.48	10.48	10.72	10.97
13	11.71	11.47	10.97	10.48	10.48	10.48	10.48	10.48	10.48	10.23	10.23	10.48	10.48	10.72	10.97
14	11.47	11.22	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.23	10.23	10.48	10.48	10.72	10.97
15	11.22	11.22	10.97	10.72	10.48	10.48	10.48	10.48	10.48	10.23	10.48	10.48	10.48	10.72	10.97
16	10.97	10.97	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.72	10.72	10.97
17	10.97	10.72	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.48	10.72	10.72
18	10.97	10.72	10.48	10.48	10.23	10.23	10.23	10.23	10.23	10.48	10.48	10.48	10.48	10.48	10.72
19	10.97	10.72	10.48	10.48	10.23	10.23	10.23	10.23	9.98	10.23	10.48	10.48	10.48	10.48	10.72
20	10.98	10.98	10.98	10.48	10.23	10.23	10.23	10.23	10.23	10.48	10.48	10.48	10.48	10.72	10.72
21	10.98	10.98	10.73	10.48	10.24	10.24	10.24	10.24	10.24	10.48	10.48	10.48	10.48	10.73	10.73
22	10.98	10.73	10.48	10.24	10.24	10.24	10.24	10.24	10.24	10.48	10.48	10.48	10.48	10.48	10.48
23	10.98	10.73	10.48	10.24	10.24	10.24	10.24	10.24	10.24	10.48	10.48	10.48	10.48	10.48	10.48
24	10.98	10.48	10.48	10.24	10.24	10.24	9.99	10.24	10.24	10.48	10.73	10.48	10.48	10.48	10.48

Fig.15. The Viking View Whole Grid Screen with the kHz option illustrated. Rolling of the data is performed by activating the adjacent scroll buttons. The "mm" or the "S/F" options are activated by clicking the "mm" or the "S/F" buttons, fig. 16 and 17.

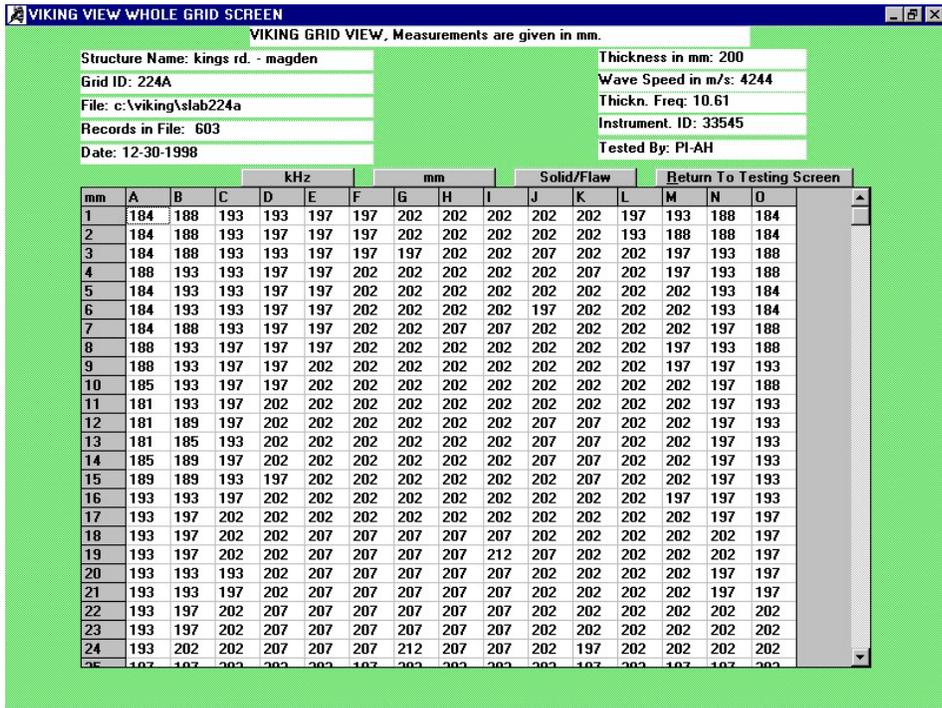


Fig.16. The Viking View Whole Grid Screen with the mm option illustrated.

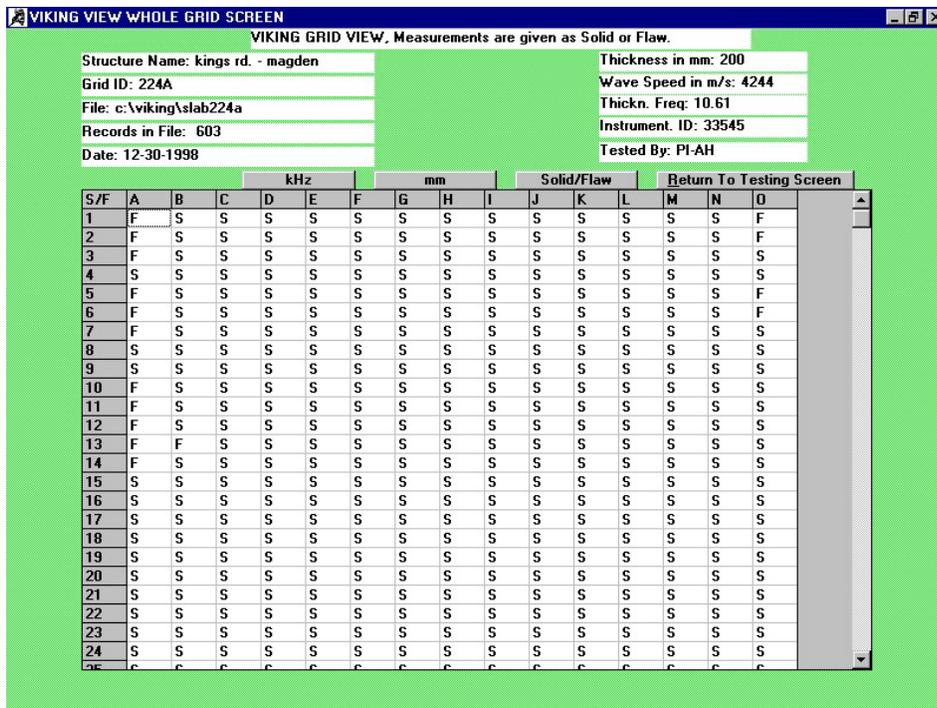


Fig.17. The Viking View Whole Grid Screen with the Solid/Flaw option illustrated.

Records jumped over, or not used, are presented blank (empty).

**NOTE:** After testing it is imperative to confirm the Impact-Echo test results.

For thickness estimation this may be done by measuring the actual thickness through openings, e.g. made by coring or by drilling of a minimum 12 mm diameter hole perpendicular to the surface, or by testing close to an edge with known thickness.

For flaw detection a limited number of cores has to be taken for confirmation/rejection of the test results. Alternatively, drilling of a 12 mm diameter hole for an endoscope to be inserted may be attempted.

On homogeneous concrete the wave speed calibrated by thickness measurement may be compared to the surface P-wave speed measurements deducted 4%.

Surface wave speed measurements deducted the 4% tends to be equivalent to wave speed found by thickness measurement. However, differences may occur depending on e.g. the presence of cracking and/or moist conditions at the surface compared to the interior of a concrete member.

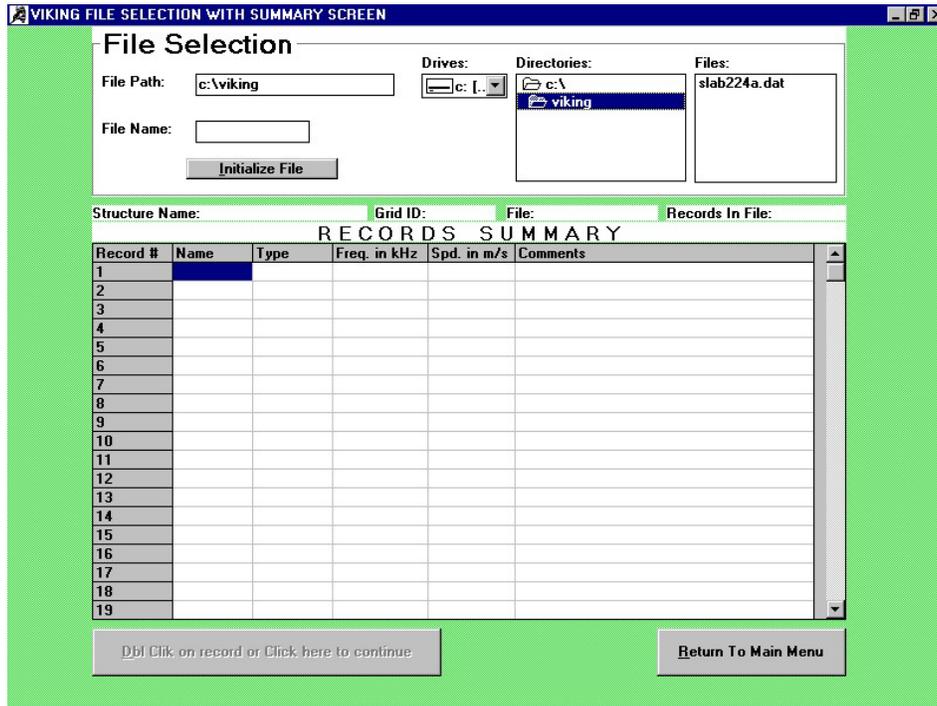
In addition - all other factors being constant - the systematic error on the thickness estimate is about 2.6% using surface wave speed as the basis for the estimate compared to approximately 1.2% when measurements are based on wave speed calibrated by thickness measurement.

***NOTE: For exporting grid values, e.g. thickness measurements, to Excel for color mapping, follow the instruction in clause 4.3.3 “Export Grid values to ASCII”, p.51.***

## 4.2 EXAMINE RECORDS AND PRINT

Clicking the “Examine Records and Print” button in the Main Menu, fig. 2, will produce the Viking File Selection with Summary Screen as shown in fig. 18.

### 4.2.1 The Viking File Selection with Summary Screen



*Fig.18. The Viking File Selection with Summary Screen*

Before a file can be initialized for presentation of the record summary, the drive and the relevant directory have to be specified.

#### 4.2.1.1 Choosing the drive

The default driver is the “c:” drive.

Alternatively, the floppy “a:” drive can be selected by activating the “Drives” button, one click, and selecting the drive.

### 4.2.1.2 Selecting the directory

Double click on the “c:\” folder in the “Directories” window. The directories available are exhibited in the window. Double click on the directory in question. The directory chosen is highlighted and shown behind the “c:\” designation in the “File Path:” window. At the same time all the files in the directory are shown in the “Files:” window.

Fig. 37 illustrates such a selection. The directory “Viking” under the "c:\" drive it is highlighted in the “Directories:” window and exhibited behind the “c:\” designation in the “File Path:” window. At the same time the files in the “Viking” directory are shown in the “Files:” window (here only the "slab224a.dat" file).

### 4.2.1.3 Selecting the file

Double click on the name of the file required in the “Files:” window, in this example on the “slab224a.dat” file. The file is highlighted and exhibited in the “File Name:” window, fig. 19.

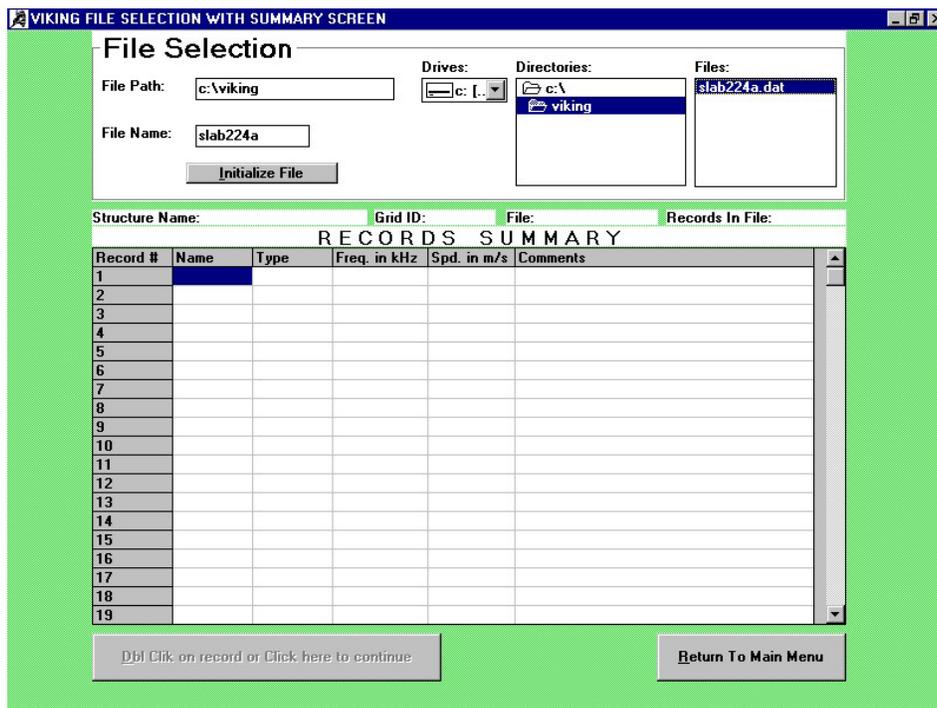
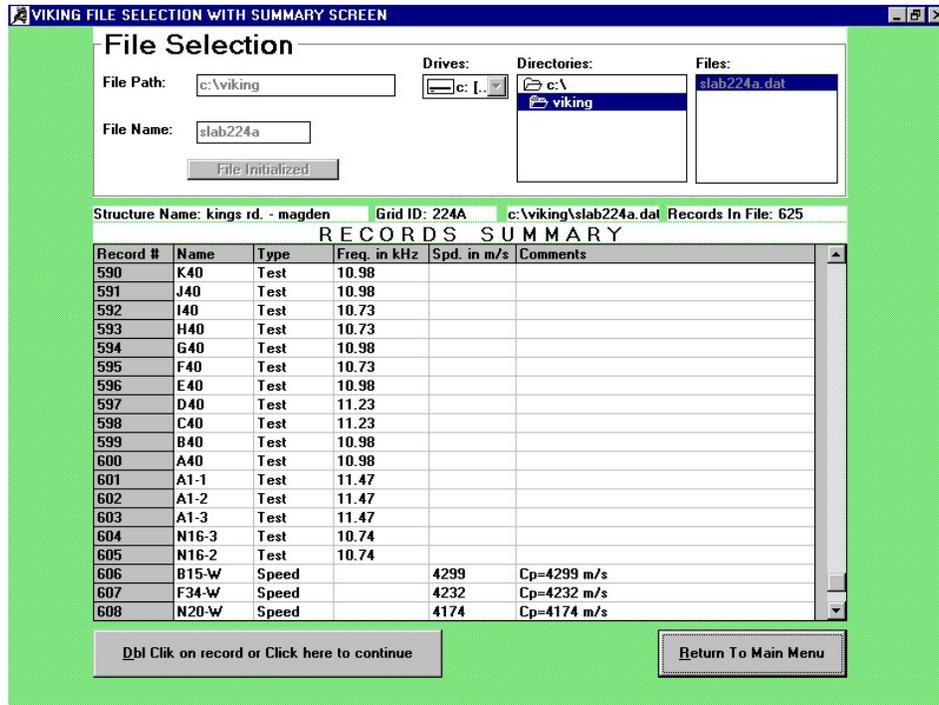


Fig.19. The file "slab224a.dat" has been selected by double clicking on the file in the Files window

Click the “Initialize File” button. The button change content to “File Initialized” and the records summary of the file will be illustrated in the tabulation, fig. 20, with Structure Name, Grid ID, File and number of Records in File stated on top.



*Fig.20. The file particulars with record summary for records #590 - #608 of the file Slab224a*

For analysis of the single records click the button “Dbl. Click on Record or Click here to Continue” in fig. 20. The first record in the file will be exhibited, the “A1” record.

Alternatively, any of the windows in the record summary table in fig. 20 can be double clicked on for the record in question, which will bring the record on the screen for further analysis, re-saving and printing, which only can be done from the examine records screen, fig. 21.

Wave speed records will be shown with the designation “Speed” and the wave speed in “m/s” indicated, crack depth records with the designation “Crack-Depth” and the depth estimated in “mm” given.

#### 4.2.2 Viking Examine Record(s) Screens

There are two types of Viking Examine Record(s) Screens, one for test records and another for surface P-wave speeds or depth of surface opening crack.

They are described in the following.

From the screens analysis can be performed and records re-saved. Printing of reports can be made only from the screen containing the test records.

### 4.2.2.1 Examine test records

Fig. 21 illustrates the screen with an example of a test record from the slab case, the extra grid record N16-2 (#605).

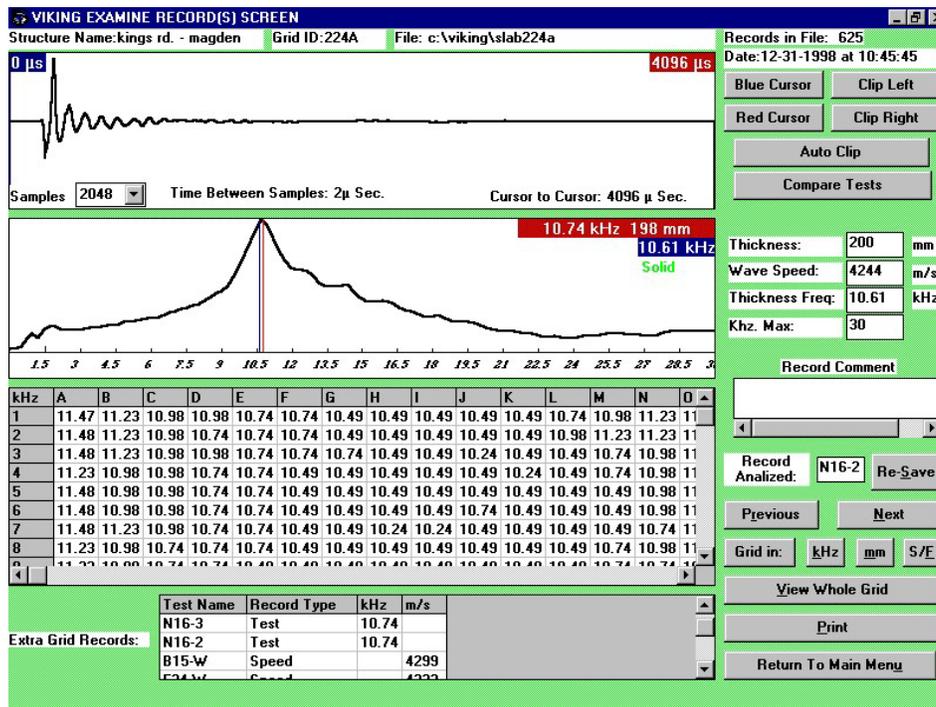


Fig.21. The Viking Examine Record(s) Screen for record N16-2 in the file "c:\viking\slab224a"

The screen has a similar layout as the Viking Test Screen, fig. 10, and the functions are the same, only the "Measure Surf. P-wave Speed" button has been deleted and the following buttons added:

#### 4.2.2.1.1 The "Record Analyzed" box

The name of the record chosen from the Viking File Selection with Summary Screen is stated in the box adjacent to the "Record Analyzed:" box, e.g. "N16-2" as shown in fig. 21. When choosing the "previous" or the "next" record, the record name change accordingly. Alternatively, the records in the grid can be brought to the screen by double clicking on the record in the grid or the extra grid records.

#### 4.2.2.1.2 The "Re-Save" button

Re-saving of a record can be made in the existing records or as an extra record.

**Re-saving of an existing record** is typically done after clipping of the waveform for more accurate analysis, or if e.g. the comments have been forgotten during testing.

To perform such a re-saving click the "Re-Save" button. The "VIKING CHANGE RECORD WARNING" pop-out screen will emerge with the message/question:

A record has already been saved in the Grid at this position. Do you want to overwrite this record with the one on the screen?

If affirmative, the record on the screen will be saved at the location indicated.

**Re-saving of a record as an extra grid record** may be done similarly, after e.g. clipping of the waveform. Click in the "Record Analyzed" box after the designation number and delete the record name with the "←BS"-key.

Make sure the record name to be entered is not the same as an earlier used one. Enter the new record name in the box adjacent to the "Re-Save" button and click the button.

The pop-out screen "VIKING EXTRA GRID RECORDS WARNING" will emerge with the message/question:

"This record does not belong to the grid. Do you want to save it as an extra grid record?"

If affirmative, the record will be saved in the "Extra Grid Records" file at the bottom of the Viking Examine Record(s) Screen.

#### **4.2.2.1.3 The "Previous" button**

One click on the "Previous" button will bring the previous record in the moving pattern to the screen. The record name will change accordingly in the "Record Analyzed" box.

#### **4.2.2.1.4 The "Next" button**

Similarly, one click on the "Next" button will bring the next record in the moving pattern to the screen. The record name will change accordingly in the "Record Analyzed" box.

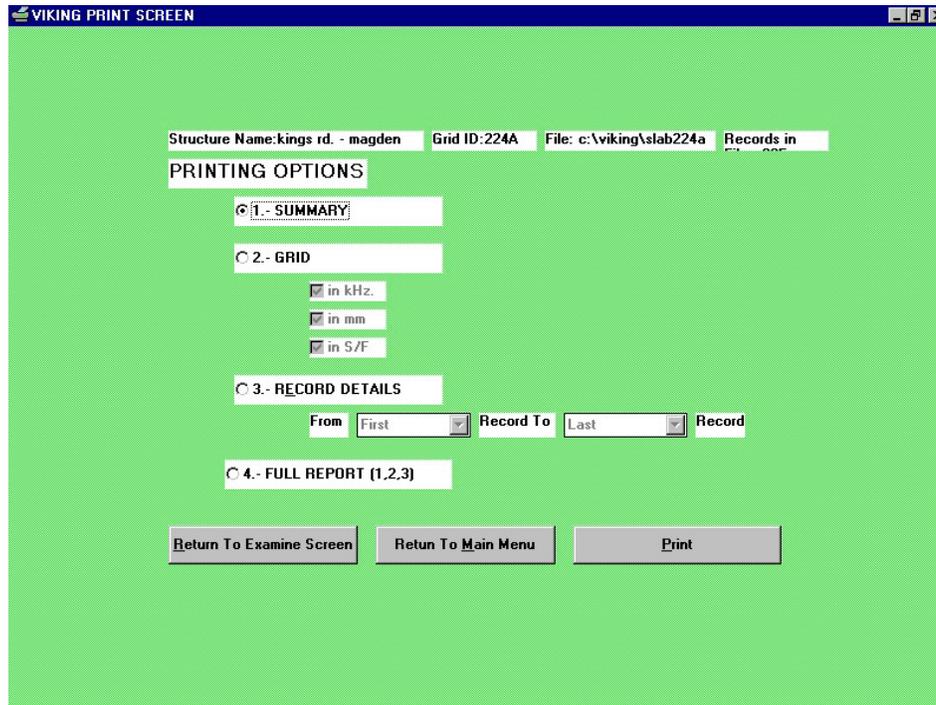
**NOTE:** The "Previous" and the "Next" selection of records can only be made within each category of tests - the test records, the wave speed records and the crack depth records. To get to another class, return will have to be made to File Selection.

#### **4.2.2.1.5 The "Print" button**

One click on the "Print" button will produce the Viking Print Screen, fig. 22.

Four printing options are available:

1. Printing of a summary of the records
2. Printing of the grid (in kHz, in mm and/or in S/F's)
3. Printing of record details
4. Printing of a full report including the summary, the grids and all records.



*Fig.22. The Viking Print Screen*

One of the four options is chosen by clicking in the related circle. When the option has been decided upon, the “Print” button is clicked and printing will start out.

NOTE: Before printing can take place the printing drivers for the printer used has to be installed. Make sure sufficient amount of printing paper is available in the printer.

#### **4.2.2.1.5.1 Printing of a summary**

A summary will be printed out, first of all the grid records, then the extra grid records and finally, the surface P-wave speed records, as illustrated in fig. 23. The data shown in part are from the slab testing case, and the printer used was a HP DeskJet 890C.

Summary of the crack depth records, if any, will be printed out after the wave speed records.

*Fig.23. Summary printout of records. Only a part of the grid records in the slab case is illustrated. The file contains no crack depth records*

#### ***4.2.2.1.5.2 Printing of a grid***

Fig. 24 illustrates the grid printout of the slab example with the measured kHz indicated. Fig. 25 and fig. 26 shows the same grid in mm and in S/F, respectively.

*Fig. 24. Grid printout in kHz*

*Fig. 25. Grid printout in mm*

*Note: For export of grid values to Excel follow the instruction in section 4.3.3. page 53*

*Fig.26. Grid printout in S/F (Solid/Flaw) according to the Solid/Flaw Criterion specified*

#### ***4.2.2.1.5.3 Printing of record details***

Before printout of record details the records have to be chosen, fig. 22, the Viking Print Screen. Click on the scroll buttons in the windows. A curtain will appear with the numbers and the record names stated. Select the record(s) “From” and to “Record To” by one click on the relevant designation.

Once selected, the “Print” button is clicked.

Fig. 27 and 28 show the printout of one test record and one surface P-wave speed record from the slab case (only for the DOC-1000 / DOC-2000).

*Fig.27. Record details for the test record M4 in the slab case*

*Fig.28. Record details for the surface P-wave speed record G5-W in the slab case  
(only for DOC-1000 / DOC-2000 systems)*

#### ***4.2.2.1.5.4 Printing of a full report***

One click in the fourth option, “FULL REPORT (1,2,3) in the Viking Print Screen, fig. 22, will print out the summary, as well as the grid (in specified units) and the record details for the chosen records as illustrated on the previous pages. .

#### 4.2.2.2 Examine Surface P-wave speed records for the DOC-1000 / DOC-2000 systems

The second type of records in the Viking Examine Record(s) is the wave speed records or the crack depth records.

The records can be reached from the Viking File Selection with Summary Screen, fig. 19, or from the Viking Examine Record(s) Screen, fig. 21, in the Extra Grid Records. First use the scroll buttons, and then double click on one of the boxes of the record in question, labeled “Speed”.

An example of a surface P-wave speed record is shown in fig. 29.

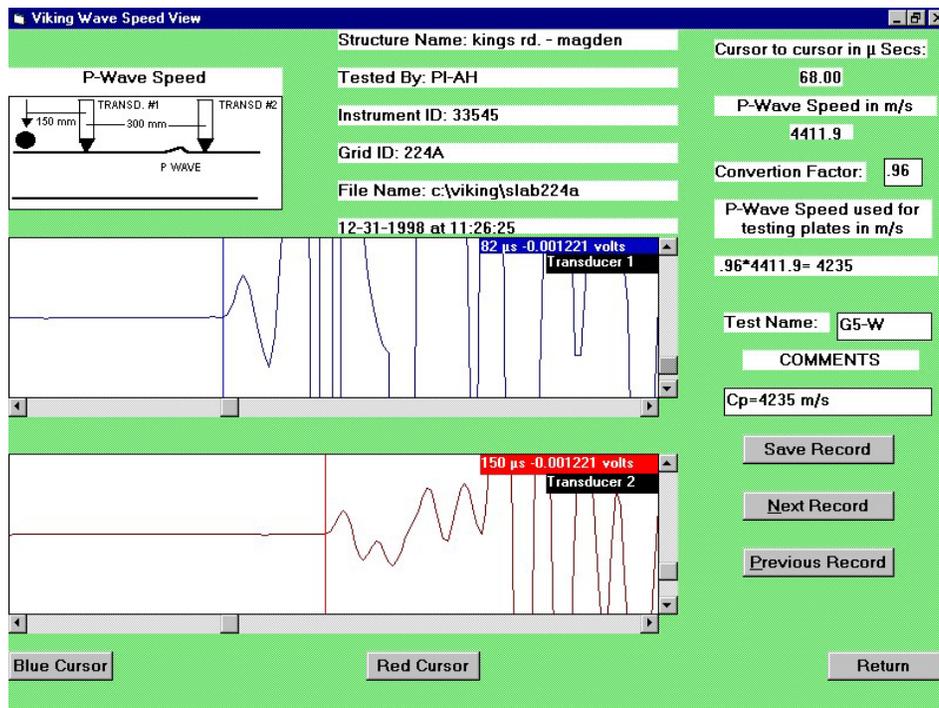


Fig.29. An example of a surface P-wave speed record from the slab case, record G5-W

The screen has a similar layout as the Viking Surface P-wave Speed screen as illustrated in Appendix B, fig. 37 and fig. 38, only the tabulation for wave speed storage has been removed, and two extra buttons have been added, the “Next Record” button and the “Previous Record” button.

The operation of the blue and the red cursors is as described in Appendix B, page 62.

##### 4.2.2.2.1 The “Next Record” button

One click in the “Next Record” button will bring the next wave speed record to the screen.

#### **4.2.2.2.2 The “Previous Record” button**

One click in the “Previous Record” button will bring the previous wave speed record to the screen.

#### **4.2.2.2.3 The “Save Record” button**

Saving of a changed wave speed record can be made in the Extra Grid Records. After the appropriate changes have been made, a new test name is entered in the “Test Name” window after which the “Save Record” button is clicked.

To check if the changed record has in fact been saved go to the main menu, into the examine option, bring the file on the summary screen, and roll the screen until the record appears.

#### **4.2.2.3 Examine Crack Depth records**

Selection of a “Crack-Depth” record is similarly made from the Viking File Selection with Summary Screen, fig. 20, or from the Viking Examine Record(s) Screen, fig. 21, in the Extra Grid Records.

The records in this group are labeled “Crack-Depth”. Clicking any of the records related boxes would bring the record to the screen.

The operation of the blue and the red cursors and the “Next Record”, the “Previous Record” and the “Save Record” buttons is as with a wave speed record.

### 4.3 FILE UTILITIES

Clicking the “File Utilities” button in the Main Menu, fig. 2, will produce the Viking File Utilities screen as shown in fig. 30.



*Fig.30. The Viking File Utilities screen*

Five options are available, "Parameter Change", "Export records to ASCII", "Export Grid records to ASCII", "Export File to Floppy Disk" and "Import File From Floppy Disk".

#### 4.3.1 Parameter Change

One click on the “Parameter Change” button will bring forward the Viking Parameter Change screen, fig. 31.

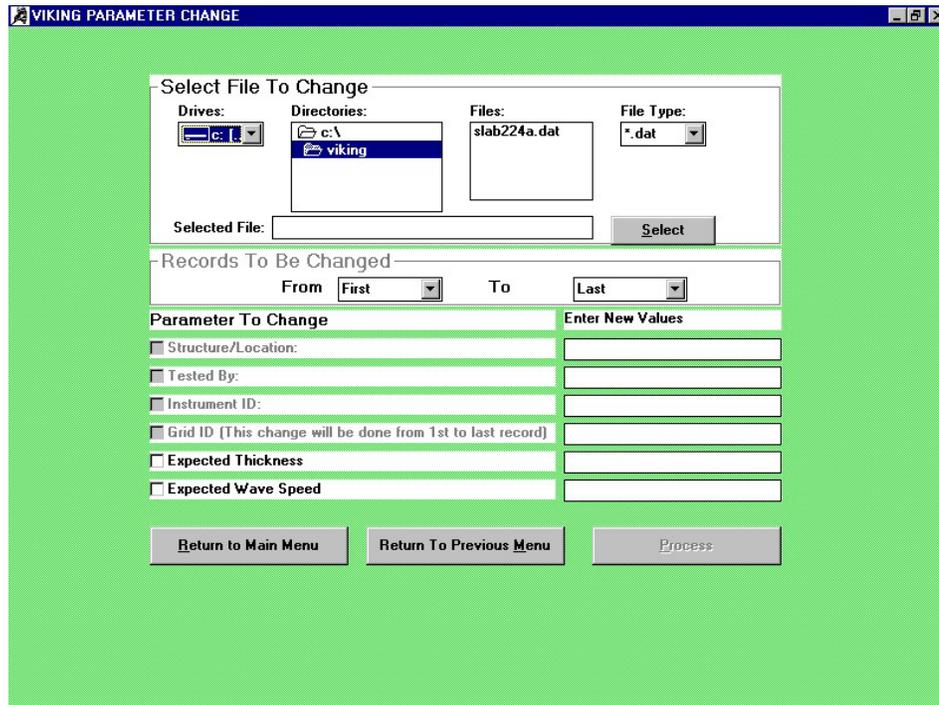


Fig.31. The Viking Parameter Change screen

#### 4.3.1.1 Select File to Change

Select first the drive to change from, the “c:\” drive or the “a:” drive. The default value is the “c:\” drive.

Double click on the “Directories” “folder c:\” window and select the directory with another double click. The files in the directory chosen will be shown in the “Files:” window as illustrated in fig. 31.

Double click on the file to be selected in the “Files:” window. The file in this window will be highlighted and the file shown in the “Selected File:” window.

Click the “Select” button. The file to be changed is now ready for changing of the parameters.

Once the “Select” button has been clicked on, no other file can be selected unless returning to the File Utility menu and repeating the process.

#### 4.3.1.2 Records To Be Changed

Should all records in the file selected need to be changed the windows following “From” (exhibiting “First”) and “To” (exhibiting “Last”) are not touched. Otherwise, select the needed records.

For selection of a certain number of the file records to be changed, the scroll buttons in the “From” window and in the “To” window are touched. A pull-down menu will appear and the selection can be made by one click on the relevant record. The selected records are illustrated by the number in the file as well as the record name in the “From” and the “To” windows.

The following parameters of the records can be changed as shown in fig. 31: Structure/Location Name, Tested by, Instrument ID#, Grid ID, expected thickness and expected wave speed.

To change any of the parameters click in the adjacent window by which a check mark is pictured in the box (another click in the window will remove the check mark). At the same time a cursor is blinking in the window right to the parameter, for entering of new values.

Enter the new parameter value. Proceed to another parameter, if so desired.

**NOTE:** Both the expected thickness parameter and the expected wave speed parameter can be changed at the same time. In this case the calibrated frequency will be re-calculated according to the equation:  $f = C_p/2T$ . Should only one of the two parameters need to be changed the calibrated frequency will be re-calculated based on a value of the other parameter as entered previously.

**NOTE:** Be careful with changing of the thickness and/or the wave speed of all records should different thickness or wave speeds have been encountered during testing and entered in the test records. Such a change will alter the parameters of all the specified records.

**NOTE:** Should the wave speed parameter needs to be changed, only TEST records in a file will be changed while WAVE SPEED records and CRACK DEPTH RECORDS will be unaffected.

Make sure of the correctness of the new parameter change. Click the “Process” button once.

The records will be changed.

To make sure the change has been as required, return to the main menu, click on “Examine Records and Print”, select the file in question and bring the record(s) to the screen in the summary for examination by a double click on one the of the related record window.

Checking in this manner can only be done for the “Structure/Location Name”, the “Grid ID”, the “Expected Thickness” and the “Expected Wave Speed” parameters.

To check a new entered information related to the remaining two parameters, “Tested by” and “Instrument ID#”, printout has to be made, unless all the records have been changed. In the latter case the new entered values will also be exhibited in the Viking Setup Screen, fig. 9, page 22.

### 4.3.2 Export Records to ASCII

The purpose of this utility is to be able to export records to be used by other applications like EXCEL for analysis purposes. The ASCII file contains the result from each of the 2048 samples made for each test point.

One click in the “Export Records to ASCII” button in the VIKING FILE UTILITIES screen will produce the screen shown in fig. 32.

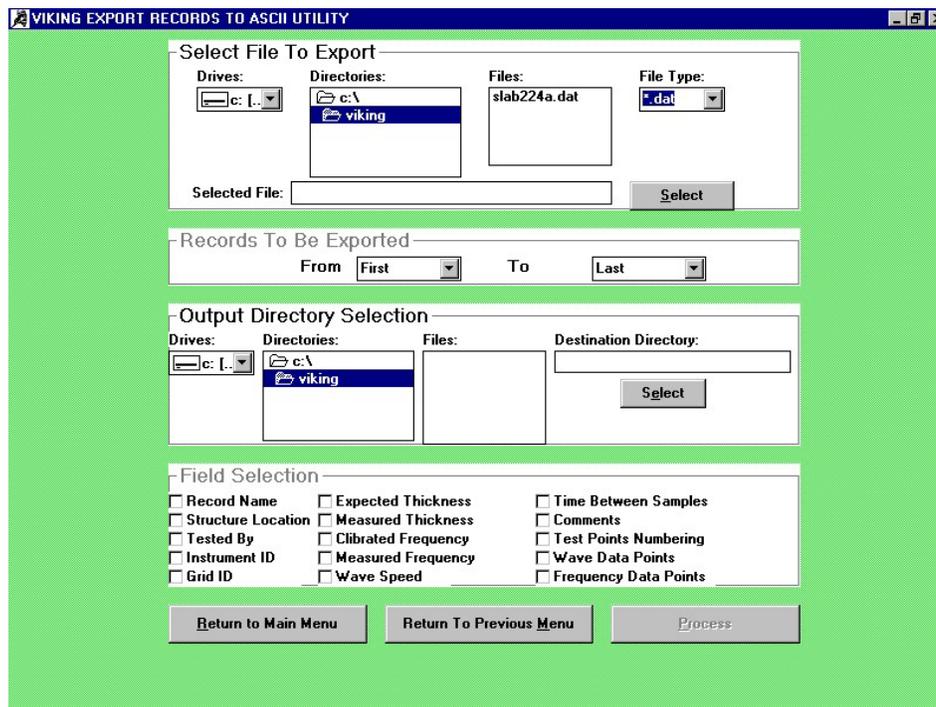


Fig.32. The Viking Export Records to ASCII Utility screen

#### 4.3.2.1 Select File to Export

Select first the driver to change from, the “c:\” drive or the “a:” drive. The “c:\” drive is the default drive.

Double click on the “Directories” “folder c:\” window and select the directory with another double click. The files in the directory chosen will be shown in the “Files:” window as illustrated in fig. 50.

Double click the file to be selected in the “Files:” window. The file in this window will be highlighted and the file shown in the “Selected File:” window.

Click the “Select” button. The file to be exported is now ready for export.

Once the “Select” button has been clicked on, no other file can be selected, unless returning to the File Utilities menu and repeating the procedure.

#### ***4.3.2.2 Records to be Exported***

The records to be exported are specified. Activate the “From” windows pull-down menu and select the first record by clicking on the record number with belonging record name. Perform the same procedure for the last record to be exported in the “To” window.

#### ***4.3.2.3 Output Directory Selection***

This utility will create one file for each record. For this purpose the files that are going to be created have to be selected.

Again, choose the driver, the directory by a double click and the file (name has to be specified) with a double click.

Once the information is checked for correctness, click once the “Select” button.

The Destination Directory with file will be exhibited in the “Destination Directory” window.

If the “a:” drive has been selected, insert a formatted disk in the disk slot.

Click the “Process” button. After export of the records at pop-out screen will emerge stating that the export has been terminated.

#### ***4.3.2.4 Field Selection***

As shown in fig. 32 a range of parameters can be selected.

The selection is made by clicking in the adjacent window by which a check-mark is indicated. As an example, should graphs of the waveform need to be made in a special manner, the "Time Between Samples" and the "Wave Data Points" are selected for further analysis.

Once the proper selection has been made the "Process" button is clicked in and the processing takes place.

After processing has been completed, the transfer of data to e.g. EXCEL is made from the output directory selected.

### 4.3.3 Export Grid values to ASCII

The purpose of this utility is to be able to export records to be used by other applications like EXCEL for analysis purposes, typically for color plotting of thickness measurements. The ASCII file contain the information about the Test Name, Test Type, Wave Speed, Calculated Frequency, Measured Frequency, Calculated Thickness, Measured Thickness, Solid/Flaw, Crack Depth and Comments for each test point.

One click in the “Export grid values to ASCII” button in the VIKING FILE UTILITIES screen will produce the screen shown in fig. 33.

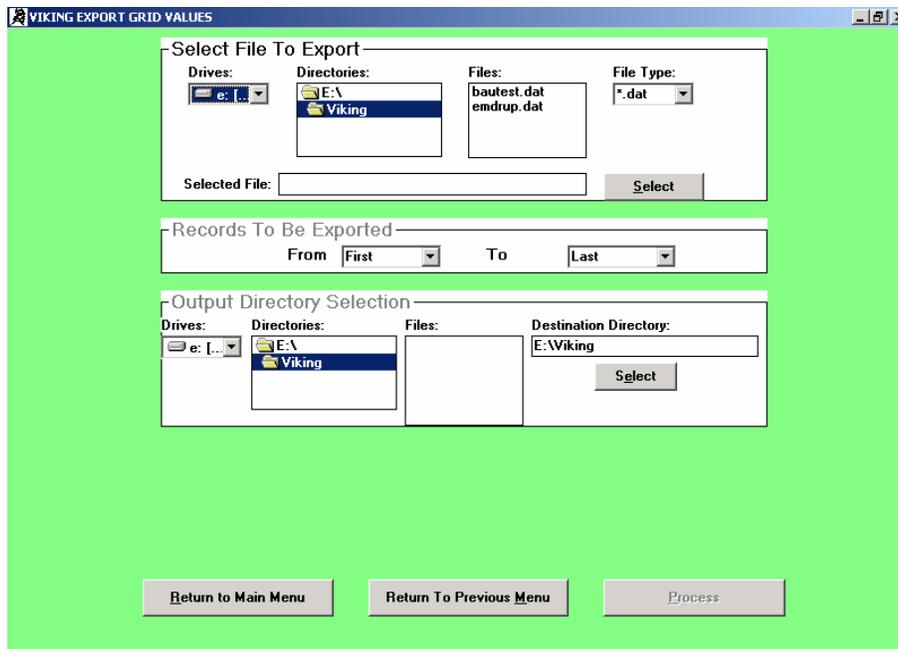


Fig.33. The Viking Export Records to ASCII Utility screen

#### 4.3.3.1 Select File to Export

Select first the driver to change from, the “c:\” drive or the “a:” drive. The “c:\” drive is the default drive.

Double click on the “Directories” “folder c:\” window and select the directory with another double click. The files in the directory chosen will be shown in the “Files:” window as illustrated in fig. 33.

Double click the file to be selected in the “Files:” window. The file in this window will be highlighted and the file shown in the “Selected File:” window.

Click the “Select” button. The file to be exported is now ready for export.

Once the “Select” button has been clicked on, no other file can be selected, unless returning to the File Utilities menu and repeating the procedure.

#### ***4.3.3.2 Records to be Exported***

The records to be exported are specified. Activate the “From” windows pull-down menu and select the first record by clicking on the record number with belonging record name. Perform the same procedure for the last record to be exported in the “To” window.

#### ***4.3.3.3 Output Directory Selection***

This utility will create one file for each record. For this purpose the files that are going to be created have to be selected.

Again, choose the driver, the directory by a double click and the file (name has to be specified) with a double click.

Once the information is checked for correctness, click once the “Select” button.

The Destination Directory with file will be exhibited in the “Destination Directory” window.

If the “a:” drive has been selected, insert a formatted disk in the disk slot.

Click the “Process” button. After export of the records at pop-out screen will emerge stating that the export has been terminated.

#### 4.3.4. Export File to Floppy Disk

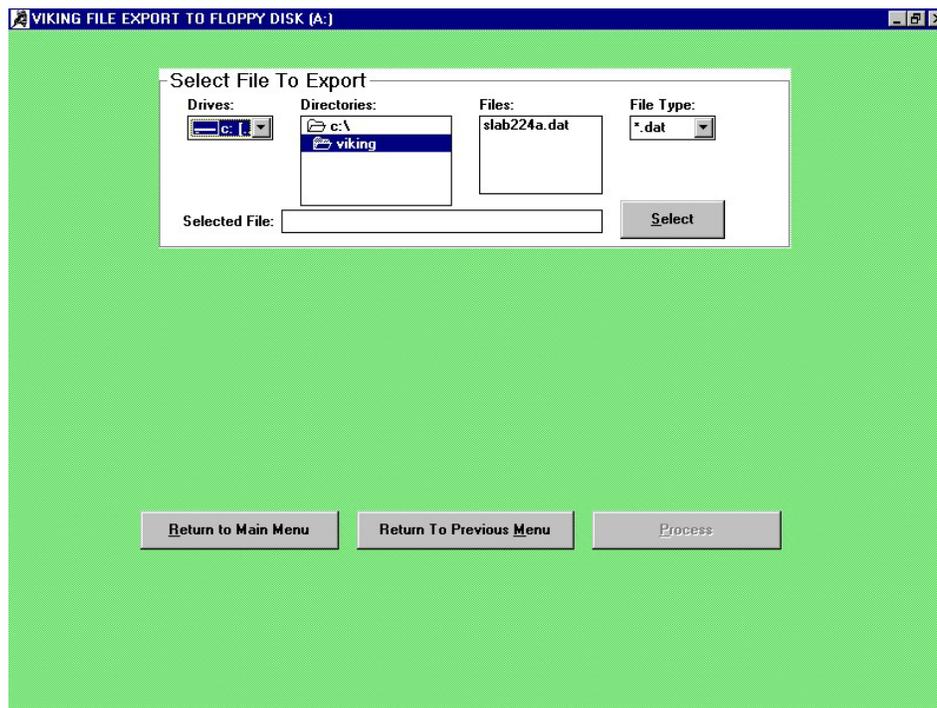
This operation is typically done for transferring records from one laptop to another.

For export of a file to a floppy the VIKING software will compress the records.

600 records will require about 600 KB of floppy disk space. This means that a 1.44 MB floppy disk will be able to store about 1200 records.

Click the "Export File to Floppy Disk" button in the Viking File Utilities Screen, fig. 30, page 48.

The Viking File Export to Floppy Disk (A:) screen will emerge as shown in fig. 34.



*Fig.34. The Viking File Export to Floppy Disk (A:) screen*

After selecting the driver (the default driver is the "c:" drive), the directory is chosen after double clicking on the "folder c:\\" by another double click on the directory in question.

All the files in the directory chosen are shown in the "Files:" window and the file type in the "File Type" window.

Select the file by double clicking. The file is shown in the "Selected File:" window.

Click the "Select" button after which the "Process" button will become active.

Insert a formatted floppy disk in the floppy disk drive and click the "Process" button.

First, the message comes up on the screen: "File being checked. Please wait". Then another message comes up: "File being compressed. Please wait" followed by "File being copied to floppy. Please wait". When the last message disappears, the export of the file to the floppy has been terminated.

If the disk is not able to contain the file the message comes up: "Viking Error: Floppy is not in place or full. Check Floppy Disk", followed by "Viking Error: Export has been cancelled".

If unsuccessful, try again, or use another floppy disk, formatted and with sufficient storage capacity.

To check if the file has been exported as required, exit VIKING, insert the floppy in the disk drive and go to "My Computer" Floppy A: drive icon. Double click the icon. The file(s) on the floppy are shown.

Remove the floppy disk from the disk drive.

### 4.3.5 Import File from Floppy Disk

Insert the floppy with the file(s) to be imported from in the disk drive of the laptop with installed PCMCIA card driver and Viking 6.0 software.

Click the "Import File From Floppy Disk" button. The Viking Import from Floppy Utility screen will show up as illustrated in fig. 35.

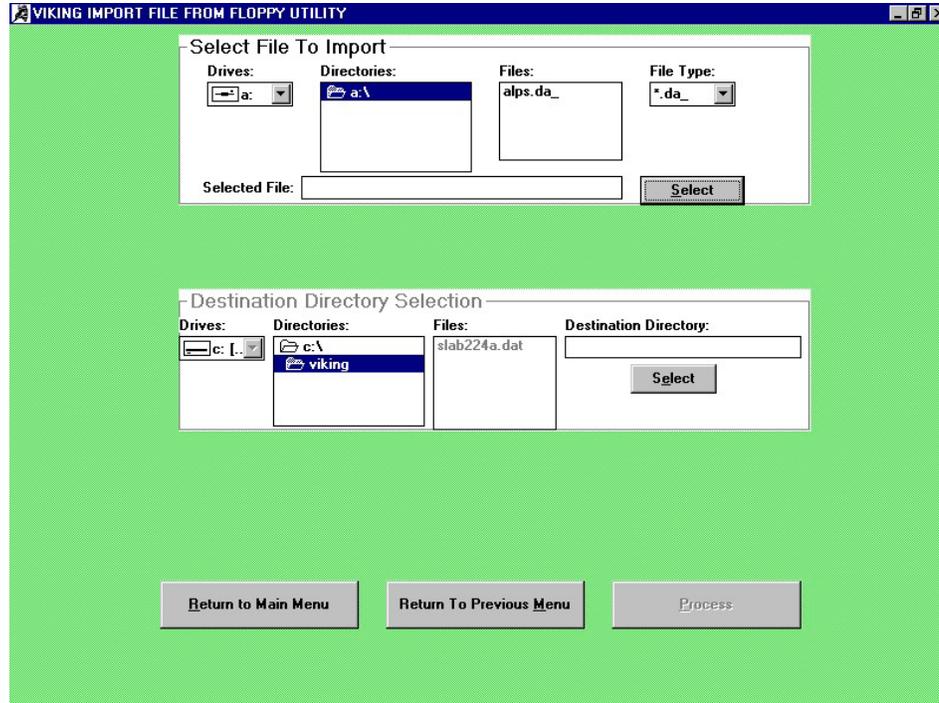
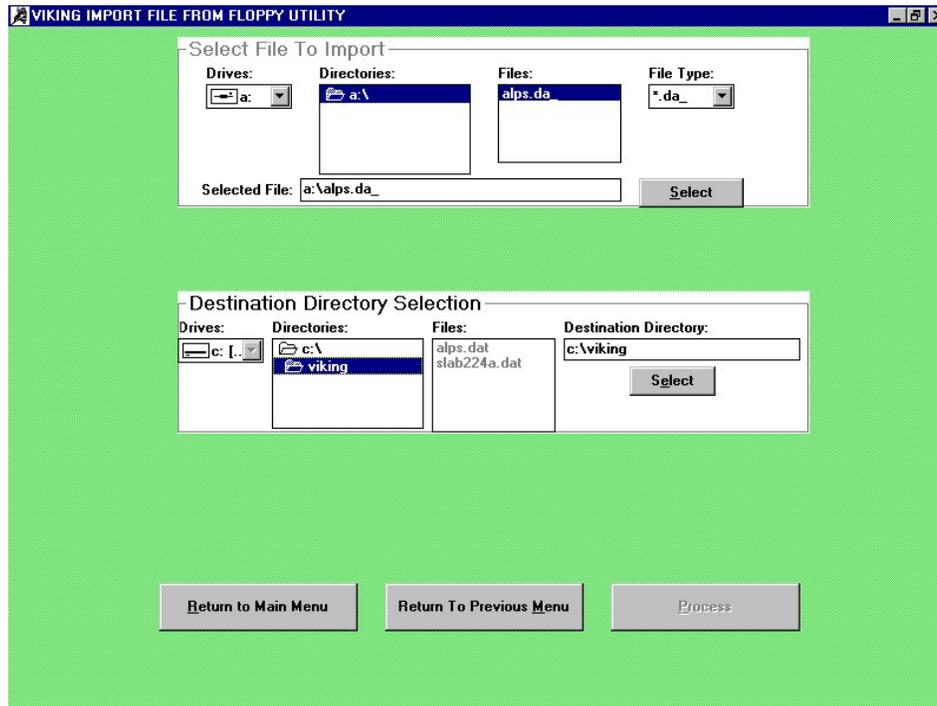


Fig.35. The Viking Import File from Floppy Utility screen

Select from the "a:\\" directory the file to be imported. Double clicking on the file name, which will be highlighted and shown in the "Selected File:" window, does this. Click the "Select" button in this part of the menu. The file is ready to be imported.

In the "Destination Directory Selection" part of the menu the driver is selected followed by the selection of the directory. Double click the "Directories" "c:\\" folder. The "c:\\" is shown in the "Destination Directory" window. Select the directory by a double click. The directory chosen will be highlighted and shown in the "Destination Directory" window. An example is shown in fig. 36.



*Fig.36. The import file a:\viking\alps is ready to be imported to c:\viking\alps.dat. Clicking the "Select" button will make the "Process" button active, ready for import.*

Click the "Select" button in this part of the menu. The "Process" button becomes active. Click this button.

A message comes up: "File being expanded. Please wait". After it has disappeared the file has been copied in the directory chosen.

To check the copying, go to the main menu and select the Viking Setup and Test. The imported file has to be shown in the "Files" window.

Should the directory have a file with the same name as the one being imported, the file will be overwritten. This process will be notified by a Viking Overwrite Message:

This Directory has a file with the same name. The process will overwrite this file. Do you want to continue?

If affirmative, the file will be overwritten.

## Appendix A

### Directions for selection of a drive, a directory and file(s), and making changes

#### A1. Choosing a drive

As shown in fig. 2, page 13, the default driver is the "c:" drive. Clicking the driver window will produce a pull-down menu from which selections can be made.

Alternatively, the floppy "a:" drive can be selected by activating the "Drives" button, one click, and selecting the drive. This is not recommended since only 167 records can be stored on a floppy. Also the a: drive is slow.

#### A2. Making a new directory, selecting an existing one or removing/deleting a directory

##### A2.1 Making a new directory

A directory has to be specified. The default directory is the VIKING directory and this should only be used. Attempting to make a new directory, double click on the "c:\\" folder in the "Directories" window. The File Path is now exhibiting only "c:\\". Click in the "File Path" window and enter the name of the directory, maximum eight (8) characters. Press the Enter-key. The directory selected is displayed in the "Directories" window. Proceed as illustrated in section A3 for making or selecting a file under the chosen directory.

NOTE: A directory name, once initialized, cannot be changed. Only a new directory with the correct name can be initialized and the incorrect one recycled to the recycle bin and deleted. Therefore, make sure the directory name is correct before initializing.

##### A2.2 Selecting an existing directory

For selecting an existing directory, double click on the "Directories" windows "c:\ folder". All existing directories will be displayed in the "Directories" window for selection. Double click on the directory in question. The selected directory is highlighted at the same time as the directory name is exhibited in the "File Path" window after the "c:\\" designation. Proceed as illustrated in section A3 for making or selecting a file under the chosen directory.

##### A2.3 Removing/deleting a directory

For removing/deleting a directory, exit to Windows. Double click on the icon "My Computer" and double click on the displayed (C:) drive. Drag the directory in question to the recycle bin. The directory has been removed from the software. From the recycle bin the directory can be deleted. Double click on the recycle bin icon. Highlight the directory in question, press the "Del"-key and confirm. The directory has been deleted.

### **A3. Making a new file, selecting an existing or removing/deleting a file**

#### ***A3.1 Making a new file***

Position the mouse arrow in the “File Name” window and click once. A cursor is blinking in the window. Enter the file name, maximum eight (8) characters. Press the Enter Key or click the “Initialize File” button. The “Initialize File” window will change to “File initialized” and the remaining part of the VIKING SETUP SCREEN shows up on the screen, as illustrated in fig. 8, p. 21.

NOTE: A file name, once initialized, cannot be changed. Only a new file with the correct name can be initialized and the incorrect one recycled to the recycle bin and deleted. Therefore, make sure the file name is correct before initializing.

#### ***A3.2 Selecting an existing file***

Selecting an existing file in a given directory is made by double clicking on the file in question, shown in the “Files” window.

The file is shown in the “File Name” window. Click the “Initialize File” button. The “Initialize File” change to “File Initialized” and the remaining part of the Viking Setup Screen shows up on the screen.

#### ***A3.3 Removing/deleting a file***

For removing a file, exit to Windows. Double click on the icon “My Computer” and on the (C:) drive illustrated. Double click on the directory containing the file. Drag the file to the recycle bin. The file has been removed from the directory. To delete the file from the recycle bin, first double click on the recycle bin icon, select the file to be deleted with one mouse click, press the “Del”-key and confirm.

The file has been deleted.

## Appendix B

### Measurement of the surface P-wave speed with the DOC-1000 / DOC-2000 systems

#### ***B1. Considerations to be taken into account before testing***

Measuring the surface P-wave speed is used for thickness estimates at locations where the thickness is not known. Once the wave speed and a solid frequency has been measured, the thickness can be evaluated by means of the Impact-Echo equation:

$$T = C_p/2f$$

This equation applies only for testing cases where the acoustic impedance of the test member is much greater than of the media adjacent to the member, as with an air interface.

Similarly, accurate detection of the depth of flaws require the wave speed to be estimated more precisely than by just assuming a wave speed of 4000 m/s for concrete. If such a determination is not possible by calibration of the P-wave speed by thickness measurement, the P-wave speed measured on the surface can be useful.

When performing such measurements for thickness estimation or for flaw detection four considerations have to be taken into account.

***First, the surface has to be smooth*** at the points where the transducer tips are resting and where the impact is made to produce a good contact. Also the caps protecting the transducer tips have to be intact and with a clear indent from the tips. Otherwise, the measurements become erratic.

***Secondly, the elastic properties of the surface have to be the same as of the interior*** of the member tested. The relative difference in these properties may change by e.g. cracking/spalling of the surface, special finishing techniques, by moist and by temperature.

***Thirdly, the systematic error is larger*** on estimating the thickness (or the depth of a flaw) than if the estimate is based on calibration of wave speed by thickness measurement alone.

The maximum systematic error  $e_p$  in measuring the P-wave speed with the DOCter system is calculated as  $e_p = \delta t/\Delta t$ . The sampling interval  $\delta t$  is 1.6 $\mu$ s.  $\Delta t$  is the time difference between arrival of the surface P-wave to the two transducers with an internal space of 300 mm. For  $\Delta t = 70\mu$ s the maximum systematic error in calculating the P-wave speed is:

$$e_p = \delta t/\Delta t = 1.6\mu\text{s}/70\mu\text{s} \cong 2.3\%$$

This error has to be added the maximum error from the frequency measurement  $e_f$ , see page 16, producing a maximum combined error in the 200 mm slab case of:

$$e = \sqrt{e_p^2 + e_f^2} = \sqrt{2.3^2 + 1.2^2} = 2.6\%$$

**Fourthly, the surface P-wave speed is the "true" wave speed**, while the wave speed calibrated by thickness measurement is the so-called "apparent" wave speed. The "true" wave speed is

$$C_{p,true} = \sqrt{\frac{E}{\rho}} \cdot \sqrt{\frac{(1-\nu)}{((1+\nu)(1-2\nu))}}$$

where E is Young's modulus of elasticity,  $\rho$  the mass density and  $\nu$  is Poisson's dynamic ratio.

This wave speed is the wave speed as measured by "through going"-techniques as ultrasound or by Impact-Echo on the surface using two transducers.

In contrast, the P-wave speed measured in the longitudinal direction on a slender member as on a core is:

$$C_{p,core} = \sqrt{\frac{E}{\rho}}$$

by which  $C_{p,true} \cong C_{p,core} \cdot 1.05$  for a Poisson's Ratio of  $\nu = 0.20$ .

The wave speed measured by Impact-Echo on a plate by thickness measurement, the "apparent" wave speed  $C_{p,apparent}$  is slightly different from the "true" wave speed  $C_{p,true}$  due to vibrations of the plate. This  $C_{p,apparent}$  wave speed is about 4% less than the "true" wave speed.

Throughout this manual the  $C_{p,true}$  wave speed is called the "surface P-wave speed" and the  $C_{p,apparent}$  wave speed "the wave speed  $C_p$ " or, simply, the "wave speed".

When transforming a measured surface P-wave speed to this wave speed used for Impact-Echo testing of plates and plate-like structures, the default value of the conversion factor ( $\beta$ ) is:

$$C_p = \beta \cdot \text{Surface P-wave speed} = 0.96 \cdot \text{Surface P-wave speed}$$

The Viking allow, if needed, the conversion factor to be changed.

All aspects taken into account, surface P-wave speed measurements for thickness estimate should only be made if the wave speed cannot be found by calibration through thickness measurement.

In any case, whenever possible, the estimate of the thickness should be checked against physical thickness measurements.

## B2. The Viking Surface P-wave Screen

To measure the surface wave speed one click is made in the "Measure Surface P-Wave Speed" window in the Viking Setup Screen, fig. 8, page 21.

Similarly, clicking the "Measure Surf. P-Wave Speed" button in the Viking Test Screen, fig. 9, page 22, will produce the Viking Surface P-wave Screen as shown in fig.37.

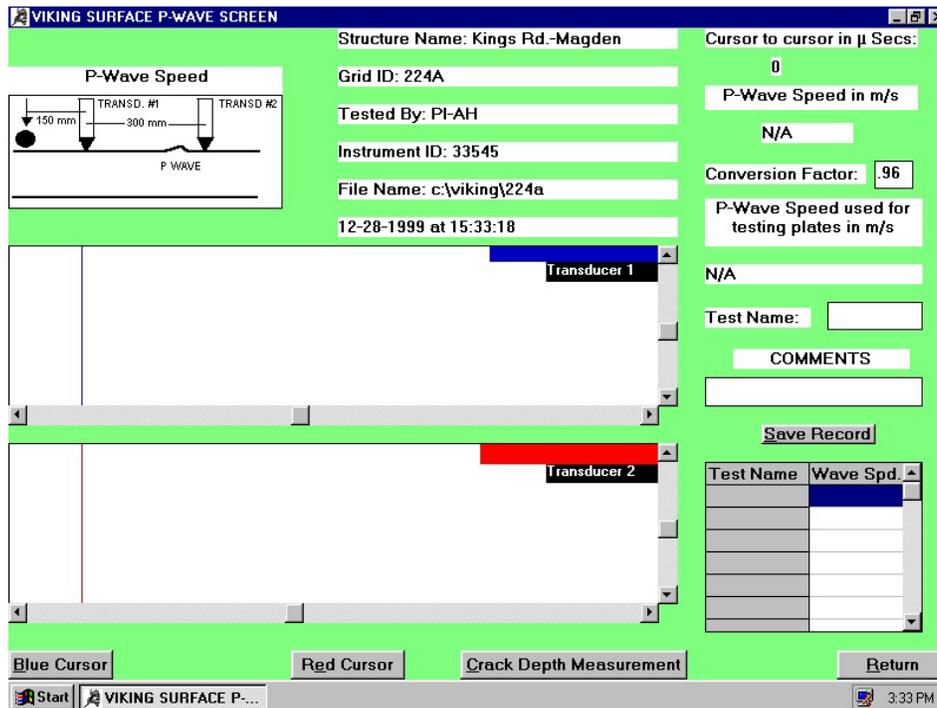


Fig. 37. The Viking Surface P-wave Screen

Adjacent to the illustration of the test set-up in the LONGSHIP (see the Operation and Maintenance Manual) the job particulars are given (structure name, grid ID, tested by, instrument ID, file name and the date/time of testing).

Below the job particulars are two frames for the displacement of the two transducers be exhibited after impact, Volts on the vertical axis against time in microseconds on the horizontal. Scroll buttons allow the signals to be magnified or compressed, vertically or horizontally.

The blue and the red boxes in the frames contain information of the horizontal position of the cursors (in  $\mu\text{s}$ ) and the cursor intersection with a horizontal line (stated in Volts).

The "Red Cursor" and the "Blue Cursor" buttons are activating the two related cursors in the frames. The cursors are moved in increments of  $1 \mu\text{s}$  by the keyboards two arrow keys " $\leftarrow$ " and " $\rightarrow$ ". An increment of  $1 \mu\text{s}$  change the wave speed by about 50 m/s. When pressing first the "Shift"-key and then the arrow keys the moving of the cursors takes place increments of  $26 \mu\text{s}$ .

On the right side of the screen the "Cursor to Cursor" value in  $\mu\text{s}$  is given. This value is divided into the spacing between the transducers - 300 mm - to produce the surface P-wave speed in m/s exhibited in the window below.

The conversion factor mentioned on the previous page is stated in the following window. The default value is 0.96. Should another factor be needed for the calculation of the wave speed used for Impact-Echo testing, the window is clicked in after the number, the " $\leftarrow$ BS" -key activated until the number has disappeared, and a new number is entered.

Calculation of the wave speed for Impact-Echo testing is made in the following window with the algorithm and the result indicated.

The test name is entered in the "Test Name:" window after clicking in it, max five (5) characters. Pressing the enter key will make the cursor move to the "Comments" window, where a maximum fifty-two (52) character comment can be entered.

Clicking the "Save Record" button will store the test result. The summary of the test result will be exhibited in the tabulation below the "Save Record" button with the test name and the wave speed shown.

An average of 3 test results is recommended at each location.

Clicking the return button of the screen will produce a pop-out screen:

"Viking Average P-wave", with the message: The average is ----- m/s. Is this value OK for you?

If answered "No" to the question, the listed wave speeds in the tabulation in fig. 38 will be cleared for new wave speeds to be entered. The wave speeds will, however, all be saved as extra grid records. If answered "Yes" to the question, the wave speed average will be used in the further testing.

Should no test records previously have been stored in the grid, the average will be used in the further testing and exhibited as well in the Viking Setup Screens "Expected Wave Speed" window as well.

For test records stored in the grid prior to the testing for surface wave speed, the average will not affect these records.

Only in the further test records the calibrated frequency will be changed based on the expected thickness as stated in the Viking Setup Screen, or if changed later, on the value indicated in the test record screen.

At the bottom of the screen is a "Crack Depth Measurement" button. When clicked in after surface wave speed measurements have been performed, a pop-out Viking Average Wave Speed screen will emerge with the information and question:

The average wave speed in m/s is: ----- . Do you want to use this speed for estimation of the depth of surface opening crack?

If affirmative, the wave speed will be used for depth estimation of surface opening crack, fig. 40, page 68, in the emerging "Measure Depth of Surface Opening Crack Screen".

Should no wave speeds have been made, prior to clicking the “Crack Depth Measurement” button, the  $C_p$  value is set at zero. A wave speed is then entered in the  $C_p$  box before testing continues.

### B3. Testing example from the slab case

The 300 mm spacer unit containing two Mark II transducers is prepared for testing. The twin cable to the two PC cards in the computer connects the transducers. Testing takes place as outlined in the Operation and Maintenance Manual.

One test result is illustrated in fig. 38 from the slab case.

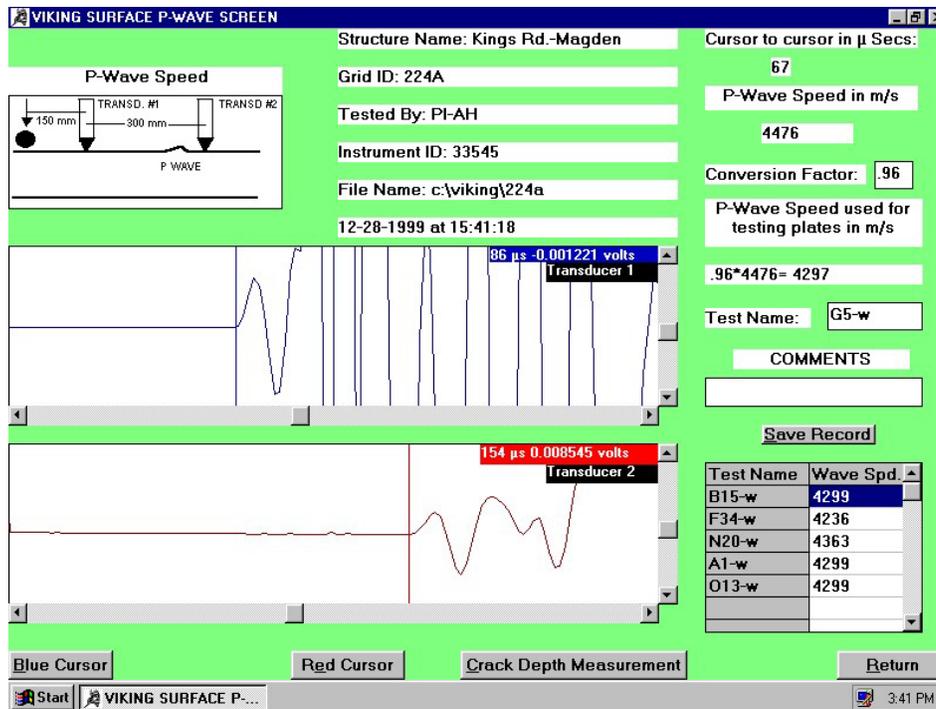


Fig.38. The O13-W surface P-wave speed record from the slab case. The next test name G5-W has been entered for a new test record to be stored.

Arrival of the P-wave to the two transducer tips is indicated by the first upward shaped curvature from the horizontal line in the signals. The vertical cursors in the two displacement signals are, in general, positioned automatically at these locations with the time in microseconds and a voltage given. The voltage indicates the vertical position of the intersection of the cursor with the displacement curve.

In fig.38 the difference in arrival time of the P-wave to the two transducer tips is 67 microseconds. This produce a Surface P-wave speed of 4476 m/s calculated as 300 mm divided by the 67 microseconds.

For a conversion factor of 0.96 between the Impact-Echo wave speed and the surface wave speed, the P-wave speed for testing of plates with Impact-Echo is  $0.96 \cdot 4476 \text{ m/s} = 4297 \text{ m/s}$ .

Before accepting a measurement, make sure that the P-wave arrival to both transducers is clearly visible as illustrated in fig. 38, and that the cursor is placed at the beginning of the P-wave. For moving the cursors manually, click the blue or red cursor buttons and activate subsequently the arrow keys “←” or “→”.

A clear, upward shaped curvature has to start out from the horizontal signal line, followed by an S-wave (very clear for transducer 2, less prominent for transducer 1), the large R-wave and multiple reflections.

The signals can be amplified by clicking the vertical scroll buttons pointing downwards, and diminished by clicking the buttons pointing upwards. Similarly, the horizontal scroll buttons can be clicked in to spread-out or compress the signals.

Pressing the Enter-key two times will save the record. Alternatively, click the “Save Record” button. The test name and the wave speed measured are, upon saving, exhibited in the table below the “Save Record” button. The screen is ready for another test with a new name typed in the “Test Name” window as illustrated in fig. 38. .

*In the slab case, twenty locations, selected at random, exhibited the wave speeds:*

Wave Speed Records:

Record Number	Record Name	Calibrated Wave Speed (m/s)
606	B15-W	4299
607	F34-W	4232
608	N20-W	4174
609	C40-W	4363
610	A1-W	4299
611	O13-W	4299
612	G5-W	4236
613	H4-W	4174
614	J3-W	4236
615	L7-W	4115
616	N9-W	4115
617	A14-W	4174
618	B19-W	4299
619	N36-W	4299
620	C38-W	4115
621	H39-W	4174
622	D40-W	4236
623	E40-W	4299
624	J40-W	4236
625	N40-W	4299

*Fig.39. Twenty surface wave speed estimations of the P-wave speed for impact-echo testing of the slab 224A, the average being 4234 m/s with a standard deviation of 75 m/s or 1.8%.*

**NOTE:** For evaluation of the quality of the signal obtained, keep in mind that the P-wave speed for Impact-Echo of concrete usually is about 4000 m/s, more or less. Always compare, whenever possible, the wave speed obtained with wave speed measured on a solid section for a known thickness. This is important, as the surface properties of a plate can be different from the interior of a member. Should there be a significant difference between the two estimates, it is recommended to adhere to the wave speed found by thickness measurement, provided the section tested is solid.

**NOTE:** Should the P-wave not be clearly visible at both transducers, repeat the testing. Check the surface for smoothness at the transducer tips. Check the caps for intactness and no penetration of the transducer tip, and smoothen the indents with a fingernail. Produce a good, hard impact. To avoid electrical noise on the horizontal displacement lines before the arrival of the P-wave, it may be necessary to run the computer from the battery, only.

## Appendix C

### Estimation of the depth of surface opening crack with the DOC-1000 / DOC-2000 systems

#### *C1 Preparation*

The transducer setup in the LONGSHIP is illustrated in the Operation and Maintenance Manual.

Access to the “Measure Depth of Surface Opening Crack” screen in the Viking software is always made from the “Viking Surface P-wave” screen, page 64.

**NOTE:** The crack depth records cannot be stored in the test grid itself. All records are stored in the Extra Grid Records requiring proper designations referring to the location of the test positions in the test grid. In this manner regular testing for voids (or thickness), wave speed testing and crack depth testing can be made interchangeably throughout a grid.

When passing through the Viking Surface P-wave screen, page 64, the surface P-wave speed is most conveniently measured in a solid area in the vicinity of the surface opening crack, prior to the estimation of the depth of the crack. It is recommended to perform three tests and use the average.

When clicking the “Crack Depth Measurement” button in the Viking Surface P-wave Screen after such measurement has been made, a pop-out Viking Average Wave Speed screen will emerge with the information and question:

The average wave speed in m/s is: ----- . Do you want to use this speed for estimation of the depth of surface opening crack?

If affirmative, the wave speed will be used for depth estimation of surface opening crack in the emerging “Measure Depth of Surface Opening Crack Screen”, fig. 40, following page.

Alternatively, when passing through the Viking Test Screen, the P-wave speed found by calibration over a solid portion of the plate with known thickness can be used.

However, the “Measure Depth of Surface Opening Crack” screen can also be activated from the Viking Surface P-wave Screen, fig. 37, page 62, without performing P-wave speed measurements.

If no wave speed information has been entered in the software prior to activating the screen, the  $C_p$  will be zero. A best-guess wave speed has to be entered before testing can commence.

The entered wave speed can be changed at any time as desired, as well as re-testing for surface P-wave speed can be performed by clicking the “Return” button.

## C2. The Viking Depth of Surface Opening Crack screen

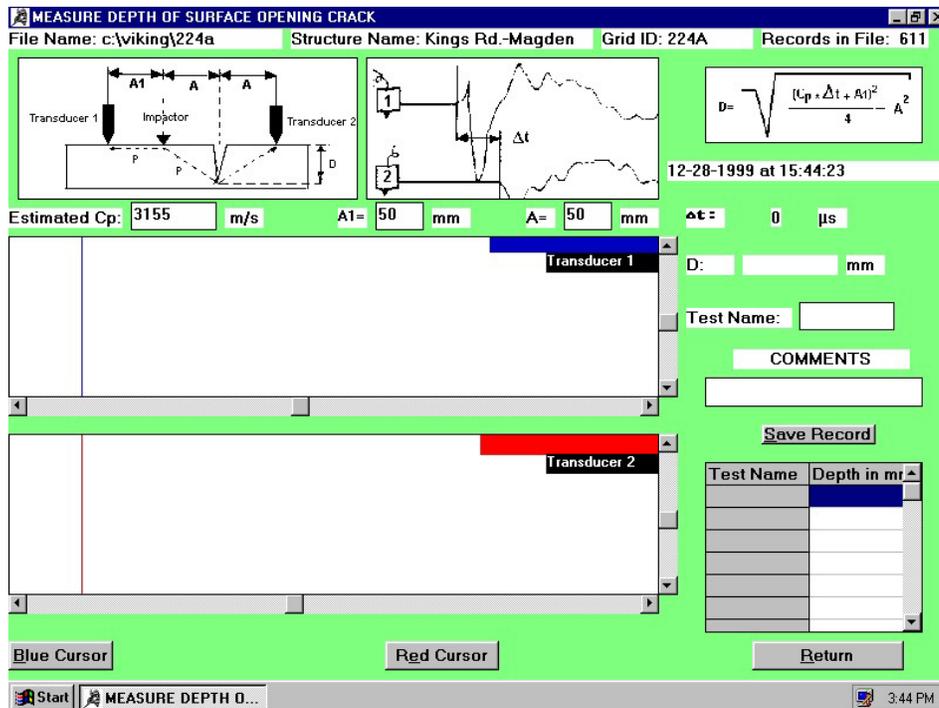


Fig.40. The "Measure Depth of Surface Opening Crack" screen. The  $C_p$  was estimated by surface P-wave speed measurements prior to entering the screen. The example is from a fire damaged slab exhibiting surface opening cracks

At the top of the screen the file name, the structure name, the grid ID and the number of records in the file are illustrated.

The three following windows illustrate the transducer setup in the LONGSHIP, a typical test record with  $\Delta t$  shown, and the equation used for calculation of the crack depth. The equation is outlined in the Operation and Maintenance Manual as well as in its Appendix A.

The wave speed estimated is shown in the "Estimated  $C_p$ " box. Another value can be entered as desired, e.g. for sensitivity analysis once the test result is on the screen. To change the value click in the box, delete the number and enter a new one terminated by pressing the Enter-key.

For the standard transducer setup the distances A1 and A are both 50 mm. Other values can be entered as desired, provided they are matched by the actual transducer setup.

The time difference in  $\mu s$  between the blue and the red cursor positions is shown in the " $\Delta t$ " box followed by the depth estimate of the surface opening crack "D" in mm, a test name (max. 5 characters) and a comments box (max. 40 characters).

Saving of records can be made by clicking the "Save Record" button, or - once a test name has been entered - simply by pressing the Enter-key three times. Saving is made in the tabulation shown with test name and depth in mm indicated.

The remaining two large windows will, after the test has been made, contain the response of transducer 1 (the transducer closest to the impactor) and of transducer 2.

The transducer 1 window contains a blue cursor and a blue bar at the top right corner of the frame. The blue cursor can be moved manually by clicking the “Blue Cursor” button and activating the arrow keys “←” or “→”. Speedy moving of the cursor can be made by activating the Shift-key as well.

The windows blue bar will contain the cursor position in  $\mu\text{s}$  after a test has been made, and a voltage number indicating the vertical position of the intersection between the cursor and the transducer signal.

Similarly, the transducer 2 window contains a red cursor and a red bar at the top right corner of the frame. The red cursor can be moved manually by clicking the “Red Cursor” button and activating the arrow keys “←” or “→”. Speedy moving of the cursor can be made by activating the Shift-key as well.

The windows red bar will contain the cursor position in  $\mu\text{s}$  after a test has been made, and a voltage number indicating the vertical position of the intersection between the cursor and the transducer signal.

Both windows have scroll buttons for vertical as well as horizontal magnification or reduction of the signals.

Clicking the “Return” button will make the software return to the “Viking Surface P-wave Screen”. The test records will be saved in the Extra Grid Records of the Viking Test Screen.

Upon returning to the “Measure Depth of Surface Opening Crack” screen the tabulation containing the previously saved records is cleared, ready for new records to be saved.

### ***C3. Testing example from a fire damaged slab***

Fig. 41 illustrates a correct and acceptable signal.

After impact, the P-wave travelling on the surface will cause an upward displacement to transducer 1.

So, the ***transducer 1*** signal has to exhibit a straight line from the left to the right followed by an ***upward*** curvature.

The same P-wave will not be able to pass the surface opening crack to transducer 2, but will travel along the crack surface. When it reaches the bottom of the crack, the P-wave will send out a diffracted signal that will reach transducer 2 as a tension wave. As this wave is a tension wave, the surface at transducer tip 2 will move ***downwards*** the first time the P-wave arrive to ***transducer 2***.

Therefore, the **transducer 2** signal has to exhibit a straight line from left followed by a *downward* curvature.

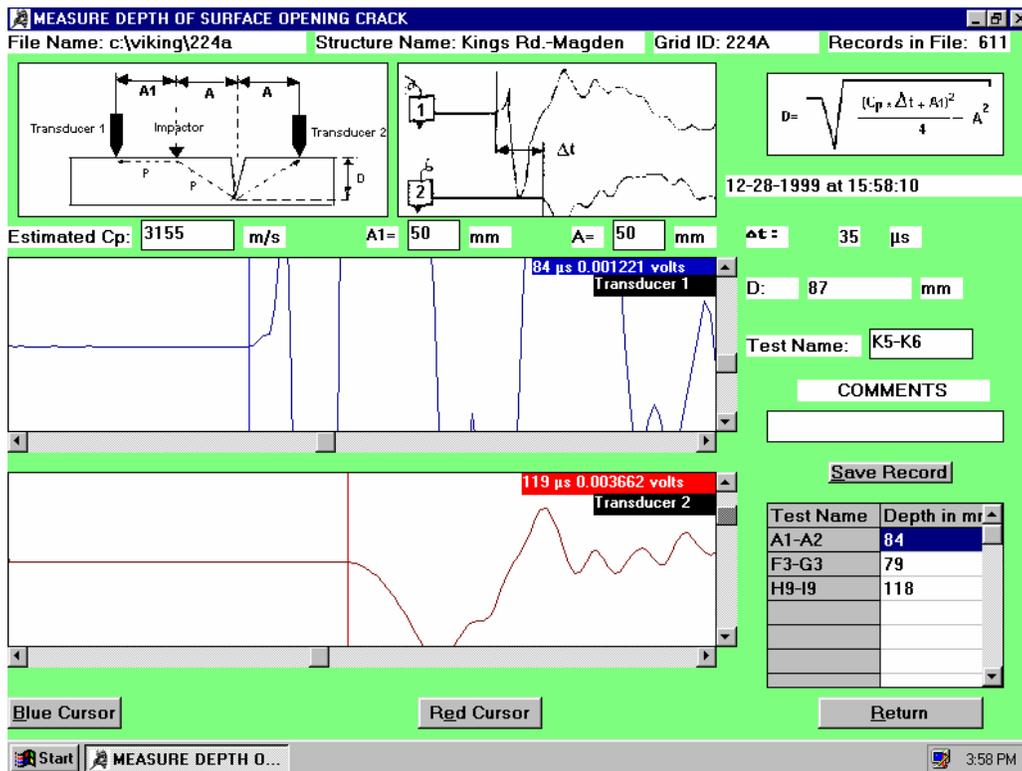


Fig.41. Typical test record from testing of the depth of surface opening crack. The example is from testing of a fire-damaged slab, hence the low wave speed of 3155 m/s. The depth of the surface opening crack is  $D = 87$  mm. Coring showed an actual crack depth of 85-88 mm

Observe the following requirements for evaluation of the correctness of the signal before saving of the record:

1. From left to the right, both transducer signals have to start out with a straight line. Should the lines be supplemented by irregularities, the software will not be able to position the cursors at the arrival of the P-wave. Such “Bumps” on these lines may be caused e.g. by defective transducer caps of the Mark IV's, bad seating of the transducer tips, loose particles on the surface, insufficient impact force or by electrical interference from the surroundings..
2. The upper transducer 1 signal has to exhibit the shortest time period from impact to P-wave arrival (here 84  $\mu$ s) compared to the transducer 2 signal's (119  $\mu$ s). Should the order be reversed, the reason is typically that the impact force is too small. Re-test, using a bigger impact force.
3. A clear upward curvature following the straight line of the transducer 1's blue signal. The blue cursor has to be positioned at the beginning of this upward curvature. Use, if needed, the vertical scroll buttons to magnify the signal and make sure the software has positioned the cursor at the beginning of the upward curvature. Otherwise, move the cursor manually to the correct position evaluated by

the Volts-value indicated in the blue bar of the window when moving the cursor from left to right on the straight line. For moving the blue cursor click the “Blue Cursor” button and activate the arrow keys, “←” or “→”.

4. A clear downward curvature following the straight line of the transducer 2’s red signal. The red cursor has to be positioned at the beginning of this downward curvature. Use, if needed, the vertical scroll buttons to magnify the signal and make sure the software has positioned the cursor at the beginning of the downward curvature. Otherwise, move the cursor manually to the correct position evaluated by the Volts-value indicated in the red bar of the window when moving the cursor from left to right on the straight line. For moving the red cursor click the “Red Cursor” button and activate the arrow keys, “←” or “→”.

The time difference between the cursor positions on the time axis in fig. 41 is  $\Delta t = 35 \mu\text{s}$ , calculated as  $119 \mu\text{s}$  deducted  $84 \mu\text{s}$ .

The estimated crack depth “D” is 87 mm for  $C_p = 3155 \text{ m/s}$ ,  $A1 = A = 50 \text{ mm}$  and for  $\Delta t = 35 \mu\text{s}$ , using the equation in the upper right corner of the screen.

The test name is entered, in this case “K5-K6”. Activating the Enter-key will move the cursor to the “Comments” box. Any comments are entered.

Activating the Enter-key two more times will save the record in the tabulation.

After saving the screen is ready for a new test.

Reviewing the records can be made from the Viking Test Screens “Extra Grid Records”. Click in any of “Crack-Depth” records boxes. Alternatively, return to the Main Menu and go to File Selection with Records Summary.

Printing of records is made from the Viking Examine Records Screen after a Test Record has been activated and the records selected for printing.