



Masterscan 350 User's Guide



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1 How to Use This User's Guide

This user's guide has been designed so that a person with a good knowledge of the basics of ultrasonic non-destructive testing may understand the operation and use of the features offered by the Masterscan 350. The user is advised, however, of the important nature of ultrasonic non-destructive testing and is referred to Section 2 for important information on the proper use of this technology.

Section 1: [How to Use This User's Guide](#) is this section.

Section 2: [Disclaimers and Notices](#) contains important information that must be understood by users of the Masterscan 350

Section 3: [Quick Start](#) provides a user familiar with ultrasonic testing a means to operate the instrument's basic functions and to quickly achieve familiarity without having to understand all of its features in detail.

Section 4: [Detailed Menu Description](#) is an in-depth description of the menu items found in the Masterscan 350 with brief descriptions of each item.

Section 5: [Flaw Testing](#) gives guidelines on performing flaw testing with examples of how to calibrate the Masterscan 350 and how to set up the unit for DAC, TCG, DGS/AVG and how to use the A-Scan storage facilities.

Section 6: [Thickness Gauging](#) gives guidelines on performing thickness measurements including the calibration of the Masterscan 350, using TCG and how to use the thickness measurement memory functions.

Section 7: [Power Supply](#) describes important aspects of using and caring for the battery power supply so as to get maximum battery duration time and life.

Section 8: [Interface Connections](#) is for users who desire to operate the Masterscan 350 with ancillary equipment.

Section 9: [Features of the Masterscan 350](#) is a quick reference listing the pertinent characteristics of the instrument and the various functional testing methods that may be used with the instrument.

The function keys are shown throughout this manual as shown in Section 3.1, [Front Panel](#) and [Optional Keyboard Controls](#).

1.1 Typographical Conventions


When describing front panel buttons the text is **printed in this font**.

When describing settings in the Masterscan 350 the text is `printed in this font`

2 Disclaimers and Notices

The following information must be read and understood by users of the Sonatest Masterscan 350 ultrasonic flaw detector and thickness gauge. Failure to follow these instructions can lead to serious errors in test results or damage to the flaw detector. Decisions based on erroneous results can lead to property damage, personal injury or death. Anyone using this instrument should be fully qualified by their organization in the theory and practice of ultrasonic testing, or under the direct supervision of such a person.

2.1 Specific Warnings

The Masterscan 350 contains a high-energy, precision pulser allowing optimum testing results to be obtained by matching the pulse width to the probe characteristics. This circuitry may be damaged by voltage spikes. It is recommended that the instrument be switched off, or the pulser stopped (by pressing the  key) before changing transducers (probes).

2.2 General Warnings

Proper use of the ultrasonic test equipment requires three essential elements:

- Knowledge of the specific test or inspection and applicable test equipment.
- Selection of the correct test equipment based on knowledge of the application.
- Competent training of the instrument operator.

This user's guide provides instruction in the basic operation of the Masterscan 350 flaw detector. In addition to the methods included, many other factors can affect the use of this flaw detector. Specific information regarding these factors is beyond the scope of this manual. The user should refer to appropriate textbooks on the subject of ultrasonic testing and thickness gauging for more detailed information.

2.3 Operator Training

Operators must receive adequate training before using this ultrasonic flaw detector. Operators must be trained in general ultrasonic testing procedures and in the set-up and performance required by each specific test or inspection. Operators must understand:

- Sound wave propagation theory.
- Effects of the velocity of sound in the test material.
- Behaviour of the sound wave at the interface of two different materials.
- Sound wave spread and mode conversion.

More specific information about operator training, qualification, certification and test specifications can be obtained from technical societies, industry groups and government agencies.

2.4 Testing Limitations

In ultrasonic testing, information is obtained only from within the confines of the sound beam as it propagates into the test material. Operators must exercise great caution when making inferences about the nature of the test material outside the limits of the sound beam. The condition of materials can vary significantly and the results can be erratic if operators don't exercise good judgment.

2.5 Critical Operating Factors

The following procedures must be observed by all users of this ultrasonic flaw detector in order to obtain proper and accurate results.

2.5.1 Calibration of the Sound Velocity

An ultrasonic flaw detector operates on the principle of measuring the time of flight of a burst of high frequency sound through the test piece as well as evaluating the amplitude of reflected or transmitted echoes. The sound velocity of the test piece multiplies this time in order to obtain an accurate distance or thickness reading. Since the actual sound velocity in materials can vary from the published values, the best result is obtained when the instrument is calibrated on a reference block made from the same material as the test piece. This block should be flat, smooth and as thick as the maximum thickness expected of the test piece.

Users should also be aware that the sound velocity might not be constant throughout the test piece due to effects such as heat-treating. This must be taken into consideration when evaluating the results of ultrasonic thickness testing. The calibration should always be checked after testing to minimize errors.

2.5.2 Transducer (Probe) Zero Procedure

The transducer calibration procedures must be performed as described in this manual. The calibration block must be clean, in good condition and free of noticeable wear. Failure to perform the transducer zero and calibration procedure will cause inaccurate thickness readings.

2.5.3 Flaw Detection Calibration

When performing flaw detection, it is important to note that the amplitude of indications is not only related to the size of the discontinuity; the depth of a discontinuity below the test piece surface will also have an effect on the amplitude due to characteristics of the sound beam spread and near field zone of the transducer. In addition, the characteristics of the discontinuity such as orientation and classification can alter the expected amplitude

response. For these reasons, calibration should be performed on test blocks made of the same material as the test piece with artificial discontinuities within the range of size and depth in the material to be detected. The user is again cautioned to refer to reference books which are beyond the scope of this manual.

2.5.4 Effects of Temperature on Calibration

The sound velocity in test pieces and the transducer wear face changes with temperature variations. All calibrations should be performed on site with test blocks at or near the same temperature as that expected on the test piece, to minimize errors.

2.5.5 Transducer Condition

The transducer used for testing must be in good condition, without noticeable wear of the front surface. The specified range of the transducer must encompass the complete range of the thickness to be tested and/or the types of discontinuities to be investigated. The temperature of the material to be tested must be within the transducer's specified temperature range.

2.5.6 Use of Couplant

Operators must be familiar with the use of ultrasonic couplant. Testing skills must be developed so that couplant is used and applied in a consistent manner to eliminate variations in couplant thickness which can cause errors and inaccurate readings. Calibration and actual testing should be performed under similar coupling conditions, using a minimum amount of couplant and applying consistent pressure to the transducer.

2.6 Disclaimer of Liability

All statements, technical information and recommendations contained in this manual or any other information supplied by Sonatest Limited in connection with the use, features and qualifications of the Masterscan 350 are based on tests believed to be reliable, but the accuracy or completeness thereof is not guaranteed. Before using the product you should determine its suitability for your intended use based on your knowledge of ultrasonic testing and the characteristics of materials. You bear all risk in connection with the use of the product.

You are reminded that all warranties as to merchantability and fitness for purpose are excluded from the contract under which the product and this manual have been supplied to you. The Seller's only obligation in this respect is to replace such quantity of the product proved to be defective.

Neither the seller nor the manufacturer shall be liable either in contract or in tort for any direct or indirect loss or damage (whether for loss of profit or otherwise), costs, expenses or other claims for consequential or indirect compensation whatsoever (and whether caused by the negligence of the company, its employees or agents or otherwise).

2.7 Electromagnetic Compatibility

This product conforms to the following European Directives:

Directive 2002/95/EC on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)

Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)

Low Voltage Directive (LVD) 73/23/EEC

CE Marking Directive 93/68/EEC

EMC Directive 89/336/EEC. However, in order to ensure the equipment meets the requirements, the following should be read:

⚠ WARNING! This is a "CLASS A" product. In a domestic environment, this product may cause radio interference. In which case the user may be required to take adequate measures.

Note: This product should not be connected to cables greater than three (3) meters in length. If this is necessary, the installation may require further EMC testing to ensure conformity.

The Masterscan 350 also complies with EN 12668-1, Non-destructive testing and verification of ultrasonic examination equipment – Part 1: Instruments. For any questions relating to the proper use of this product, please contact the manufacturer at the number indicated on page i.

3 Quick Start

3.1 Front Panel and Optional Keyboard Controls

The front panel controls consist of a series sealed, pressure sensitive, tactile buttons that allow the instrument settings to be changed and the movement through the menus on the screen. An optional keyboard connected to the USB port can also be used to navigate through the menus and make changes to the parameter values. A more detailed description of each button is shown below followed by an overview of the front panel:

When the term “highlighted” is used, it refers to text with a bright background and dark letters which is the selected item.



Power on & off push button for switching the instrument on and off. Operates as a toggle.

N.B Random lines or characters may be displayed for a second or two after switch on, before the memory is initialized, this is normal.



The Menu button is used to display the 4 main menu levels (**CAL**, **MEAS**, **UTIL** and **MEMORY**) on the right hand side of the screen. The **MENU** button can be pressed at any time. To select the required sub-menu press the plain grey button associated with it. Corresponds to the “ESC” key when using a keyboard.



These buttons move the highlighted cursor along the top of the screen left and right to the sub menu to be selected. These are momentary buttons with no repeat. The parameter boxes along the right hand side of the screen



change as the sub menu is selected. Corresponds to left and right arrows (← and →) when using a keyboard.



The four grey buttons on the right side of the display are used to select the menu boxes, which appear on the right side of the A-Trace. When a menu box is selected, it will be highlighted. Pressing the button a second time will, on certain parameters, display a drop-down list with a selection of values that can be chosen by using the ↶ and ↷ buttons. When using a keyboard F1 to F4 correspond to the 4 grey buttons.



This button operates in connection with the plain grey buttons next to the parameter boxes to increase the value or step the selection in the positive direction. In the case of transducer **Zero** or **Delay**, it moves the signals to the right. This is a repeat button with acceleration to facilitate quick scrolling of the value. Corresponds to up arrow (↑) when using a keyboard.



This button operates in connection with the plain grey buttons next to the parameter boxes to decrease the value or step the selection in the reverse direction. In the case of transducer **ZERO** or **Delay**, it moves the signals to the left. This is a repeat button with acceleration to facilitate quick scrolling of the value. Corresponds to down arrow (▼) when using a keyboard.



This button changes the size of the steps that are used to adjust the parameters; there are two sizes: small and large that are dependant on the parameter that is being changed. The button toggles between the two sizes and the current state is indicated by ► for small and by ►► for the larger step in the parameter box that is being adjusted. Corresponds to the letter "I" when using the keyboard.

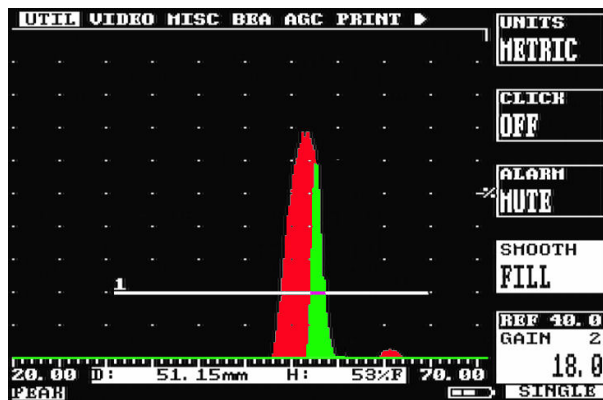


This button operates in conjunction with the memory menus to accept a store or to accept a recall of a memory already in storage. In the print mode, **OK** acts as the print button. Corresponds to "Enter" or the return key.



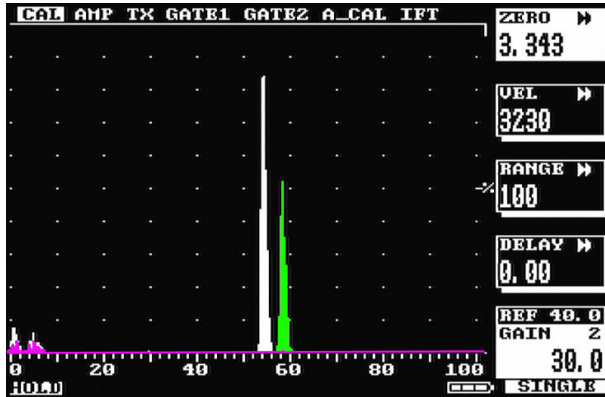
Press this button once to select freeze mode for the A-Scan display. This is a useful feature for holding an echo for evaluation. When in this mode, a box is highlighted showing **FREEZE** below the graticule.

Pressing the button a second time selects peak mode, which holds and updates all echoes on the display during inspection. This feature allows an envelope or echo dynamic pattern to be drawn on the screen with the "live" signal shown within, which is useful for angle beam inspection to locate the peak signal. When in this mode, a box is highlighted showing **PEAK** below the graticule as shown below:



Pressing the key again invokes the Hold mode that captures the current A-Scan in white allowing a comparison to be made with the live A-Scan that is shown in green. When this mode is selected a box is highlighted showing

HOLD as shown below:



If key lock is enabled from within the **UTIL** menu, pressing the button a fourth time selects **KEYLOCK** mode, preventing accidental changing of parameters

Pressing the button a fifth time returns the A-Scan display to normal mode. This is a momentary button with no repeat action. Corresponds to the letter “F” when using the keyboard.

HELP

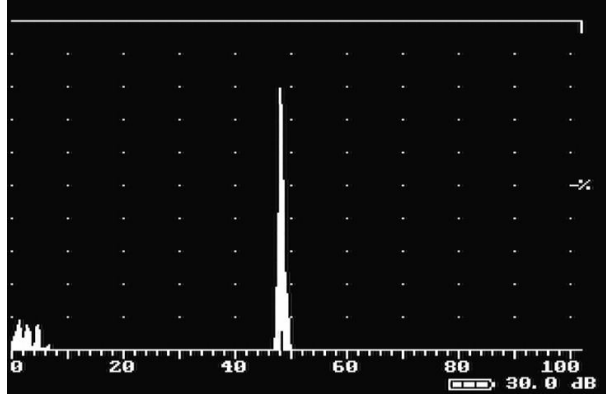
This button selects the help menu which overlays the display. The help menu explains how the Masterscan 350 operates with a choice of three options:

- ↶ Using the Masterscan 350
- ok Description of the active menu
- ↶ Calibration procedure.

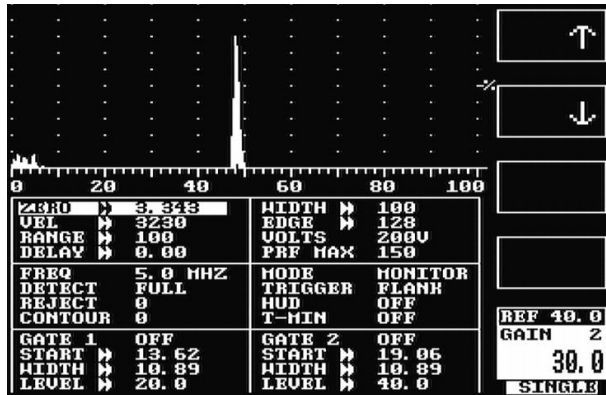
Pressing the **HELP** button again at any point in the help screens returns the display to normal mode. The Help Screen also displays the Instrument serial number & software version. Corresponds to “F5” when using a keyboard.

FULL
SCREEN

The full screen button is used to toggle between showing the A-Scan on the full display and showing it with the menus and parameter boxes as shown below:



Full display is useful for maximising the size of the A-Scan while performing inspections. While in full screen mode the user can still change the gain in the normal way and use the **FREEZE/PEAK** button; all other buttons are disabled. If split screen is enabled from the **UTIL** menu this button is used to display the A-Scan in the upper half of the display and parameters in the lower half as shown below:



In this mode the main parameters are shown in a grid that the user navigates by using the grey buttons next to the \uparrow & \downarrow arrows to scroll up or down and the \leftarrow and \rightarrow buttons to move from left to right. Once the required parameter has been selected it can be changed in the normal way by pressing the \rightarrow , \leftarrow and \gg buttons.



Press to select the dB step value of amplifier gain as 0.1, 0.5, 1, 2, 6, 10, 14, or 20dB. The selected value is indicated at the top right-hand corner of the gain box, which is always located at the bottom right side of the screen. This is a momentary button with no repeat. Corresponds to the letter “X” when using a keyboard.



Press to increment or decrement the gain value indicated in the gain box. This is always located at the bottom right side of the screen. This is a repeat button with acceleration to facilitate quick changing of the value.



Corresponds to “Page Up” and “Page Down” when using a keyboard.



Selects either reference or gain settings within the gain box. When reference is selected, the increment and decrement buttons will change both the reference and gain values together. This is a momentary button with no repeat. Corresponds to the letter “R” when using a keyboard.



This button toggles between single and double element transducers. The user should switch the unit off or stop the pulser by pressing the **FREEZE/PEAK** key before changing transducers. Corresponds to the letter “S” when using a keyboard.



BNC or LEMO 1 connector is the transmitter and receiver socket used for single transducers or as the transmitter only, for twin or dual transducer operation.



BNC or LEMO 1 connector is the receiver socket used for twin or dual transducer operation.

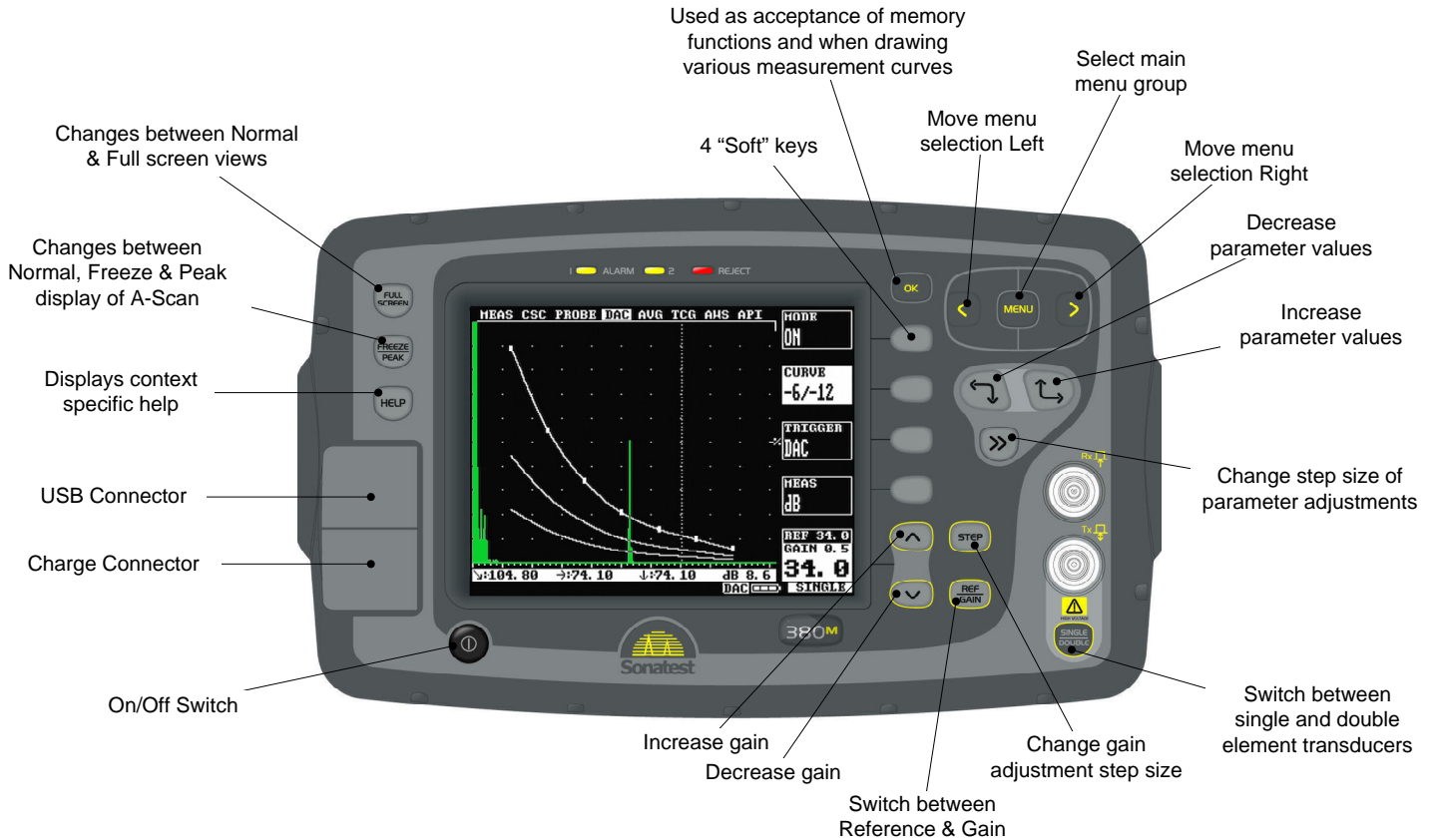


A socket to connect various USB devices such as a printer, keyboard or the user's PC.



A socket used to connect the battery charger for recharging the battery pack. A red dot is provided on both the socket and plug to facilitate alignment.

Refer to [Power Supply](#) for information on power supplies and charging of the battery pack.



3.2 Flaw Detection

Perform the following steps to establish a basic flaw detection mode for the Masterscan 350. Units shown are in inches. For metric units, select **METRIC UNITS** from the **UTIL** menu and use the corresponding values for the parameters.

1. Select a suitable transducer, preferably a 5MHz, half inch diameter narrow band.
2. When making a quick adjustment on a menu parameter, press the **>>** button until the double arrow appears next to the parameter name. This establishes the fast scroll using the **↶** and **↷** buttons.
3. In the **CAL** menu, set the following parameters:
ZERO to **0.000**
VEL should be set the specimen material velocity.
RANGE to **125** or other suitable value to cover the test range of interest.
DELAY to **0.000**
GAIN to **50.0**
4. In the **AMP** menu, set the following parameters:
DETECT to **FULL**
PRF to **150Hz**
5. In the **GATE1** menu, set the following parameters:
STATE to **ON +VE**
START to **10.0**
WIDTH to **50** or other suitable value to cover the test range of interest.
LEVEL to **50.0**
6. In the **GATE2** menu, set the **STATE** to **OFF**
7. In the **MEAS** menu, set the following parameters:
MODE to **DEPTH**
TRIGGER to **FLANK**
HUD to **OFF**
T-MIN to **OFF**

The Masterscan 350 is now configured for basic flaw detection. Using an appropriate calibration block, adjust the **GAIN** parameter to establish the correct sensitivity. Adjust other parameters as necessary to optimize the calibration. For more in-depth features of the Masterscan 350, see [Flaw Testing](#) on page 45.

3.3 Thickness Gauging

Perform the following steps to establish a basic thickness-gauging mode for the Masterscan 350. Units shown are in metric. For inch units, select **INCHES** from the **UTIL** menu and use the corresponding values for the parameters.

1. Select a suitable transducer, preferably a broadband, 5MHz, with a 10mm diameter.
2. Select an appropriate calibration block with at least three known thickness sections covering the range to be inspected and made from the same material as the test piece.
3. When making a quick adjustment on a menu parameter, press the **>>** button until the double arrow appears next to the parameter name. This establishes the fast scroll using the **↶** and **↷** buttons.
4. In the **CAL** menu, set the following parameters:
ZERO can be left alone
VEL should be set the specimen material velocity.
RANGE to **125** or other suitable value to cover the test range of interest.
DELAY to **0.000**
GAIN to **50.0**
5. In the **AMP** menu, set the following parameters:
DETECT to **+VE HW**
PRF to **150Hz**
6. In the **GATE1** menu, set the following parameters:
STATE to **+VE**
START to **10**
WIDTH to **50** or other suitable value to cover the test range of interest.
LEVEL to **25.0**
7. In the **MEAS** menu, set the following parameters:
MODE to **DEPTH**
TRIGGER to **FLANK**
HUD to **ON**
T-MIN to **OFF**
8. Calibrate the thickness readout on the selected calibration block using the procedure in [A-Cal](#) on page [82](#).


The Masterscan 350 is now configured for basic thickness gauging. Adjust parameters as necessary to optimize the calibration. For more in-depth features of the Masterscan 350, see [Thickness Gauging](#) on page 79.

3.4 Masterscan 350 Memory

The settings of the Masterscan 350 always remain in memory when the instrument is turned off, even if the battery pack is removed. That is, whatever the settings are just prior to turning the instrument off will be the settings in place the next time the instrument is turned on.

At times it may be desirable to start with default settings. This is especially true when beginning a new test procedure or going from flaw detection to a thickness gauging procedure. Otherwise, it may be necessary to go through all of the menus to reset various functions. A reset function is provided to facilitate the returning of all panel calibration settings to the factory defaults.

3.4.1 Reset to factory defaults:

1. Switch the instrument off.
2. Depress the **FULL SCREEN** button and hold while switching the instrument on until the reset display is seen.
3. Press the  button to reset the instrument to factory defaults

NOTE: Before performing this procedure, be sure to save any favourite settings to memory by using the procedure outlined in [Storage & Recall of Calibration Setups](#) on page 41.


NOTE: When resetting to factory default settings the following dialogue is displayed allowing the user to choose imperial or metric defaults:



NOTE: The video always defaults to PAL.

3.4.2 Clearing the Memory

The Masterscan 350's memory can store A-Scans, thicknesses and calibration set-ups. Erasing these values accidentally could have serious consequences and should only be done after suitable consideration. To erase the memory follow this sequence:

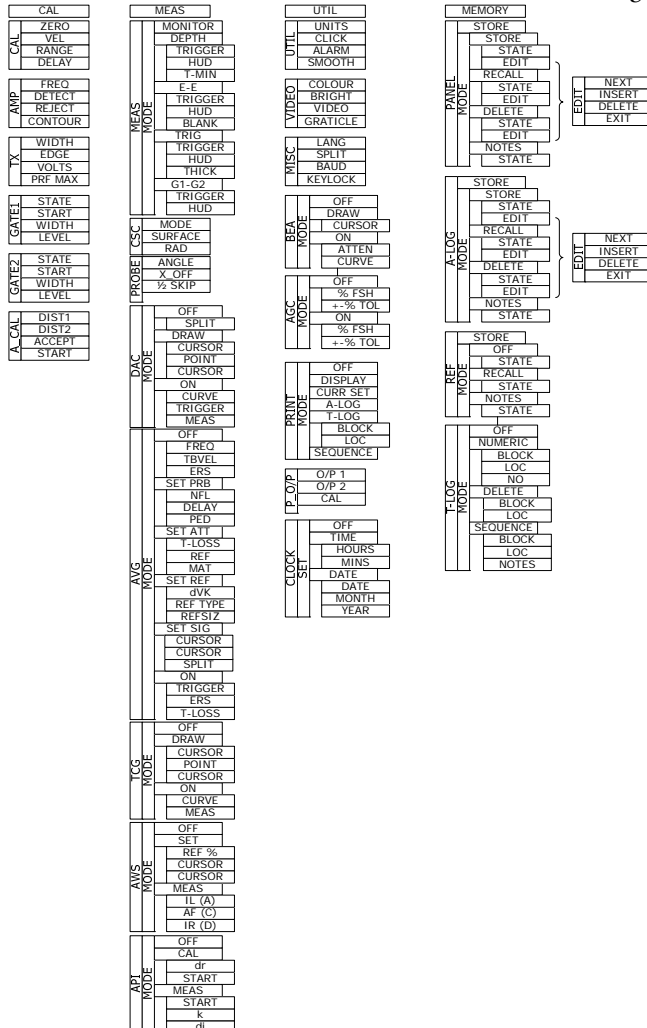
1. Switch the instrument off.
2. Depress the **MENU** button and hold while switching the instrument on until the reset display is seen.
3. Press the  button to clear the Masterscan 350's memory

4 Detailed Menu Description

Before proceeding with this section, the user should be familiar with the front panel controls described in section 3.1 Front Panel and Optional Keyboard Controls on page 6. It is also assumed that the user has a good understanding of the theory and practice of ultrasonic testing.

4.1 Menu Tree

This diagram represents the menu structure of the Masterscan 350; there are 4 main menu items with sub-menus below. The sub-menus are described in the following section.



When The Masterscan 350 is switched on, an information screen is displayed momentarily showing the instrument serial number and software version number while a self-test is performed as shown below:



4.2 Main Menu

After the information screen disappears the main menu selections are shown on the right hand side of the screen. To select a particular menu press the plain grey button to the right of it. You can return to the main menu selection at any time by pressing the **MENU** button.

4.2.1 Main Menu Selection

- CAL** Used to select the Calibration menu items: **CAL**, **AMP**, **TX**, **GATE1**, **GATE2** and **A_CAL**
- MEAS** Used to select the Measurement menu items: **MEAS**, **CSC**, **PROBE**, **DAC**, **AVG**, **TCG**, **AWS** and **API**
- UTIL** Used to select the Utilities menu items: **UTIL**, **VIDEO**, **MISC**, **BEA**, **AGC**, **PRINT**, **P_O/P** and **CLOCK**
- MEMORY** Used to select the Memory menu items: **PANEL**, **A-LOG**, **REF** and **T-LOG**.



Note: The **REF/GAIN** box always appears at the bottom right of the screen and can be changed using the **STEP**, **REF/GAIN** and the **^** and **v** keys.

Throughout the menus there are parameter boxes that have a thick line underneath them as shown here:



Pressing the grey button next to one of these parameter boxes produces a drop-down list as shown here:

Press the grey button again to remove the drop-down list after the required value has been selected.



4.3 CAL Menu

The CAL menu is the most used menu and contains those items that allow the Masterscan 350 to be easily calibrated. For full instruction on how to perform a calibration see [Flaw Testing Calibration](#) on page 46

4.3.1 Calibration Menu

- ZERO** Used to calibrate the screen and thickness readout for zero offsets that are inherently different for each transducer. Units are microseconds in both mm and inch modes.
- VEL** Used to calibrate the screen and thickness span readout based on the velocity of sound in the test material. Units are meters per second in mm mode and inches per microsecond in inch mode.
- RANGE** Used to set the full screen width of the horizontal A-Trace in mm, inches, or microseconds depending on the Units chosen in the **UTIL** menu. The range is 1mm to 20 meters (0.05 to 800 inches).
- DELAY** Used to set the delay or offset of the left side of the A-Trace for viewing of a portion of a signal. The range is 0 to 20 meters (0 to 800 inches).



4.3.2 Amplifier Menu

- FREQ** Used to set the centre frequency band of the amplifier to match the transducer. Ranges are 500 kHz, 1, 2.5, 5, 10 & 15MHz narrow bands and 1-35MHz WIDE band.
- DETECT** Used to set the display mode for the desired rectification of the signals from **FULL** (rectified full wave), **RF** (unrectified), **-VE HW** (negative half-wave) and **+VE HW** (positive half-wave)
- REJECT** Used to remove low level noise from the A-Trace. Reject is linear and is adjustable from 0 up to 80% of full screen height. The **REJECT** LED is lit when a reject is active.
- CONTOUR** Used to contour the shape of the echo signals, adjustable from 0 or no contouring to a level of 6 maximum contouring. See [Contour](#), Peak Echo & Hold Dynamics on page 76 for a full description.



4.3.3 TX (Transmitter) Menu

TX WIDTH Used to adjust the width of the square wave pulser to match the transducer. Adjustable in 10 or 1ns steps from 20 to 2,000ns. Usually set to match the transducer frequency at ½ its wavelength. Thus, the nominal settings would be:

| | |
|--------|--------------|
| 500kHz | 1,000ns |
| 1MHz | 500ns |
| 2MHz | 250ns |
| 5MHz | 100ns |
| 10MHz | 50ns |
| 15MHz | 30ns |
| WIDE | 30ns (SPIKE) |



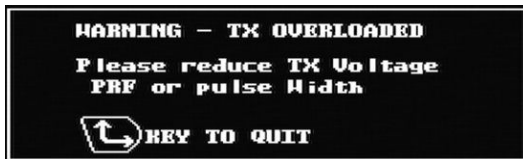
Adjust to optimize the shape and amplitude of echoes.

EDGE Used to change the ActiveEdge™ parameter.

VOLTS Allows switching between 100 and 450 Volts in 50 Volt steps. Note that in 400V operation the pulse width is limited to a minimum of 100ns

PRF MAX Used to set the maximum pulse repetition frequency that may be reduced for large values of display range and delay. Selectable values are from 15 to 100 in 5Hz steps, from 100 to 1,000 in 50Hz steps and 1,000 to 5,000 in 100Hz steps. Lower values will reduce ghosting and noise echoes.

NOTE The TX has an overload protection circuit which monitors output power. If the output is overloaded a message is shown on the display:



If this occurs reduce either TX WIDTH, PRF MAX, or decrease VOLTS. No damage will occur in overload, but the output voltage may be reduced.

4.3.4 GATE1 & GATE2 Menus

There are two gates available in the Masterscan 350 with slightly different options depending on the gate and the measurement mode chosen. The following describes the available settings for each gate with the differences between the gates stated. The gates can be identified by the fact that gate 1 has the number "1" above the line and gate 2 has the number "2" above it.

| | |
|----------------|--|
| STATE | Set the state of the gate as follows: |
| OFF: | Switches the gate off. |
| +VE: | The alarm triggers when an echo in the gate exceeds the threshold level. |
| -VE: | The alarm triggers when an echo in the gate falls below the threshold level. Usually used to monitor for loss of back wall echo. |
| EXPAND: | Expands the gate width to fill the horizontal display width. Only applies to gate 1. |
| START | Used to set the start position of the gate relative to the initial pulse. |
| | Units are mm or inches and range is from 0 to the full time base of the horizontal display. |
| WIDTH | Used to set the width of the gate. Units are mm or inches and range is from 0.15mm (0.001 inch), depending on the range selected, to the full time base of the horizontal display. |
| LEVEL | Used to adjust the alarm threshold level, which corresponds to the vertical height on the A-Trace. Adjustable in 0.5% or 2% steps from 0% to 100% full screen height. |



4.3.5 A-CAL Menu

This menu provides automatic calibration of sound velocity and transducer zero. Gate 1 is used to select the reference echoes. See [A-Cal](#) on page 82 for a full procedure.

- DIST1** The actual distance to the first or thinnest reference echo in the calibration block.
- DIST2** The actual distance to the second or thickest reference echo in the calibration block
- ACCEPT** After pressing OK to accept **DIST1** and **DIST2**. Press OK when **ACCEPT CAL** is highlighted.
- START** Used to adjust the start of the gate to assure that the first and second echoes are measured.



4.4 MEAS Menu

The menus in this section allow the various measurement techniques to be configured; these include the general measurement set-up and specialist methods such as DAC, AVG, TCG, AWS and API. Select the **MEAS** menu at any time by pressing the **MENU** button.

4.4.1 Measurement Menu

In the measurement menu, the top selection box shows the selected measurement mode and the remaining three selection boxes vary depending on the mode selected as follows:

MODE : MONITOR In this mode, gates 1 and 2 act as two independent monitor gates

MODE : DEPTH In this mode, gate 1 functions as a depth or thickness monitor and displays the depth (D:) and height (H:) of the first signal after the start of the gate that reaches or exceeds the gate level threshold. Values are displayed in a highlighted box below the A-Trace.

TRIGGER Used to select the depth or thickness measurement to the **FLANK** (left edge) of the first echo after the start of the gate or the **PEAK** measurement within the gate i.e. the largest value in the gate.

HUD When turned **ON**, provides a large, Head-Up Display of the depth or thickness reading at the top right of the A-Trace.

The ↶ button sequences the selections as follows:

| G1-G2 | E-E | DEPTH | TRIG |
|--------|--------|----------|----------|
| OFF | OFF | OFF | OFF |
| DIST | DIST | DIST | DIST |
| DIST + | DIST + | HEIGHT | HEIGHT |
| | | DIST + | DIST + |
| | | HEIGHT + | HEIGHT + |
| | | | ↓ |
| | | | ↓ + |
| | | | ↘ |
| | | | ↘ + |

T-MIN When turned **ON**, the depth or thickness reading will freeze that last minimum or lowest value measured. To reset, toggle the function to **OFF** and then **ON**. Only available in **DEPTH** mode.



- MODE :
E-E** In this mode, gate 1 functions as a thickness monitor and measures the thickness between the first signal in the gate and the second signal in the gate that reaches or exceeds the level threshold. A second bar is shown representing the blanking (see BLANK)
- BLANK** This function sets the blanking distance, as a percentage of the total gate width, which is a blind zone after the first echo, after which a second echo can be measured. This helps to eliminate undesired noise in the first echo from being measured, as thickness but will limit the minimum thickness capability if set too large
- MODE :
TRIG** The Trigonometry mode is used with angle beam transducers for weld inspection to calculate the three important measurements based on the echo position: the Beam path distance (↘:), the Surface distance (→:), and the Depth distance (↓:) from the index point of the transducer.
- THICK** Set to the thickness of the material being tested to account for multiple skips of the angled sound beam in the test material.
- MODE :
G1-G2** This is similar in concept to E-E mode, but uses gates 1 & 2, allowing the thresholds for the two gate measurements to be completely independent.

4.4.2 CSC (Curved Surface Correction)

This menu allows the user to configure the Curved Surface Correction (CSC) parameters. This feature is used when testing pipes and other curved surfaces. In order for the correction to be made the correct wall thickness must be selected in the **THICK** option when **TRIG** is selected in the **MEAS** menu. CSC is only active when in TRIG measurement mode.

- MODE** Turn CSC **ON** or **OFF**.
- SURFACE** Choose **CONCAVE** for internal surfaces or **CONVEX** for external surfaces
- RAD** Select the radius of the curvature.



4.4.3 PROBE Menu

- ANGLE** Set to the nominal refracted angle of the transducer to calibrate the Surface and Depth measurements
- X-OFFSET** Used to enter the distance from probe emission point to front of probe case. This is used by the TRIG function in MEAS menu to give the surface distance.
- 1/2 SKIP** Used as a quick way to turn on the 1/2 skip graticule.



4.4.4 Distance Amplitude Correction (DAC) Menu

This menu is used to create DAC curves using a series of reference echoes. Once drawn, the DAC curve acts as an alarm threshold level for the gate where the level varies to match the attenuation and field characteristics of the transducer and test material combination. The DAC procedure is described fully in [DAC Operation](#) on page 50.

- MODE: OFF** Turns the DAC measurement mode off.
- SPLIT** Activates or deactivates the split DAC function where an additional DAC curve is generated if the signal drops below 20%
- MODE: ON** Displays the DAC curve on the screen
- CURVE** Used to display the DAC curve alone, the -6/-12dB, -6/-14dB, -2/-6/-10dB, -2dB, -6dB or -10dB reference curves.
- TRIGGER** Used to set the alarm threshold for the DAC curve, -2dB, -6dB, -10dB, -12dB or -14dB curve or the gate.
- MEAS** Used to select the measurement value in dB, % Full Screen Height (FSH) or %REF for any signal that is in the curve or gate.
- MODE: DRAW** Used to create the DAC curve.
- CURSOR** Used to move the cursor over the reference echo for which a DAC point is being set.
- POINT** Display only. Shows the number of points created after pressing the **OK** button.
- CURSOR** Toggles the width of the selection cursor between 25 pixels (default) and 5 pixels for more accurate selection of peaks.



4.4.5 DGS/AVG

This menu is used to create a DGS/AVG curve allowing flaw sizing and distance compensation without requiring the reference standards for establishing a DAC curve or to set up a TCG correction. DGS/AVG is described fully in [DGS/AVG Operation](#) on page 62.

| | |
|--------------|--|
| MODE: | Initial mode. Turns off the display of the DGS/AVG curve |
| OFF | |
| FREQ | Used to set the transducer frequency taken from its datasheet. |
| TBVEL | Used to set the reference (test) block velocity in m/s |
| ERS | Used to set the Equivalent Reflector Size. |

| |
|----------|
| MODE |
| OFF |
| FREQ ▶ |
| 2.00 |
| TBVEL ▶ |
| 5930 |
| ERS ▶ |
| 3.2 |
| REF 10.0 |
| GAIN 2 |
| 40.0 |
| SINGLE |

| | |
|----------------|---|
| MODE: | Mode used to define curvature correction and probe delay |
| SET PRB | |
| NFL | Used to set the Near Field Length taken from the transducer datasheet |
| DELAY | Used to set the probe delay material velocity in m/s and is used in conjunction with the probe zero and specimen velocity to calculate the sound field equivalent length. |
| PED | Calculated Probe Effective Diameter – This value is for information only and cannot be changed |

| |
|----------|
| MODE |
| SET PRB |
| NFL ▶ |
| 30.0 |
| DELAY ▶ |
| 2700 |
| PED |
| 18.9 |
| REF 10.0 |
| GAIN 2 |
| 40.0 |
| SINGLE |

| | |
|----------------|--|
| MODE: | Used to set attenuation parameters |
| SET ATT | |
| T-LOSS | Used to set the transfer loss in dB due to surface condition, poor coupling etc... |
| REF | Used to set the reference material attenuation in dB/m |
| MAT | Used to set the test material attenuation in dB/m |

| |
|----------|
| MODE |
| SET ATT |
| T-LOSS ▶ |
| 0.0 |
| REF ▶ |
| 0.0 |
| MAT ▶ |
| 0.0 |
| REF 10.0 |
| GAIN 2 |
| 40.0 |
| SINGLE |

MODE: SET REF Used to define the various reference values

dVK Used to set the curvature correction factor in dB and is taken from the transducer datasheet.

REF TYPE Used to select the reference reflector type: Flat Bottom Hole (**FBH**), Side Drilled Hole (**SDH**) or Back Wall Echo (**BWE**)

REFSIZ Used to define the size of the reference type. If **REF TYPE** is set to **BWE**, **REFSIZE** is set to **INFINITE**



MODE: SET SIG Mode used to perform calibration

CURSOR Select than use the ↶ and ↷ keys to move the selection over the echo and press **OK**. The Masterscan 380 will calculate the sensitivity and draw the curve on the screen

CURSOR Used to change the width of the cursor between 25 pixels and 5 pixels

SPLIT Select to activate or deactivate multiple DGS/AVG curves.



MODE: ON Mode in which DGS/AVG is on.

TRIGGER Used to select either the **GATE** or the **CURVE** as the measurement reference

ERS Used to set the Equivalent Reflector Size.

T-LOSS Used to set the transfer loss in dB due to surface condition, poor coupling etc...



4.4.6 TCG Time Corrected Gain Menu

This menu is used to create TCG curves using a series of reference echoes. Once drawn, the TCG curve acts as swept gain control on the amplifier to set different gain levels relative to distance. The TCG procedure is described fully in [TCG Operation](#) on page [53](#)

| | |
|------------------|--|
| MODE : | Used to create the TCG curve. Cannot be drawn in RF display mode. |
| DRAW | |
| CURSOR | Used to move the cursor over the reference echo for which a TCG point is being set |
| POINT | Display only. Shows the last point created after pressing the OK button. |
| CURSOR | Used to change the width of the cursor between 25 pixels and 5 pixels |
| MODE : ON | Activates the TCG curve to adjust the gain. Can be activated in RF or rectified display modes. |
| CURVE | When switched ON, the TCG curve is displayed. |
| MEAS | Used to select between dB, %FSH and %REF for measurements |



4.4.7 AWS Menu

This menu is used when performing weld inspection in accordance with the American Welding Society's Structural Welding Code, ANSI/AWS D1.1-94. It provides a convenient method to automatically calculate the Indication Rating as defined in the code. The AWS procedure is described fully in [Weld Inspection Using the AWS Menu](#) on page 57

- MODE:** Used to set up the AWS measurement mode.
- SET**
- REF** Used to set the Indication Level.
- CURSOR** Used to move the cursor over the reference echo to set the reference level.
- MODE:** Used to make measurements in accordance with the code.
- MEAS**
- IL (A)** The dB required setting the indication to the reference level.
- AF (C)** The attenuation factor to correct for the depth of the indication.
- IR (D)** The indication rating calculated in accordance with the code. Also the difference the IL and the reference level with correction for attenuation.



4.4.8 API Menu

This menu is used to assist users in performing tests according to the American Petroleum Institute (API) Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections using the Amplitude Distance Differential Method (ADDM). Users are referred to the publication: "API Recommended Practice 5UE, Second Edition, June 2005" The API procedure is described in [Evaluation of Pipe Imperfections using API 5UE](#) on page 59

MODE: Used to set the initial calibration of the defect.
CAL

dr Depth of the reference indicator; should be set by the user according to the size of the reference defect.

START The position of the gate that is used to set the calibration.

LEVEL The height of the gate that is used to set the calibration.

MODE: Used once the calibration has been done to make comparative measurements.
MEAS

START Used to position the start of the gate used for making measurements.

k The k factor derived during the calibration phase and used to calculate the depth of the defect. It can't be changed during the measurement phase and is displayed for reference.

di Imperfection depth calculated by the Masterscan 350.



4.5 UTIL Menu

Press the **MENU** button followed by the plain gray button next to **UTIL** to select these menu options. The items in this section allow the user to configure features such as units, display preferences, language, back wall echo attenuation (BEA), print options, proportional output configuration and date and time settings.

4.5.1 UTIL Menu

| | |
|---------------|---|
| UNITS | Selects INCHES , μs , or METRIC measurement units. When in μs mode, the velocity is fixed at 2000 m/s (5000in/μs) and is not adjustable. |
| CLICK | When on, a beep will sound to confirm each button press. |
| ALARM | When set to AUDIBLE , a buzzer sounds during any gate alarm. |
| SMOOTH | When SMOOTH is selected the signal is displayed as an envelope. When FILL is selected the area under the trace is filled. |




4.5.2 VIDEO Menu

| | |
|------------------|---|
| COLOUR | Selects one of eight colour schemes for the display |
| BRIGHT | Controls the display brightness. The level selected affects the battery life. A value of 1 gives 16 hours, 10 gives 12½ hours and a value of 20 will give 9 hours of operation, assuming the battery is in good condition at 22°C. |
| VIDEO | Select NTSC (USA) or PAL (UK/Europe) composite video output modes. The screen update rate is 50Hz in PAL and 60Hz in NTSC. |
| GRATICULE | Selects graticule options from the following choices: OFF: No graticule. ON: A complete 100% graticule SPARSE: A row of dots at 10% intervals. 50%: Divisions at 50% full screen height. 1/2 SKIP: Sparse with vertical dotted lines representing the ½ skip, full skip and 1½ skip distances. Press ↶ again to get the ½ skip lines with calculated distances shown |





4.5.3 MISC Menu

- LANG** Selects one of 6 built in languages or a user selectable language. The built in languages are selectable at time of ordering the Masterscan 350.
- SPLIT** Allows the user to display a vertically compressed A-Scan in the upper half of the screen and a sub-set of the menus in the lower half. When set to **ACTIVE** the **FULL SCREEN** button switches between normal, full and split screen views.
- BAUD** Allows the user to select a Baud rate for the serial port to operate at. The choices are: 9,600 (**9K6**), 19,200 (**19K2**), 38,400 (**38K4**), 57,600 (**57K6**) or 115,200 (**115K2**).
- KEYLOCK** Allows the user to “lock out” the keys on the unit to stop inadvertent changes. When set to **ACTIVE** the  button toggles between freeze, peak, hold and keylock.



4.5.4 BEA (Backwall Echo Attenuator)

- MODE** Allows selection between **OFF**, **DRAW** and **ON**
- ATTEN** In **ON** mode this is used to select the level of attenuation to apply to the backwall. The value can be selected between 0dB and the REF gain value to a maximum of 40dB
- CURSOR** In **DRAW** mode this is used to adjust the cursor so that it covers the area on the display that corresponds to the backwall. The cursor starts from the right hand side of the display and is made wider by using the  button and made narrower by using the  button. The attenuation is reduced by the selected **ATTEN** value for the width of the cursor.
- CURVE** Used to display a line representing the amount of attenuation applied



4.5.5 AGC (Automatic Gain Control)

Automatic Gain Control feature is generally used in thickness logging.

By setting a percentage of full screen height (% **FSH** – default 50%) and ensuring that the signal is breaking gate 1, the gain will be adjusted automatically to bring the signal height to the user defined value subject to an adjustable tolerance (+-% **TOL**).

AGC MODE Turn AGC **ON** of **OFF**

% **FSH** Choose the screen height, between 10% and 90%, to which the user wants the gain to be adjusted.

+-% **TOL** Choose the tolerance on the % **FSH** to stop the AGC “hunting” due to signal height jitter. The range can be set between 5% and 20% **FSH**



To Use:

- Set Gate 1 **+ve**, to a height of, say 10% or 20% **FSH** and ensure that the signal will cross the gate.
- Ensure that **MEAS** mode is anything but **MONITOR**
- Set the %**FSH** parameter to the signal height required.
- Enable AGC by changing AGC Mode to **ON**.
- For poor surface conditions, adjust the +-% **TOL** to increase the tolerance of variation in the signal before the gain is adjusted
- When a signal is present in Gate 1 and a suitable measurement mode is selected the gain will be automatically adjusted to bring the signal to the specified height on the screen.

NOTES:

- When the Masterscan 350 is switched on the AGC is turned OFF.
- The gain value that is last set by AGC remains when AGC is switched off.
- If the gate level is above the user defined %**FSH**, AGC is internally inhibited.

4.5.6 PRINT Menu

This menu allows printing of information to a suitable USB printer connected to the USB port on the Masterscan 350. Please note that this requires a printer with a USB port from the Sonatest certified list of printers.

- OFF** The print mode is switched OFF
- DISPLAY** With the print mode in **DISPLAY**, the screen display will be sent to the printer when the **OK** button is pressed.
- CURR SET** With the print mode in **CURR SET**, the current calibration settings, the screen and all notes are sent to the printer when the **OK** button is pressed.
- A-LOG** In the **A-Log** print mode, all of the stored A-Scans that are valid will be printed when the **OK** button is pressed, along with the calibration settings and notes. This can take considerable time if all 800 A-Scans are stored.
- T-LOG** In the **T-Log** print mode, all of the stored thickness measurements are printed when the **OK** button is pressed. This can take considerable time if all 8,000 thicknesses are stored
- SEQUENCE** In the **SEQUENCE** print mode, all of the sequence thicknesses are printed along when the **OK** button is pressed. This can take considerable time if all 8,000 thicknesses are stored.



4.5.7 P_O/P Proportional Output Control Menu

This menu controls the analogue and digital proportional outputs. Two outputs are provided. The outputs are active when the associated gate is triggered and are updated at the PRF.

- O/P 1 **DEPTH1:** (Gate1)
- and** **DEPTH2:** (Gate2)
- O/P 2 **E1-E2:** Distance between the two depth measurements
- ALARM 1:** Voltage output when alarm 1 is active (O/P 1 only)
- LEVEL1:** (Gate1)
- LEVEL2:** (Gate2)
- L1-L2:** The difference between the two amplitudes
- ALARM 2:** Voltage output when alarm 2 is active (O/P 2 only)



CAL Allows the user to change the voltage on the proportional outputs between 0V and 10.1V

4.5.8 CLOCK Menu

- SET OFF** Do not display the time at the bottom of the display
- SET TIME** Used to set the current time.
- HOURS** Used to set the current hour in 24 hour format
- MINS** Used to set the current minutes.
- SET DATE** Used to set the current date. (Selected by pressing the plain grey button next to **SET** , then ↵)
- DATE** Used to set the current day.
- MONTH** Used to set the current month.
- YEAR** Used to set the current year.



4.6 MEMORY Menu

Press the **MENU** button then the plain grey button next to the **MEMORY** option to access the Memory menu. These menus allow the user to save panel settings, A-Scans and thicknesses as well as recalling an A-Scan to be used as a reference.

4.6.1 PANEL Memory Menu


This menu provides storage and recall of up to 100 calibration settings. The use of this feature is described fully in [Storage & Recall of Calibration Setups](#) on page [41](#)

- STORE** Used to select a storage location (1-100). Pressing the grey button twice lists all of the locations along with the associated notes. Use ↵ & ⏪ to scroll through the list; pressing the **OK** key will recall the selected panel.
- MODE : STORE** Stores the current calibration settings in memory to the selected Store set. Press **OK** to store. Press **OK** again after the confirmation prompt.
- MODE : RECALL** Used to recall a stored calibration set to the active memory. Press **OK** to recall
- MODE : DELETE** Used to delete a **VALID** (used) calibration set. Press **OK** to delete. Press **OK** again after the confirmation prompt
- MODE : NOTES** Shows the notes associated with the stored calibration set. Pressing **OK** will recall the calibration set at which time the Notes can be edited.
- STATE** Display only. **VALID** indicates that the store location is used. **EMPTY** indicates that it is not used. To change **VALID** to **EMPTY**, use the **DELETE** function.
- EDIT** (See [Adding NOTES to PANEL and A-LOG sets](#) on page [41](#).)



4.6.2 A-LOG Memory Menu



This menu provides storage and recall of up to 800 A-Scans with settings. The use of this feature is described fully in [A-LOG](#), A-Scan Storage on page 73

- STORE** Used to select a storage location (1-800). Pressing the grey button twice lists all of the locations along with the associated notes. Use ↶ & ↷ to scroll through the list; pressing the **OK** key will recall the selected panel.
- MODE : STORE** Stores the current A-Scan and its settings in memory to the selected Store set. Press **OK** to store. Press **OK** again after the confirmation prompt.
- MODE : RECALL** Used to recall a stored A-Scan and settings to the active memory. Press **OK** to recall. The A-Scan is displayed in FREEZE mode. Press  to remove.
- MODE : DELETE** Used to delete a **VALID** (used) A-scan and its settings. Press **OK** to delete. Press **OK** again after the confirmation prompt.
- MODE : NOTES** Shows the notes associated with the stored A-Scan and its settings. Pressing **OK** will recall the calibration set at which time the Notes can be edited.
- STATE** Display only. **VALID** indicates that the store location is used. **EMPTY** indicates that it is not used. To change **VALID** to **EMPTY**, use the **DELETE** function.
- EDIT** (See [Adding NOTES to PANEL and A-LOG sets](#) on page 41.)



4.6.3 REF Menu

This menu allows a waveform stored in A-LOG memory to be displayed as a reference on the display. Before a waveform can be recalled, it must be stored in an A-LOG location as described above.

- STORE** Used to select an A-LOG storage location (1-800). Pressing the grey button twice lists all of the locations along with the associated notes. Use  &  to scroll through the list; pressing the **OK** key will recall the selected panel.
- MODE :** Used to remove a Reference: waveform. Set **MODE** to **OFF**, and press **OK**.
- OFF**
- MODE :** Used to recall the stored A-Scan and display it. Press **OK** to recall.
- RECALL**
- MODE :** Shows the notes associated with the: stored A-Scan. Pressing **OK** will recall the waveform.
- NOTES**
- STATE** Display only. **VALID** indicates that the store location is used. **EMPTY** indicates that it is not used.

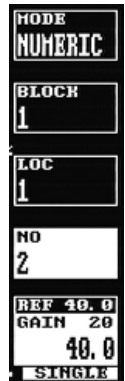


4.6.4 T-LOG Menu Numeric Mode

This menu provides storage and recall of up to 8,000 thickness readings. Numeric and Sequential modes are available. This feature is described fully in [T-LOG Thickness Storage](#) on page 84

Readings are stored under a three level code, starting with BLOCK (1-14), followed by Location (1-2000) and NO (1-2000).

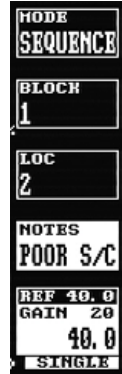
- MODE** Used to select the T-Logging mode, between **OFF**, **NUMERIC**, **DELETE** and **SEQUENCE**.
- BLOCK** Used to select the block number (1-14) for storage or viewing of a thickness reading.
- LOC** Used to select the location number for storage or viewing of a thickness reading.
- NO** The individual thickness reading number into which a thickness reading is stored. Increments automatically when storing a reading by pressing the **OK** button.



4.6.5 T-LOG Menu Sequential Mode

Readings are stored by block (1-14) and location (1-8000) number combination only. In this mode location and historical thickness data can be downloaded to the Masterscan 350 from a computer, a fixed series of four notes can be added to a location. This feature is described fully in [T-LOG Thickness Storage \(Sequential & Download\)](#) on page 85.

- MODE** Used to select the T-Logging mode, between **OFF**, **NUMERIC**, **DELETE** and **SEQUENCE**.
- BLOCK** Used to select the block number (1-14) for storage or viewing of a thickness reading.
- LOC** Used to select the location number for storage or viewing of a thickness reading.
- NOTES** One of four notes can be selected or blank. **OBSTRC** for obstruction, **PITTING**, **POOR S/C** for poor surface contact, and **NO BWE** for no back wall echo.



4.6.6 T-LOG Menu Delete Mode

- MODE** Used to select the T-Logging mode, between **OFF**, **NUMERIC**, **DELETE** and **SEQUENCE**.
- BLOCK** Used to select the block number (1-14), this value can also be set to **ALL** – for deleting all readings. When block is set to **ALL**, location number is also set to **ALL**.
- LOC** Used to select the location number (1-2000), this value can also be set to **ALL** – for deleting all readings under the specified BLOCK number.



4.7 Storage & Recall of Calibration Setups

After the Masterscan 350 has been properly calibrated for a particular testing scheme, it is possible to store all of the panel settings for subsequent recall when performing the same test at a later time. Although the last panel settings are “remembered” by the Masterscan 350’s memory, this feature is useful when the instrument is being used for many different tests requiring substantially different panel calibration settings. In addition to the panel settings, a freeform note can be stored with the panel set that includes provision for a label, an operator name or number, a location identifier, and a transducer identifier. It is possible to store up to 100 sets of panel settings; each assigned a set number from 1 to 100. A set of panel settings can be printed after the set is recalled to active memory by using the LIST CPY function in the PRINT menu.

4.7.1 To store a panel set:

Press the **MENU** button followed by the plain grey button next to the **MEMORY** option to access the Memory menu.

Use the **<** and **>** buttons to highlight the PANEL menu.

If it is desired to store Notes with the panel settings, see the description for entering notes below.

Select the STORE box and, using the ↶ and ↷ buttons, select a desired STORE number from 1 to 100. Note that as the STORE number is changed, the STATE parameter indicates if the number is used (VALID) or EMPTY.

Select the MODE box and using the ↶ and ↷ buttons, select the STORE mode.

Press the OK button to store the panel settings.

If you forgot to enter Notes, create the Notes as described below and then re-save the panel settings starting at step 5 above.

4.7.2 To recall a panel set:


Follow the above procedure but set the MODE parameter to RECALL and then press the OK button.

4.7.3 To delete a panel set:

Follow the above procedure but set the MODE parameter to DELETE and press the OK button.

4.7.4 Adding NOTES to PANEL and A-LOG sets

When storing panel calibration settings or waveforms, it is often useful to add some notes to the set so it can later be identified, or to help the user recall the correct set. This is possible in the **PANEL** and **A-LOG** menus by using the **EDIT NOTES** feature.

When a panel calibration or waveform is to be stored, first calibrate the instrument as desired, or capture the waveform by pressing the  button. Then select the **EDIT NOTES** box in the menu and notice that the window shown below overlays the display area.





The **LABEL** line is 8 characters long, and is used by the SDMS PC program to allow quick identification. The **OPERATOR**, **LOCATION** and **PROBE** lines are 25 characters each, while the three **NOTES** lines allow up to 75 characters.

The **<** and **>** buttons are used to move the cursor from right to left along a line of text. The plain grey button adjacent to the **NEXT LINE** box is used to advance the cursor down to the next line. When the cursor is at the bottom line, the **NEXT LINE** function moves it back to the top line.

To delete a character, position the cursor over it and press the plain grey button adjacent to the **DELETE CHAR** box.

To insert a character space, position the cursor to the right of the desired insert location and press the plain grey button adjacent to the **INSERT CHAR** box.

To select a character from the character map below the notes use the  and  buttons to move the cursor through the map, pressing the **OK** button to add the highlighted character to the currently selected position in the notes.

Once the desired notes have been added or edited, press the plain grey button adjacent to the **EXIT** box. The text is now entered but not stored. It is now necessary to store the notes using the methods outlined in the **PANEL** and **A-LOG** sections.

If a stored panel or A-LOG is recalled, its notes will be loaded into the window. The notes can then be viewed and edited using the same procedure detailed above.

NOTE: When notes are displayed, the menu cursor buttons are disabled. Exit the Notes window to change to another menu.

The following shows a completed notes window:



4.7.5 Edit Notes Summary

The following sections provide a summary of the navigation techniques needed to edit notes using either the front panel keypad or the optional USB keyboard:

4.7.5.1 Using the Front Panel Keypad

- EDIT NOTES :** Press to bring up the editing boxes as follows: Use the < and > buttons to move the cursor horizontally along a text line. Use the ↵ and ↩ buttons to highlight a character from the map. Press **OK** to write a character to a line.
- NEXT LINE** Press to scroll through and select a line for editing.
- INSERT CHAR** Inserts a blank character space before the one the cursor is currently on.
- DELETE CHAR** Deletes the character under the cursor.
- EXIT** Exits back to the PANEL or A-LOG menu. Store the calibration set to save the notes.

4.7.5.2 Using the Optional Keyboard

- Keyboard Function** Connect the optional keyboard to the USB socket on the front panel of the set. Press **EDIT NOTES** from the keypad to enter the keyboard function.
- Small Character & Numbers** Press any key on the keyboard to edit the characters, the same applies to numbers.

| | |
|---------------------------|---|
| Capital Character & Signs | Press SHIFT + the wanted character or sign. |
| Insert a Space | Press the space bar to insert a blank character at the position the cursor is currently on. |
| Delete Character | Press the backspace to delete the previous character to the position the cursor is currently on. |
| Delete Character | Press Delete to delete the character under the cursor |
| Up Arrow | Press ▲ to move the cursor up. |
| Down Arrow | Press ▼ to move the cursor down. |
| Left Arrow | Press ◀ to move the cursor left |
| Right Arrow | Press ▶ to move the cursor right |
| EXIT | Press the Esc to exit back to the PANEL or A-LOG menu. Store the calibration set to save the notes. |

5 Flaw Testing

5.1 Basic Flaw Testing

Reliable flaw detection requires three important considerations:

- Proper transducer selection

- An accurate reference block of the same material as that being tested with reference holes representing the orientation and sensitivity desired

- Proper calibration of the instrument.

Transducers used for flaw detection are usually of the narrow band variety to provide the best possible sensitivity to the anticipated discontinuities. In some cases, broadband varieties are chosen to optimize near or far surface resolution – the ability to separate discontinuities from the front surface or back surface echo. In either case, the frequency is chosen so that the wavelength in the material is optimized for the orientation and size of expected discontinuities. The single element contact transducer is used for general-purpose flaw detection. The angle beam transducer is used for weld inspection, which is covered in [Weld Inspection Using Trigonometry Mode](#) on page 55. Other specialty transducers including dual and surface wave can be used but these topics are beyond the scope of the manual.


The next requirement for reliable flaw detection is a calibration or reference block. This block should be made of the same material as the parts to be inspected. In other words, it should have the same sound velocity and attenuation characteristics. The calibration block should have surfaces that mimic the parts to be inspected so that attenuation and sensitivity characteristic is similar. Most importantly, the calibration block should have a series of fabricated discontinuities representing those expected to found in the test piece. That is, the size and orientation of the fabricated discontinuities should match the expected natural discontinuities in the test piece. In some cases this may mean flat bottom holes perpendicular to the test surface, side drilled holes parallel to the testing surface, or in some cases, narrow notches representing planar surfaces parallel or perpendicular to the testing surface. Fabricated discontinuities must also be placed near the front and back surface of the calibration block to verify resolution of the transducer and instrument setting combination.

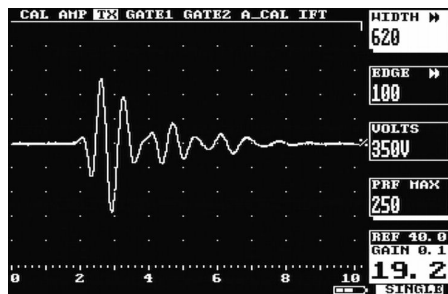
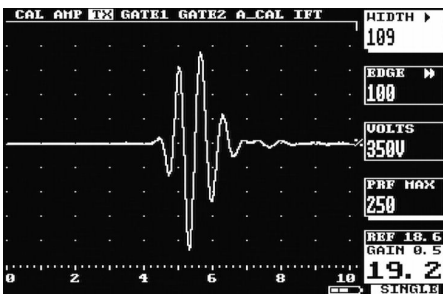
Finally, it is necessary to establish the proper calibration of the Masterscan 350 in order to assure reliable flaw detection.

5.2 Flaw Testing Calibration

The essence of this calibration is to set the pulser, amplifier and gate parameters to provide the necessary sensitivity and resolution. The Masterscan 350 has an automatic calibration technique that sets the necessary parameters by using a calibration block that has known thicknesses; see [A-Cal](#) on page 82 for details.

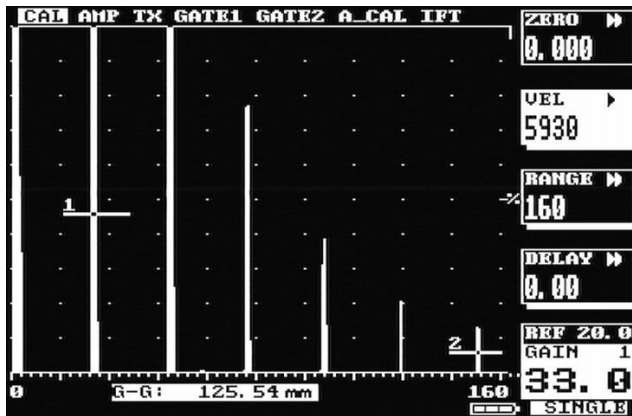
Alternatively a manual method can be used to perform the calibration and the following are the essential steps for basic flaw detection:

1. Select the appropriate single element contact transducer and calibration block that matches the material and expected discontinuities under test.
2. In the **CAL** menu, select the proper **RANGE** and **DELAY** so that several echoes from the expected material depth can be viewed.
3. From the **AMP** menu, set the **FREQ** to the nominal value of the transducer and set the detection mode to **RF**.
4. Use the  button to set the transducer to **SINGLE**.
5. Couple the transducer to the calibration block and obtain an echo from a fabricated discontinuity or the back surface and adjust the **GAIN** to set the peak of the echo to about 80% screen height.
6. From the **TX** menu, adjust the **WIDTH** parameter so as to obtain the maximum amplitude from the echo while optimizing the symmetrical shape of the echo. The left hand image below shows the proper echo shape while the right hand image indicates an improper setting of the TX **WIDTH** parameter.

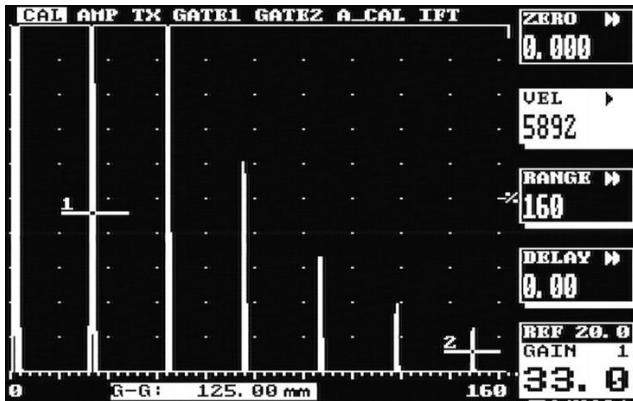


7. From the **TX** menu, adjust the ActiveEdge™ (**EDGE**) parameter to obtain desired echo shape and width for the near surface resolution desired. Check the resolution on a fabricated discontinuity in the calibration block that is near the front surface.
8. From the **AMP** menu, set the **DETECT** parameter to **FULL** and the **CONTOUR** parameter to a value to obtain the desired “filling” of the echo.

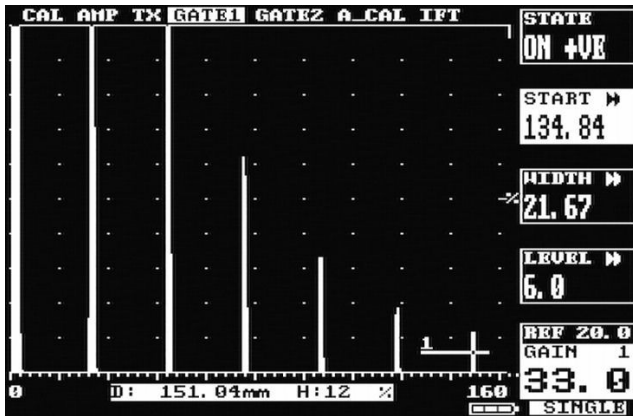
9. Adjust the gain to set a reference echo from mid thickness of the calibration block to about 80% amplitude.
10. From the **MEAS** menu, set the **MODE** parameter to **G1-G2** and the **TRIGGER** parameter to **PEAK**.
11. From the **GATE1** menu, set the gate to **ON +VE** and adjust the **START**, **WIDTH** and **LEVEL** so that the gate covers the first echo. From the **GATE2** menu set the gate to **ON +VE** and adjust the **START**, **WIDTH** and **LEVEL** so that it covers an echo that is a known multiple of echoes from the first. For instance if a 25mm thick calibration block was being used the first gate would be set on the first backwall echo and the second gate on the 6th backwall giving a distance between them of 125mm as shown below:



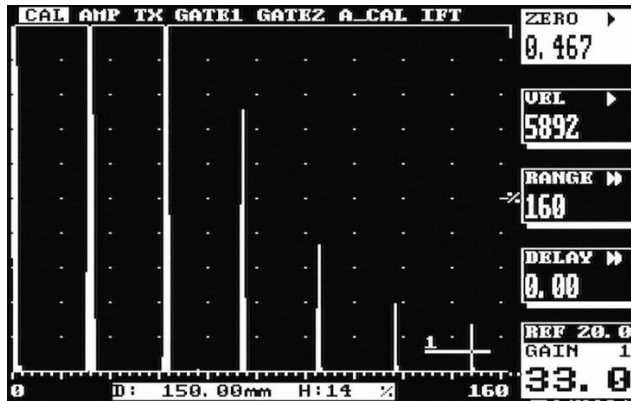
12. The distance between the echoes is shown in the G-G measurement at the bottom of the display (in this case 125.54). It is unlikely that the value will be exactly correct as the velocity of sound in the material will not match one of the preset values. Select a velocity that is close to the material then adjust it so that the exact distance is obtained as shown below:



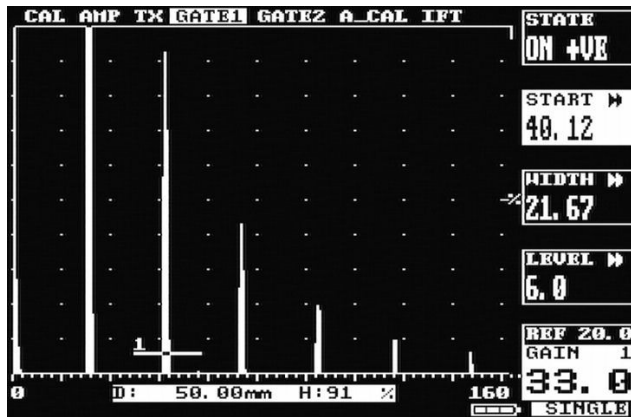
13. Next the calibration needs to take account of the distance between the transducer crystal and the front face of the transducer by setting the correct **ZERO** value: From the **MEAS** menu change the **MODE** to **DEPTH**.
14. From the **GATE2** menu change the **MODE** to **OFF**, from the **GATE1** menu change the **START**, **WIDTH** and **LEVEL** values so that the gate covers the 6th peak as shown below:



15. The distance measurement is shown at the bottom of the display (in this case 151.04). From the **CAL** menu adjust the **ZERO** value until the correct distance is shown as below:



16. As a final check move the gate across the other echoes to ensure that the correct distances are shown; From the **GATE1** menu adjust the **START** and **LEVEL** parameters so that the gate covers each echo in turn. Check that the correct values are shown as below:



Now that the Masterscan 350 has been calibrated it can be used to perform inspections using any of the techniques described in the following sections.

For weld inspection using an angle beam transducer, follow the instructions in [NOTE: A TCG](#) curve cannot be drawn while in RF display mode. It should be noted that the range of TCG is limited only by the dynamic range of the set.

1. Use the MEAS parameter to display the echo height relative to Full Screen Height (FSH), percentage of TCG Reference (%REF) or dB relative to TCG Reference.

Weld Inspection Using Trigonometry Mode on page [54](#).

For storage and printing of A-Scans, refer to [A-LOG](#), A-Scan Storage on page [73](#)

5.3 DAC Operation

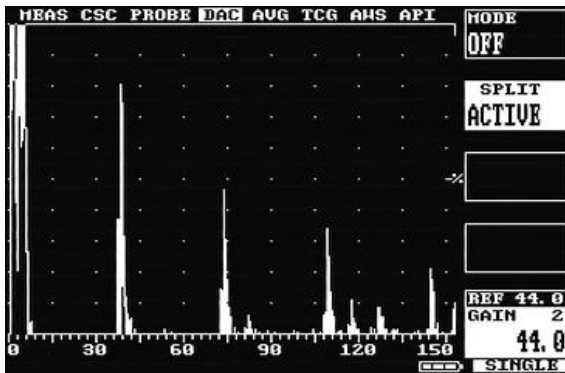
Distance Amplitude Correction curves act as monitoring gate triggering thresholds to compensate for attenuation and sound beam characteristics. When properly established, the DAC curve will provide consistent alarming from discontinuities of equal relative size at different depths in the test piece. Functionality is provided to automatically draw 6dB and 14dB or 6dB and 12dB reference curves below the calibrated curve.



It should be noted that since the DAC function only provides a dynamic alarm threshold capability, the dynamic range is limited to about 16dB. Therefore, for materials that attenuate more than 16dB over the depth range of interest, DAC should not be used. Instead, the TCG function may be more applicable. See [TCG Operation](#) on page 53 for the use of the Time Corrected Gain feature.

Proper use of the DAC feature requires a reference block made from the same material as that being examined, with flat-bottom or side-drilled holes of the desired size placed at depths covering the range to be inspected.

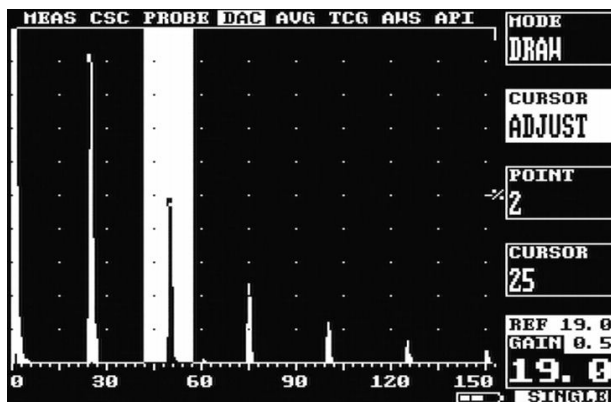
To establish a DAC curve, follow the following instructions:

1. Establish the basic calibration of the Masterscan 350 using the desired transducer and the proper reference block. From the **MEAS** menu, select the **DAC** feature.
2. Choose **SPLIT** mode to be **ACTIVE** allowing up to 3 DAC curves, complying with EN 583-2:2001.



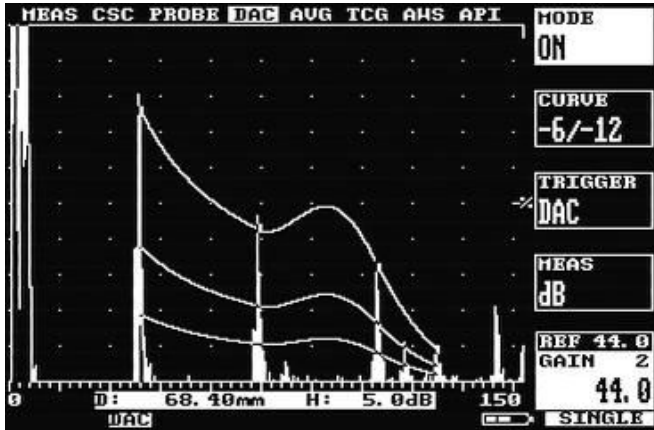
3. Select the **MODE** parameter by pressing the plain grey button next to it and use the  button to select **DRAW**. The other parameters will now be **CURSOR** and **POINT**.
Note: When in the **MODE** parameter, only press the  button to turn the DAC off. This will erase any logged echoes.

4. The DAC system is now ready to accept reference points. Position the transducer to give a maximum echo from the first or topmost reference hole in the reference block. Be careful to use a consistent amount of coupling and transducer pressure.
5. Use the ↶ and ↷ buttons to position the bright cursor bar over the echo from the reference hole.
6. Press the **OK** button to accept the point. A small square will appear as a reference point on the display showing the peak of the signal just recorded.
7. Repeat steps 6 and 7 for each additional reference hole in the reference block, being careful to be consistent with the amount of coupling and transducer pressure. A maximum of 10 points can be recorded for a DAC curve.
8. Press the plain grey button adjacent to **MODE** and use the ↷ button to select **ON** mode. The DAC curve will now be displayed and the other parameters will change to **CURVE** and **TRIGGER**
9. Use the **CURVE** parameter and the ↶ button to select just the DAC reference curve, the DAC curve along with the -2dB, -6dB, -10dB or -12dB curves, or the DAC curve along with the -6dB and -12dB curves, the -6dB and -14dB curves or -2dB, -6dB and -10dB curves. These additional, automatically generated, reference curves provide a method for helping to evaluate discontinuities smaller than those in the reference block.
10. Use the **TRIGGER** parameter to select the alarm trigger from Gate 1, the DAC curve, or any of the additional curves listed in the curve parameter above that are currently selected.

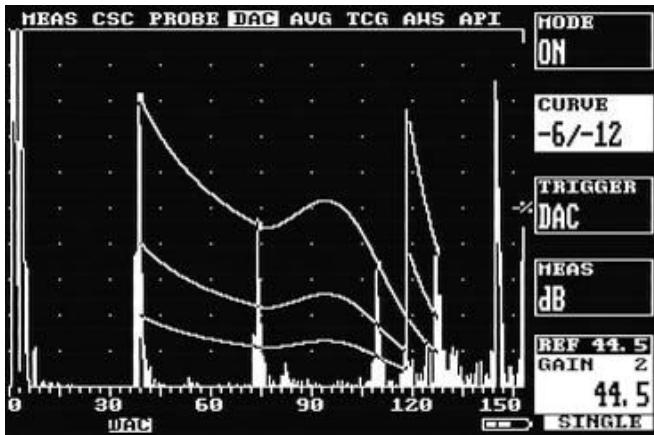


If depth measurement is switched on with the DAC feature, the depth mode display below the A-Trace will show the distance to the echo peak and the relative amplitude to the DAC

reference curve in dB. Note that the relative dB display is dependent on the REF gain setting, but not the GAIN setting.



With split DAC mode active, if the reference echoes drop below 20 %FSH another DAC curve will be generated at that point boosting the gain by 12dB each time, for up to 3 split DAC curves.






To turn off the DAC feature, select the **MODE** parameter from the **DAC** menu and press the ↶ button until **OFF** is indicated.

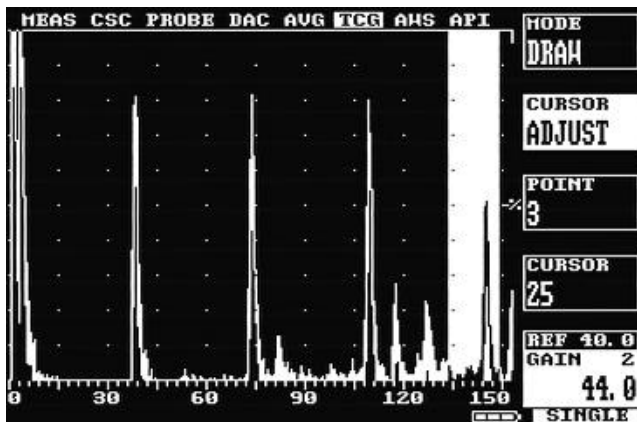
5.4 TCG Operation

The Time Corrected Gain feature provides a means of creating an attenuation curve that sets the gain in a swept manner as a function of transit time. A properly constructed TCG curve will compensate for material attenuation and sound beam characteristics so that discontinuities of equal relative size at different depths in the test piece will give an equal amplitude response on the display.

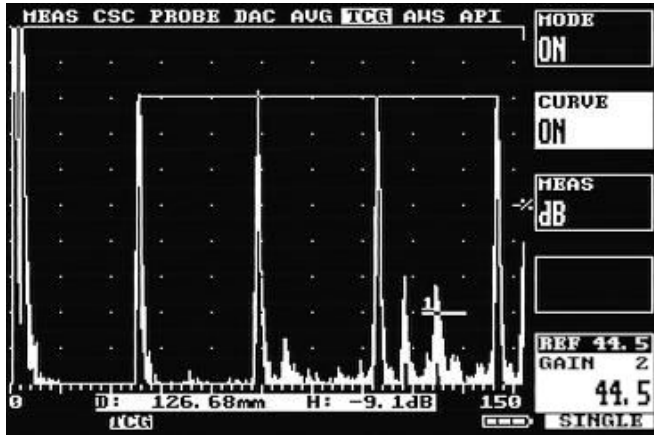
Proper use of the TCG feature requires a reference block made from the same material as that being examined, with flat-bottom or side-drilled holes of the desired size placed at depths covering the range to be inspected.

To establish a TCG curve, follow the following instructions:

2. Establish the basic calibration of the Masterscan 350 using the desired transducer and the proper reference block.
3. From the **MEAS** menu, select the **TCG** feature.
4. Select the **MODE** parameter by pressing the plain grey button next to it and use the  button to select **DRAW**. The other parameters will now be **CURSOR** and **POINT**.
5. The TCG system is now ready to accept reference points. Position the transducer to give a maximum echo from the first or topmost reference hole in the reference block. Be careful to use a consistent amount of coupling and transducer pressure.
6. Use the  and  buttons to position the bright cursor bar over the echo from the reference hole.
7. Press the **OK** button to accept the point. The **POINT** parameter will then increment to indicate the next point. As each point is entered, the gain will change to place the echoes at about 80% amplitude as Shown below:



8. Repeat steps 5 and 6 for each additional reference hole in the reference block, being careful to be consistent with the amount of coupling and transducer pressure. A maximum of 10 points can be recorded for a TCG curve.
9. Press the plain grey button adjacent to **MODE** and use the ↶ button to select **ON** mode. The TCG curve will now be displayed, the amplifier gain will now swept, and the other parameters will change to **CURVE** and **MEAS**.
10. Use the **CURVE** parameter and the ↷ button to select ON or OFF for the display of the TCG curve.

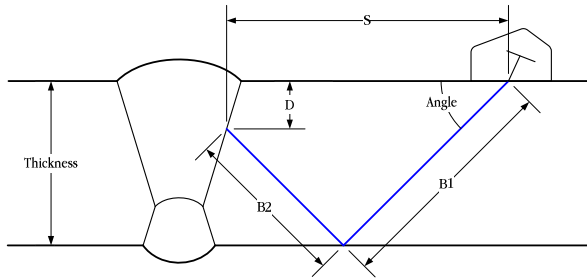


NOTE: A TCG curve cannot be drawn while in RF display mode. It should be noted that the range of TCG is limited only by the dynamic range of the set.

11. Use the MEAS parameter to display the echo height relative to Full Screen Height (FSH), percentage of TCG Reference (%REF) or dB relative to TCG Reference.

5.5 Weld Inspection Using Trigonometry Mode

The trigonometry mode provides a convenient method for measuring the location of discontinuities when inspecting welds with angle beam transducers. Essentially, the trigonometry mode uses the thickness gauging features of the Masterscan 350 to calculate the surface distance and depth to a discontinuity from the actual beam path measured. This is accomplished by calibrating the trig mode with the actual refracted angle of the transducer being used. Additionally, the thickness of the test piece must be established in the menu in order to calculate depth and surface distance when using multiple skips in angle beam testing. The measurements being calculated are depicted in the following diagram:



These measurements are displayed below the A-Trace on the Masterscan 350 as follows:

- ↘ Beam path distance B from the central exit point on the transducer to the discontinuity, the sum of B1 and B2 in double skip mode.
- Surface distance S from the central exit point on the transducer to a point directly above the discontinuity on the test piece. By entering the distance from the Front of the Probe to the emission point in the PROBE menu, this distance may be displayed relative to the front of the probe, which is usually more convenient.
- ↓ Depth distance D from the surface on which the transducer rests to the discontinuity.

Depending on the measurement technique being used there is an additional value displayed on the right of the measurement bar as shown below:

↘:146.13 →:103.33 ↓:96.67 H: 85%

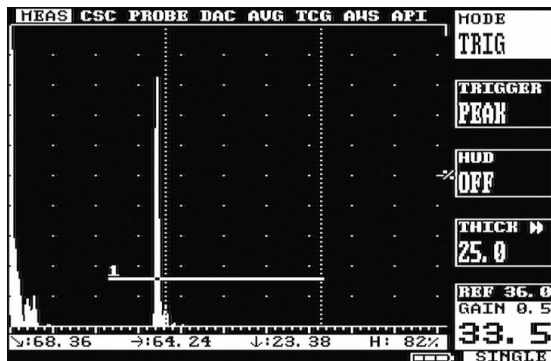
The example shows above the normal height value as a percentage of full screen; in this case 85%. If DAC is being used then the user has the choice of displaying either dB, %FHS or %DAC. If DGS/AVG is being used then ERS is displayed in the right hand side.

It is important to note that discontinuities in welds can be discontinuous and can extend over a distance. The measurements made will, therefore, be close approximations to the

discontinuity if the user properly calibrates the Masterscan 350 and uses care to locate the desired peak amplitude signal to which a measurement is made.

To calibrate and use the trigonometry mode, follow the following instructions:

1. Using a suitable IIW or other calibration block, measure and establish the central sound beam exit point and actual refracted angle for the transducer being used.
2. Establish the zero and velocity (span) for the transducer and material under test using the A-CAL procedure described in [A-Cal](#) on page 82. Use a suitable calibration block that has two drilled holes representing the thin to thick range of thickness expected in the test piece. In the **MEAS** menu set the **TRIGGER** parameter to **PEAK**. As in any ultrasonic thickness measuring method, it is important that the calibration be performed using a calibration block of the same material as that being inspected. Alternately, if you know the velocity of sound in the test piece, you may calibrate using the A-CAL method on a different material and then set the velocity parameter.
3. Set the **START** and **WIDTH** of Gate1 to encompass the desired testing region.
4. From the Main menu, select **MEAS** and place the **MODE** to **TRIG**.
5. Set the **TRIGGER** parameter to **PEAK**.
6. Select the **ANGLE** parameter and using the ↶ and ↷ buttons, set the refracted angle of the transducer measured in step 1 above.
7. Select the **THICK** parameter and using the ↶ and ↷ buttons dial in the thickness of the test piece. You may have to readjust this parameter if the test piece had varying thickness and you are using a multiple skip mode of angle beam testing.
8. When measuring a discontinuity, position the transducer so as to obtain the maximum amplitude signal before recording the readings. A typical TRIG mode display is shown below.



5.6 Weld Inspection Using the AWS Menu

The AWS menu provides a means for evaluating discontinuities when inspecting welds in accordance with the American Welding Society's Structural Welding Code, ANSI/AWS D1.1-94. The user is referred to the AWS standard for full details of the method.

The AWS menu provides a convenient method of automatically calculating the "Indication Rating" (IR) as defined by the standard. The AWS menu can be used in conjunction with the trigonometry mode which will simultaneously indicate beam path, surface distance and depth distance at the bottom of the graticule. The AWS menu will not operate with either the DAC or TCG switched on.

To set up the AWS measurements, perform the following:

1. Calibrate the Masterscan 350 for weld testing and set up the trigonometry mode by following the steps in [Weld Inspection Using Trigonometry Mode](#) on page 55.
2. From the **MEAS** menu, select **AWS** and place the **MODE** to **SET**.
3. Highlight REF on the menu and set to the desired reference level, usually 80% of full screen height.
4. Place the probe on the test block and obtain the maximum signal from the reference indication.
5. Place the cursor over the indication by selecting **CURSOR ADJUST** and using the ↶ and ↷ arrow keys.
6. With the signal maximized, press the **OK** key.

The Masterscan 350 is now calibrated to make Indication Rating measurements in accordance with AWS D1.1-94. To use the AWS mode, do the following:

1. On the **AWS** menu, highlight **MODE** and select **MEAS**.
2. Ensure that the gate and measurement (**TRIG**) function are operative and properly adjusted.
3. When the AWS menu is selected and a signal is in the gate, the sub-menu boxes will show the resulting AWS measurements as follows:

$$IR = IL - RG - AF$$

(Indication Rating = Indication level – Reference Gain – Attenuation Factor)

Where:

IL: Indication Level The dB setting required to bring an indication to the reference level.

| | |
|------------------------|--|
| RG: Reference Gain | The dB setting of the calibrated reference indication as a function of the reference standard and probe being employed. |
| AF: Attenuation Factor | The attenuation factor required by the AWS standard and is: Depth in inches minus 1, multiply by 2 and then rounded to the nearest $\frac{1}{2}$ dB. |
| IR: Indication Rating | The difference in dB between the indication and the reference gain with attenuation factor correction. |


It is not necessary to bring the indication to the reference level to obtain the correct measurement information as the Masterscan 350 adjusts for gain offset. However, to ensure the best accuracy of calculation, it is advised to adjust the indication to be above 40% and below 100% of full screen height. In addition, in the AWS mode, gain offset is shown as +/- dB from reference as opposed to absolute gain.

5.7 Evaluation of Pipe Imperfections using API 5UE

The Masterscan 350 is able to assist the user in making measurements in accordance with the American Petroleum Institute (API) Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections using the Amplitude Distance Differential Method (ADDM). Users are referred to the publication: "API Recommended Practice 5UE, Second Edition, June 2005"

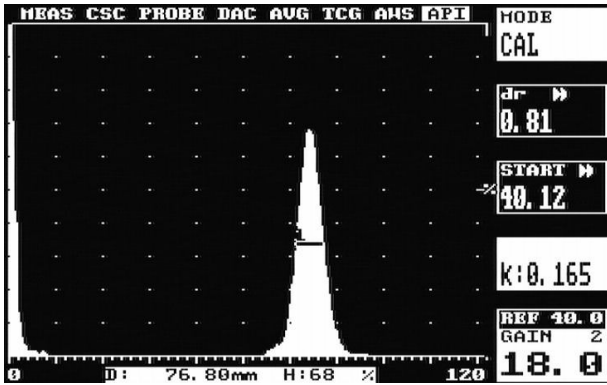
The ADDM employs a combination of amplitude comparison and 6dB drop techniques to determine the radial depth of an imperfection. The technique is based on the premise that radial depth of an imperfection affects both the amplitude of the received echo signal and the differential time of flight of the transmitted ultrasonic wave as it passes over the imperfection.

The first step is to perform a standardisation using a reference indicator such as a notch of a known depth or a through drilled hole. It is assumed that the Masterscan had been setup with the correct values for the transducer and specimen being used for the inspection.

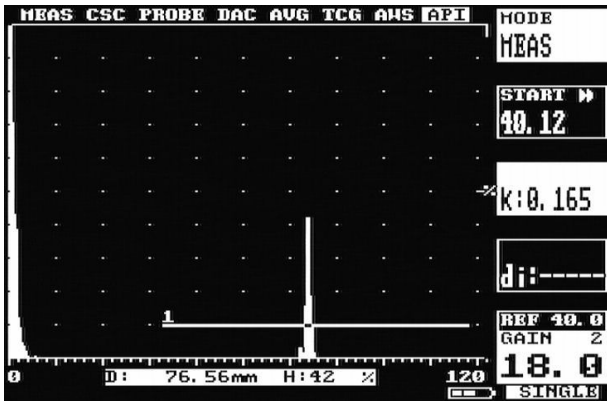
First turn on **GATE1** from the **CAL** menu and position it on the display so that it will cover the signal that will be produced by the reference indicator; the height of the gate is not important. Ensure that the signal will be between 5% and 100% of full screen height. Select **API** from the **MEAS** menu and select **PEAK** by pressing the  button twice then capture the reference signal and the following display should be shown:




Once the desired signal is obtained press the **OK** button and the k factor (a derived factor for calculating depth) is calculated and displayed as shown:




The Masterscan 350 automatically goes into **FREEZE** mode. Pressing the OK button again puts the API facility into measurement mode as shown below. The k value is displayed but cannot be changed while in measurement mode.



To take measurements select **PEAK** mode by pressing the  button twice and capture the echo dynamic signal; once the desired signal has been captured press the OK button. The di value is calculated and displayed as shown below:



Once the measurement has been made, pressing the **OK** button clears the current reading.

To take the next measurement select peak mode by pressing the  button twice.

5.8 DGS/AVG Operation

The DGS (Distance Gain Size) method, often known by its German acronym AVG (Amplituden Vergleichs Größe), allows a theoretical model to be used for assessment of ultrasonic echoes.

The DGS/AVG method allows flaw sizing and distance compensation without requiring the large range of reference standards for each test which would be required in order to establish a measured DAC curve, or to set up a TCG correction.

The relative response from 'Equivalent reflectors' of different sizes at different distances can be predicted mathematically from the probe effective diameter, frequency and near field length (a function of the first two). Probe sensitivity can be calibrated from a single measurement (usually the back wall echo)

DGS/AVG has several limitations:

It is a predicative method, so only works in 'standard' configurations where the mathematical model is valid

It must be applied with care with non-circular probe elements as we have to approximate an 'effective diameter'

It does not work well on broadband probes, where the frequency is not well defined.

It should only be applied to single element probes, as dual element probes have an inherent focus.

Corrections may be required for several factors:

Internal time delays within the probe

Attenuation with distance, both within the material to be tested and the reference block, if significant over the distances involved.

Transfer correction, e.g. if the tested material has a significantly rougher surface than the reference block

When using an angle probe and calibrating on a curved reflector (e.g. V1 or V2 Block) a correction must be applied.

NOTE: For DGS/AVG to work accurately the probe zero must be set correctly.

5.8.1 Theory

For a flat, disk shaped crystal of given frequency and size, the general beam profile can be defined in terms of a 'normalised' standard curve, scaled by the Probe 'effective diameter' and near field length.

The near field length is defined by the equation:

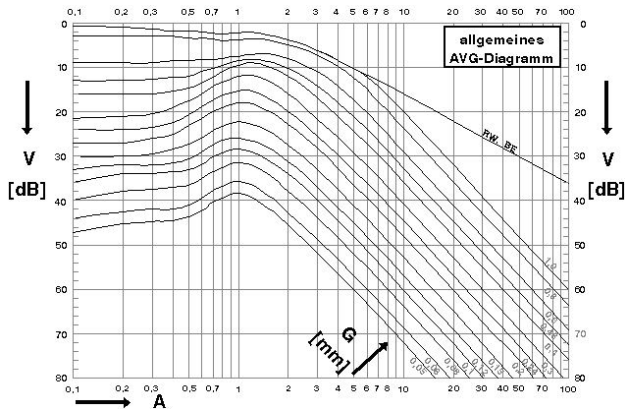
$$N = \frac{D_{EFF}^2 - \lambda^2}{(4\lambda)}$$

Where D_{EFF} is the probe effective diameter and λ is the wavelength (Velocity/Frequency)

The echo height from a small (much less than sound field width) reflector will be proportional to its size.

The echo height from a given reflector in the far field (distance from the probe greater than 2-3 Near Field Lengths (NFL)) will be inversely proportional to the square of its distance from the probe.

It is therefore possible to define a standard relationship, knowing the basic probe parameters, which only need be corrected for the sensitivity of the probe by measuring the response from a known reflector.

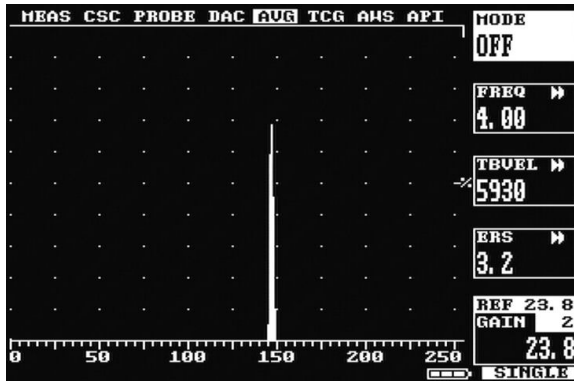


The picture shows a 'general' DGS/AVG diagram plotted on logarithmic scales, Relative gain in dB, Distance as a multiple of Near Field Length, The various curves represent the signal from an Equivalent Reflector Size (ERS) expressed as a multiple of the effective probe diameter.

Note that the signal from the back wall echo ('infinite' reflector) falls off with distance, rather than with the square of distance.

Press **MENU** then the plain grey button next to **MEAS** and select the **AVG** menu, **MODE** should be **OFF**

5.8.2 DGS/AVG ~ Frequency, TBVEL and ERS



Set **FREQ** from the probe data sheet

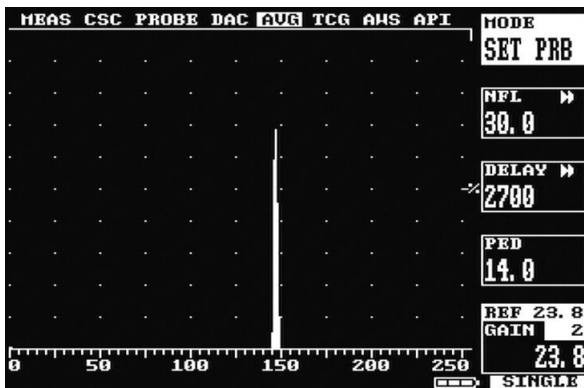
TBVEL – Reference (Calibration) Block Velocity, in meters per second

This parameter is used internally and will take the same range of values as the Velocity parameter. This parameter **MUST** be entered. The Wavelength, which is calculated from this velocity and the Probe frequency, is critical to the DGS/AVG calculations.

Desired test sensitivity (**ERS**) may also be set now. (This can be adjusted later)

5.8.3 DGS/AVG ~ NFL, DELAY and PED

Set **MODE** to **SET PRB**



NFL – Near Field Length in mm.

This value should be copied from the probed data sheet (It is recommended that figures from specific probe tests are used rather than those from generic data sheets as typical manufacturing variations are sufficient to affect the accuracy of the results)

DELAY – Probe Delay Velocity, in meters per second

This is the velocity of compressive sound waves in the material of the probe wedge. It is used mostly in angle probes but also in zero degree compression probes which have a delay line. This wedge material is typically Perspex, which has a compressive sound wave velocity of 2700 m/s.

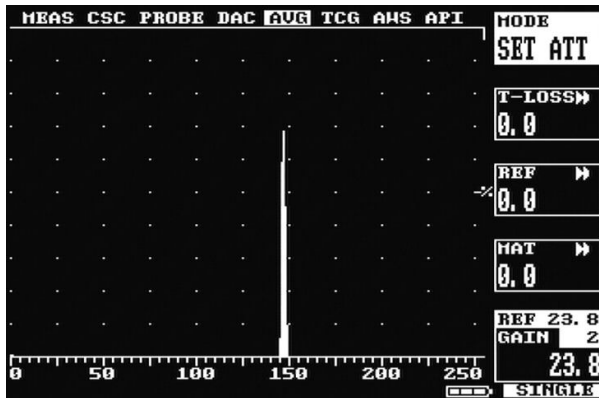
It is used, in conjunction with the probe zero and the specimen velocity, to calculate the Sound field equivalent length, this being the effective distance of the crystal to the test piece/wedge interface.

PED – Probe Effective Diameter, in mm

This is the calculated probe effective diameter and is for reference only; the value cannot be changed.

5.8.4 DGS/AVG ~ T-Loss, REF and MAT

Change MODE to 'SET ATT'.



This menu allows the operator to enter attenuation parameters relating to the materials of the Calibration Block and the item under test, these parameters being:

T-LOSS – Transfer Loss, in dB.

This is the loss due to surface roughness, poor coupling etc between the probe and the object under test. Generally it can be assumed that the Reference block will have a clean surface, but this may not apply to the object under test, methods exist for measuring this, experienced based 'rules of thumb' are also commonly used. This parameter can be changed once DGS/AVG is switched on.

REF – Reference Material Attenuation, in dB per meter

Attenuation of ultrasound in the Reference (Calibration) block material in dB per Meter

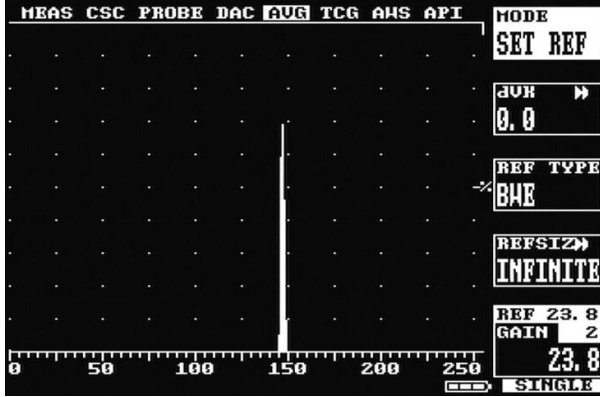
MAT – Test Material attenuation, in dB per meter

Attenuation of Ultrasound in the material of the object under test in dB per Meter

The **REF** and **MAT** are used where the ultrasound attenuation in these materials is such that it would cause a disparity in signal heights between similar reflectors in these materials. At long path lengths these factors become very important.

5.8.5 DGS/AVG ~ dVK, REF TYPE and REFSIZE

Change **MODE** to **SET REF**



dVK (ΔV_K) – Curvature Correction Factor in dB

This value allows the use of a curved surface to provide a back wall echo for use as a reference signal, thus the same reference block can be used irrespective of probe angle.

The amplitude correction factor shows by how many dB the echo from the cylindrical surface is larger or smaller than the echo from a flat backwall, normal to the probe field axis at the same distance.

This value is subtracted from the gain to compensate for the focusing effect of the curved reference reflector. It should be entered as a positive or negative value as expressed in the probe data sheets.

Probe datasheets typically express this value as ΔV_{K1} , for use with the K1/V1 calibration block, or ΔV_{K2} for use with the K2/V2 calibration block. These calibration blocks are specified in standards EN12223 / DIN54122 / BS2704

REF TYPE – Reference Reflector Type

The user can select one of a number of different reference reflectors.

In this implementation, these have been derived from EN 583-2:2001 Annex B.

These reflector types are:

BWE – Back Wall Echo

FBH – Flat Bottom Hole

SDH – Side Drilled Hole

Reference type SDH is converted internally to the equivalent DSR diameter according to the formulae in EN 583-2:2001 Annex B.

When using reference SDH reflectors it is essential to select the correct calibration (test) block velocity (**TBVEL**). This is because the calculations for the equivalent DSR use the wavelength of sound that is calculated from the Calibration Block velocity and the probe frequency.

REFSIZ – Reference Reflector Size, diameter in mm

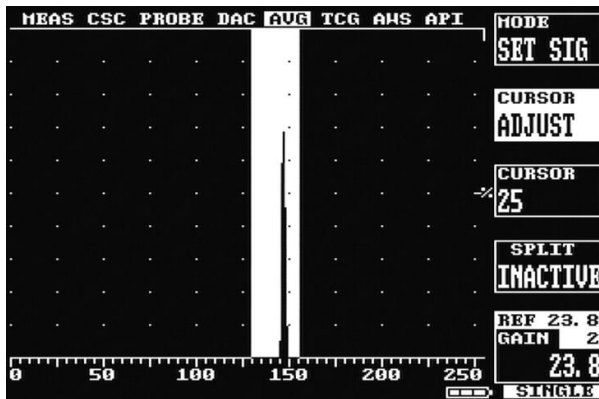
Allows the user to enter a diameter, in mm, for a reflector. The reflector type is set using the **REF TYPE** parameter above.

The set will automatically compensate for the varying 'reflectivity' of different reflector types as specified by the **REF TYPE** parameter. Thus a 3 mm side drilled hole should be entered as **REF TYPE: SDH** and **REFSIZ: 3.0**

In this implementation, a diameter of 0 (zero) is used to represent a reflector of infinite size and is expressed as **BACKWALL** or **INFINITE**.

5.8.6 DGS/AVG Calibration

Set **MODE** to **SET SIG**



Place probe on reference block and maximise echo, select **CURSOR ADJUST** and use up/down keys to centre the selection bar over the echo.

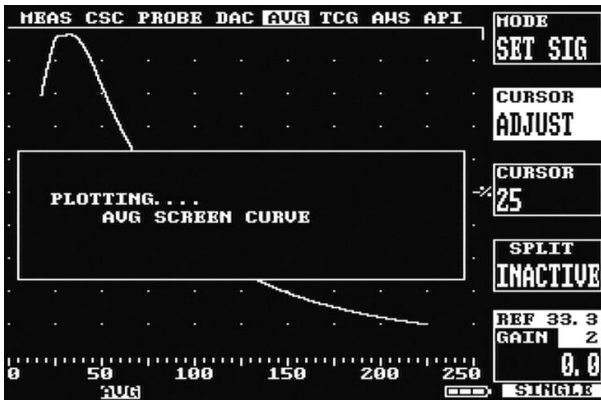
If necessary change the **CURSOR** width to 5 pixels instead of 25 pixels to accurately select an echo that is close to others.

Selecting the **SPLIT** parameter to **ACTIVE** causes the AVG curve to recalculate and any point where the curve drops below 20 %FSH the gain is boosted by 12dB at that point. Up to 3 split DGS/AVG curves are possible.

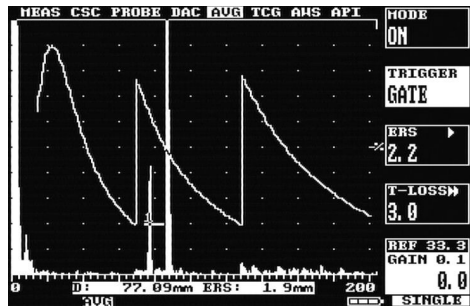
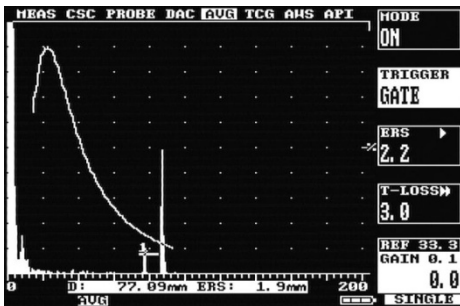
The calibration of the DGS/AVG system sets the Probes 'absolute sensitivity' based on the response from the reference block.

Changing any parameters relating to the reference echo will invalidate the calibration, which must then be repeated. The current version of the software does not enforce this – it is the responsibility of the operator.

Check that the echo is still maximised and Press **OK**; the instrument will adjust gain as necessary to get a good echo reference and then perform the necessary sensitivity calculation; the curve will then be drawn.

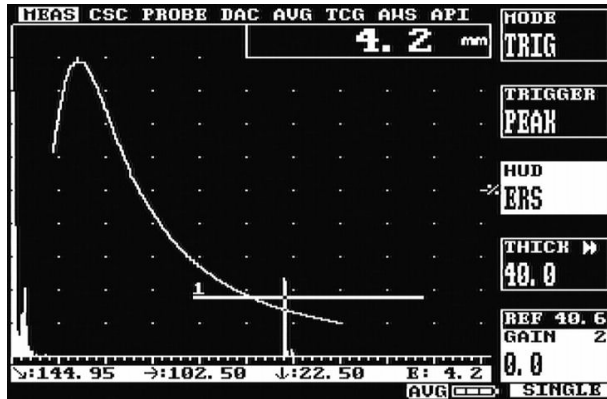


DGS/AVG is now on. In this screen it is possible to adjust the curve ERS level (the instrument will redraw the curve, but a new calibration is not required) and select either the Curve or Gate as the measurement reference. It is also possible to change the T-LOSS value when DGS/AVG is on.

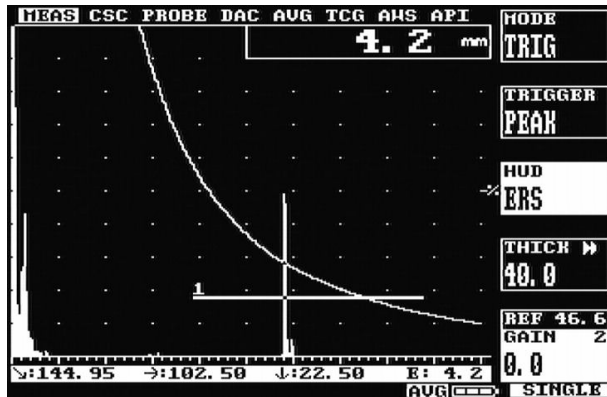


5.8.6.1 Adjustment

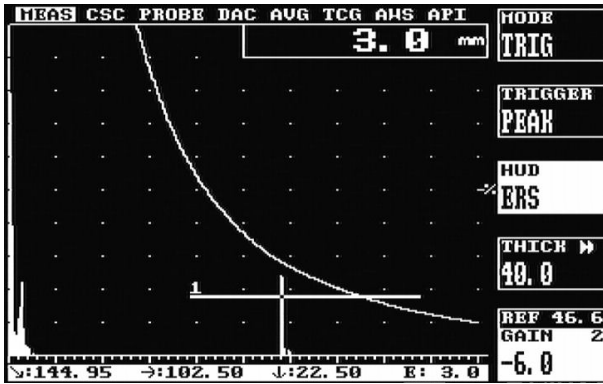
When the DGS/AVG has been calibrated it is possible to leave the DGS/AVG menus and adjust other settings of the instrument, for example range and gate settings.



Gain may be adjusted with understanding – Changing the Gain setting will remove the correlation with the DGS/AVG curve, so should only be done in accordance with a specification, for example to compensate for varying material conditions (better done with the T-LOSS function). If it is desired to change the gain to give a larger signal (for example at long range) the REF gain should be adjusted. This will change the curve by an equivalent amount and preserve the measurement accuracy.



Increasing REF Gain by 6dB moves curve and preserves measurement



Decreasing Gain by 6dB returns to original height, but loses measurement

The Reference gain may be selected by pressing the **REF/GAIN** Button. (DGS/AVG is only appropriate for Single probe mode)

When the Display Range or REF Gain is changed the DGS/AVG curve will recalculate at each step. If the settings must be changed by more than one or two steps it may be more convenient to Switch DGS/AVG off, Change REF gain and range etc as needed, and then switch DGS/AVG on again. This will not invalidate the curve provided the following are not changed:

FREQ, NFL, dVK, DELAY, REF dB/m, TBVEL, REF TYPE, REFSIZ, (new **REFERENCE** Entered), Probe Zero, Filter, Contour, TX Parameters (Width, Damping, Voltage,) or Probe Angle.

The following should not be used in DGS/AVG Mode:

Detect Modes other than Full Wave, non-zero REJECT, Dual probe mode, Smooth, A_CAL (other than for initial setup before using DGS/AVG), DAC, TCG, AWS,

5.8.7 Measurement

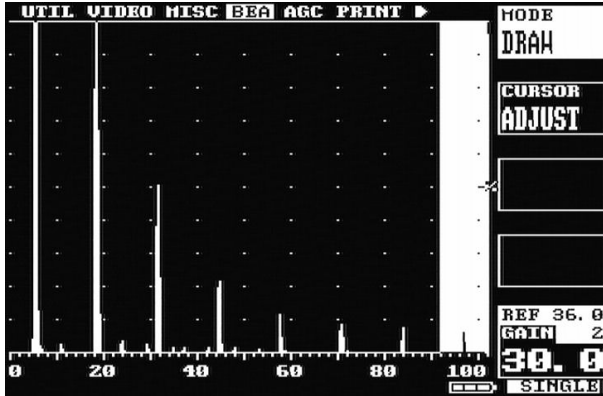
Having set up the DGS/AVG system, it is possible to use the measurement system to calculate an Equivalent Reflector Size for the flaw.

This is achieved by using Gate 1 to identify the flaw indication and the DEPTH measurement mode to calculate its equivalent size. This Equivalent Size is calculated as the Test Sensitivity (ERS value) multiplied by the Ratio of the Signal height to the DGS/AVG curve height at that distance. It is displayed in place of the signal amplitude (%FSH) as a diameter, in mm.

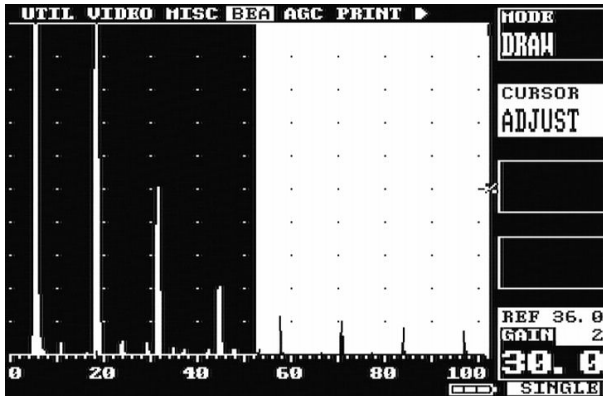
It is also possible to 'size' the flaw in terms of dB with respect to the DGS/AVG curve. This is achieved by increasing, or decreasing, the set gain until the peak of the flaw signal lies on the DGS/AVG curve. The difference in Gain required can then be read directly from the displayed Gain Value.

5.9 Backwall Echo Attenuator (BEA)

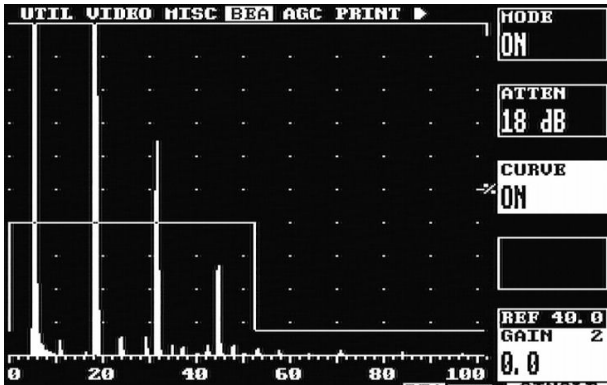
The backwall echo attenuator allows the gain to be independently adjusted over a defined area of the A-Scan. To enable the backwall attenuator, select the **UTIL** main menu followed by the **BEA** feature. Changing the **MODE** to **DRAW** displays a solid block on the right hand side as shown below:



Select **CURSOR ADJUST** and use the \curvearrowright and \curvearrowleft buttons to select the area over which the attenuator will be applied as shown below:



Once the required area has been selected, change the **MODE** to **ON**. The attenuator is switched on and a line is drawn on the screen showing where the attenuator becomes active as shown below:



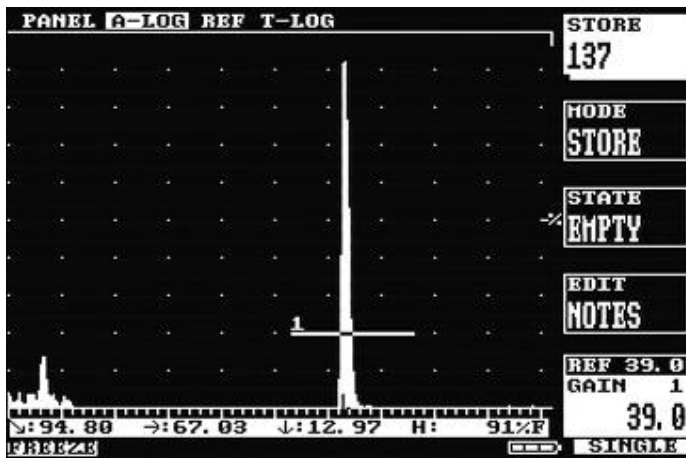
Once the backwall attenuator is **ON** the size of the attenuator can be changed by adjusting the **ATTEN** parameter. The maximum area over which the backwall attenuator can be active is 50% and the maximum attenuation is the same as the available gain up to a maximum of 40dB.


5.10 A-LOG, A-Scan Storage

The A-LOG feature provides for storage, recall and printing of A-Scans with all of the instrument settings. Up to 800 A-Scans and their settings can be stored. This feature is useful to record an indication for later review or for printing a hardcopy. In addition, recalling an A-Scan and its settings will allow for easy follow-up inspection of the same indication on the test piece. Simply unfreeze the display after recalling and the Masterscan 350 is ready to repeat the same inspection. Be sure to use the same transducer that was used for the original recording.

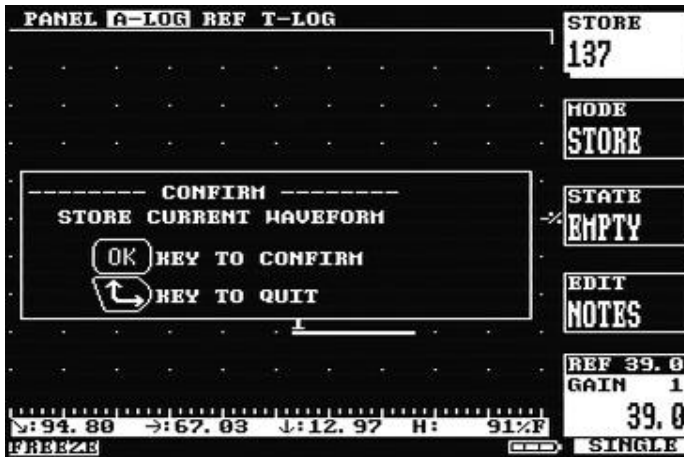
5.10.1 To Store An A-Scan:


1. Establish the basic calibration of the Masterscan 350 using the desired transducer and the proper reference block.
2. From the **MEMORY** menu, select the **A-LOG** feature.
3. Select the **STORE** parameter by pressing the plain grey button next to it and use the ↶ and ↷ buttons to select a store location. The **STATE** parameter shows whether the store location is **VALID** (used) or **EMPTY**. Be careful not to store over a valid location unless you desire to erase what is there and replace it with the current A-Scan and settings.
4. Select the **MODE** parameter by pressing the plain grey button next to it and use the ↶ button to select **STORE**.
5. Obtain a desired echo from a discontinuity or reference block.







Optionally press the  button to freeze the display before storing it.

- Press the **OK** button to store the waveform and instrument settings; the display will show a dialogue box:



- At the **CONFIRM** prompt, press the **OK** button again to store the A-Scan or press the  button to continue without storing the A-Scan.
- After pressing the **OK** button a second time, the **NOTES** window opens automatically to allow the creation of any desired notes for the stored A-Scan and its settings. See the section [Adding NOTES to PANEL and A-LOG sets](#) on page 41. When finished adding notes, press the plain grey button next to the **STORE** parameter to return A-LOG menu.

5.10.2 To Recall an A-Scan:

- From the **MEMORY** menu, select the **A-LOG** feature.
- Select the **STORE** parameter by pressing the plain grey button next to it and use the  and  buttons to select the desired store location to be recalled. The **STATE** parameter shows whether the store location is **VALID** (used) or **EMPTY**.
- Select the **MODE** parameter by pressing the plain grey button next to it and use the  button to select **RECALL**.
- Press the **OK** button to recall the waveform and instrument settings. This may take a couple of seconds at which time the display will be in **FREEZE** mode and the number of the A-LOG is displayed at the bottom of the display. To return to normal testing mode with the recalled settings, press the  button.
- Alternately, you may review the notes pages stored with each A-LOG to determine which set you want to recall. Set the **MODE** to **LIST** and using the **STORE** parameter, move through each one to view the **NOTES** page. When the desired A-LOG is found,

press the **OK** button to recall it. To remove the notes review window, set the **MODE** back to **STORE**, **RECALL** or **DELETE**.

5.10.3 To Delete a Stored A-Scan

Follow the steps above but set the **MODE** parameter to **DELETE** and then press the **OK** button. At the **CONFIRM** prompt, press the **OK** button again to delete the A-Scan or press the ↩ button to continue without deleting the A-Scan.

To edit notes in an A-LOG, press the plain grey button next to the **EDIT NOTES** parameter and then follow the instructions in the section on [Adding NOTES to PANEL and A-LOG sets](#) on page 41.

NOTE: When notes are displayed, the menu cursor buttons are disabled. Switch off list mode to change to another menu.

5.10.4 REF, Reference Waveform Comparisons

This feature allows the user to select a waveform from one stored in the A-LOG menu, and to display this reference waveform on the graticule along with the real time waveform. This makes easy comparisons possible between an expected signal response (the reference waveform) and that obtained from the test piece.

5.10.5 To Recall an A-Scan as a Reference Waveform:

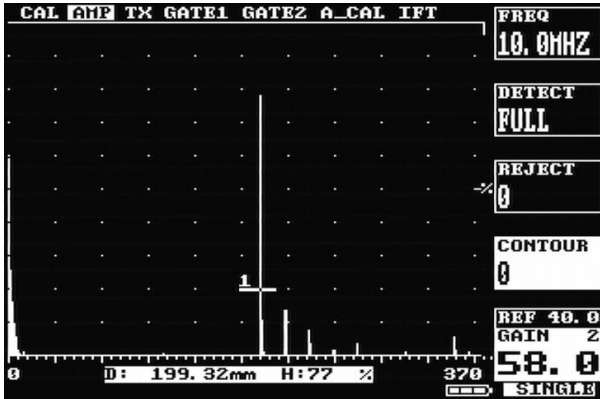
1. In order for a reference waveform to be recalled, the required trace must first be stored into an A-LOG store.
2. From the **MEMORY** menu, select the **REF** feature.
3. Select the **STORE** parameter by pressing the plain grey button next to it and use the ↩ and ↪ buttons to select a store location. The **STATE** parameter shows whether the store location is **VALID** (used) or **EMPTY**.
4. Select the **MODE** parameter by pressing the plain grey button next to it and use the ↩ or ↪ button to select **RECALL**. If set to **LIST**, the note associated with the reference waveform will be displayed.
5. Press the **OK** button to display the reference waveform on the graticule. The reference waveform will be a different colour as compared to the real time waveform, depending on which display colour is chosen.
6. To remove the reference waveform, set the **MODE** to **OFF** and press the **OK** button.

NOTE: When the reference is recalled, no setting parameters are changed. Therefore, if the **RANGE** or **DELAY** are changed, the reference signal will not match the real time waveform. This means that the **RANGE** and **DELAY** used for storing the reference waveform in A-LOG must match that used for the comparison of real time signals to the reference waveform.

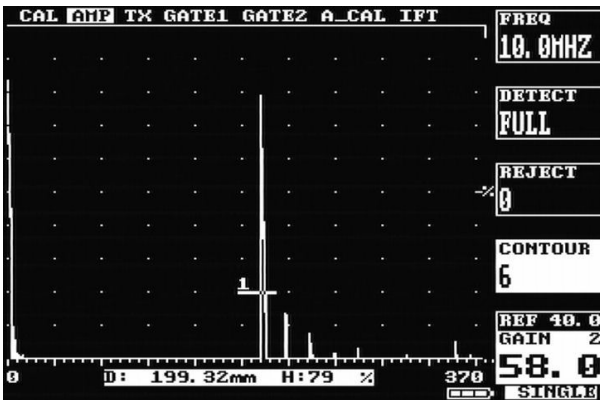
The reference waveform cannot be displayed in video colours 0 and 1 (All white and all yellow).

5.10.6 Contour, Peak Echo & Hold Dynamics

Contouring is a technique that enables the significant echoes to be enhanced by extending the trailing edge of the echoes thus making them appear wider than they actually are making the Masterscan 350 operate more like an older analogue flaw detector. Only the trailing edge is modified so that depth measurements using FLANK and PEAK are not effected. From the AMP menu in CAL, select CONTOUR as shown below:




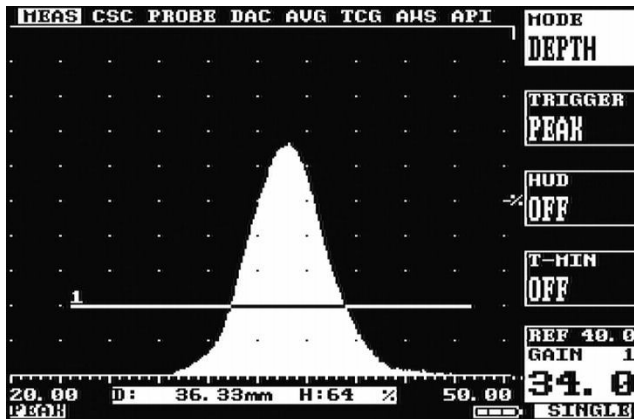
Change the value until the required shape is achieved, note how the measurement values do not change:




During flaw testing it is sometimes difficult to determine the exact peak of a discontinuity echo due to its geometry, coupling and surface anomalies and part geometry. The Masterscan 350 incorporates a Peak feature that, while activated, stores all of the signal excursions on the display using a fill technique.

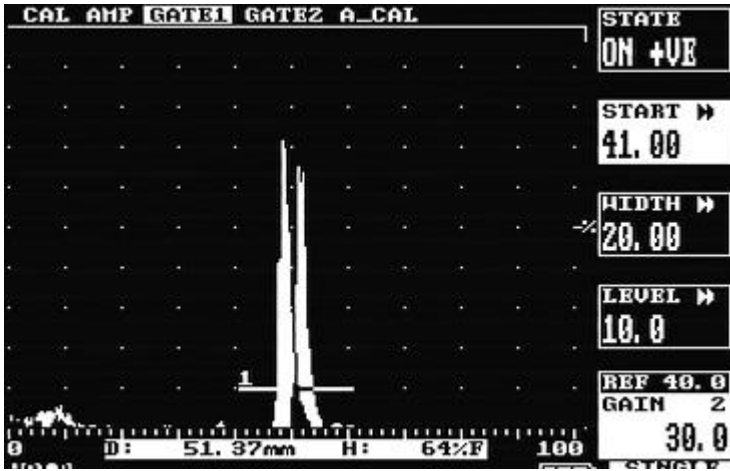
In addition to providing an effective method of capturing peak echo information, the Peak mode is useful for crack tip diffraction methods in angle beam weld inspection. In the case of crack tip diffraction, the extent of a crack type discontinuity can be inferred by the positional excursions of the signal as it reflects from both tips of a crack. Thus, as the transducer is moved past the indication, the signals will be “filled-in” on the display and the resultant width of the envelope or “echo dynamic pattern” will infer the crack length.



To use the echo dynamic pattern feature, position the transducer just off one side of the indication. Press the  button twice to activate the Peak mode which is indicated by a box-displaying PEAK below the graticule. Move the transducer past the indication to fill-in the envelope pattern. In the case of angle beam testing, it is advisable to rotate the transducer slightly and move it from side to side while moving forward past the indication. This will assure the capturing of all amplitude and distance information. An example of peak echo mode capture is shown below:



To return the display to normal mode, press the  button twice more. This will erase the envelope pattern and return the instrument to the instantaneous mode of display. While the display is showing the dynamic echo pattern, it is possible to record the A-Scan as indicated in [A-LOG](#), A-Scan Storage on page [73](#).

Hold mode is similar to freeze mode except that it stores the currently displayed waveform as a reference trace and leaves the live waveform active. This is a quick and useful way to make comparisons between echoes.



Hold mode can be activated by pressing the  button three times. Pressing the  button again will return the Masterscan 350 to its normal mode of operation.

6 Thickness Gauging

6.1 Basic Thickness Gauging

Accurate and reliable thickness gauging requires three important considerations:

- a) Proper transducer selection
- b) An accurate reference block of the same material as that being tested, and
- c) Proper calibration of the instrument.

There are three types of transducers used in ultrasonic thickness gauging, all employing the straight or longitudinal beam method. The single element contact transducer is used for general purpose thickness gauging where material thickness is generally expected to be above 2.5mm. The delay line contact transducer is used for measuring thin material down to 0.5mm where the surfaces are clean and parallel. The dual element contact transducer is used for moderately thin materials down to about 1.0mm where the surfaces may be irregular and not necessarily parallel. The dual transducer is most commonly used for corrosion thickness inspection where its ability to obtain echoes from a pitted surface is superior. Nevertheless, dual transducer inspection on corroded materials is nowhere near as accurate as single element and delay line inspection, due to the nature of the material under test. In addition, the dual element transducer usually incorporates a slight included angle on both the transmit and receive side, resulting in a small non-linearity of the measurements. For this reason, dual transducer thickness testing is usually calibrated and performed over a limited thickness range.


Regardless of the type of transducer used, it is important that it be specifically designed for thickness gauging. This means that it must have broadband or highly damped characteristics that provide a sharp leading edge. Otherwise, amplitude variations of the signals can cause half-wavelength errors due to smaller "build-up"

The next requirement for thickness gauging is a calibration or reference block. This block should be made of the same material as the components to be inspected. In other words, it should have the same sound velocity and attenuation characteristics. The calibration block should have parallel machined surfaces representing the thickness range to be inspected. Although two thicknesses representing the minimum and maximum values are sufficient for calibration, it is recommended that the calibration block have four sections covering the range anticipated. This will allow for verification of the calibration.

It is possible to calibrate the Masterscan 350 using a generic test block and only one known sample thickness of the material under inspection. This is a less desirable method because there is no way of verifying the calibration. With this method, the calibration would first be performed on the generic test block, which would have three to four sections covering the expected thickness range. Essentially, calibrating on the generic block would set the

transducer zero point. Then the Masterscan 350 Velocity would be adjusted on the known sample of the test material until the thickness readout matched the known thickness. This established the sound velocity for the test material.

Finally, it is necessary to establish the proper calibration of the Masterscan 350 in order to assure accurate and reliable thickness testing. The essence of this calibration is to set the pulser and amplifier characteristics to provide sharp leading edges on the echoes. The following are the essential steps for basic thickness gauging:

1. Select the appropriate broadband transducer and calibration block that matches the material under test.
2. In the **CAL** menu, select the proper **RANGE** and **DELAY** so those echoes from the range of thickness can be viewed.
3. From the **AMP** menu, set the **FREQ** to the nominal value of the transducer and set the detection mode to **RF**.
4. Use the  button to select **SINGLE** for delay line and single element transducers and **DOUBLE** for dual element transducers.
5. Couple the transducer to a mid-range thickness section on the calibration block and obtain an echo.
6. From the **TX** menu, adjust the **TX WIDTH** parameter so as to obtain the maximum amplitude from the echo while maintaining a symmetrical shape to the echo.
7. From the **TX** menu, adjust the ActiveEdge™ (**EDGE**) if using a single element transducer. Adjust the value to reduce the width of the TX pulse. This is not necessary for dual or delay line transducers.
8. Repeatedly adjust both the **TX WIDTH** and the **EDGE** parameters until the echo shape is optimized.
9. From the **AMP** menu, set the **DETECT** parameter to either **-VE HW** or **+VE HW**, depending on which half of the RF provides the best half-cycle as determined in step 7 above.
10. Adjust the gain to set the echo at about 80 %FSH and increase the **REJECT** parameter to remove any undesirable noise from the baseline.
11. From the **GATE1** menu, set the gate to **ON +VE** and adjust the **START** and **WIDTH** so that the gate encompasses the thickness range of interest. Place the transducer between the thin and thick area on the calibration block to verify proper coverage. Adjust the **LEVEL** parameter to about 30 %FSH.

12. From the **MEAS** menu, set the **MODE** parameter to **DEPTH** and the **TRIGGER** parameter to **FLANK**.
13. If desired, set the **T-MIN** parameter to **ON** so that the thinnest reading obtained will be held in the display. Reset by using the ↶ or ↷ buttons.
14. If desired, set the **HUD** parameter to **ON** to display the thickness in a large window at the top right of the graticule.
15. To calibrate the Masterscan 350 for thickness readings, follow the steps outlined in [A-Cal](#) on page 82. Alternately, you can use an iterative process from the **CAL** menu of setting the **ZERO** on the thinnest calibration block sample and the **VELOCITY** on the thickest sample. Using this technique, you must repeat **ZERO** to **VELOCITY** several times until the two values are correct.

When using a delay line transducer, there are two modes of measurement:

- a) Interface to first return echo, and
- b) multiple echo mode which usually measures from the first to the second return echoes after the interface echo.
 1. Follow steps 1-10 above.
 2. From the **MEAS** menu, set the **MODE** to **E-E** for echo to echo measurement. You will notice that a second gate bar appears below gate 1 and that its start point is slightly to the right of gate 1. This is the Blocking gate explained below.
 3. For measuring from interface to first echo, position the start of gate 1 before the interface echo. Using the **BLANK** parameter in the **MEAS** menu, position the start of the second gate just after the interface echo but before the thinnest expected first echo.
 4. For measuring multiple echoes after the interface, position the start of gate1 just after the interface echo. Using the **BLANK** parameter in the **MEAS** menu, position the start of the second gate just after the first echo but before the thinnest expected second echo.
 5. The **BLANK** parameter determines the blanking or starting position of the second gate relative to the starting position of gate1. This prevents noise and spurious echoes associated with the interface or first echo from terminating the measurement and producing a false reading.

For storage and printing of thickness readings, refer to [T-LOG Thickness Storage](#) on page 84 and [T-Log Editing and Printing](#) on page 87.

6.2 A-Cal



A-CAL is an automated calibration feature for thickness gauging applications or when measuring depth to an indication in flaw testing.



In order to achieve proper calibration for measuring time-of-flight in ultrasonic testing, two factors must be known; the velocity of sound in the material under test, and the offset of the transducer caused by wear face and phase shifts.

Conventional thickness calibration technique usually requires setting the zero (offset) and span (velocity) using an iterative technique. This means alternately placing the transducer on a thin sample to set the zero and a thick sample to set the span. This process is repeated several times until both readings are correct. The reason for this is that raising the span will also raise the zero.

The A-CAL feature automates this process so that only two readings are required, one on the thin sample and one on the thick sample. The Masterscan 350 then calculates the correct offset and span factors and sets the velocity and zero. Any time the test material is changed (velocity) or the transducer is changed (zero); this procedure must be repeated. Using this procedure will result in quicker calibration of the instrument and more accurate measurements.

The A-CAL calibration procedure is as follows:

1. Select a test block of the same material as that being inspected, with reference thickness covering the minimum to maximum thickness expected in the test parts. The difference between the thick sample and the thin sample should be no less than five to one.
2. From the main menu, select **CAL** and adjust the **RANGE** and **DELAY** so that the thin and thick reference echoes show on the display.
3. From the **CAL** menu, select **GATE1** and place the **STATE** in **ON +VE**. Adjust the **START** and **WIDTH** of the gate to encompass the echoes from the thin and thick samples.
4. From the main menu, select **MEAS** and place the **MODE** to **DEPTH**.
5. From the **CAL** menu, select the **A-CAL** menu.
6. Select **DIST1** using the adjacent plain grey button. Adjust the value using the  and  buttons to the known thickness of the thin sample.
7. Place the transducer on the thin reference sample and obtain an echo. Adjust the gate start if necessary to obtain distance readout of the echo.
8. Press the **OK** button to log the echo.

9. Select **DIST2** using the adjacent plain grey button. Adjust the value using the  and  buttons to the known thickness of the thick sample.
10. Place the transducer on the thick reference sample and obtain an echo. Adjust the gate width if necessary to obtain distance readout of the echo.
11. Press the **OK** button to log the echo.
12. Select **ACCEPT CAL** using the adjacent plain grey button.
13. Press the **OK** button. The transducer zero and velocity will now be adjusted.

The **DIST1** and **DIST2** values can be stored when the calibration information in **PANEL** and **A-LOG** functions are stored. This overcomes the need to set these values and gate positions every time a calibration is desired. Once established, all that is required is to obtain each echo and press **OK**, and then press **OK** on **ACCEPT CAL** and the instrument is calibrated.

If a delay transducer is used set **DIST1** to **0.0** and use the interface echo as the thin reference echo. The instrument will then set the transducer zero to compensate for the delay line.

Once calibrated, it might be desirable to record the velocity and zero values from the **CAL** menu for future reference. Note that this is a convenient method for determining the velocity of sound in an unknown material. Once the Masterscan 350 is calibrated on a known material, all that needs to be known is one fixed thickness point and the velocity can be determined.

6.3 TCG for Reliable Gauging

As previously mentioned, reliable thickness gauging requires that the shape of the echoes be consistent with sharp leading edges. When measuring the thickness of material with higher than normal attenuation to ultrasonic energy or a wide thickness range, it is difficult to maintain proper characteristics of the echoes. One way to overcome this is to use the Time Corrected Gain feature of the Masterscan 350. TCG can improve the reliability of thickness gauging by increasing the amplitude of echoes from thicker sections of the test material so as to maintain the correct detection threshold on the leading edge. The objective is to equalize the amplitude of echoes over the entire thickness range to be expected.

To set up the TCG feature, refer to [TCG Operation](#) on page 53.

6.4 T-LOG Thickness Storage (Numeric)



The T-LOG menu provides a convenient method to store thickness readings for record keeping and analysis. The maximum number of readings that can be stored is 8,000. When using **NUMERIC** mode selected from the **T-LOG** submenu on the **MEMORY** menu, each thickness reading is stored under a three level code. The top level is the **BLOCK** number which can be 1 to 14. This is followed by the **LOC** (location) number which can be set between 1 and 2,000. Last is the reading number (**NO**) itself which can also be between 1 and 2,000.

This hierarchy of coding for a thickness reading allows readings to be associated with physical characteristics of the component under inspection. Thus, it is up to the user to devise a scheme of assigning blocks, locations and readings to the inspection, keeping in mind the maximum combination of 8,000.

To store readings, follow these simple steps:

1. Set up the instrument for the thickness measuring mode as described in [Basic Thickness Gauging](#) on page 79.
2. From the **MEMORY** menu, select the **T-LOG** menu.
3. Select the **MODE** to **NUMERIC**.

Note: The T-LOG table that appears at the bottom of the screen will display the stored values in the previous and currently selected location. The currently measured thickness value will be shown in the measurement line and in the HUD if switched on.

4. Use the corresponding plain grey buttons to select **BLOCK**, **LOC**, and **NO** in turn and  or  the value to obtain the desired location number for storing the thickness.
5. Obtain the desired thickness reading and press the **OK** button to store the reading. Notice that the **NO** value automatically increments to the next reading number.
6. To review a reading, select the desired **BLOCK**, **LOC** and **NO** to identify the location. The value in the table at the bottom of the screen shows the reading stored for that location. Readings can be printed using the **PRINT** menu in utilities, see [PRINT Menu](#) on page 35.


Please note that numeric mode and sequence mode (see next page) occupy the same space in memory. This means that values stored in numeric mode may affect data stored in sequence mode and vice-versa.

6.5 T-LOG Thickness Storage (Sequential & Download)

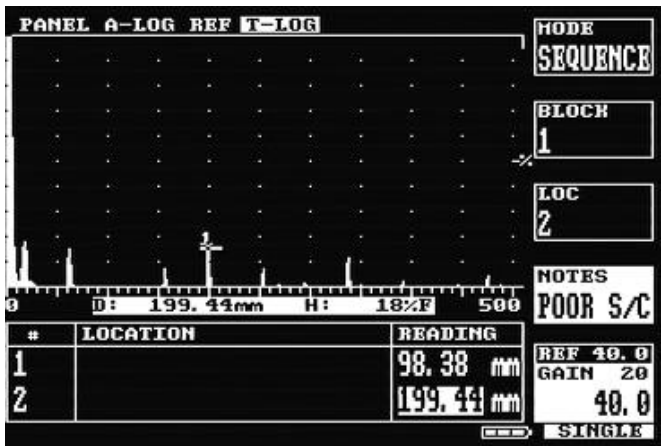
The Sequential mode of thickness storage allows readings, locations and notes to be transferred between a computer and the Masterscan 350.

Typically, the user would create a thickness location sequence on the computer and download it to the Masterscan 350, which can then be used to guide the operator when collecting thickness readings. The collected readings could then be uploaded to the computer for further analysis and storage, releasing the Masterscan 350 to collect readings from another component. When a component is re-inspected, the historical readings can be downloaded to the Masterscan 350 along with the location information, providing the operator with an instant check of thickness variation while collecting new readings. The new readings can then be downloaded back to the computer for analysis, storage and printing.

To use the Sequence/Download mode, follow these steps:

1. Using suitable software or text editor, generate a location sequence on the host computer. Each location is comprised of a location number (1 to 8,000) and a text string of 32 characters. The text strings of 32 characters are subsequently displayed on the Masterscan 350 as two lines of 16 characters each in a table at the bottom of the screen, when the Masterscan 350 is in the Sequence mode. Generally, the first 16 characters are used to identify the location so as to direct the operator to the proper point for a thickness reading. The second 16 characters are for general use and can be used for the historical readings or baseline readings if this is the first inspection of the component.
2. Turn on the sequence mode by selecting the **T-LOG** function from within the **MEMORY** menu using the arrow buttons, pressing the plain grey select button next to the **MODE** option, and using the  button to select **SEQUENCE** mode. Once selected, the graticule will reduce in size and a table is drawn along the bottom of the screen. The location and thickness data will be shown in the table if any data has been downloaded to the Masterscan 350. Alternately, the Sequence mode can be turned on by a command from the host computer.
3. Set up the instrument for the thickness measuring mode as described in [Basic Thickness Gauging](#) on page 79.
4. From the **MEMORY** menu, select the **T-LOG** menu.
5. Obtain the desired thickness reading and press the **OK** button to log the reading. Notice that the **LOC** value automatically increments to the next reading number. Any historical reading downloaded from the computer will show in the window on the screen for comparison purposes.

6. To attach one of the four available notes with the reading, press the plain grey select button next to the **NOTES** option, and using the ↶ or ↷ buttons, select **OBSTRC** (obstruction), **PITTING**, **POOR S/C** (poor surface contact), or **NO BWE** (no backwall echo).
7. To review a reading, select the desired **LOC** number to identify the location. The value in the bottom line of the table shows the reading stored for that location.
8. Once all of the readings for a component have been taken, they can be uploaded to the computer for further analysis and storage. The location data transferred is the 32 character string associated with the location, the thickness value, the units of measure, and the notes. Locations with a blank note will contain the characters "OK."



6.6 T-Log Editing and Printing

The T-LOG menu provides capability for the deletion of thickness reading stored with the T-LOG feature. With the T-LOG mode set to **DELETE**, it is possible delete a single location, all locations within a block, or all blocks (all readings).

6.6.1 To delete a single location:

1. Select the **T-LOG** menu from the **MEMORY** menu.
2. Select the **MODE** parameter by pressing the plain grey button next to it and pressing the ↵ button to select **DELETE** mode.
3. Select the desired block number by pressing the plain grey button next to the **BLOCK** parameter using the ↵ or ↶ buttons.
4. Select the desired location number by pressing the plain grey button next to the **LOC** parameter using the ↵ or ↶ buttons.
5. Press the **OK** button to delete the thickness reading for the selected location.

6.6.2 To delete all Locations in a single Block:

1. Select the **T-LOG** menu from the **MEMORY** menu.
2. Select the **MODE** parameter by pressing the plain grey button next to it and pressing the ↵ button to select **DELETE** mode.
3. Select the desired block number by pressing the plain grey button next to the **BLOCK** parameter using the ↵ or ↶ buttons.
4. Set the Location number to **ALL** by pressing the plain grey button next to the **LOC** parameter and using the ↶ button if not already selected.
5. Press the **OK** button to delete the thickness reading for the selected block.

6.6.3 To delete all Blocks and all Locations:

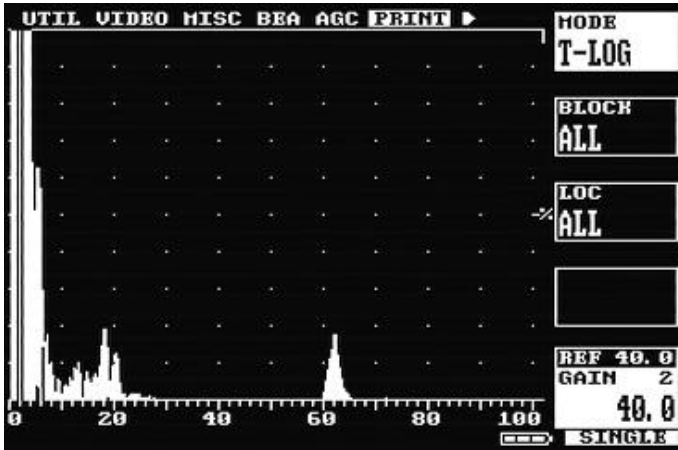
1. Select the **T-LOG** menu from the **MEMORY** menu.
2. Select the **MODE** parameter by pressing the plain grey button next to it and pressing the ↵ button to select **DELETE** mode.

3. Set the **Block** number to **ALL** by pressing the plain grey button next to the **BLOCK** parameter and using the ↩ button if not already selected. The location number will be automatically set to **ALL**.
4. Press the **OK** button to delete the thickness reading for all of the blocks and locations.

6.6.4 To print thickness logs

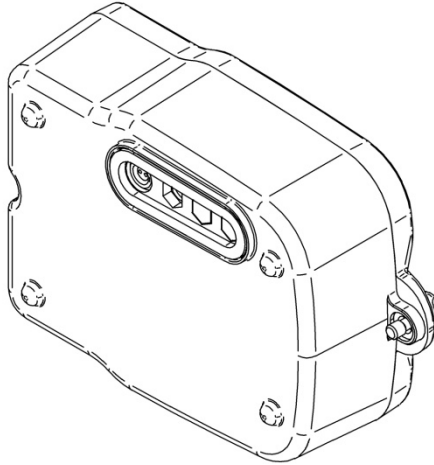
It is possible to print thickness logs by selecting the **PRINT** menu from the **UTIL** menu.

1. Select the **PRINT** menu from the **UTIL** menu.
2. Ensure printer is connected, switched on and contains paper.
3. Select the **MODE** parameter by pressing the plain grey button next to it and pressing the ↩ button to select **T-LOG** mode to print normal thickness logs or **SEQUENCE** to print sequence mode data.
4. Set the block and location to the required values. Note it is possible to set the block and location numbers to **ALL** this will print all blocks and locations – all stored readings.
5. Press the **OK** button to print the thickness readings selected by the block and location numbers.



7 Power Supply

The Masterscan 350 is powered by a Lithium-Ion battery pack, which is shown below. The battery pack attaches to the rear of the Masterscan 350 with two thumbscrews and connects to the instrument via two terminal contact points.



7.1 Lithium-Ion Battery Pack

7.1.1 Battery Cautions

Misuse of Lithium-ion batteries may result in the following hazards: smoke, fire, or battery rupture. Misuse can also cause other battery damage or degradation of battery performance

⚠ DANGER! Use and charge only the specified Sonatest battery pack with the Masterscan 350. Only the Sonatest battery pack is tested and approved for use with the Masterscan 350. Using third-party or counterfeit battery packs may cause smoke, fire, or cause the battery to burst.

⚠ DANGER! DO NOT hammer or otherwise impact the battery. Do not use the battery if it has been severely impacted or dropped, or if the battery has been subjected to heavy pressure. Battery damage may not be visible on the outside of the case. Even if the surface of the battery does not show cracks or any other damage, the cells inside the battery may rupture or catch fire.

⚠ DANGER! NEVER use or leave battery pack in areas with temperatures above +60°C. High temperature build-up in the battery, such as could occur near fires or stoves, inside a sun-heated car, or by setting the battery in direct sunlight may cause the battery to rupture or catch fire. Excessive temperatures may also degrade battery performance or shorten battery life.

⚠ DANGER! DO NOT expose the battery to rain, snow, seawater, or any other liquids. Do not charge or use a wet battery. If the battery gets wet, be sure to wipe it dry before using. The battery by itself is not waterproof.

⚠ DANGER! NEVER incinerate a used battery pack since internal battery gas may cause a rupture or explosion.

⚠ DANGER! NEVER solder the battery terminals, or modify the battery pack. This may cause heat generation, and the battery may rupture, emit smoke or catch fire.

⚠ DANGER! Use the battery only with the Masterscan 350 for which it is specified. Never use a battery with any other equipment, or for any purpose that is not specified in this instruction manual.

⚠ DANGER! If fluid from inside the battery gets in your eyes, blindness can result. Rinse your eyes with clean water, without rubbing them, and see a doctor immediately.

⚠ WARNING! Immediately stop using the battery if it emits an abnormal odour, heats up, or is discoloured or deformed. If any of these conditions occur, contact Sonatest.

⚠ WARNING! Immediately wash, using clean water, any part of the body that comes into contact with fluid from inside the battery.

⚠ WARNING! NEVER put the battery in a microwave oven, high-pressure container, or in an induction heating cooker. This could cause overheating, a fire, or cause the battery to rupture.

- **CAUTION!** Always use the battery within the specified temperature range for the Masterscan 350 (-10°C to +55°C) and the battery itself (-20°C to +60°C). Using the battery out of its specified temperature range will reduce the battery's performance and battery life. Please note that the specified temperature range of the battery may exceed that of the Masterscan 350. In such cases, the Masterscan 350 may not work properly because it is out of its operating temperature range.

- **CAUTION!** Shorter battery life could occur if the battery is left fully charged, completely discharged, or in an excessive temperature environment (above +45°C) for an extended period of time. If the battery must be left unused for a long time, it must be detached from the Masterscan 350 after discharging. You may use the battery until the battery indicator shows half-capacity, and then keep it safely in a cool dry place with the temperature between -20°C to +25°C. If the battery pack is not going to be used for a long time it must be periodically charged every 4 months; failure to do so will render the battery inoperable and it will need to be returned to Sonatest for re-charging. If a number of spare battery packs are in use the easiest way to maintain optimum conditions is to rotate the battery packs so that when one is discharged it is swapped with a fully charged one.

7.2 Battery Charging

7.2.1 Charging Caution

⚠ DANGER! Only use the CH700-P charger to charge the battery. Using any other charger may cause smoke, fire, or cause the battery to burst.

⚠ DANGER! NEVER charge the battery pack in areas with extremely high temperatures, such as near fires or stoves, inside a sun-heated car, or in direct sunlight. In such environments, the safety/protection circuit in the battery will activate, causing the battery to stop charging.

⚠ WARNING! DO NOT charge or leave the battery in the battery charger beyond the specified time for charging. If the battery is not completely charged by the specified time, stop charging and remove the battery from the battery charger. Continuing to charge the battery beyond the specified time limit may cause a fire, overheating, or the battery may rupture.

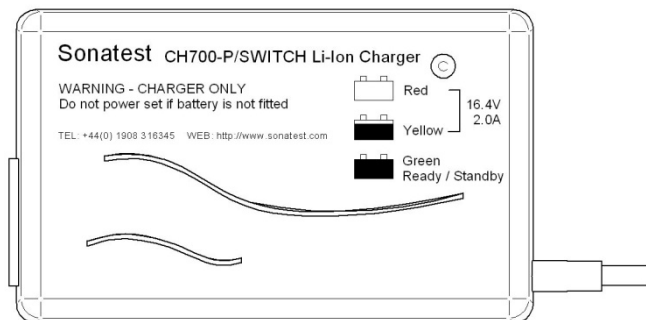
⚠ WARNING! NEVER insert the battery charger into the Masterscan 350 or battery if it is wet or soiled. This could corrode the battery charger terminals or damage the charger. The charger is not waterproof.


- CAUTION! DO NOT charge the battery outside of the specified temperature range: 0°C to +40°C. Sonatest recommends charging the battery at +20°C. The battery may heat up or rupture if charged out of the specified temperature range. Additionally, battery performance or battery life may be reduced.

When fully charged, the battery pack should enable the unit to be operated for 16 hours when the brightness is at level 1 in the VIDEO menu under UTIL, for 12½ hours with a brightness of 10 (the default) or for 9 hours with a brightness of 20. The battery pack can be charged while mounted to the Masterscan 350 by use of the connector on the front panel. Alternately, the battery pack can be charged separate from the Masterscan 350 by using its own connector shown above allowing continued operation of the Masterscan 350 with the use of multiple battery packs.

When shipped the battery has only a nominal charge and must be fully charged before being used for the first time.

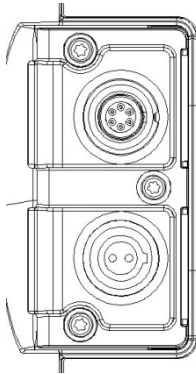
The Sonatest CH700-P battery charger shown below is suitable for use with main supply from 100 to 240 volts AC. The LED on the charger illuminates to indicate power on. When the battery level is low the LED will glow red. When the battery level is almost full the LED will glow yellow. When the battery level is full the LED glows green. The output voltage from the charger is 16.4 Volts DC. The output current when charging is a constant 2.0 Amps. The part number for a battery pack is Y-04.



 **WARNING** – The CH700 is a battery charger only. Any attempt to use it to power a Masterscan 350, without a battery fitted, WILL damage your CH700-P battery charger.

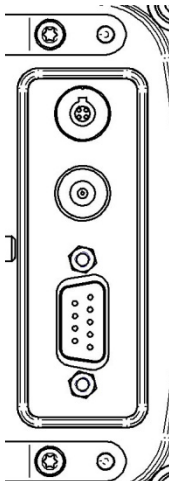
8 Interface Connections

There is a 6-pin connector on the front of the Masterscan 350 as shown below:



This connector is used to connect the flaw detector to a PC using a modified USB cable; this allows information to be transferred to the computer using Sonatest's program SDMS. For information on how to purchase SDMS please contact Sonatest using the details inside the front cover of this user's guide. The USB connector also allows a USB keyboard to be connected and used for data entry in the notes fields. A printer can also be connected allowing information to be printed directly from the Masterscan 350. Please contact Sonatest for a list for a list of supported printers.

At the rear of the Masterscan 350 there are various interface connections in a sealed compartment under a spring-loaded door. The connections are shown below and described in the following.



8.1 RS232

The RS232 port on the Masterscan 350 allows for bi-directional communication between the instrument and a personal computer. Various control commands are available within three general categories; Write parameter values, Read parameter values, and Action commands. The Write and Read parameters allow the computer to set a parameter and to read parameters current value. The Action commands provide special functions such as waveform and thickness logging transfer. The RS232 port is the D-shaped connector at the bottom.

The communication handshake is as follows:

Baud rate: 9,600, 19,200, 38,400, 57,600 or 115,200

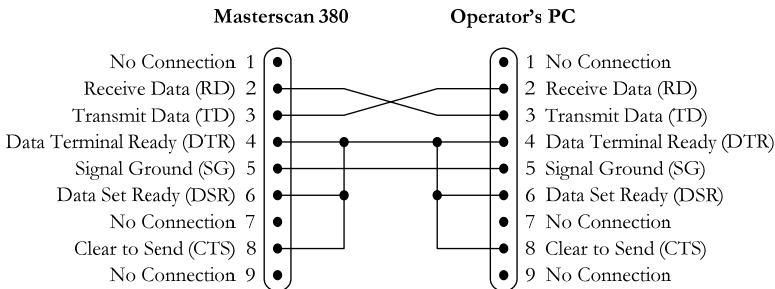
Parity: None

Data Bits: 8

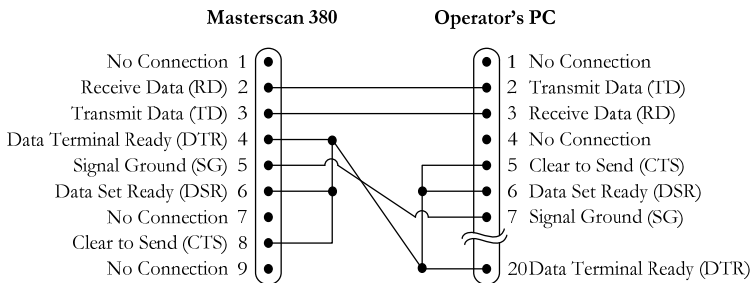
Stop Bits: 1

Handshake: Hardware

The cable connections for a 9-pin RS232 port are as follows:



The cable connections for a 25-pin RS232 port are as follows:



A 9-pin to 9-pin communications cable is available from Sonatest as part number 152120.

No cable is available for the 25-pin RS232 port.

8.2 Composite Video

The composite video output is for connecting the Masterscan 350 to a compatible video monitor or projector. The output is either NTSC (USA/Japan) or PAL (UK/Europe), depending on the VIDEO selection in the UTIL menu. The screen update rate is 50Hz in PAL and 60Hz in NTSC. The composite video connector is the second connector from the top with one centre pin.

8.3 Proportional Outputs

The Masterscan 350 has two proportional outputs which can be independently configured, both proportional outputs can be used to output the following readings: Depth 1 (gate 1), Depth 2 (gate 2), E1-E2 (distance between gate 1 and gate 2 readings), Level 1 (gate 1), Level 2 (gate 2), L1-L2 (difference between the amplitudes of signals through gate 1 and gate 2) and an Alarm signal (Alarm 1 (Gate 1 triggered) is available on proportional output 1 and Alarm 2 (Gate 2 triggered) is available on proportional output 2).

The choice of which reading to output is made using the O/P 1 and O/P 2 parameters in the P_O/P feature in the UTIL menu. The proportional outputs are updated at the currently selected PRF.

The voltage of the outputs is controlled by the CAL parameter in the P_O/P feature in the UTIL menu. This allows the voltage to be varied between 0V and 10.0V. The calibration voltage applies to all proportional outputs.

It is the small upper connector with 4 pins; the top 2 pins are used for the proportional outputs. The ground is achieved using the outer case of the connector.

8.4 Synchronisation Outputs

The Masterscan 350 provided two synchronisation outputs on the small 4 pin connector: S1 and S2.

S1 is synchronised with the TX pulse so that it goes high (3V) for 50ns, at the start of the TX signal to the analogue board.

S2 goes high (3.3V) for the duration of the acquisition period.

9 Features of the Masterscan 350

The Masterscan 350 is a user-friendly ultrasonic digital flaw detector and thickness gauge, which is simple to use and provides the experienced ultrasonic operator with a full-function device that incorporates many productivity enhancing features. All of the features of the Masterscan 350 are accessed through a menu system using the front panel keypad.

9.1 Functional Testing Methods

The Masterscan 350 supports the following ultrasonic testing methods:

- Pulse-Echo Flaw Detection
- Transmit-Receive Flaw Detection
- Time of flight measurement
- Angle Beam (Shear Wave) Testing
- Angle Beam (Surface Wave) Testing
- Crack Diffraction Methods
- Depth of Flaw Measurement
- Single Transducer Thickness Measurement
- Dual Transducer Thickness Measurement
- Indirect Measurement of Sound Velocity in Materials
- Time measurement in microseconds
- Phase change display in un-rectified mode
- Through transmission testing
- Creep wave testing
- Pitch and catch techniques

10 Specifications

| Feature | Details |
|------------------|---|
| Test Range | 0 - 1mm (0.05in) up to 0 - 20000 mm (800 in.) at steel velocity. Variable in 1,2,5 sequence or continuously in 1mm |
| Velocity | 256 to 16000m/s continuously variable. |
| Probe Zero | 0 to 999.999 μ s, continuously variable. |
| Delay | Calibrated delay from 0 -20000mm in 0.05 mm steps at steel velocity (0-400in. in 0.002 in. steps). |
| Gain | 0 to 110dB. Adjustable in 0.1, 0.5, 1, 2, 6, 10, 14 and 20dB steps. Direct access to gain control at all times. |
| Test Modes | Pulse echo and transmit/receive. |
| Pulser | 100V - 350V square wave pulser. Pulse width from Spike to 2,000ns duration - rise/fall times <10ns into 50 ohms at 200V: Width adjustable in 2% of nominal width, minimum 1ns maximum 40ns. |
| ActiveEdge™ | Used to improve the pulse shape and improve near-surface resolution. |
| P.R.F | Selectable 15 to 100 in 5Hz Steps; 100 to 1,000 in 50Hz steps and 1,000 to 5,000Hz in 100Hz steps. |
| Update Rate | 60Hz (NTSC Mode); 50Hz (PAL Mode). |
| Rectification | Full wave, positive or negative halfwave and unrectified rf. |
| Frequency Range | 6 narrow bands centred at 0.5 MHz, 1MHz, 2MHz, 2.25MHz, 5MHz, 10MHz and 15MHz. Broad band at 2 MHz to 22MHz (-6dB) and 1MHz to 35 MHz (-20dB). |
| System Linearity | Vertical = 1% Full Screen Height (FSH). Amplifier Accuracy \pm 0.1dB. Horizontal \pm 0.4% Full Screen Width (FSW). |
| Reject | 80% linear reject. LED warning light when selected. |
| Units | Metric (mm), inch (in) or time (μ s). |

| Feature | Details |
|----------------------------------|---|
| Display Colour Transflective TFT | Display area 111.4 x 83.5 mm (4.39 x 3.29 in) 320 x 240 pixels. A-Scan Area 255 x 200 pixels (315 x 200 expanded), 8 colour options and variable brightness. |
| Gate Monitor | Two fully independent gates for echo monitoring and thickness measurement. Start and width adjustable over full range of unit, amplitude variable from 0 to 100% FSH. Bar presentation. Positive or negative triggering for each gate with audible and visual alarms. |
| Gate Expansion | Expands range to width of Gate 1. |
| Gate Monitor Delay | Selectable 0.6 seconds delay on gate 2 negative monitor tracking. |
| Measurement Modes | |
| Mode 1 | Signal Monitor |
| Mode 2 | Depth and amplitude of first signal in gate. |
| Mode 3 | Echo-to-Echo distance measurement. (single gate) |
| Mode 4 | Trigonometric display of beam path, surface distance and depth of indication, curve surface correction and X-OFFSET for probe index. Half skip indication on screen. |
| Mode 5 | Gate to Gate distance measurement (independent gates). |
| Mode 6 | T-Min mode for holding minimum thickness reading. |
| Resolution | to 0.01mm (0.001in) for distance measurement or 1% FSH for amplitude measurement. Large display of measurement at top of A-Scan display. Measurement mode selectable between peak and flank. |
| A-Scan Memory | 800 waveforms can be printed or transferred to a PC using optional SDMS software. |
| Panel Memory | 100 stores for retaining calibrations. |
| Thickness Logging | 8,000 thickness readings configured either by Block / Location / Number mode or pre-programmable work sheets in sequential |

| Feature | Details |
|---------------------------|---|
| | mode. Readings can be exported to MS Excel using optional software. |
| AGC | Automatic Gain Control automatically sets the signal to a level between 10-90% FSH with tolerance between 5-20% accuracy. |
| DAC | DAC defined by up to 10 points and digitally drawn on screen. DAC curves meet requirements of EN 1714, JIS and ASME standards, selectable between -2, -6, -10, -12 and -14dB. Amplitude read out selectable between % DAC or relative dB. |
| TCG | Time Corrected Gain, also known as Swept Gain. 40dB dynamic range greater than 30dB per microsecond and up to 10 points may be used, setting all signals initially to 80% FSH. |
| Backwall Echo Attenuation | 0- 40dB attenuation. |
| AWS | Built in software for evaluation of defect indications in accordance with AWS D1.1 structural weld code. |
| AVG/DGS | Automatic calculation from probe data. |
| API | Flaw sizing complying with API 5UE |
| Auto-Cal | Provides automatic calibration from two echoes. |
| Clock | Sets time and date. |
| Reference Waveform | This menu displays a waveform from one of the A-log stores as a reference or fingerprint display in a colour different from the active display highlighting differences from the reference. |
| Notes | Alphanumeric labelling for panel and A-log allows the user to enter Notes for storage with panel settings and A-scans. |
| Display Freeze | For capturing the current A-scan image. |
| Peak Memory | For echo-dynamic pattern determination. |
| Keylock | Prevents accidental alteration of parameters. |

| Feature | Details |
|--------------------|---|
| Help Key | For instant operator guidance on using the Masterscan Series. |
| Language Support | Supports 6 simultaneous languages, user selectable. English, German, Spanish, French, Dutch. Others available on request. |
| Waveform Smoothing | Gives a smooth signal envelope, simulating analogue equipment. |
| Outputs | Full bi-directional serial interface to transfer parameters, thickness readings and waveform memories. Composite video, PAL or NTSC compatibility. Analogue proportional outputs programmable to distance or amplitude of signal in the gate. Transmitter sync output |
| Front USB | For connection to printers, keyboards and PC. |
| Printers | Supports any printer with PCL support including HP Deskjet and Epson. |
| Power | Lithium Ion battery pack 14.4V, 5.0 ampere hours, gives up to 16 hours duration from a fully charged pack. Indication of low battery status. Recharge time 3-4 hrs. |

11 Warranty

Warranty/Defects after Delivery: Immediately upon receipt of the goods the buyer is required to check the goods carefully and thoroughly. In order to benefit from the guarantee, any defect in the product should be immediately reported in writing to Sonatest. Sonatest will make good by repair or by the supply of a replacement or by equivalent adjustment of the price at our sole option, any defects which under proper use appear in the goods within the period of twenty-four (24) calendar months after the goods have been delivered and which arise solely from faulty design, material or workmanship, provided that the goods are carefully packed and promptly returned by you, free of charge, to the Sonatest works unless otherwise arranged. Said goods should be covered while in transit to us and must be accompanied by a written statement detailing the precise nature of the fault and the operating conditions under which the fault occurred. The repaired goods will be returned by Sonatest free of charge.

Save as in this Clause herein before expressed Sonatest shall not be under any liability in respect of defects in goods delivered or for any injury damage or loss resulting from such defects and our liability under this Clause shall be in lieu of any warranty or condition implied by law as to the quality, fitness or merchantability for any particular purpose of such goods.

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[and Optional Keyboard Controls & Recall of Calibration Setups and Optional Keyboard Controls Calibration](#), [Peak Echo & Hold Dynamics Operation](#)/[AVG Operation](#) [Operation Inspection Using the AWS Menu & Recall of Calibration Setups](#), [A-Scan Storage Inspection Using Trigonometry Mode](#), [A-Scan Storage Operation](#) [Inspection Using Trigonometry Mode](#), [A-Scan Storage Editing and Printing Operation](#) [Menu](#)