EMAT Thickness Gauge

DE-1000

Instruction Manual



CONTENTS

1. GENERAL DESCRIPTION ..... - 1 -
2. STANDARD DELIVERY ..... - 1 -
3. TECHNICAL SPECIFICATIONS ..... - 2 -
4. OVERVIEW ..... - 2 -
5. KEYPAD FUNCTIONS ..... - 3 -
6. DISPLAY SCREEN ..... - 5 -
7. QUICK STARTUP GUIDE ..... - 8 -
8. MENU ..... - 9 -
8.1 MEA. (MEASURMENT) ..... - 9 -
8.1.1 Auto measurement ..... - 9 -
8.1.2 Manual measurement ..... - 10 -
8.1.3 Average times ..... - 10 -
8.1.4 Pulse times ..... - 10 -
8.1.5 Pulse frequiency ..... - 10 -
8.2 SET. ..... - 14 -
8.2.1 Velocity rate ..... - 14 -
1. Materials ..... - 14 -
2. Velocity input ..... - 15 -
3. Velocity measurement ..... - 16 -
4. Velocity storage ..... - 16 -
8.2.2 Resolution ..... - 17 -
8.2.3 Probe Calibration ..... - 17 -
8.2.4 Measurement rate ..... - 18 -
8.2.5 Rectification ..... - 19 -
8.2.6 A-SCAN custom setting ..... - 19 -
8.2.7 B-SCAN display range ..... - 20 -
8.3 MEM. ..... - 21 -
8.3.1 Set a new file ..... - 21 -
8.3.2 Memory Read ..... - 22 -
8.3.3 Delete a file ..... - 22 -
8.3.4 Delete all files ..... - 23 -
8.3.4 Data transfer ..... - 23 -
8.4 FUN. ..... - 23 -
8.4.1 Swich off mode ..... - 23 -
8.4.2 Languages ..... - 24 -
8.4.3 Contrast ..... - 24 -
8.4.4 Default ..... - 24 -
8.4.5 Information ..... - 24 -
9. MAINTENANCE AND PRECAUTIONS ..... - 25 -
APPENDIX : SOUND VELOCITY MEASUREMENT CHART ..... - 26 -

1. General Description

The Model DE-1000 is a visual A / B scan EMAT Thickness Gauge. It is capable of measuring the thickness of various metal materials with accuracy as high as ± 0.01 mm or ± 0.001 inches.

It is a Multi-Mode thickness gauge that has the ability to measure the thickness through painted or coated surfaces. This unit can measure the thickness of metallic materials such as steel, aluminum, Bronze and so on.

The DE-1000 comes with following features:

- No couplant needed
- Suitable for high temperature upto 600 ℃
- Large colorful TFT display
- Automatic probe recognition,
- Automatic probe zero calibration
- Various optional probe from diameter 10mm to 30mm
- Automatically locates the detection point if the measurement is out of the viewable display area.
- Allow user to adjust the range of GAIN, RANGE, DELAY and GATE in manual-measurement mode.
- Limitation setting, alarm with sound and display.
- Multi-language
- Memory of 100 files X 100 data, transfer data to PC without software, available for any windows operating systems.
- Measurement screen automatic frozen, which make it easy to analyze the data for the user.

2. Standard Delivery

- Main Unit
- Transducer S020E
- Calibration block (Thickness=8mm, Velocity = 3250m/s)
- USB Cable
- Carrying case
- Operating manual
- Calibration Certificate

3. Technical Specifications

Measurement range	1.50mm～300.0mm depending on Transducer
Resolution	0.01mm(0.001inch), 0.1mm (0.01inch)
Optional probes	S010E, S015E, S020E, SH25E, S030E
Velocity range	1000m/s～9999m/s
Measurement rate	2 /s and 10/s in fast mode
Measuring Units	mm / inch
Memory	Memory of 10,000 readings in 100 files
Data output	USB to PC without software
Display	320×240 TFT Color LCD
Battery	2pc rechargeable Batteries
Operating	-20℃～+50℃
Measuring temp.	-20℃～+600℃(according to transducers)
Dimensions	180mm（L）×93mm（W）×29mm（H）
Weight	0.3kg (including batteries)

4. Overview



1. LCD Screen
2. KeyPad
3. Battery Pack
4. Transducer port
5. USB port

5. Keypad Functions



On & Off Key

Function 1 It is used to power the unit either **ON** or **OFF**.

Function 2 Pressing this key to escape the menu setting and return back to the main measurement screen.

Menu Key

Function 1 It is used to enter the menu and confirm the selection.

Function 2 It is as a shortcut key in A-scan mode. After finish one A-scan measurement (keeping the Parameters field in highlight), press this key to store the current set-up parameters into the CUSTOM SETTING.

F1 Key

Function 1 In A-scan manual mode, it is a toggle button mainly used to set up the parameters **RANGE, GAIN, DELAY, GATE, BLANK** by adjusting the key .

Function 2 In B-scan mode, press this key to clear current gragh And ready for next measurement.

F2 Key

Function 1 Press this key to toggle between display view options- A-Scan, B-SCAN and DIGITS.

Function 2 In A-scan mode, press this key to save current custom setup that has been modified or created by the user.



UP key

Function 1 It is used to navigate the menus and increase values while setting the parameters.

Function 2 In measurement mode, press this key to store the current measurement reading.



DOWN key

Function 1 It is used to navigate the menus and decrease values while setting the parameters.



LEFT Key

Function 1 It is used to navigate the menus and decrease values while setting the parameters.

Function 2 In A-SCAN mode, press this key to enter CUSTOM SETTING screen to open a setup that has been saved before.

Function 3 In B-Scan mode, press this key to control the thickness reading indicator (the small yellow triangle).



RIGHT Key

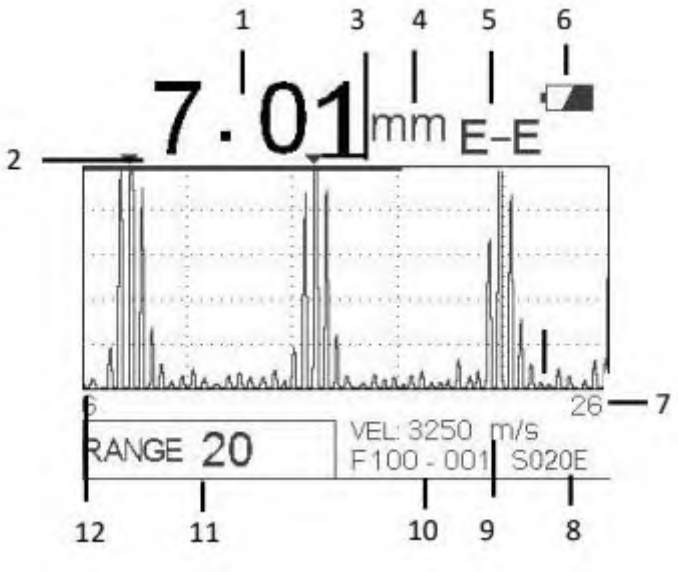
Function 1 It is used to navigate the menus and increase values while setting the parameters.

Function 2 In DIGIS and A-SCAN mode, the readout will be changed between mm to inch by pressing this key.

Function 3 In B-Scan mode, press this key to control the thickness reading indicator (the small yellow triangle).

6. Display Screen

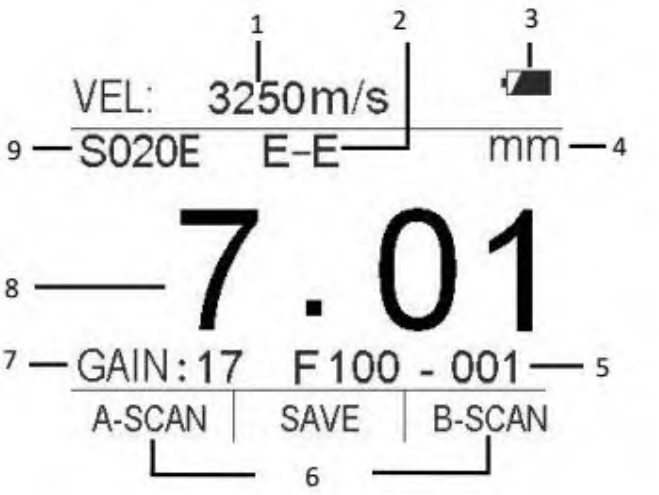
A-SCAN MODE



Full wave

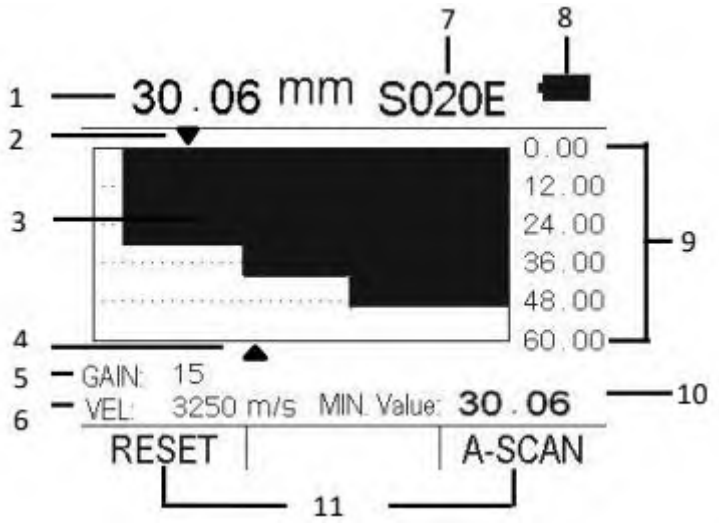
1. **Thickness reading -** Digital readout of thickness. Display with white color means in testing, with blue color means frozen.
2. **The 1st back wall indicator -** The Red▼ indicates the first back wall
3. **The 2nd back wall indicator -**The Purple▼indicates the second back wall
4. **Measuring unit-** millimeters or inches
5. **Measuring mode**
6. **Power life**
7. **End of Range indicator**
8. **Transducer model -** The transducer automatically recognizes and display
9. **Velocity**
10. **Memory location -** Files 100 X 100 data can be stored
11. **Parameters field -** Gain, Delay, Range and Gate adjustable
12. **Delay value indicator**

BIG DIGITS MODE



1. **Velocity**
2. **Measuring mode**
3. **Power life**
4. **Measuring unit -** millimeters or inches
5. **Memory location -** Files 100 X 100 data can be stored in testing, with blue color means frozen.
6. **Hot menu indicators -** Press the corresponding button, easy to converts the display or function.
7. **Gain value -** Can be adjusted from 10-50
8. **Thickness Reading -** Digital readout of thickness. Display with white color means
9. **Transducer model -** The transducer automatically recognizes and display

B-SCAN MODE



1. Thickness reading - Digital readout of thickness. Display with white color means in testing, with blue color means frozen.

2. Min. value indicator - Indicates where the minimum is located.

3. B scan graphic

4. Thickness reading indicator - Indicates where the current thickness reading is Located.

5. Gain value - Can be adjusted from 10-50.

6. Velocity

7. Transducer model - The transducer automatically recognizes and display.

8. Power life

9. B scan display range - Displays the range set in the menu and auto divides into 5 equal parts.

10. Min. value reading - Displays the minimum value of workpiece.

11. Hot menu indicators - Press the corresponding button, easy to converts the display or function.

7. Quick startup guide

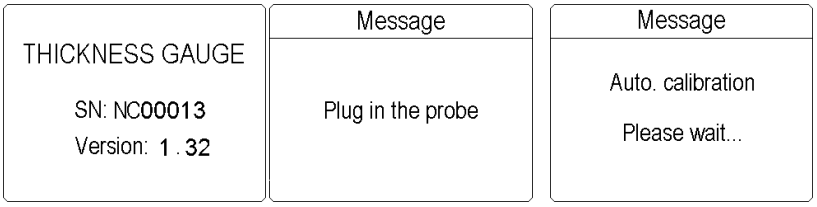
Step one: Selecting the Transducer and Probe zero & calibration

The first step in using DE-1000 is to select the transducer type according to measuring range. The optional transducers and its specification are listed below:

Type	Freq. (MHz)	Dia. (mm)	Meas. Rang (mm)	Working Temp.	Application
S010E	10	10	1.5～60	<120℃	For small diameter of pipes
S015E	15	15	1.5～150	<120℃	For small diameter of pipes
S020E	20	20	1.5～200	<120℃	For normal purposes
SH25E	25	25	1.5～300	<600℃	For high temperature of workpiece
S030E	30	30	1.5～200	<120℃	For large gaps purposes

Plug in the suitable transducer; turn the DE-1000 on using Key. The gauge does an auto calibration of the transducer, thus eliminating the need for an on-block zero. After turning on the gauge, the screen flashes the Series No. and software version, and then, it comes into the measurement mode directly.

If user turning on the unit without the transducer, screen will remind to "Plug in the probe". At this moment, please insert a transducer into the socket, the gauge directly comes into the measurement mode after Auto calibration.



Notice: *Please use the standard transducer offered. Otherwise, the unit does not work normally and displaying "Error".*

Step Two: Setting velocity

Sound velocity plays an important role in measurement. Different material is of different sound velocity. When the sound velocity is incorrect, it will cause

wrong measured results. There are 3 ways to set the material's sound velocity, which are:

1. Directly select preset material velocity. Please refer to 8.2.1.2.
2. Input the new velocity which is not preset into the menu. Please refer to 8.2.1.3.
3. Get the accurate sound velocity of the workpiece which the thickness is known. Please refer to 8.2.1.4.

Step Three: Measurement

The DE-1000 is now ready to measure. There are four different measurement view options, A-Scan RF+, A-Scan HALF+, B-Scan and DIGITS, each with a specific purpose.

A-Scan RF+: It shows both the positive and the negative peaks.

A-Scan HALF +: It shows the positive.

B-Scan: It displays a time-based cross section view of test material.

DIGITS: It is a basic digital thickness gauge look and feel. The color and larger digits make it much easier for the operator to monitor the thickness readings.

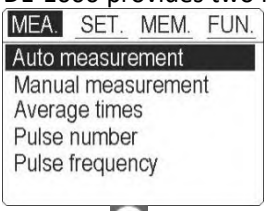
User can toggle between the different view mode options by pressing 

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8. MENU

8.1 MEA. (Measurement)

DE-1000 provides two measurement modes, T-E mode and E-E mode.

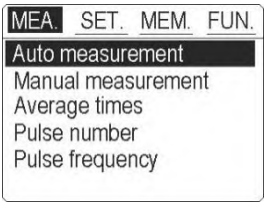


1) Press  key to set **MEA.**

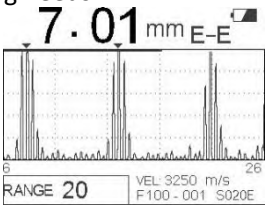
2) Press   to select Auto or Manual measurement, Averages, Pulse number and Pulse frequence, press  to confirm.

8.1.1 Auto measurement

When Auto measurement is selected, all probes are available.



With this function, DE-1000 displays the current measurement value, satisfy with the normal measuring needs.

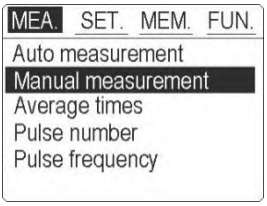


The following pages outline how to enable and set up this feature.

1) Press key to choose **MEA.-Auto Measurement,** and confirm.

8.1.2 Manual measurement

This feature allows user to make fine adjustment of RANGE, GAIN, DELAY, GATE and so on manually in A-SCAN mode. They can be set through toggle the HOT MENUS what is displayed at the lower left side of the screen.
And once the above-mentioned parameters are set, it will remain the same for B-SCAN and DIGITS display.

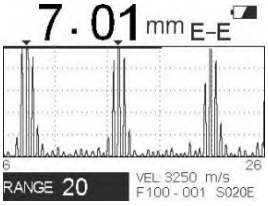


The following pages outline how to enable and set up this feature.

1) Press key to choose **MEA.-Manual measurement,** and confirm.

Range

The range refers to the overall viewable range being displayed on the screen. Make change the range of display, shorten or enlarge it, finally serve User conveniently.



The following steps outline how to enable and adjust the RANGE.

1) Press  once to set **RANGE.**

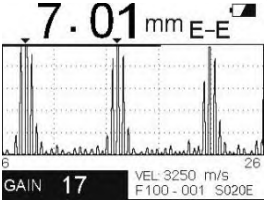
2) Use keys  (+1),  (-1),  (-coarse adjustment),  (+ coarse adjustment) to adjust value.

Gain

The gain can be adjusted over a wide range. The setting of the gain is crucial in order to obtain valid reading during the measurement process. Too much gain may result in erroneous measurements, by detecting on noise rather than the actual material back wall itself. Too little gain may result in detection on an undesirable section of the waveform.

The gain will also be represented in both the B-SCAN and DIGITS views.

The following steps outline how to enable and adjust the GAIN.



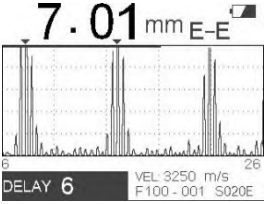
1) Press  once to set **GAIN.**

2) Use keys  (+1),  (-1),  (-coarse adjustment),  (+ coarse adjustment) to adjust value.

Delay

The starting DELAY is the value displayed on the bottom lower left side of the display in both RF+ and HALF+ views. It is the minimum thickness value that can be viewed on the display.

The following steps outline how to enable and adjust the DELAY.



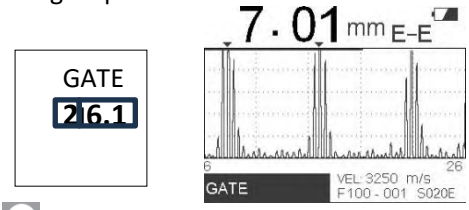
1) Press  once to set **DELAY.**

2) Use keys  (+1),  (-1),  (-coarse adjustment),  (+ coarse adjustment) to adjust value.

Gate

GATE is used in both STD (Standard) and E-E modes. The purpose of GATE is to force DE-1000 to measure the useful echo wave.

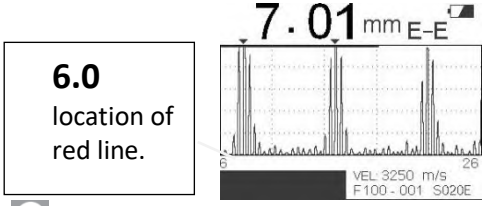
The following steps outline how to enable and adjust the GATE.



1) Press F1 once to set **"GATE"**

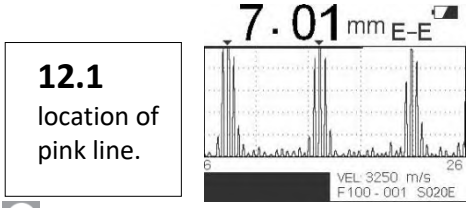
2) Use keys ▲ or ▼ to set quantities of Gate (location of Number 2 on above picture), ◀ or ▶ to set width of each Gate(location of Number 6.1 on above picture).

Notice: *Under E-E mode, users should set quantities of Gates as 2; Under Standard (STD) mode, users should set quantities of Gate as 1.*



1) Press F1 once to set **"GATE"**

2) Use keys ▲ (+1), ▼ (-1), ◀ (-coarse adjustment), ▶ (+ coarse adjustment)to adjust value.



1) Press F1 once to set **"GATE"**

2) Use keys ▲ (+1), ▼ (-1), ◀ (-coarse adjustment), ▶ (+ coarse adjustment)to adjust value.

Saving the setting

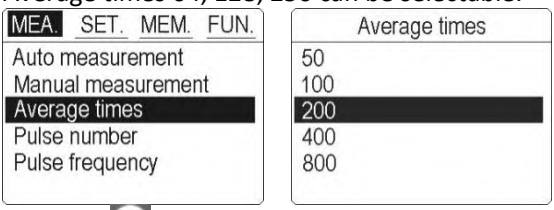
Once all the parameters are set, there is two ways to save the setting.

1) The user can Press  to store this setting into the current location. When turn on the gauge next time, this setting will be displayed.

2) Or the user can Press  to store this setting into the **A-SCAN CUSTOM SETTING** for further use while measuring the same workpiece.

8.1.3 Average times

Average times 64, 128, 256 can be selectable.



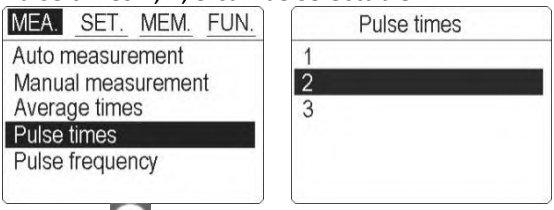
1) Press  key to set **MEA.-Average times,**

2) Use  keys to select.

3) Press  to return to the measurement screen.

8.1.4 Pulse times

Pulse times 1, 2, 3 can be selectable.



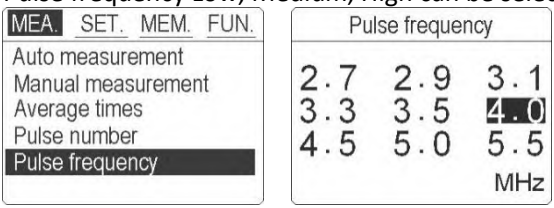
1) Press  key to set **MEA.-Pulse times,**

2) Use  keys to select.

3) Press  to return to the measurement screen.

8.1.5 Pulse frequence

Pulse frequency Low, Medium, High can be selectable.



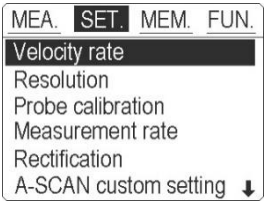
1) Press  key to set **MEA.-Pulse frequency,**

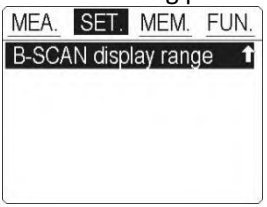
2) Use  keys to select.

3) Press  to return to the measurement screen.

8.2 SET.

This function allows user to set following parameters of measurement.

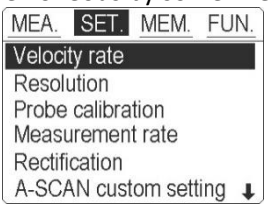


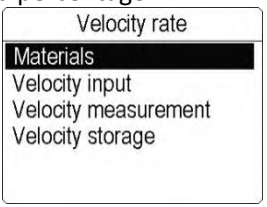


The following pages outline how to enable and set up these parameters.

8.2.1 Velocity rate

Sound velocity plays an important role in measurement. Different types of material have different inherent sound velocities. If the gauge is not set to the correct sound velocity, all of the measurements the gauge makes will be erroneous by some fixed percentage.





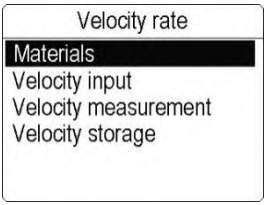
If the name or sound-velocity of the material to be measured is known, the user could select material name directly in the menu **Materials.** Or input the known velocity in the menu **Velocity Input.**

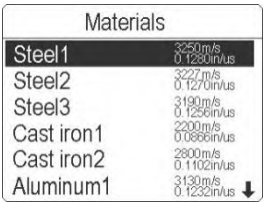
And the user could measure the sound velocity by using the function **Velocity measurement** If the sound-velocity of the material to be measured is unknown, but the exact thickness of which is known.

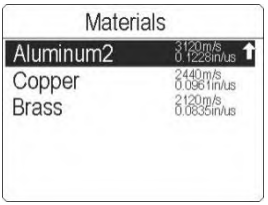
1. Materials

The DE-1000 presets 9 common materials' sound velocity. They are: Steel, Cast Iron, Aluminum, Copper and Brass.

User may opt to choose such basic material type from the menu. It's important to Notice that these velocities arel not always be an exact representation of the material being tested. Use these values only if a close approximation is acceptable.







The following pages outline how to enable and set up this feature:

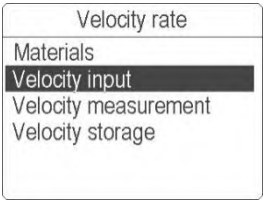
1) Press key to set **SET-Velocity rate-Materials,**

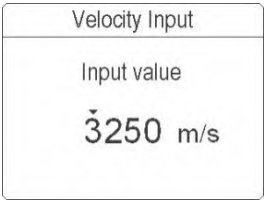
2) Use or keys to set the material. Press the key to confirm.

3) Press key to exit setting and DE-1000 is now ready to perform measurements.

2. Velocity input

If the material velocity is known, the user may wish to simply enter the velocity number into the DE-1000, rather than have the DE-1000 calculate the velocity value on using a known thickness. And DE-1000 also can store 4 new velocities as custom.



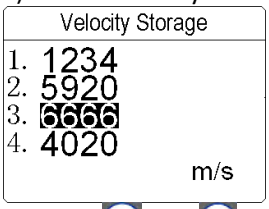


The following pages outline how to enter the velocity:

1) Press key to set **SET-Velocity rate-Velocity Input,**

2) Press or key to move the cursor, Press the or Key to change the numbers.

3) Press key to confirm and store it into **Velocity Storage,**



4) Press or key to choose the place where want to store, Press key to confirm.

5) Press key to exit setting and DE-1000 is now ready to perform

measurements.

3. Velocity measurement

Sometimes the sound velocity of a material is not known. In this case a sample with a known thickness can be used to determine the sound velocity. It would be very handy to carry a set of mechanical calipers to use in conjunction with the DE-1000 in the field.

The following steps outline how to enable and set up this feature:

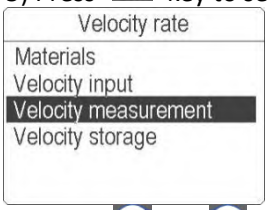
1) Physically measure an exact sample of the material or a location directly On the material to be measured using a set of calipers or a digital micrometer.

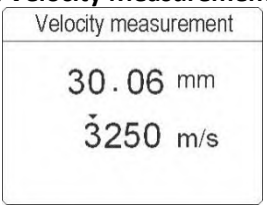
2) Place the transducer in steady contact with the sample or actual test material.

3) The display shows a thickness reading (probably incorrect).

4) Having achieved a stable reading, remove the transducer. (If the Displayed thickness changes from the value shown while the transducer Was coupled, repeat step 3.)

5) Press key to set **Velocity Measurement**; Press key to confirm.





6) Press or key to move the cursor, press or key to adjust the displayed velocity up or down, until the thickness value displayed matches the thickness of the sample piece. And now the displaying sound velocity value is accurate.

7) Press key to confirm and store it into **Velocity Storage,**

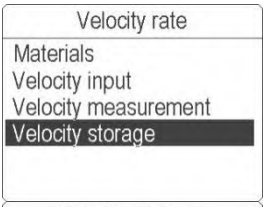
8) Press or key to set the target place, Press key to confirm.

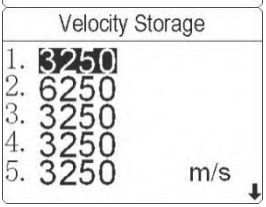
9) Press key to exit setting and DE-1000 is now ready to perform measurements.

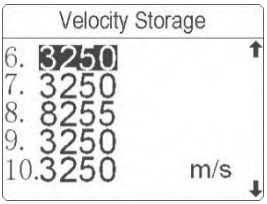
Notice: *Please do not remove the transducer from the test block when make velocity measurement.*

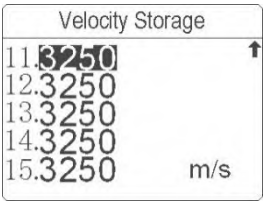
4. Velocity storage

It allows user to store 15 new Velocities as custom and use it in future measurement. User can get the custom velocities by the features of **Velocity input** or **Velocity measurement**.









The following steps outline how to enable and set up this feature:

1) Press key to set **SET-VELOCITY RATE-Velocity storage,**

2) Press key to set the target velocity, Press to confim.

3) Press to exit and DE-1000 is now ready to perform measurements.

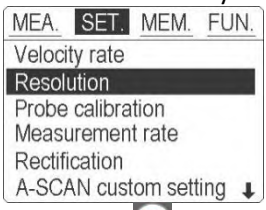
8.2.2 Resolution

User can select the displayed resolution. When 0.01mm or 0.001 inch be selected, the workpiece surface to be measured should be smooth for the purpose of getting an accurate value.

The following pages outline how to enable and set up this feature:

1) Press the key to set **SET-Resolution.**

2) Press key to select resolution and unit. Press to confirm.





3) Press the key to exit setting and DE-1000 is now ready to perform measurements.

8.2.3 Probe Calibration

It causes error during the primary stage of usage or operate for long time. User should make probe calibration during following three aspects are happened.

1. The probe itself or the temperature variation,
2. System error caused by the match between the unit and the transducer,
3. Calculation error caused by the sound velocity set in the unit is different

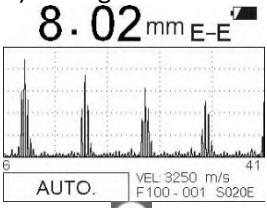
from that of the actual material.

This feature requires a sample piece of the specific material to be measured, the exact thickness of which is known. E.g. from having been measured by some other means. Or to use the standard test block (8mm) comes with DE-1000.

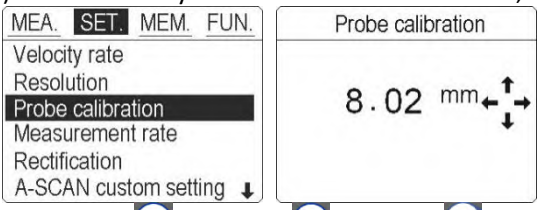
The following steps outline how to enable and set up this feature:

1) Place the transducer in steady contact with the sample or standard test block.

2) Having achieved a stable reading and do not remove the transducer.



3) Press key to set **SET-Probe calibration**,



4) Use keys (+0.01), (-0.01), (-coarse adjustment 0.1), (+ coarse Adjustment 0.1)to adjust value until the thickness value displayed matches the thickness of test block or sample piece. Press key to confirm.

5) Press key to exit setting, Test the block or sample piece again to verify the result.

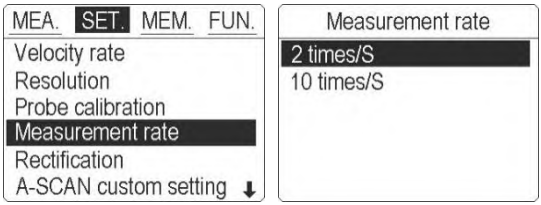
***Notice**: Calibration is recommended to be made on the standard test block in the standard delivery.*

***Notice**: calibration range is within ±5mm. If it is out of range, which means users should replace a new probe.*

***Notice**: Please do not remove the instrument from the test block when make probe calibration.*

8.2.4 Measurement rate

DE-1000 performs measurement of 2 times/second and 10 times / second. 2 times/second is quite adequate for single measurements. And 10 times/second is recommended to measure the high temperature surfaces.



The following steps outline how to enable and set up this feature:

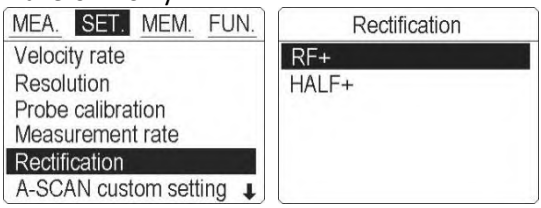
1) Press key to set **SET-Measurement rate**,

2) Press or key to select **2 times/S** or **10 times/S**. Press key to confirm.

3) Press key to exit setting and DE-1000 is now ready to perform measurements.

8.2.5 Rectification

DE-1000 supply two display views of A-Scan. RF+ mode shows both the positive and the negative peaks. HALF+ mode shows the upper of complete waveform only.

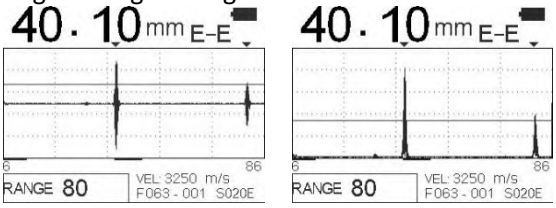


The following steps outline how to select the RECTIFICATION.

1) Press key to set **SET-RECTIFICATION**,

2) Press key to select RF+ or HALF+,

3) Press to confirm, press return to the measurement screen and begin taking readings.



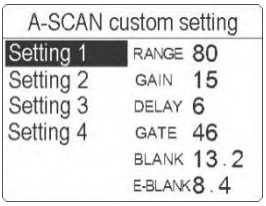
RF+ HALF+

8.2.6 A-SCAN custom setting

DE-1000 can store 4 A-SCAN custom settings. This feature saves a great deal of time and knowledge for future inspection of the same job or project.

Also, it eliminates error between two or more users during the setup and calibration process.





The following steps outline how to open/store an A-SCAN CUSTOM SETTING.

1. Opening a custom setting.

1) Press key to set **SET- A-SCAN CUSTOM SETTING**,

2) Press key to select target setting.

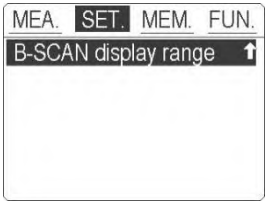
3) Press to confirm, press return to the measurement screen and begin taking readings.

2. Store a custom setting

Once the DE-1000 parameters and features have be adjusted for an application, user can Press to save this setting to any one of 4 custom setting locations.

8.2.7 B-SCAN display range

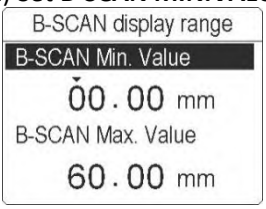
It's important to Notice that the measurement range of B-scan on the display be set wide enough, so that the Maximum thickness of the material can be viewed on the display.



The following steps outline how to set the B-SCAN DISPLAY RANGE.

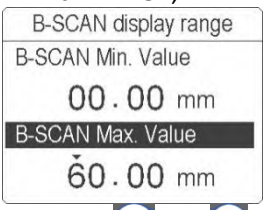
1) Press key to set **SET-B-SCAN DISPLAY RANGE,**

2) Set **B-SCAN MIN.VALUE**,



3) Press  or  to move the cursor, press  or  to change Numbers.

4) After setting of **B-SCAN MIN.VALUE**, Press  key to set **B-SCAN Max.VALUE**,



5) Press  or  to move the cursor, press  or  to change Numbers, press  to confirm.

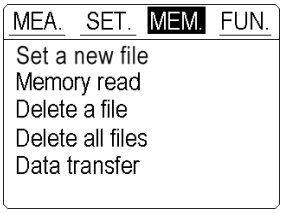
6) Press  again to return to the measurement screen. Then Press  twice go to B-SCAN interface.

***Notice**: There is a reminder of "Input error" When users set Max. Value is lower than Min. Value and confirm this setting.*

8.3 MEM.

The gauge has a memory capacity of 10,000 measurements in 100 files. The current memory location will be displayed on the screen as F000-000 in both A-scan and DIGIS mode. The files are numbered from 1-100, and measurement number will be followed automatically from 001.

This feature allows user to complete following function:

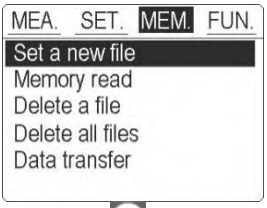


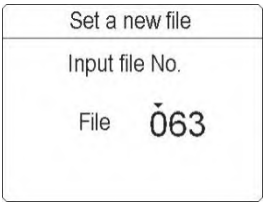
8.3.1 Set a new file

The following steps outline how to set a **new memory file.**

1) Press  key to set **MEM.-Set a new file,**

2) Press  or  to move the cursor, press  or  set the file Number (001-100 can be set), Press  to confirm.





3) Press to return to the measurement screen.

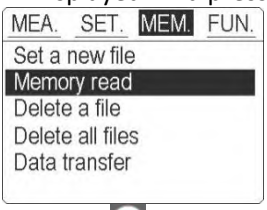
Notice: *After taking every measurement, press key to store this reading with a location number.*

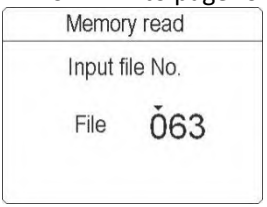
8.3.2 Memory Read

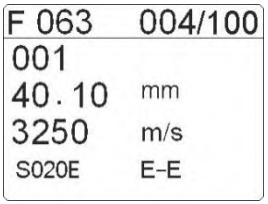
It is sometimes necessary to go back and view the stored readings. The following procedures outline how to read memory.

1) Press key to set **MEM.-Memory read,**

2) Press to move the cursor, press to set the target File Number. Press to confirm. All stored readings in this file will be Displayed. And press or to page forward or backward.





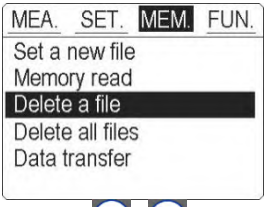


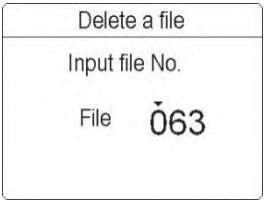
3) Press to return to the measurement screen.

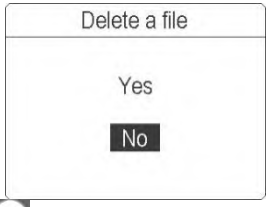
8.3.3 Delete a file

1) Press key to set **MEM.-Delete a file**

2) Press to move the cursor, press to set the target File Number. Press to confirm.







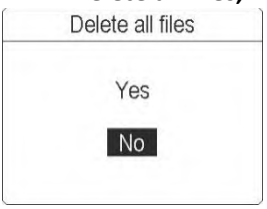
3) Use keys to select YES or NO, press key to confirm.

4) Press to return to the measurement screen.

8.3.4 Delete all files

1) Press key to set **MEM.-Delete all files,**





2) Use keys to select YES or NO, press key to confirm.

3) Press to return to the measurement screen.

Notice: *Once data in all files is deleted, it could not be recovered. Please be cautious.*

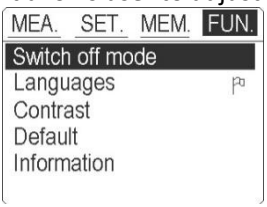
8.3.5 Data Transfer

The data can be transferred to PC using USB cable. Then User could copy them into DOC. ,TXT. Or Excel for further analysis. Procedure is as follows:

1) Press the key to illuminate **MEM.-Data transfer**
2) Connect the DE-1000 with PC using the cable which comes with the standard delivery; then a file will be shown on the PC.
3) Open this new file and all files stored in DE-1000 will be shown as .TXT document.
4) Open it, user could copy the data into Word, Excel for further analysis.

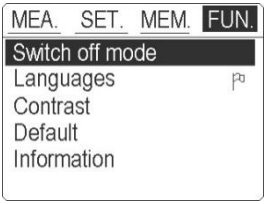
8.4 FUN.

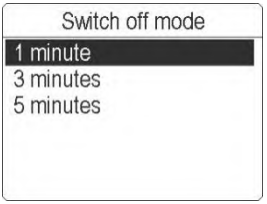
It allows user to adjust following functions:



8.4.1 Switch off mode

Auto shut down after 1 Min. 3 Min. 5 Min. can be selectable.





1) Press key to set **FUN-Switch off mode,**

2) Use keys to select.

3) Press to return to the measurement screen.

8.4.2 Languages

The gauge provides muti-languages for selection.



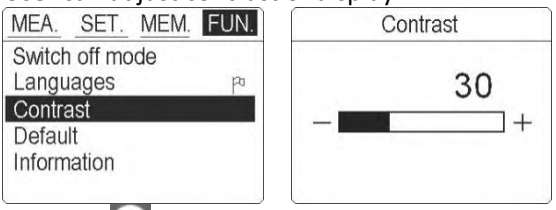
1) Press key to set **FUN-Languages,**

2) Use keys to select.

3) Press to return to the measurement screen.

8.4.3 Contrast

User can adjust contrast of display.



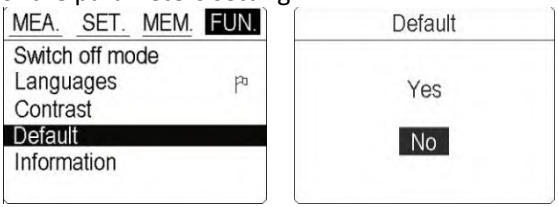
1) Press key to set **FUN-Contrast,**

2) Use keys (+1), (-1), (-coarse adjustment), (+ coarse adjustment) to adjust value.

3) Press to return to the measurement screen.

8.4.4 Default

During the usage, when User can not ensure why the problems comes out and with some questions on setting, he can use this function to make the parameters to restore the factory status to eliminate any abnormal because of the parameters setting.



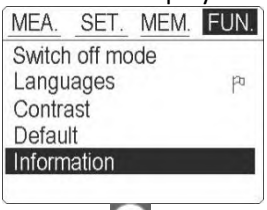
1) Press key to set **FUN-Default,**

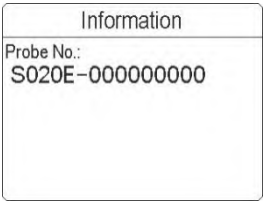
2) Use keys to select Yes or No.

3) Press to return to the measurement screen.

8.4.5 Information

The screen displays the Transducer Number.





1) Press key to check Probe information from **FUN-Information,**

2) Press to return to the measurement screen.

9. Maintenance and precautions

9.1 Power check

When the power is low, the low battery indicator will appear, at this moment User should replace the battery in time, or it will affect the measuring accuracy. The backlight cannot be switched on for a long time, because it is a big consumer of electricity.

Notice: if the unit did not used for a long time, please take out of the battery to avoid leakage to damage the unit.

9.2 Precautions

9.2.1 General precautions

The unit should avoid strong vibration, do not let it in an excessively humid environment, plug in or out the probe should hold the jacket to avoid the core wire of the probe damaged.

9.2.2 Precaution during the measuring

1. During the measurement, only the measuring icon appears and displayed stable, it can be regarded as a good measurement.
2. If there are large quantity coupling agents attached on the measured surface, when taking away the probe, it will cause error, so when the measurement is completed, please move the probe away from the measured surface quickly.
3. If the probe wears out, it will cause the displayed value unstable, please replace the probe.

APPENDIX : Sound Velocity Measurement Chart

Material	Sound Velocity	
	M/s	Inch/μS
Steel 1	3250	0.128
Steel 2	3227	0.127
Steel 3	3190	0.1256
Cast Iron 1	2200	0.0866
Cast Iron 2	2800	0.1102
Aluminum 1	3130	0.170
Aluminum 2	3120	0.1232
Bronze	2440	0.0961
Copper	2120	0.0835