Color Waveform
Ultrasonic Thickness Gauge
PM-5 Series

Operating Manual

YUSHI INSTRUMENTS

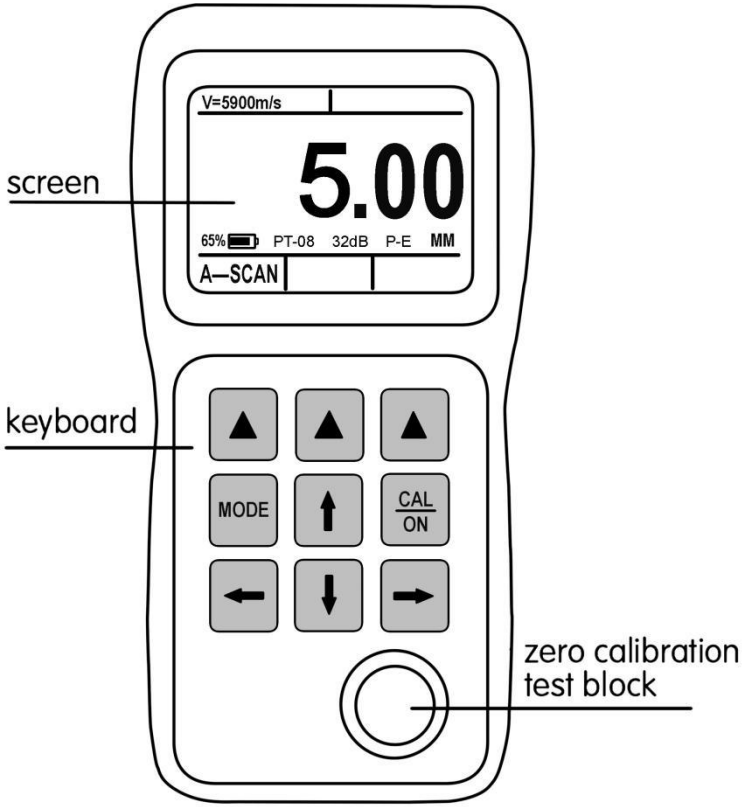
Content

1. General Information of the Gauge

PM-5 series High precision ultrasonic thickness gauge made by our factory according to ultrasonic measuring principle, take advantage of single delay probe, transmit the ultrasonic wave from one side of the measured work-piece to the internal of the material, real-time measure the digitized thickness, without cutting the object. It is a sub-miniature measuring gauge. The features include fast response, non-destruction and precise measuring. It adopts the Multiple-wave check method to enhance the accuracy, makes the resolution reach to 0.001mm, and the lower limit as little as 0.2mm. In addition, A/B-scan waveform display is available by showing the echoes, which enables the more extensive measure range, more precise result and very little measurement error and finally makes the measuring processes more controllable.

This series of Instrument can be widely used to measure the thickness of metal materials. Especially display its advantage for measuring the thin piece and high precision measuring. What's more, it can also be used to measure ultra thin wall with paint layer like fire extinguisher through the thin coating layer and paint layer.

1.1 Construction of the Gauge



1.1 Instrument Illustration

1.2 Standard Configuration

NAME	NUMBER
THICKNESS GAUGE	1
PROBE	1
ALKALINE BATTERY	2
COUPLANT	1
CARRYING CASE	1
OPERATING MANUAL	1
USB CABLE	1（PM-5DL）
SOFTWARE CD	1（PM-5DL）
RUBBER SHEATH	1

1.3 Optional Configurations

PROBE CABLE	PROBE
RUBBER SHEATH	STEPPED CALIBERATION BLOCK

1.4 Specifications

Display Type	2.4 inch color 320*240 dot matrix LCD screen
Operating Principle	Adopts ultrasonic measuring principle with single delay probe
Measuring Range	0.2mm to 27mm(0.007874" to1.0629921")
Error	±0.01 H≤3mm ，±0.05 3＜H＜10mm ±(0.5%H+0.01) H≥10mm “H” is the thickness of the tested material
Measuring Resolution	Selectable 0.001mm, 0.01mm or 0.1mm (selectable 0.0001, 0.001", 0.01")
Units	Inch or Millimeter
Display Mode	Normal, Minimum / Maximum capture, DIFF/RR%, A-Scan, B-Scan
V-Path Correction	Automatic

Update Rate	Selectable 4Hz, 8Hz, 16Hz per second
Material Velocity Range	500-9999m/s，0.0179-0.3937in/u
Languages	Chinese, English, French, Germany, Japanese,Multiple languages available
Alarm Settings	Minimum and Maximum alarms. Dynamic waveform color change on alarm
Power Requirements	2 AA size batteries
Operating Time	Greater than 35 hours
Instrument Shut-off	Selectable ALWAYS ON or AUTO OFF after 5, 10, 20 minutes of inactivity
Operating Temperature	-10°C to +50°C (+10°F to +120°F); -20°C for special requirements
Size	153mm × 76mm ×37mm(H ×W ×D)
Weight	280g including batteries
Warranty	One year

1.5 Main Functions

1.Unique Multiple-wave check method, make use of multiple consecutive echos to verify. Meanwhile accomplish measuring of thin piece and high precision.

2.Unique AUTO measuring mode, can be selected automatically available upon the request of the thickness of the work piece, easy and simple to operate.

3.Parameter configuration interface is simple and easy to operate.

4.Adjustable Live A-scan waveform display, control of Gain, Blanking, Gate, Range and Delay etc.

5.Time-based B-scan function, displays a cross section of the test piece, for observing the underside outline of the piece.

6.Numerical view, display thickness values with big digit.

7.Thickness alarm: programmable Hi-Low alarm set point with dynamic change thickness value's color.

8.Limit value mode: catching the minimum and maximum values when measuring.

9.Difference mode: getting the difference between the actual value and the normal value as well as the percentage of difference value and normal value.

10.Selectable units of Millimeter and inch.

11.Optional resolution: X.XXX mm, X.XX mm and X.X mm; X.XXXX inch, X.XXX inch and X.XX inch.

12.Optional waveform style: outline mode or fill mode.

13.Optional rectification mode: RF+, RF-, full wave, half +, half -

14.Support adjustment of velocity and single-point calibration

15.Multi-languages Available: Chinese, English, German, French and Japanese.

16.Approx. battery life: 35 hours.

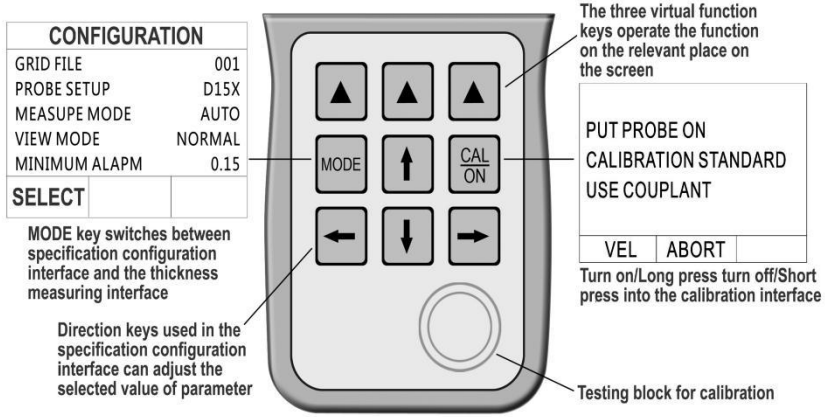
17.Great capacity data storage function: Stores 100,000 thickness values&1000 wave-forms.（only PM-5DL）

18.Connectable to the PC, and derive data from the Instrument.（only PM-5DL）

19.Measure the net thickness of the workpiece through the coating.

2. Keyboard Functions

There are 9 keys on the keyboard totally, including 3 virtual function keys (▲), four direction keys (▲ ▼ ◀ ▶), two specialized function keys (CAL ON MODE). See the following illustration:



2.1 Keyboard Fuctionillustration

3. Measuring Thickness

3.1 Instrument Calibration

Before using PM-5 series, set the sound velocity of the material to be measured, without calibrating the instrument and probe, the thickness of the work-piece can be measured directly.When the sound velocity of the material to be measured is unknown, calibration can be selected to find out the sound velocity of the material to be measured, which is very important.The calibration function is divided into two types:

One-point calibration: use the same velocity and curvature of standard test block as the material being tested to calibration.

Manual setting the velocity: for the known velocity of the material, e.g. The velocity of the steel is 5900/s, then input the velocity manual.

3.1.1 One Point Calibration

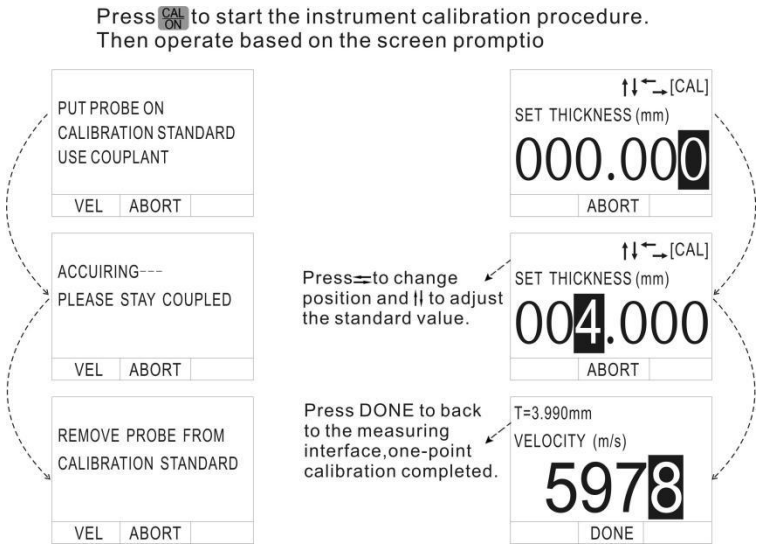
When the sound velocity of the material to be measured is unknown, sound velocity measurement must be made before measuring the thickness.

① Prepare a test block with the same composition as the object to be measured, and its surface must be suitable for measurement.

② Measure the thickness of the test block with a vernier caliper.

③Coat the couplant on the surface of the test block.

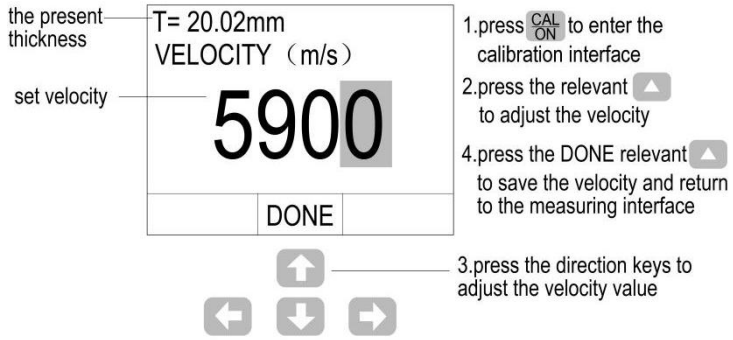
④ Refer to Figure 3.1 for the measurement process



3.1 One point Calibration Steps

3.1.2 Velocity Adjusting Steps

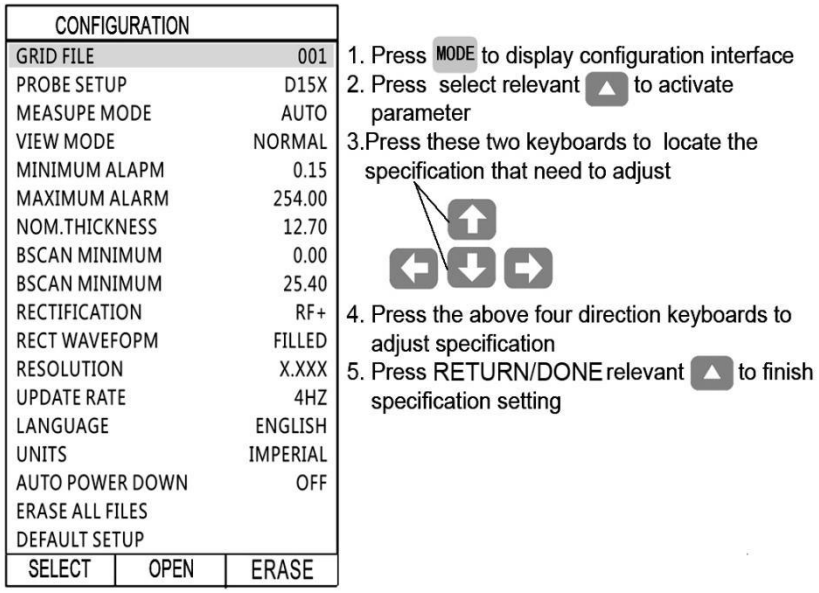
When the sound velocity of the material to be measured is known, the value of sound velocity can be adjusted manually before measurement, The method is as follows (Figure 3.2)



3.2 Specification Adjusting Steps

3.2 PRESET OTHER SPECIFICATIONS

Press MODE to enter the specification configuration interface, which including many specification adjusting options like FILE NUMBER, MEASURING MODE, VIEW MODE, PROBE SETUP, MINIMUM ALARM, MAXIMUM ALARM, NORMAL THICKNESS, THE MINIMUM OF B SCAN, THE MAXIMUM OF B SCAN, RECTIFICATION, RECTIFICATION WAVEFORM, RESOLUTION, UPDATE RATE, LANGUAGE, UNITS, AUTO POWER DOWN, ERASE ALL FILES AND DEFAULT SETUP. See the following figure:



3.3 Specification Adjusting Steps

FILE NUMBER – Select the current file. Total 400 files and each file could save 252 thickness values or wave-forms.

PROBE SETUP: D15X (means single crystal delay probe)

MEASURING MODE:

The Thickness Gauge has 4 measurement modes:

I-E: interface wave- Echo, measurement range 2mm-27mm;

E-E: Echo-Echo, measurement range 0.2mm-15mm;

ME-E: Multiple-wave check method, measurement range is 0.2mm-10mm. According to 3(Min. times) to 9Max.times) times echos every time when measuring, the more measuring times, the higher precision will get. Furthermore the reading values are all through checkout, to make sure the results are accurate.

AUTO: Automatic mode, measurement range is from 0.2mm-27mm. On the basis of thickness, it selects the measuring model automatically. When H≤10mm, it adopts ME-E measuring mode; when 0.2mm<H≤5mm, it adopts E-E measuring mode; and when H>2mm, it adopts P-E mode. Under this mode, the user only needs to adjust the Gain. It is easy to operate, we recommend the common users to adopt this mode. H is the thickness of the material to be measured.

VIEW MODE: normal mode, difference mode and limit scanning mode.

MINIMUM ALARM: Set the minimum thickness alarm value, range of 0.15-635mm. The result will be displayed in red if the actual thickness is less than the minimum value preset.

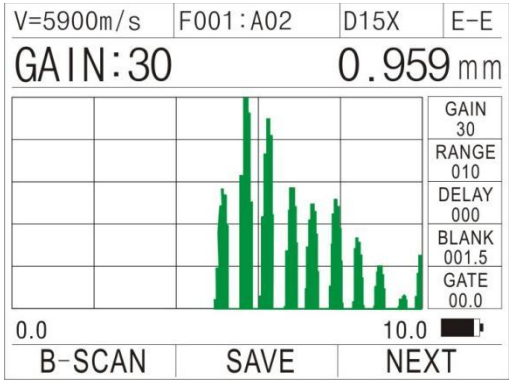
MAXIMUM ALARM: Set the maximum thickness alarm value, range of 0.15-635mm. The result will be displayed in red if the actual thickness is more than the maximum value preset.

NORMAL THICKNESS: Set the normal thickness, range of 0.15-635mm. The real concrete application will be introduced in the difference mode.

MINIMUM OF B SCAN: Set the minimum thickness of the B scan.

MAXIMUM OF B SCAN: Set the maximum thickness of the B scan.

RECTIFICATION MODE: RF+ and half +. RF+ describes the complete echo waveform; half + means putting off the half － echo and only left the half + echo.



3.4 Half-Wave Filling

RECTIFICATION WAVEFORM: outline mode and filled mode.

RESOLUTION: Set the decimal digits of the measurement result. Metric of X.X, X.XX and X.XXX; imperial of X.XX,， X.XXX and X.XXXX.

UPDATE RATE: Update the rate of measurement result. Optional 4Hz, 8 Hz and 16Hz.

LANGUAGE: Set the interface language.

UINTS: Selectable units of mm/inch.

AUTO POWER DOWN: The device will be automatic power off if no key presses or measurements occur for set 5 minutes, 10 minutes or 20 minutes.

DELETE ALL FILES － Empty the thickness readings and waveforms of all files.

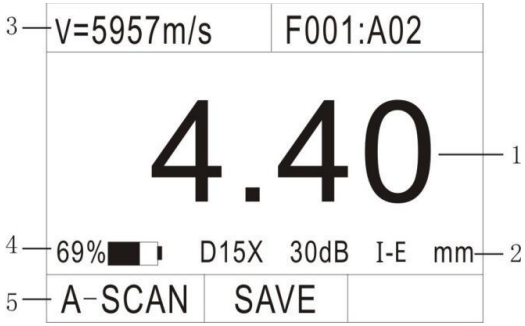
DEFAULT SET UP － Set all parameters to their factory default values.

3.3 Normal Mode

PM-5 series have three measuring interface: normal mode, A-scan interface, B-scan interface. And there are three display modes of normal interface: Thickness value mode, Difference/rate-of-reduction measurement mode, MAX. /MIN. measurement mode. Select in the “VIEW MODE” of CONFIGURATION.

When the probe and the object are not completely coupled, the letters in the various interfaces are in GREEN, when properly coupled, they are displayed in WHITE color and when the either the upper or lower limited are exceeded, the letters are displayed in RED color.

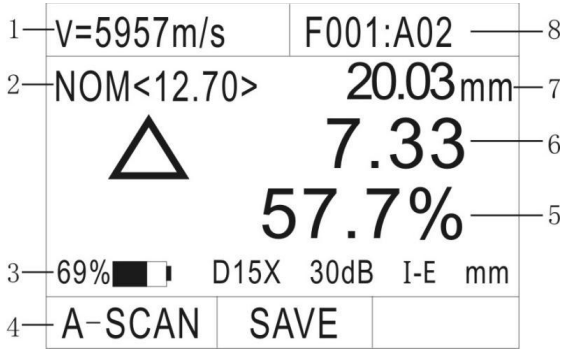
THICKNESS VALUE MODE: the acquiescent opening interface. This interface mainly shows the present thickness value with large digits.



3.5 Normal Mode Interface

1—the present thickness value 2—probe types, gain degree, Pulse Echo measuring mode, measuring units 3—material velocity 4—battery power display 5—A-scan interface

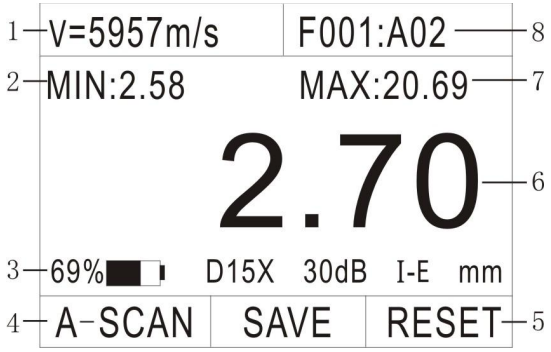
DIFFERENCE/RATE-OF-REDUCTION MODE: this interface displays the currently measured and a nominal thickness input by user, the difference between the currently measured thickness and the nominal thickness and the ratio between the difference and the nominal thickness. Before using this mode, presetting the nominal thickness is needed.



3.6 Difference Mode Interface

1—material velocity 2—the nominal value 3—respectively are battery power, probe type, degree of gain, Pulse Echo measuring mode and measuring unit 4—A—scan interface 5—the ratio between the difference and the nominal value 6—the difference between the nominal value and the currently measured 7—the currently measured thickness value 8—file number

MAX. /MIN. MEASUREMENT MODE: This mode allows the user to catch the real-time maximum and minimum thicknesses when test the thickness of material continuously. It shows the minimum and maximum values during the tests as well as the currently thickness. Press the RESET relevant ▲ to get the limits when measuring the thickness.

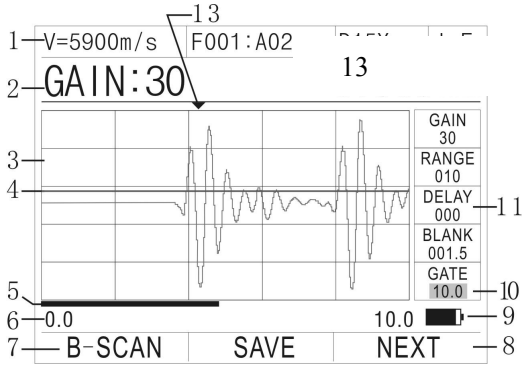


3.7 Limits Value Mode Interface

1—material velocity 2—the minimum value 3—respectively are battery power, probe type, degree of gain, Pulse Echo measuring mode and measuring unit 4—A-scan interface 5—reset 6—the current thickness value battery power 7—the maximum value 8—file number

3.4 A-Scan Interface Mode

In this mode, users could view the current thickness value and the A-scan waveform at the same time. The right side of the interface is the specification adjusting area, in which the specifications can be adjusted and finally solve various difficult and complicated thickness measuring applications to the capacity. The detailed introduction is shown in chapter.



3.8 A-Scan Mode Interface

1—material velocity 2—gain 3—waveform display area 4--gate 5--the blank confines 6--the beginning coordinate on the scr een 7—B-Scan mode 8—specification choosing 9--battery power 10—the selected specification 11--the specification adjusting area 12--the present thickness value 13--measuring point (the first point of intersection between the wavefor m and the gate)

Attention: when the probe and the object are not complete coupled, the letters in the various interfaces are in GREEN, while if they coupled well, in WHITE color and when the either the upper or lower limited are exceed, the letters are displayed in RED color.

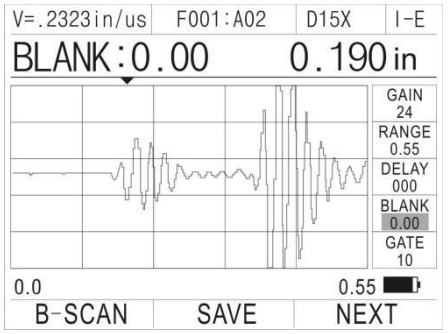
In the A-scan interface, press the bottom right button NEXT ▲ to highlight the value to be adjusted. Then press the direction keys to adjust the values. Up and down keys are used for small increments, while left and right for large increments.

GAIN—adjust the sensitivity of the gauge with unit db. This function is very useful for the testing of attenuation materials (like metal cast).

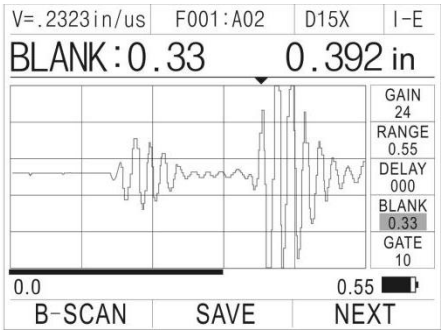
RANGE—adjust the range of waveform that the screen displays. The waveform can be compressed or spread visually and it’s invisible if the display range is set incorrectly and the echo waveform is beyond the display area, however, the testing value can also be read correctly.

DELAY—Shown at the beginning point of the screen. The waveform will move horizontally adjusting this value, and it’s invisible if the delay is set incorrectly and the echo waveform is beyond the display area, however, the testing value can also be read correctly.

BLANK—Hide the unnecessary and useless clutter in front of the main waves. The red line on the bottom of the screen shows the blank confines. The adjusting blank confines are the present range confines. In the real testing, wrong measurement due to the material may exist, such as near surface serious corrosion, AL material, inside defects, uneven component, lamination structure and so on. While adjusting the gain or gate can solve part of the problem, but only blank function can avoid the mistake when those clutter echoes are higher than the bottom echoes.

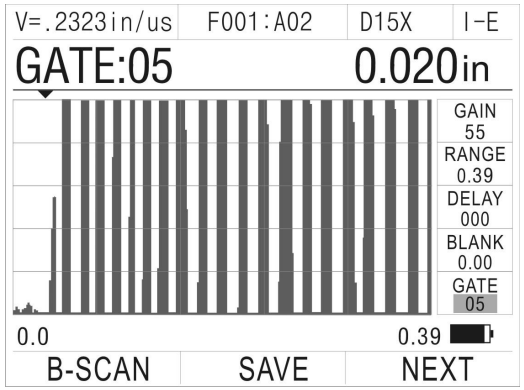


3.9 The Waveform without Blanking



3.10 Omit the Front Noise Waves by Blanking

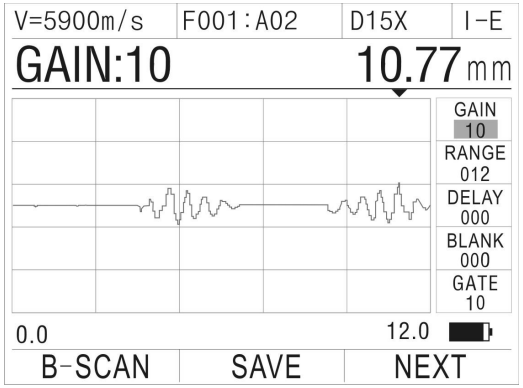
GATE—adjust the height of the gate. Only when the waveform is higher than the gate, the gate can take the echo and show the value. Attention: this will only show when the GATE specification is highlighted. The first intersection point between the waveform and gate is pointed by a red arrow, which can help judging whether the thickness value is correct (the red arrow should point the front of the first bottom echo if correctly tested).



3.11 Waveform of the thin plate

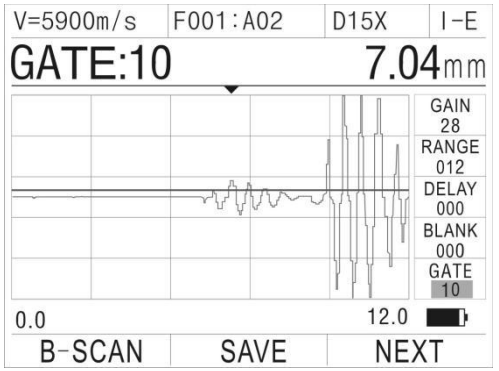
3.5 Real Class Analysis of A-SCAN

1. When measuring the thickness, it’ s possible that that over small gains prevent the precise results. As showed in the following figure, the thickness of the testing object is about 5mm, but as for the over small gain, the measuring result is 10.77mm as the first echo has not broken the gate and the gate locates the second echo automatically. This is obviously an incorrect result, and customer can pull up the echo by enhancing the gain setting to make the first echo brake the gate and finally pinpoint the correct measurement.



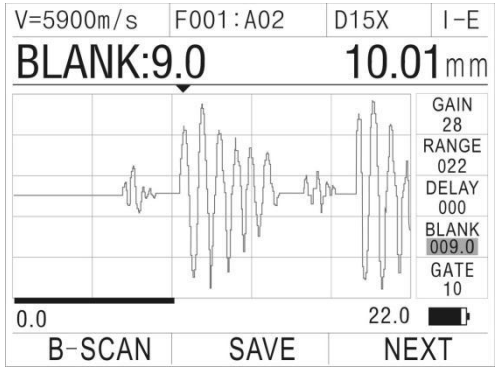
3.12 Real Case 1

2. There are some defects in the testing object, and the gate locks the defect echoes. As showed in the following figure, the thickness of the testing object is about 10mm, but as there are obvious defects (the defect echoes are showed on the display) and the gate locks the defect echoes which have broken the gate, thus, the testing result shown is the thickness of the defect area. The right measurement can be realized by adjusting the gate setting above the defect echoes.



3.13 Real Case 2

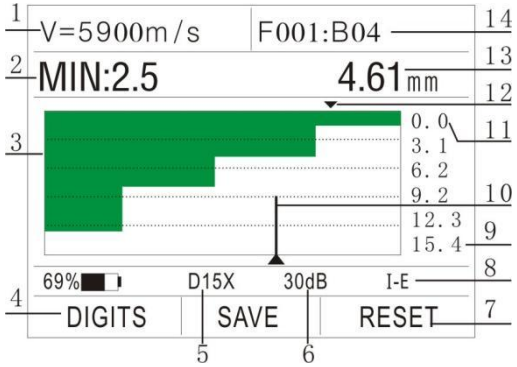
3. If there are some surface faults in the testing object and the gate locks the defect echoes, the measuring result will be the thickness of the defect area. In this condition, the customer can use the BLANK function to get the correct testing result. As showed in the following figure, the line on the bottom of the screen, which we use to shield the defect echoes, indicates the blank confines and makes the gate not catch the echoes within the blank confines, thus, the right thickness value is acquired.



3.14 Real Case 3

3.6 Operation of B-Scan Interface

3.6.1 B-Scan Display



3.15 B-Scan Interface Diagram

1—Sound velocity 2—The minimum thickness range in B-scan 3—B-scan image display 4—Enter the numerical measurement interface 5—type of probes 6—gain value 7—Erasing the current B-scan images and measurements 8—Interface wave-echo mode 9—The maximum thickness value in B-scan 10—White pointer 11—The minimum thickness value on the B-Scan image 12—Red triangle (display the min. thickness value) 13—The thickness value of the pointer position 14—Saved file number

3.6.2 Introduction of B-Scan

PM-5 series thickness gauge has time-base B-scan function. Move the probe along the work piece surface, then the cross-sectional profile of the work piece display, use for observe the underside contour of the work piece.

When remove the probe from work piece, it could be automatically capture a minimum value of the B-scan image, and indicate the position of the minimum by a red triangle. You can see any point thickness value of the B-scan image by moving the pointer.

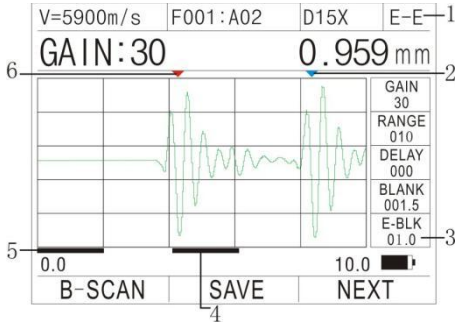
3.7 Dual-Echo (Thru-Thin Coating) Mode

For the thin protect coating and paint, the thickness measurement of the underlying metal will lead significant error when using conventional thickness gauge. PM-5DL can accurate measure the actual thickness of the underlying metal with dual-echo measurement principle and without having to remove the coatings or destroy the surface process. This function is achieved by measuring the two consecutive bottom echo of base material.

Press MODE into parameter configuration interface, set the measurement mode to dual-echo and press MODE again back to thickness measurement interface. And then user can measure the thickness through coating.

3.7.1 A-scan Interface In Dual-Echo Mode

The menu options on the right side have changed of A-scan interface under echo-echo mode, added E-blanking option, and canceled GATE option. The blue strips area indicate the length of echo-blanking when measuring, the waveform above the blue strips is invalid. See following figure：



3.16 A-scan Interface in Dual-Echo Mode

1—Identification of dual-echo measurement mode 2—Blue arrow indicate the secondary echo 3—E-blanking 4—Blue line: the length of echo-blanking 5—Red line: the length of initial-blanking 6—Red arrow indicate the first echo

Blanking in the dual-echo mode:

1. Initial-blanking: red blanking line indicated on the screen, starting at zero, so named initial blanking. Waveform with the scope of red strip is invalid, for omitted the clutter between the starting point and the first echo.

2. E-blanking (echo-blanking): blue blanking line indicated on the screen, only appearance when successful measuring. Starting at the first echo measurement point, so named echo-blanking. Waveform within the scope of blue stripe is invalid, for omitted the clutter between the first echo and secondary echo.

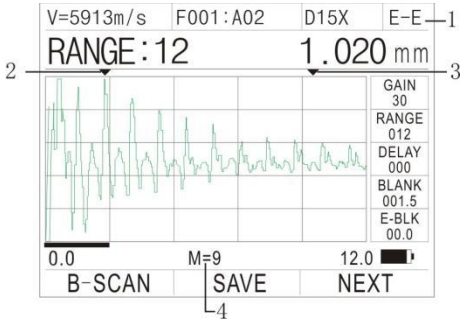
3.8 Interface wave-Echo Mode

Interface wave mode makes use of interface wave and echo to measure the thickness of the work piece. This method has wide-range of measuring, the upper limit can reach to 27mm.

3.9 Multiple-wave check method(High Precision Mode)

PM-5 series provides Multiple-wave check method, the measurement range is 0.2mm-10mm. According to 3(Min. times) to 9Max.times) times echos every time when measuring, the more measuring times, the higher precision will get. Furthermore the reading values are all through checkout, to make sure the results are accurate.We recommend to use this mode when measuring super thin and high precision work piece.

3.9.1 Illustration of Multiple-wave check mode



3.17 Multiple-Wave Check Mode

1—Identification of multiple-wave mode 2—red arrow indicates the first echo that participates in verifying 3—blue arrow indicates the last echo that participates in verifying 4—M indicates the numbers the participates in verifying

This picture shows A-scan snapshot wave of measuring the wall thickness of fire extinguisher under Multiple-wave check mode. The wall of the fire extinguisher is very thin and has paint coating as well, which make it difficult to measure by using the normal thickness gauge. Through using Multiple-wave check mode of PM-5DL, we can see from the picture that there are 9 verifying waves to make sure the measuring result accurate and stable.

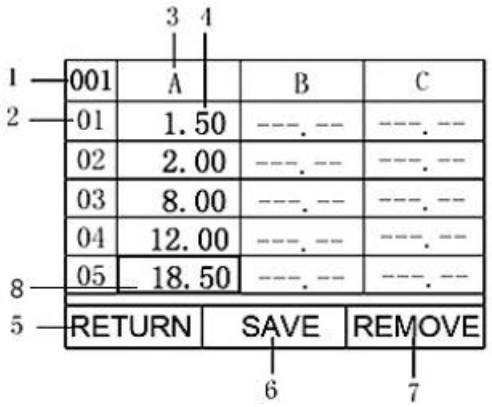
3.10 AUTO Mode

The unique Auto mode of PM-5 series measurement range is from 0.2mm-27mm. On the basis of thickness, it selects the measuring model automatically. When H≤10mm, it adopts ME-E measuring mode; when 0.2mm<H<=15mm, it adopts I-E measuring mode; and when H>2mm, it adopts P-E mode. Under this mode, the user only needs to adjust the Gain. It is easy to operate, we recommend the common users to adopt this mode. H is the thickness of the material to be measured

4.Date Storage Function（ PM-5DL）

PM-5DL adopt the storage mode of micro-grid format, it can save one hundred thousand thickness values and one thousand A/B-scan wave-forms, waveform and thickness values can be mixed stored in the same file. The measurement data files can be transferred from the instrument to a PC via USB communication to generate EXCEL or TXT format files. Using our powerful Data View software to statistical and analyze measurement, report via connect printer.

4.1 Thickness Value and Waveform Storage



4.1 Grid Format Storage Mode

1—storage file number 2—line mark 3—row mark 4—data in stored 5—back to the previous menu 6—save the current thickness value or waveform 7—delete the selected data 8 - selected current cell

Whether it is in the interface of thickness value, A-scan or B-scan, the current measured thickness values will be stored for short press SAVE, and the current waveform will be stored for long press SAVE. A-scan waveform will be stored in the A-scan interface, and B-scan image will be stored in the B-scan interface.

4.2 Browsing the Storage Data

Press MODE to access the configuration display and select FILE NUMBER, then press ▲ below OPEN, the file list with thickness value will appear on the screen. Press ↑ or ↓ to select the stored file you want to recall, then press CAL ON to confirm.

5.Measurement Apply Skills

5.1 Measuring Error Prevention

1. MATERIAL INFLUENCE

In many materials like nonmetal or plastic, the change of velocity is obvious, thus, the accuracy of measuring is influenced. If the material of the object is not isotropic, the velocity varies in different directions. In this condition, the preset velocity should be the average value among the testing range, which can be acquired through testing a block with the same velocity as the object average velocity value.

2. ULTRA-THIN MATERIAL

When the thickness of the testing object is below the minimum value of the probe limit, the result may be incorrect, and the thickness can be acquired by contracting the blocks when necessary.

When testing ultra-thin materials, sometimes DUAL-ECHO happens, which is a kind of incorrect result and the result is twice of the real one. Another incorrect result called PULSE ENVELOPE AND CIRCULATORY JUMPING, which means that the testing result is higher than the real one. In order to prevent this kind of error, when testing the object with the appropriate thickness as the minimum limit and judgment is available, customer should pay attention to the waveform displayed and adjust the gain or use blank function.

3.Surface Cleaning Influence

Before measuring, all the dust, dirt and corrosion should be cleaned and the cover like paint should be removed.

4. Roughness Influence

The extremely rough surface may arouse measuring error or even reading lost, therefore, the surface of the material should be smooth before measuring through polishing, filing, grinding or using high-viscosity couplant.

5.2 Measuring Methods

1. Single-point Measurement

Using the probe to measure a random point on the surface of the object, the reading displayed is the thickness value.

2. Multiple-point Measurement

When the reading is unstable, measuring several times within a circle with a certain point as center and 30mm as diameter, the thinnest reading is the thickness value.

3. CONTINUOUS MEASUREMENT

Taking continuous measurements along a specified path at intervals of 5mm or less according to the single measurement method, the thinnest reading is the thickness value.

6. Care and Maintenance

6.1 Power Source Inspection

When the instrument can not start up, it should be changed the battery firstly.

The steps of changing batteries are as follow: 0

1.Turn off the gauge.

2. Loosen the screws on the back of the units and remove the battery cover.

3. Take out the batteries and replaces with new ones. Pay careful attention to polarity.

Attention: When not using the gauge for extended periods of time, please remove batteries to prevent any leakage or corrosion.

6.2 Considerations

1. Please be cautious of the zero block’s getting rust as couplant will be spread on the surface of it when calibrating the gauge. After using, clean the zero block. Avoid dripping sweat on the gauge in high temperature. Some grease spreading on the surface of zero block is useful to avoid rusting if the gauge will be spared for long. Wipe the grease out when reusing.

2. Be sure to avoid any caustic liquid such as alcohol or viscous fluids to prevent corrosion to the cover and the display window, clean with water only.

3. Avoid scratching the surface of the probe. A worn probe will cause unstable readings.

6.3 Maintenance

Contact with the maintaining department of our company if the following problems appears:

1. Components damage and the gauge fail to measure.
2. The display of the screen is disordered.
3. The measuring error is abnormally big in normal situation.
4. Keyboard operating is disordered or keyboard doesn’t work.

As the PM-5 series ultrasonic thickness gauge is high-tech product, the maintaining work should be made by professional operator and please avoid self-acting operations.

Sound Velocity Measurement Chart

Material	Sound Velocity	
	Inch/μS	M/s
Aluminum	0.250	6300
Alumina Oxide	0.390	9900
Beryllium	0.510	12900
Boron Carbide	0.430	11000
Brass	0.170	4300
Cadmium	0.110	2800
Copper	0.180	4700
Glass(crown)	0.210	5300
Glycerin	0.075	1900
Gold	0.130	3200
Inconel	0.220	5700
Iron	0.230	5900
Iron (cast)	0.180	4600
Lead	0.085	2200
Magnesium	0.230	5800
Mercury	0.057	1400
Molybdenum	0.250	6300
Monel	0.210	5400
Neoprene	0.063	1600
Nickel	0.220	5600
Nylon, 6.6	0.100	2600
Oil (SAE 30)	0.067	1700
Platinum	0.130	3300
Plexiglass	0.110	1700
Polyethylene	0.070	1900
Polystyrene	0.0930	2400
Polyurethane	0.0700	1900
Quartz	0.230	5800
Rubber, Butyl	0.070	1800
Silver	0.140	3600
Steel, Mild	0.233	5900
Steel, Stainless	0.230	5800
Teflon	0.060	1400
Tin	0.130	3300
Titanium	0.240	6100
Tungsten	0.200	5200
Uranium	0.130	3400
Zinc	0.170	4200