Robust Thickness Gauge

User Manual

ROBUST Consulting Engineers Pty Ltd
Civil & Structural, ABN 14 626 910 750

Disclaimer: Robust Consulting Engineers does not take any responsibility for any damages or consequences resulting from the use of the data obtained from this device. Results obtained using this device should only be used as an indication of the thickness of materials and not taken as a guarantee of the real-world scenario.

Contents

Note: Please visit www.robustengineers.com.au for a video of operation along with this manual.

1 Introduction

The Robust Thickness Gauge is capable of measuring the thickness of any materials from which an ultrasonic wave can be transmitted and reflected.

The gauge provides a quick and accurate measurement of various elements. Another important application of the gauge is to monitor various pipes, pressure vessels and wall thicknesses. It can be widely used in petroleum, chemical, metallurgy, shipping, aerospace, aviation, and other fields

1.1 Technical Specifications

- *Display:* 128 x 64 LCD with LED backlight
- *Measuring Range:* (0.75 ~ 600) mm (Steel)
- Velocity Range: (1000 ~ 9999) m/s
- Resolution: 0.01mm
- *Measuring accuracy:* ± (0.5%Thickness + 0.04mm)
- *Units:* Metric
- *Storage:* 40 values of saved data
- *Power Source:* 2pcs 1.5V AA alkaline batteries
- *Working Time:* More than 50 hours (LED backlight off).
- *Outline Dimensions:* 150mm x 74mm x 32 mm
- Weight: 238g

1.2 Main Functions and Features

- Performing measurements on a wide range of materials including metals, plastic, ceramics, composites, epoxies, glass, and other materials conductive to ultrasonic waves.
- Sound velocity calibration function
- Coupling status indicator
- Battery level indicator
- Auto sleep and auto power off function
- EL backlight
- Works with a variety of different frequencies and wafer sizes of transducer probes (Table 1.2 below)
- Portable, high reliability
- Resistant to vibration, shock, and electromagnetic interference

1.3 Measuring Principle

The thickness gauge determines the thickness of a part or structure by accurately measuring the time required for a short ultrasonic pulse generated by a transducer (probe) to travel through the thickness of the material, reflect from the back or inside surface, and be returned to the transducer. The measured two-way transit time is divided by two to account for the back-and-forth travel path and then multiplied by the velocity of sound in the material.

The result is expressed by the relationship:

$$H = \frac{v \times t}{2}$$

Where: H - Thickness of the test piece
v - Sound Velocity in the material
t - The measured round trip transit time

Table 1.2 Types of Probes

Name	Model	Frequency (Hz)	Diameter	Testing Range	Min. area Φ	Application
Large diameter Probe	N02	2.5	20mm	3.0mm ~ 400.0mm (Steel) Below 40mm (Gray Iron HT200)	20mm	Casting work piece
Large range Probe	N02	2	14mm	3.0mm ~ 600.0mm (Steel) Below 100mm (Gray Iron HT200)	20mm	Casting work piece
Standard Probe	N05/90°	5	10mm	1.0mm ~ 230.0mm (Steel)	Φ 20mm*3.0mm	General bent probe
Micro-diameter Probe	N07	7	6mm	0.75mm ~ 80.0mm (Steel)	Φ 15mm*2.0mm	Thin work piece
High Temperature Probe	HT5	5	14mm	3 ~ 200mm (Steel)	30mm	High temperature 500℃

1.4 Instrument Configuration

Table 1.1 Instrument Configuration

	No.	Name	QTY
Standard Configuration (Included)	1	Main Body	1 set
	2	Micro-diameter probe（7MHz）	1 pc
	3	Couplant	1 pc
	4	Manual	1 pc
	5	Product Certificate	1 pc
	6	Warranty Card	1 pc
	7	ABS Case	1 pc
Optional Accessories	8	Large diameter probe（2.5MHz）	
	9	Large range probe（2MHz）	
	10	Standard Probe（5MHz,D10mm）	
	11	High temperature probe（5MHz）	
	12	High temperature couplant	

2 Structure and Appearance

1 Shell

2. Keyboard

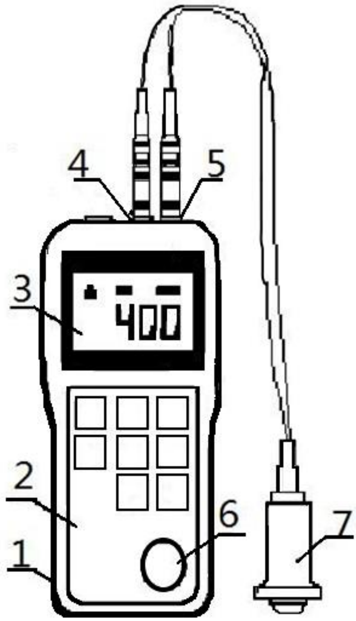
3. LED Display

4. Transmit Port

5. Receive Port

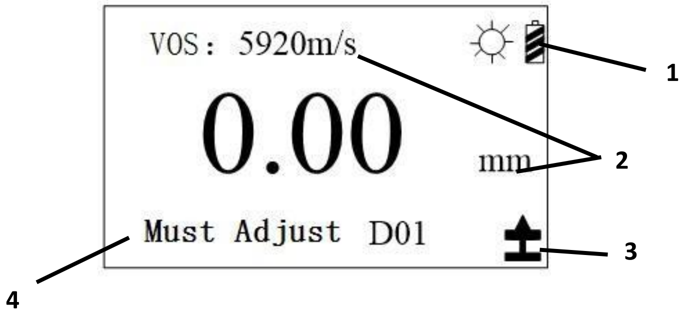
6. Calibration Block

7. Probe



2.1 Display Symbols

Power on the instrument enters the display interface automatically, as shown in the figure below:



1. Battery Indicator
2. Coupling status of probe and workpiece
3. Measurement (metric)
    - Thickness – mm
    - Sound Velocity – m/s
4. Information indicator – operation hint

2.2 Keyboard

ON / OFF	Power on/off	Menu	Menu
↑ Speed	Number Increment Key Up Key Velocity Choice Key	Back	Cancel Key Velocity and thickness mode switch key
↓	Number decrement Key Down Key Date save key	CAL	Calibration Key Enter Key
→	Select Key	←	Select Key

3 Preparation for Measurement

3.1 Preparing the instrument

- Check the instrument and accessories according to the packing list
- Ensure all supplies listed are available and in good condition

If there are any problems, contact admin@robustengineers.com.au.

3.2 Choosing Probe

Different probes will be required based on the range of measurement.

- Choose the probe according to the workpiece's thickness and shape (Refer to *Table 1.2* in **Section 1.4** above).
- When using the probe, use moderate pressure to press against the probe with your thumb or index finger to hold it in place.

3.3 Prepare the surface of the workpiece

The surface of the object being measured should be relatively smooth, clean, and free of rust, dust and other small particles. If the surface is very rough or rusty, this should be fixed by:

- Using an appropriate couplant on the workpiece
- Using a de-ruster, brush, or sandpaper to smoothen the surface
- Measuring several times at the same point

4 Instrument Operation

4.1 Operating Conditions

Working Temperature:	-20°C~+50°C
Storage Temperature:	-30°C~+70°C
Working Humidity:	≤90%

Surroundings should have no strong vibration, magnetic fields, corrosive mediums, or severe dust.

4.2 Power On/Off

1. Insert the probe plug into the ports or probe socket on the main unit.
2. Press key to turn on the instrument. The LCD display will show the measurement interface and sound velocity. (*Note: The instrument will show the last tested data*).
3. Press key to turn off.

4.3 Zero Calibration

Calibration is very important to the accuracy of the measurement. When changing the probe, velocity, battery or when there is ambient temperature change, or measurement errors, the probe should be calibrated.

To calibrate with a standard block:

1. Turn on the instrument and ensure you are on the correct mode.
2. Plug the probe into the instrument and ensure that the surface of the probe and standard block is clean and free of dust and debris.
3. Make sure the type of probe is set to the one you are using.
4. Apply a drop of the couplant to the standard block.

5. Press the transducer against the block and make sure the probe sits flat against the surface of the block. The coupling status will indicate if coupling is successful and the display will show a thickness value.

6. When the display shows the calibration value (4.00±0.01mm, VOS:5920m/s), the calibration is finished.

Calibrate several times as needed.

Note:

(1) Before calibration, confirm that you have exited the velocity revise mode. Under this mode, the device cannot calibrate the instrument.

(2) The device should be calibrated on the standard block of the instrument, not on other types of blocks, as this can cause a measurement error.

4.4 Setting Sound Velocity

If there is a known velocity, you can adjust the velocity according to the instrument offered (*Refer to Appendix A to adjust the velocity)*. To adjust the velocity:

Method 1:

1. In thickness mode, press or key to adjust velocity.
2. Press or key to adjust the velocity.
3. After revising the value, exit the velocity revise mode.

Method 2:

1. In thickness mode, press and choose the common velocity.

4.5 Calculating Sound Velocity

When the velocity is unknown, you can use the velocity measurement function to calculate the velocity.

Note: when you use this function, the thickness must be given.

1. Do zero calibration first to make sure the device is calibrated.
2. In thickness mode, press  and enter the velocity measurement mode.
3. In thickness mode, press  or  and enter to adjust the process.
4. Press  or  to revise the thickness value.
5. Press   to confirm the velocity and go back to thickness mode automatically.

4.6 Storage Function

Storage of the measured values

This instrument can save up to 40 thickness values. After measurement, the values can be directly saved to the current file by pressing the  key.

If you want to check the data:

1. In thickness mode, press  to enter the menu.
2. Press  and choose ‘ReadData’.
3. Press  to check the data saved previously.
4. Press  or  to check the last 40 thickness values.

The instrument will hold the last measurement made until a new one is measured.

4.7 Backlight Function

- The instrument display has an EL backlight function for reading values in dim or dark areas.

- Power will be used by opening the EL backlight, only use it when necessary.

To enable the EL backlight:

1. In thickness mode, press Menu to enter the menu and set up the EL backlight.

4.8 Battery Indicator

- The instrument uses x2 AA alkaline batteries.
- When the power is almost used up, the indicator will flicker.
- Ensure you change the batteries in time.

4.9 Auto Power Off

The instrument has an auto power off function to save battery power.

- Set up the function under “MENU” by selecting the amount of time before the instrument automatically powers off.

Note: 0 mins means turn off this function.

Note: When the battery is low, the instrument also will power off automatically.

5 Measurement

5.1 Measurement of Thickness

1. Put the couplant on the workpiece uniformly. Make sure the probe is in tight contact with the workpiece.
2. When the probe contacts the workpiece well, the display will show the couplant indicator. If the symbol flickers or there is no couplanting symbol, this indicates that the couplanting has not been successful. The display will also show a thickness value.
3. Once you get a stable value, you can remove the probe. If the displayed thickness value changes from the value given when coupled, repeat until you get a stable thickness measurement.

5.2 Method of Measurement

- **Single measurement**: Measure at one point
- **Double measurement**: Measure with the probe at one point twice. During the two measurements, the probe's crosstalk interlayer plate should be placed in a perpendicular direction. Take the minimum readout as the accurate thickness of the material.
- **Multi-point measurement**: Make several measurements in a range and take the minimum readout as the thickness of the material.
- **Continuous measurement**: Measure at one point and make several measurements in a range (not less than 5mm) and take the minimum readout as the thickness of the material.

Note: Single and double measurements must be performed on materials with paint or coating removed.

5.3 Pipe Wall Measurement

1. Couple the probe with the material to be measured, ensuring that the probe's crosstalk interlayer plate is perpendicular or parallel to the axial line of the object.
2. Move the probe vertically along the axial line of the object. The readouts displayed on the screen will change regularly.
3. Select the minimum readout from the ones displayed.

6 Maintenance and Optimal Operation

6.1 Check Power

Replace the batteries when the battery indication shows low battery. To do this:

1. Turn off the instrument
2. Open the battery chamber
3. Take out the batteries, put in new ones. Please note the polarity as reversed polarity may result in instrument damage.

If the instrument will not be used for a long time, take out the batteries to avoid leakage and corrosion in the battery chamber and pole piece.

6.2 Maintenance of Probe

- When the probe is coupled with the material to be measured, the instrument will display the coupling indicator
    - If the indicator flashes or doesn't appear, it means that the coupling is not successful.
- If the workpiece surface has a large coupling agent, when the probe leaves the workpiece, it can cause errors, so at the end of the measurement, remove the probe rapidly.
- The surface of the probe is allyl resin, which is very sensitive to heavy scratches from coarse surfaces.
    - During operation, press the probe onto the surface lightly, firm and flat.
    - When measuring coarse surfaces, try to minimize scratches on the working surface of the probe.

- After a long time of usage, the roughness of the surface of the probe will increase, and sensitivity will drop.
    - If you are sure that this is the reason for error in measurements, you can grind the surface with sandpaper or oilstone to make it smooth and more parallel to the surface being measured.
        - If it is still not stable, the probe must be replaced.
- Probes should be inspected on a regular basis to ensure that there are no signs of uneven wear on the surface.
- When measuring in normal temperatures, the temperature of the surface to be measured should not be more than 60 degrees Celsius, otherwise the probe can't be used.
- Probes and workpiece surface should be wiped off after each use to avoid damage from the coupling agent.

6.3 Cleaning Standard Test Block

It is important to prevent rusting of the test pieces.

- After the measurement, the test pieces should be cleaned.
- When the weather is hot, avoid getting sweat on the pieces.
- If the pieces are not to be used for a long time, please coat them with oil to prevent rust. Then, when you want to use them again, first clean them, and then use them normally.

6.4 Cleaning Instrument Case

Alcohol and diluents will corrode the case, especially the LCD of the instrument. Therefore, when you clean the instrument, just use clean water to clean it

6.5 Maintenance of the Instrument

If there is an error of measurement or it is too large, refer to relevant chapter in this manual.

Otherwise, please contact Robust if:

- A component of the instrument is damaged and it is impossible to measure
- The LCD is abnormal

- During normal operation, the error is too large
- The keyboard doesn’t function or is in disorder

Maintenance of the device should be conducted by someone who is professionally trained, do not disassemble and try to repair it yourself.

- Avoid instrument and probe shock
- Avoid putting the instrument in environments that are too humid
- When plugging the probe, hold the cord along the axis and do not rotate the probe, so that you do not damage the cable core.
- Oil and dirt will age and break the probe line, so remove dirt on the cable after operation.

7 Storage and Transportation

The device should be stored away from strong vibration, magnetic fields, and corrosive mediums. It should be stored at a normal temperature and away from moisture and dust.

8 Appendix A – Sound Velocity

Material	Velocity	
	in/µs	m/s
Aluminum	0.250	6340-6400
Steel, common	0.233	5920
Steel, stainless	0.226	5740
Brass	0.173	4399
Copper	0.186	4720
Iron	0.233	5930
Cast Iron	0.173-0.229	4400-5820
Lead	0.094	2400
Nylon	0.105	2680
Silver	0.142	3607
Gold	0.128	3251
Zinc	0.164	4170
Titanium	0.236	5990
Tin	0.117	2960
-	0.109	2760
Epoxy resin	0.100	2540
Ice	0.157	3988
Nickel	0.222	5639
Plexiglass	0.106	2692
Porcelain	0.230	5842
PVC	0.094	2388
Quartz glass	0.222	5639
Rubber, vulcanized	0.091	2311
Water	0.058	1473

9 Appendix B: Common Problems and Treatment Methods

9.1 Influence of Material Surface

9.1.1 Unclean Surfaces

Before measuring, clean any dust, dirt, and rust on the object, and remove any coating or damage such as paint, etc.

9.1.2 Roughness

A surface that is too rough will cause errors in measurement. Before measuring, smooth the surface of object by grinding, polishing, or filing, etc. or using a coupling agent with high viscosity.

9.1.3 Rough Machined Surfaces

The regular fine slots on a rough machined (by such machines as lathe or planer) surface will also cause errors in measurement.

Refer to **section 9.1.2** above to make the surface smoother.

Otherwise, to get better results:

1. Adjust the angle between the probe's crosstalk interlayer plate (the metallic layer passing through the center of probe bottom) and the fine slots of the object so that the interlayer plate is perpendicular or parallel to the fine slots.
2. Take the minimum value of the readouts as the measured thickness.

9.2 Cylindrical Materials

When measuring cylindrical materials, such as pipes, oil tubes, etc., it is very important to properly select the included angle between the probe's crosstalk interlayer plate and the axial line of the material to be measured.

To measure cylindrical materials:

1. Couple the probe with the material to be measured, ensuring the probe's crosstalk interlayer plate is perpendicular or parallel to the axial line of the object.
2. Then move the probe vertically along the axial line of the object. The readouts displayed on the screen will change regularly.
3. Select the minimum readout as the accurate thickness of the object.

The standard for selecting the included angle between the probe's crosstalk interlayer plate and the axial line of the object depends on the curvature.

- For a pipe with a large diameter, the probe's crosstalk interlayer plate should be perpendicular to the axial line of the object.
- For a pipe with a small diameter, measure with the probe's crosstalk interlayer plate being both parallel and perpendicular to the axial line of the object and take the minimum readout as the thickness.

9.3 Compound Profile

When the material to be measured has a compound profile (such as the bend of a pipe), use the method described in **section 9.2**.

- However, you should do two measurements and get two results when the probe's crosstalk interlayer plate is both **parallel** and **perpendicular** to the axial line of the object. From these, take the minimum readout as the thickness.

9.4 Unparallel Surface

To get a satisfactory ultrasonic response, the other surface of the object must be parallel to or co-axial with the surface to be measured, otherwise it will cause measuring errors or even no display.

9.5 Material Temperature

Both the thickness and transmitting speed of an ultrasonic wave are influenced by temperature. If there is a requirement for high measurement accuracy, you can use the comparison method by using test pieces.

1. Use a test piece with the same material to and measure under the same temperature to get a temperature compensation coefficient.
2. Use this coefficient to correct the actual measurement of the object.

9.6 Materials with Large Attenuation

Some materials such as fibre have porous and coarse particles, will cause large scattering and energy attenuation in ultrasonic waves, which will cause abnormal readouts or even no readout to be displayed (generally, the abnormal readout is less than actual thickness).

- **In this situation, this kind of material should not be measured with this instrument.**

9.7 Influence of Material Types in Different Conditions

When making accurate measurements for different materials under different conditions, the closer the standard test piece is to the material being measured, the more accurate the measurement will be.

The ideal reference test pieces should be a group of test pieces with different thicknesses made of materials to be measured. The test pieces can provide calibrating factors for the instrument (such as the microstructure of the material, heat-treating condition, direction of particles, surface roughness, etc.). To get the highest measuring accuracy, a set of reference test pieces will be critical.

In most situations, you can get satisfactory measuring accuracy with only one reference test piece, which should have same material and similar thickness as the object.

- Take an even object, measure it by using a micron micrometre, then it can be used as a test piece.

For thin materials and objects:

- When its thickness is near the low limit of the probe's measuring range, use a test piece to determine an accurate low limit.
- Never measure a material with a thickness lower than the low limit.
- If the thickness range can be estimated, the thickness for the test piece should select the high limit.

For thick objects, especially for alloys with complex internal structures, select a test piece similar to the object from a group of test pieces, thus to have idea of calibration.

For most casting and forging objects, the test piece should have an internal structure with same direction as that of the object, and the transmitting direction of sound wave in it should also be same as that for the object.

Using the sound velocity table instead of test pieces:

In certain circumstances, you can look up the sound velocity table for given materials as a replacement for reference test pieces.

- However, this will be an approximate substitution to test pieces.
- Under some situations, the value in the sound velocity table will have some difference from the actual measured values, due to differences in the material's physical and chemical characteristics.
- This method is usually used for measuring low-carbon steel, and can only be taken as a rough measurement.

9.8 Measuring Casting

The Robust thickness gauge has a specialty for measuring casting. The crystal particles for castings are coarse, and the structures are not dense enough, which makes it difficult to measure their thickness as it causes large attenuation in sound energy.

If there is a coarse crystal particle and if a coarse out-phase structure exists, it will cause abnormal reflection and create different sound velocities in different directions, which will cause measuring errors. As such, it is important to measure castings carefully.

When measuring castings, pay attention to the following points:

- When measuring casting with unmachined surfaces, use engine oil, consistent grease as coupling agents.
- Calibrate the sound velocity for the object with a standard test piece that has the same material and measuring direction as that for the object to be measured.
- If necessary, take 2-point calibration.

9.9 Preventing Errors in Measurement

9.9.1 Ultra-thin Material

For any ultrasonic thickness-gauge, when the thickness of the object is less than the low limit of the probe, it will cause a measurement error. When necessary, measure the minimum limit thickness by comparing with the test pieces.

When measuring ultra-thin objects, sometimes an error called “double refraction” may occur.

- Its result is that the displayed readout is twice the actual thickness. Another error result is called “pulse envelop, cyclic leap” - its result is that the measured value is larger than the actual thickness.

To prevent these kinds of errors, ensure you repeat the measurement to check the results.

9.9.2 Rust, Corrosion and Pit

Rust and pit on the surface of the object will cause irregular changes in readouts or no readouts.

- If there is rust or pit on the surface or you are unsure, you should measure the area carefully.
- In such situations, orient the probe’s crosstalk interlayer plate in different directions to get multiple measurements.

9.9.3 Errors in Identifying Material

When calibrating the instrument with one material, and then using it to measure another material, an error will occur. As such, be careful in selecting the correct sound velocity.

9.9.4 Overlapped Material and Compound Material

You cannot use the instrument to measure overlapped or compound materials as the ultrasonic wave cannot pass an uncoupled space.

9.9.5 Influence of Oxidation Layer at Metal's Surface

Some metals can produce a dense oxidation layer on its surface, such as aluminium. Because of this, the ultrasonic wave has different transmitting speeds across these two materials, which will cause errors. Additionally, different thickness in oxidation layers will also cause errors. To resolve this issue, you can make a reference piece from a batch of objects by measuring with micron micrometre or calliper and using it to calibrate the instrument.

9.9.6 Abnormal Thickness Readout

Generally, rust, corrosion, pit and internal defects of the object will cause abnormal readouts. For the solution for this, refer to section 9.1.1 in this manual.

9.9.7 Utilization and Selection of Coupling Agent

The coupling agent is for transmitting high-frequency energy between the probe and the object.

- If the type of agent is wrong, or the utilization is wrong, it will cause errors or a flashing coupling indicator, and it will be impossible to measure.
- A proper amount of coupling agent should be used and should be coated evenly over the surface being measured.
- If the coupling status does not appear, or the thickness values are uneven, ensure you have enough couplant under the probe and that the probe is flat against the material.

It is very important to select a proper coupling agent.

For smooth surfaces:

- Use an agent with **low viscosity** (such as the coupling agent, light engine oil, etc)

For coarse surfaces, vertical surfaces, and top surfaces:

- Use an agent with high viscosity (such as glycerine grease, consistent grease, lubricating grease, etc)