Material	Sound Velocity	
	in/μs	m/s
Porcelain	0.230	5842
PVC	0.094	2388
Quartz glass	0.222	5639
Rubber, vulcanized	0.091	2311
Teflon	0.056	1422
Water	0.058	1473

Mul-ti Mode Ultrasonic Thickness Gauge

TM-8819-T6

This Ultarsonic Thickness Meter is small in size, light in weight, easy to carry. Although complex and advanced, it is convenient to use and operate. Its ruggedness will allow many years of use if proper operating techniques are followed. Please read the following instructions carefully and always keep this manual within easy reach.

suitable for most applications. In difficult applications where maximum transfer of sound energy is required, glycerin is recommended. However, on some metals glycerin can promote corrosion by means of water absorption and thus may be undesirable. Other suitable couplants for measurements at normal temperatures may include water, various oils and greases, gels, and silicone fluids. Measurements at elevated temperatures will require specially formulated high temperature couplants.

Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the back surface of the material being measured while in standard pulse-echo mode. This may result in a thickness reading that is TWICE what it should be. The Responsibility for proper use of the instrument and recognition of these types of phenomenon rests solely with the user of the instrument.

CONTENTS

1.1 Overview

This is a multi-mode ultrasonic thickness gauge. Based on the same operating principles as SONAR, the instrument is capable of measuring the thickness of various materials with accuracy as high as 0.1/0.01 millimeters.

The multi-mode feature of the gauge allows the user to toggle between pulse-echo mode (flaw and pit detection), and echo-echo mode (eliminate paint or coating thickness).

1.2 Main Functions

* Multi-mode: Pulse-Echo mode and Echo-Echo mode.
* Capable of performing measurements on a wide range of material, including metals, plastic, ceramics, composites, epoxies, glass and other ultrasonic wave well-conductive materials.
* Transducer models are available for special application, including for coarse grain material and high temperature applications.
* Probe-Zero function, Two-Point Calibration function.
* Sound-Velocity-Calibration function.
* Single point mode and Scan mode.
* Coupling status indicator showing the coupling status.
* Units: Metric/Imperial unit selectable.
* Backlight display, easy to use in dim light environment.

the velocity of the paint is 2300m/s. If the user is calibrated for mild steel pipe and measures through both materials, the actual coating thickness will appear to be 2.5 times thicker than it actually is, as a result of the differences in velocity. This error can be eliminated by using a special echo-echo mode to perform measurements for applications such as these. In echo-echo mode, the paint/ coating thickness will be eliminated entirely and the steel will be the only material measured.

6.5 Suitability of materials

Ultrasonic thickness measurements rely on passing a sound wave through the material being measured. Not all materials are good at transmitting sound. Ultrasonic thickness measurement is practical in a wide variety of materials including metals, plastics, and glass. Materials that are difficult include some cast materials, concrete, wood, fiberglass, and some rubber.

6.6 Couplants

All ultrasonic applications require some medium to couple the sound from the transducer to the test piece. Typically a high viscosity liquid is used as the medium. The sound used in ultrasonic thickness measurement does not travel through air efficiently.

A wide variety of couplant materials may be used in ultrasonic gauging. Propylene glycol is

Appendix Sound Velocities

Material	Sound 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
Epoxy resin	0.100	2540
Ice	0.157	3988
Nickel	0.222	5639
Plexiglass	0.106	2692
Polystyrene	0.092	2337

Next page continued

When performing measurements on hot surfaces, it may also be necessary to use a specially constructed high-temperature transducer. These transducers are built using materials which can withstand high temperatures. Even so, it is recommended that the probe be left in contact with the surface for as short a time as needed to acquire a stable measurement. While the transducer is in contact with a hot surface, it will begin to heat up, and through thermal expansion and other effects, may begin to adversely affect the accuracy of measurements.

6.3 Measuring laminated materials

Laminated materials are unique in that their density (and therefore sound-velocity) may vary considerably from one piece to another. Some laminated materials may even exhibit noticeable changes in sound-velocity across a single surface. It is not recommended to measure laminated materials with a thickness gauge based on ultrasonic reflection principle.

6.4 Measuring through paint & coatings

Measuring through paints and coatings are also unique, in that the velocity of the paint/ coating will be significantly different form the actual material being measured. A perfect example of this would be a mild steel pipe with approximately 0.6mm of coating on the surface. Where the velocity of the pipe is 5920m/s, and

* Battery information indicates the rest capacity of the battery.
* Auto sleep and auto power off function to conserve battery life.
* Optional software to process the memory data on the PC.

1.3 Measuring Principle

The digital ultrasonic 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 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 down-and-back travel path, and then multiplied by the velocity of sound in the material. The result is expressed in the well-known 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.

2.1 Specifications

Display: LCD with backlight
Range:Pulse-Echo mode:(0.65~600)mm (in Steel)
Echo-Echo mode: (3~60)mm
Sound Velocity Range: (1000~9999) m/s
Resolution: 0.1mm/0.01mm/0.001inch
Accuracy: ±(0.5%Thickness+0.05), depends on

will be shown as  and will begin to flash. When this occurs, the batteries should be replaced.

Please take out the batteries when not working during a long period of time.

5.12 Auto Power Off

The instrument features an auto power off function designed to conserve battery life. If the tool is idle for 5 minutes, it will turn itself off. While the voltage of the battery is too low this function will also work.

5.13 System Reset

Press down the 

Select Key while powering on the instrument will restore factory defaults. All the memory data will be cleared during system reset. The only time this might possibly helpful is if the parameter in the gauge was somehow corrupted.

5.14 Connecting to a Computer

The gauge is equipped with a USB port. Using the accessory cable, the gauge has the ability to connect to a computer. Measurement data stored in the memory of the gauge can be transferred to the computer through the USB port. Detailed information of the communication software and its usage refer to the software manual.

6 Applications Notes

6.1 Measuring pipe and tubing

When measuring a piece of pipe to determine the

Table 1 Probe Selection

Probe Model	Range	Diameter	Frequency	Operation Temperature
P5.0	1.5~600mm (Steel)	Φ8mm	5MHz	0~50°C
P2.5	1.0~50mm (Plastics)	Φ10mm	2.5MHz	0~50°C
	3.0~40mm (Cast Iron)			
P7.0	1.0~50mm (Steel)	Φ6mm	7MHz	0~50°C
H5.0	3.0~200mm (Steel)	Φ12mm	5MHz	0~300°C

materials and conditions

Measurement Period: 4 times per second for single point mode and 10 times per second for scan mode

Memory for up to 20 files (up to 99 values for each file) of stored values

Working Mode: There are two working modes of thickness measurement: single point mode and scan mode

Unit System: metric system or British system (optional)

Operating Temperature: 0~40°C;

Relative Humidity: <85%RH;

The surrounding environment should avoid of vibration, strong magnetic field, corrosive medium and heavy dust.

Power Source: 4x1.5 V AAA (UM-4) batteries

Communication: USB

Outline dimensions: 142×72×34mm

Weight: 175g (Not Including Batteries)

2.2 Accessories

Standard Accessories:

Main Unit.....1pcs.
Standard Probe.....1pcs.
Coupling Agent.....1pcs.
Carrying Case.....1pcs.
Operating Manual.....1pcs.

Optional Accessories:

Other Special-purpose Probe (See Table 1)

3.1 Front Panel Descriptions

3-1 Sensor Plug
3-2 LCD Display
3-3 BL Backlight Key
3-4 SELECT Select Key
3-5 in/mm inch / mm Key

thickness of the pipe wall, orientation of the transducers is important. If the diameter of the pipe is larger than approximately 4 inches, measurements should be made with the transducer oriented so that the gap in the wearface is perpendicular (at right angle) to the long axis of the pipe. For smaller pipe diameters, two measurements should be performed, one with the wearface gap perpendicular, another with the gap parallel to the long axis of the pipe. The smaller of the two displayed values should then be taken as the thickness at that point.

Perpendicular Parallel

6.2 Measuring hot surfaces

The velocity of sound through a substance is dependant upon its temperature. As materials heat up, the velocity of sound through them decreases. At elevated temperatures, it is recommended that the user perform a calibration procedure on a sample piece of known thickness, which is at or near the temperature of the material to be measured. This will allow the gauge to correctly calculate the velocity of sound through the hot material.

3 Press the ENTER Enter Key to enter the selected file. It will display the current record number (for example, L012) and the record content.

4 Use the SCAN Plus Key and the PE-EE Minus Key to select the desired record.

5 Press the SAVE/DEL Delete Key on the desired record. It will automatically delete this record, and display "-DEL".

6 Press the in/mm inch/mm Key to exit the data logging functions and return to measurement mode.

5.10 Backlight

With the background light, it is convenient to work in the dark condition. Press the BL Backlight Key to switch on or switch off the background light at any moment as you need after power on. Since the light will consume much power, turn on it only when necessary.

5.11 Battery Information

Four AAA size alkaline batteries are needed as the power source. After several hours' usage of the preset batteries, the battery symbol on the screen will be shown as . The more of dark part indicates the more close to fill. When the battery capacity runs out, the battery symbol

file be completely cleared of all measurements. This would allow the user to start a new list of measurements starting at storage location L00. The procedure is outlined in the following steps.

1 Press the ENTER Enter Key to activate the data logging fuctions. It will display the current file name and the total record count of the file.

2 Use the SCAN Plus Key and the PE-EE Minus Key to scroll to the file that will be cleared of all measurements.

3 Press the SAVE DEL Save Key on the desired file. It will automatically clear the file, and display "-DEL".

4 Press the in mm inch/mm Key, at any time, to exit the data logging functions and return to measurement mode.

5.9.3 Viewing/deleting stored record

This function provides the user with the ability to view/delete a record in a desired file previously saved in memory. Following is the steps:

1 Press the ENTER Enter Key to activate the data logging functions. It will display the current file name and the total record count of the file.

2 Use the SCAN Plus Key and the PE-EE Minus Key to select the desired file.

3-6 SCAN Plus / Scan Key
3-7 CAL SET Calibration / Set Key
3-8 PE-EE Minus / Mode Key
3-9 POWER ESC Power / ESC Key
3-10 SAVE DEL Save / Delete Key
3-11 ENTER Enter Key
3-12 Data Cable Interface
3-13 Battery Cover on The Back
3-14 Standard Block
3-15 Probe

3.2 Keypad Definitions

BL	Turn on/off the backlight
SELECT	Probe-Zero operation
in mm	Unit switch between Metric and Imperial system
SCAN	Plus; Turn on/off Scan mode

displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the gauge performs ten measurements every second, and displays the readings while scanning. While the transducer is in contact with the material being measured, the gauge is keeping track of the lowest measurement it finds. The transducer may be "scrubbed" across a surface, and any brief interruptions in the signal will be ignored. When the transducer loses contact with the surface for more than two seconds, the gauge will display the smallest measurement it found. When the transducer is removed from the material being scanned, the gauge will display the smallest measurement it found.

When the scan mode is turned off, the single point mode will be automatically turned on. Turn on/off the scan mode by the following steps:

Press the SCAN Scan Key to switch the scan mode on and off. It will display the current condition of the scan mode on the main screen.

5.7 Changing Resolution

The gauge has selectable display resolution, which is 0.1mm and 0.01mm.

Press down the in mm inch/mm Key while turning on the gauge will switch the resolution between

3-17 Unit: Current unit system. mm or in for thickness value. m/s or in/μS for sound velocity.
3-18 Battery Information: Display the rest capacity of the battery.
3-19 Information Display: Displays the measured thickness value, the sound velocity and shows hints of current operation.

4 Preparation

4.1 Transducer Selection

The gauge is capable of performing measurements on a wide range of materials, from various metals to glass and plastics. Different types of material, however, will require the use of different transducers. Choosing the correct transducer for a job is critical to being able to easily perform accurate and reliable measurement.

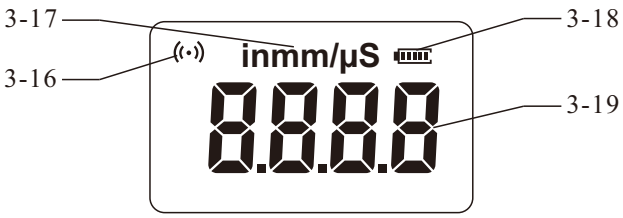
Please select the probe according to Table 1-2 Probe Selection.

4.2 Condition and Preparation of Surfaces

In any ultrasonic measurement scenario, the shape and roughness of the test surface are of paramount importance. Rough, uneven surfaces may limit the penetration of ultrasound through the material, and result in unstable, and therefore unreliable, measurements. The surface being measured should be clean, and free of any small particulate matter, rust, or scale. The presence of such obstructions will prevent the

CAL SET	Sound velocity calibration
PE-EE	Minus; Switch between pulse-echo and echo-echo mode
POWER ESC	Turn the instrument on/off
SAVE DEL	Data Save or Data Delete
ENTER	Enter

3.3 LCD Display



3-16 Coupling Status: Indicate the coupling status. While the gauge is taking a measurement, the coupling status should be on. If it is not on or not stable, the gauge is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.

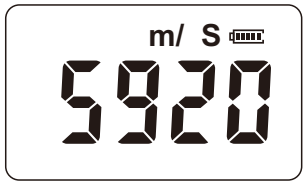
transducer from seating properly against the surface. Often, a wire brush or scraper will be helpful in cleaning surfaces. In more extreme cases, rotary sanders or grinding wheels may be used, though care must be taken to prevent surface gouging, which will inhibit proper transducer coupling. Also, using coupling agent on the surface of the measured body, or multiple measurements near the same point may help to proper transducer coupling.

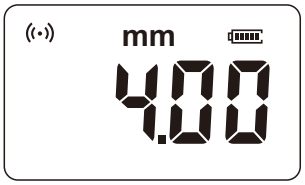
5 Operation

5.1 Power On/Off

Insert the probe plug into the probe socket of the instrument.

The instrument is turned on by pressing the POWER ESC Power Key. After one second, the gauge will display the sound velocity now used, indicating the gauge is ready for use.





The gauge can be turned off by pressing the POWER ESC Power Key. The tool has a special memory that retains all of its settings even when the

"High" and "Low".

5.8 Changing Units

On the measurement mode, press the in mm inch /mm Key to switch back and forth between imperial and metric units.

5.9 Memory Management

5.9.1 Storing a reading

There are twenty files (F00-F19) that can be used to store the measurement values inside the gauge. At most 100 records (thickness values) can be stored to each file. By simply pressing the SAVE DEL Save Key after a new measurement reading appears, the measured thickness value will be saved to current file. It is added as the last record of the file. To change the destination file to store the measured values, follow the steps:

1 Press the ENTER Enter Key to activate the data logging functions. It will display the current file name and the total record count of the file.

2 Use the SCAN Plus Key and the PE-EE Minus Key to select the desired file to set as current file.

3 Press the in mm inch/mm Key to exit the data logging functions at any time.

5.9.2 Clearing selected file

The user may require the contents of an entire

material that is being measured, the instrument will perform four measurements every second, updating its display as it does so. When the transducer is removed from the surface, the display will hold the last measurement made.

Note: Occasionally, a small film of couplant will be drawn out between the transducer and the surface as the transducer is removed. When this happens, the gauge may perform a measurement through this couplant film, resulting in a measurement that is larger or smaller than it should be. This phenomenon is obvious when one thickness value is observed while the transducer is in place, and another value is observed after the transducer is removed. In addition, measurements through very thick paint or coatings may result in the paint or coating being measured rather than the actual material intended. The responsibility for proper use of the instrument, and recognition of these types of phenomenon, rests solely with the user of the instrument.

5.6 Scan mode

While the gauge excels at making single point measurements, it is sometimes desirable to examine a larger region, searching for the thinnest point. The gauge includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the gauge performs and

must be no air gaps between the wear-face and the surface of the material being measured. This is accomplished with the use of a “coupling” fluid, commonly called “couplant”. This fluid serves to “couple”, or transfer, the ultrasonic sound waves from the transducer, into the material, and back again. Before attempting to make a measurement, a small amount of couplant should be applied to the surface of the material being measured. Typically, a single droplet of couplant is sufficient.

After applying couplant, press the transducer (wearface down) firmly against the area to be measured. The coupling status indicator should appear, and a digit number should appear in the display. If the instrument has been properly “zeroed” and set to the correct sound velocity, the number in the display will indicate the actual thickness of the material directly beneath the transducer.

If the coupling status indicator does not appear, not stable, or the numbers on the display seem erratic, firstly check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the material. If the condition persists, it may be necessary to select a different transducer (size or frequency) for the material being measured.

While the transducer is in contact with the

power is off. The gauge also features an auto-power down mode designed to conserve battery life. If the gauge is idle for 5 minutes, it will turn itself off.

5.2 Setting the Measurement Mode

Often times users and inspectors in the field are faced with coated materials such as pipes and tanks. Typically inspectors will need to remove the paint or coating prior to measuring, or allow for some fixed amount of error introduced by the paint or coating thickness and velocity.

The error can be eliminated with this gauge by using a special echo-echo mode to perform measurements for applications such as this. The gauge gives you this feature in a simple way, one button toggle, eliminating the need to remove the paint or coating.

To switch between pulse-echo mode and echo-echo mode, simply press the PE-EE Mode Key.

5.3 Perform Probe Zero

Note: Probe Zero operation apply only to Pulse-Echo mode. Do not perform Probe Zero in Echo-Echo mode.

The SELECT Select Key is used to “zero” the instrument in much the same way that a mechanical micrometer is zeroed. If the gauge is not zeroed correctly, all the measurements that the gauge makes may be in error by some fixed

4 Press the CAL SET Calibration Key to exit from the calibration mode. The gauge is now ready to perform measurements.

5 To achieve the most accurate measurements possible, it is generally advisable to always calibrate the gauge to a sample piece of known thickness. Material composition (and thus, its sound velocity) sometimes varies from lot to lot and from manufacturer to manufacturer. Calibration to a sample of known thickness will ensure that the gauge is set as closely as possible to the sound velocity of the material to be measured.

5.4.3 Two Point Calibration

Note: This procedure requires that the operator has two known thickness points on the test piece that are representative of the range to be measured.

1 Perform a Probe-Zero.

2 Apply couplant to the sample piece.

3 Press the transducer against the sample piece, at the first/second calibration point, making sure that the transducer sits flat against the surface of the sample. The display should show some (probably incorrect) thickness value, and the coupling status indicator should appear steadily.

4 Having achieved a stable reading, remove the transducer. If the displayed thickness changes from the value shown while the transducer was

making actual measurements. Though the instrument will remember the last “probe zero” performed, it is generally a good idea to perform a “probe zero” whenever the gauge is turned on, as well as any time a different transducer is used. This will ensure that the instrument is always correctly zeroed.

Press the SELECT Select Key while in probe zero mode will stop current probe zero operation and return to the measurement mode.

5.4 Sound Velocity Calibration

In order for the gauge to make accurate measurements, it must be set to the correct sound velocity for the material being measured. 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. The One-Point calibration is the simplest and most commonly used calibration procedure optimizing linearity over large ranges. The Two-point calibration allows for greater accuracy over small ranges by calculating the probe zero and velocity.

Note: One and Two point calibrations must be performed on material with the paint or coating removed. Failure to remove the paint or coating prior to calibration will result in a multi material

value. When the instrument is “zeroed”, this fixed error value is measured and automatically corrected for all subsequent measurements. The instrument may be “zeroed ” by performing the following procedure:

5.3.1 Plug the transducer into the instrument. Make sure that the connectors are fully engaged. Check that the wearface of the transducer is clean and free of any debris.

5.3.2 Press the SELECT Select Key to activate the probe zero mode.

5.3.3 Use the SCAN Plus Key and the PE-EE Minus Key to scroll to the probe model currently being used. Be sure to set the right probe model to the instrument. Otherwise, there will be erroneous.

5.3.4 Apply a single droplet of ultrasonic couplant to the face of the metal probe-disc.

5.3.5 Press the transducer against the probe disc, making sure that the transducer sits flat against the surface.

5.3.6 Remove the transducer from the probe disc.

At this point, the instrument has successfully calculated its internal error factor, and will compensate for this value in any subsequent measurements. When performing a “probe zero”, the instrument will always use the sound velocity value of the built-in probe-disc, even if some other velocity value has been entered for

coupled, repeat step 3.

5 Press the CAL SET Calibration Key. The mm (or in) symbol should begin flashing.

6 Use the SCAN Plus Key and the PE-EE Minus Key to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.

7 Press the SELECT Select Key. The display will flash 1OF2. Repeat steps 3 through 6 on the second calibration point.

8 Press the CAL SET Calibration Key, so that The m/S (or in/μS) symbols are flashing. The gauge will now display the sound velocity value it has calculated based on the thickness values that were entered in step 6.

9 Press the CAL SET Calibration Key once more to exit the calibration mode. The gauge is now ready to perform measurements within this range.

5.5 Making Measurements

When the tool is displaying thickness measurements, the display will hold the last value measured, until a new measurement is made.

In order for the transducer to do its job, there

velocity calculation that may be different from the actual material velocity intended to be measured.

5.4.1 Calibration to a known thickness

Note: This procedure 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.

1 Perform a Probe-Zero.

2 Apply couplant to the sample piece.

3 Press the transducer against the sample piece, making sure that the transducer sits flat against the surface of the sample. The display should show some thickness value, and the coupling status indicator should appear steadily.

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 the CAL SET Calibration Key to activate the calibration mode. The mm (or in) symbol should begin flashing.

6 Use the SCAN Plus Key and the PE-EE Minus Key to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.

7 Press the CAL SET Calibration Key again. The m/S

(or in/μS) symbols should begin flashing. The gauge is now displaying the sound velocity value it has calculated based on the thickness value that was entered.

8 Press the CAL SET Calibration Key once again to exit the calibration mode and return to the measurement mode. The gauge is now ready to perform measurements.

5.4.2 Calibration to a known velocity

Note: This procedure requires that the operator knows the sound velocity of the material to be measured. A table of common materials and their sound velocities can be found in Appendix A of this manual.

1 Press the CAL SET Calibration Key to activate the calibration mode. The mm (or in) symbol should begin flashing.

2 Press the CAL SET Calibration Key again, so that The m/S (or in/μS) symbols are flashing.

3 Use the SCAN Plus Key and the PE-EE Minus Key to adjust the sound velocity value up or down, until it matches the sound velocity of the material to be measured. You can also press the ENTER Enter Key to switch among the preset commonly using velocities.