CHECKLINE®
MADE TO MEASURE

MODEL TI-25SX

ULTRASONIC THICKNESS GAUGE

Operating Manual

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1.0 INTRODUCTION

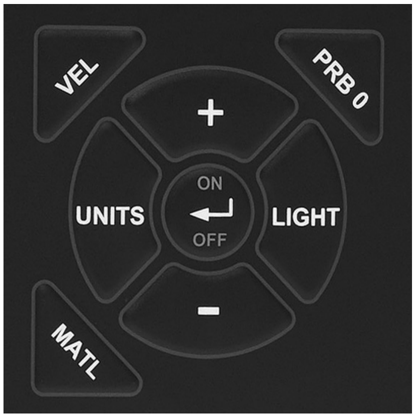
The Checkline model TI-25SX is a basic dual element thickness gauge with the ability to locate blind surface pitting and internal defects/flaws in materials. Based on the same operating principles as SONAR, the TI-25SX is capable of measuring the thickness of various materials with accuracy as high as ± 0.001 inches, or ± 0.01 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only one side of the material being measured.

1.1 Disclaimer

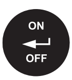
Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the back surface of the material being measured. This may result in a thickness reading that is TWICE what it should be. Responsibility for proper use of the instrument and recognition of this phenomenon rest solely with the user of the instrument. Other errors may occur from measuring coated materials where the coating is insufficiently bonded to the material surface. Irregular and inaccurate readings may result. Again, the user is responsible for proper use and interpretation of the measurements acquired.

2.0 KEYPAD, MENU, DISPLAY & CONNECTORS

The Keypad



2.1 ON/OFF/ENTER Key



The ON/OFF/ENTER key powers the unit ON or OFF. Since the same key is also used as an ENTER key, the gauge is powered off by pressing and holding down the key until the unit powers off.

Once the gauge is initially powered on, this key will function as the ENTER key, similar to a computer keyboard. This key will be used to select or set a menu option.

NOTE: Unit will automatically power off when idle for 5 minutes. All current settings are automatically saved prior to powering off.

2.2 PRB 0 Key

The PRB 0 key is used to “zero” the TI-25SX in much the same way that a mechanical micrometer is zeroed. If the gauge is not zeroed correctly, all of the measurements that the gauge makes may be in error by some fixed value. Refer to section 5.1 for a further explanation of this important feature.

2.3 VEL Key

The VEL key is used to enter and exit theTI-25SX’s calibration mode. This mode is used to adjust the sound velocity value that theTI-25SX will use for a given material type. Enter a known velocity value for specific material type, or manually continue adjusting the value until theTI-25SX displays the correct thickness value using a test sample or calibration block with a known thickness. Refer to section 5.2 for information about Velocity Calibration.

2.4 LIGHT Key

The LIGHT key accesses the backlight setting of the LCD display. The backlight has three setting options; ON, OFF, AUTO. The auto option will only illuminate the display when theTI-25SX is measuring, or receiving an echo. If either ON or AUTO are selected, there are three brightness options, LO, MED, HI, to select a preferred overall brightness of the display. Refer to page 18 for an explanation on how to enable and set the brightness.

2.5 UNITS Key

The UNITS key is used to select either English or Metric units. Refer to page 18 for an explanation of how to select the units.

2.6 +/- Increment/Decrement Key's

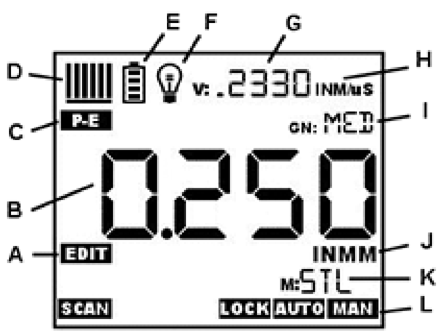
The + and - Keys are used to increment/decrement values, navigate menus, and select menu options.

2.7 MATL Key

The MATL Key is used to select a common basic material type from a short list of 9 materials and 2 programmable custom materials for calibration. Refer to 5.3 for an explanation on selecting a basic material type.

2.8 The Display

The TI-25SX uses a custom glass LCD backlit low temperature display for use in a variety of climate conditions. It contains graphic icons, as well as both 7 and 14 segment display areas. Let's take a closer look and what all these things are telling us:



NOTE: This display is used for multiple gauge models in the TI series. As a result, some of the icons and segments that are illuminated during boot up, may not be applicable to your specific model, and will never be illuminated during operation. The icons and segments that will be used with the TI-25SX are shown in the diagram above.

A. **Edit:** This icon will be displayed, and blinking, to let a user know when they are in an edit mode to change a value or setting.

B. **Large 7 segment:** The thickness measurement, velocity or alpha message will be displayed in this area.

C. **Measurement Modes:** This icon indicates the measurement mode. The TI-25SX operates exclusively in pulse-echo (P-E) mode only.

D. **Stability/Repeatability Indicator:** This is used in conjunction with the thickness measurement as a reference for the validity of the measurement. The TI-25SX takes multiple measurements per second, and when all the vertical bars are illuminated, it's a reference that the same thickness value is reliably being measured multiple times per second.

E. **Battery:** Indicates the amount of battery life the TI-25SX has remaining.

F. **Backlight :** When this icon is illuminated, it indicates the backlight is on.

G. **Small 14 Segment:** The material velocity, speed the sound wave travels through a given medium/material, is displayed in this area, informing the user what material theTI-25SX is currently calibrated too. This area is also used for alpha messages in the menu and edit modes.

H. **Units:** This combination of icons are illuminated in different sequences to inform the user what measurement units are currently being displayed in the small 7 segment area.

I. **Units:** This combination of icons are illuminated in different sequences to inform the user what measurement units are currently being displayed in the large 7 segment area.

J. **Small 14 Segment:** The material type is displayed in this area. If it is set to a value of one of the materials in our material list, it will be displayed in alpha characters indicating the material type. Otherwise it will be set to CUST, indicating custom material type.

K. **Features:** TheTI-25SX can be locked once calibrated, to avoid accidently changing the calibration. When this icon is illuminated, theTI-25SX is in lock mode.
Refer to section 6.3 for an explanation on locking the TI-25SX.

2.9 The Transducer

The transducer is the "business end" of the TI-25SX. It transmits and receives ultrasonic sound waves that the TI-25SX uses to calculate the thickness of the material being measured. The transducer connects to the TI-25SX via the attached cable, and two coaxial connectors. When using transducers manufactured by Checkline, the orientation of the dual coaxial connectors is not critical: either plug may be fitted to either socket in the TI-25SX.

The transducer must be used correctly in order for the TI-25SX to produce accurate, reliable measurements. Below is a short description of the transducer, followed by instructions for its use.

This is a bottom view of a typical transducer. The two semicircles of the wear face are visible, as is the barrier separating them. One of the semicircles is responsible for conducting ultrasonic sound into the material being measured, and the other semicircle is responsible for conducting the echoed sound back into the transducer. When the transducer is placed against the material being measured, it is the area directly beneath the center of the wear face that is being measured.

This is a top view of a typical transducer. Press against the top with the thumb or index finger to hold the transducer in place. Moderate pressure is sufficient, as it is only necessary to keep the transducer stationary, and the wear face seated flat against the surface of the material being measured.

Measuring

In order for the transducer to do its job, there 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.

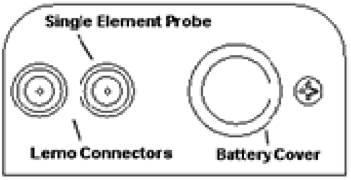
After applying couplant, press the transducer (wear face down) firmly against the area to be measured. The Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the TI-25SX has been properly "zeroed" (see page 14) and set to the correct sound velocity (see page 16), the number in the display will indicate the actual thickness of the material directly beneath the transducer.

If the Stability Indicator has fewer than five bars darkened, or the numbers on the display seem erratic, first 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. See section 4.1 for information on transducer selection.

While the transducer is in contact with the material that is being measured, the TI-25SX 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.

2.11 Top End Cap

The top end cap is where all connections are made to the TI-25SX. The diagram above shows the layout and description of the connectors.



Top End Cap

Transducer Connectors

Refer to Diagram: The transducer connectors and battery cover/probe zero disk are located on the TI-25SX's top end cap. The transducer connectors are of type Lemo "00".

NOTE: There is no polarity associated with connecting the transducer to the TI-25SX, it can be plugged into the gauge in either direction.

Probe Zero Disk & Battery Cover

Refer to Diagram: The Battery cover is the large round disk shown in the diagram.

NOTE: This same disk is also used as a probe zero reference disk. Simply remove the cover when replacing the batteries (2 AA cells). When performing a manual probe zero function, simply place the transducer on disk making firm contact. Important: Be sure the battery polarity is correct, which can be found on the back label of the TI-25SX.

NOTE: Rechargeable batteries can be used, however they must be recharged outside of the unit in a standalone battery charger.

3.0 PRINCIPALS OF ULTRASONIC MEASUREMENT

3.1 Time versus thickness relationship

Ultrasonic thickness measurements depend on measuring the length of time it takes for sound to travel through the material being tested. The ratio of the thickness versus the time is known as the sound velocity. In order to make accurate measurements, a sound velocity must be determined and entered into the instrument.

The accuracy of a thickness measurement therefore depends on having a consistent sound velocity. Some materials are not as consistent as others and accuracy will be marginal. For example, some cast materials are very granular and porous and as a result have inconsistent sound velocities.

While there are many different ultrasonic techniques to measure thickness, which will be discussed below, all of them rely on using the sound velocity to convert from time to thickness.

3.2 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.

3.3 Range of measurement and accuracy

The overall measurement capabilities, based on the wide variety of materials, is determined by the consistency of the material being measured

The range of thickness that can be measured ultrasonically depends on the material type and surface, as well as the technique being used and the type of transducer. The range will vary depending on the type of material being measured.

Accuracy, is determined by how consistent the sound velocity is through the sound path being measured, and is a function of the overall thickness of the material. For example, the velocity in steel is typically within 0.5% while the velocity in cast iron can vary by 4%.

3.4 Couplant

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 frequencies used in ultrasonic thickness measurement do not travel through air efficiently. By using a liquid couplant between the transducer and test piece the amount of ultrasound entering the test piece is much greater.

3.5 Temperature

Temperature has an effect on sound velocity. The higher the temperature, the slower sound travels in a material. High temperatures can also damage transducers and present a problem for various liquid couplants.

Since the sound velocity varies with temperature it is important to calibrate at the same temperature as the material being measured.

Normal temperature range

Most standard transducers will operate from 0°F to 250°F.

High temperature measurements

Special transducers and couplants are available for temperatures above 250°F up to 1000°F with intermittent contact. It is necessary to cool the transducer by submerging it in water between measurements.

Modes and temperature errors

In addition to errors caused by velocity changing with temperature, some modes (measurement techniques) are affected more than others. For example, dual element pulse-echo mode has larger errors due to changes in the temperature of the transducer. However, multi-echo techniques offer temperature compensation help to minimize these errors.

3.6 Measurement Modes

This section will cover the different measurements modes of the TI-25SX, the transducers required, and the reasons for using specific modes:

Pulse-Echo (P-E) Mode:

Pulse-echo mode measures from the initial pulse (sometimes referred to as an artificial zero) to the first echo (reflection). In this mode, either an automatic or manual zero can be performed depending on the zero probe setting. If the manual mode has been selected, the transducer is placed on the reference disk located on top of the TI-25SX, and the PRB 0 key pressed to establish a zero point for the transducer connected. If the Auto Zero feature is enabled, simply pressing the PRB 0 key will perform an electronic zero to establish the same zero point.

In pulse-echo mode, errors can result from surface coatings and temperature variations. Since pulse-echo only requires one reflection, it is the most sensitive mode for measuring flaw/defects when measuring heavily corroded metals.

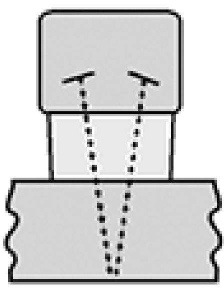
V-Path Correction

Dual element delay line transducers have two piezoelectric elements focused towards one another at a slight angle, mounted on a delay line. One element is used for transmitting sound, while the other element receives the sound reflection. The two elements and their delay lines are packaged in a single housing but acoustically isolated from each other with an insulated sound barrier. This allows the transducer the ability to achieve very high sensitivity for detecting small defects. Also, the surface of the test material does not have to be as flat in order to obtain good measurements.

Dual element transducers are normally used in pulse-echo mode for finding defects, and in echo-echo mode for through coating measurements.

Dual element delay line transducers are have a usable range of 0.025" and up, depending on the material, frequency, and diameter.

A limitation of dual element delay-line transducers is the V shaped sound path. Because the sound travels from one element to another, the time versus thickness relationship is non-linear. Therefore, a correction table in the instruments software is used to compensate for this error.



Dual Element Transducer showing V-path of signal

Searching for small defects

Dual element delay line transducers are especially useful in searching for small defects. In pulse-echo mode with high amplifier gain, very small defects can be located. As a result, this configuration is commonly used for corrosion inspections. The dual element style transducer will find wall deterioration, pits, cracks, and any porosity pockets during tank and pipeline inspections.

4.0 SELECTING THE MEASUREMENT MODE

4.1 Which mode & transducer do I use for my application?

High penetration plastics and castings: The most common mode for these types of applications is pulse-echo. Cast iron applications require 1 – 5MHz frequencies, and cast aluminum requires a 7 – 10MHz frequency depending on the thickness. Plastics typically require lower frequencies depending on the thickness and make-up of the material as well. Larger diameters offer greater penetration power based on the size of the crystal.

Corrosion & Pit Detection in steel and cast materials: Pulse-echo mode is commonly used for locating pits and defects. Typically a 5MHz transducer, or higher, will be used for these types of applications. Use low frequencies for greater penetration and use higher frequencies for better resolution.

Measuring Material & Coatings: The pulse-echo coating mode should be used when both material and coating thickness are required, while still requiring the ability to detect flaws and pits. A special coating style transducer is required for use in this mode. There are a variety of coating transducers in various frequencies available from Electromatic.

Thru Paint & Coatings: Often times, users will be faced with applications where the material will be coated with paint or some other type of epoxy material. Since the velocity of the coating is approximately 3 times slower than that of steel, pulse-echo mode will result in an error if the coating or paint is not completely removed.

Thin materials: Pulse echo mode and a high frequency transducer is commonly used for these types of applications. The most common transducers are the 7.5MHz and 10MHz models with extra resolution. The higher frequencies provide greater resolution and a lower minimum thickness rating overall.

High temperature: Special 5 MHz High temperature transducers are available for these types of applications. Both pulse-echo and echo-echo modes will also work for these applications. However, echo-echo mode will eliminate error caused by temperature variations in the transducer.

Noisy Material: Materials such as titanium, stainless steel, and aluminum may have inherent surface noise issues or mirroring effect. Higher frequency transducers 7 – 10MHz offer improved resolution to avoid erroneous measurements.

Restricted access: Measuring materials with extreme curvatures or restricted access are best suited for higher frequencies and smaller diameter transducers.

5.0 MAKING MEASUREMENTS

The steps involved in making measurements are detailed in this section. The following sections outline how to setup and prepare your TI-25SX for field use.

A manual zero must always be performed. A manual probe zero is performed using the reference disk (battery disk) attached to the top of the instrument. The zero compensates for variations of the transducer. Once the probe zero is completed, the sound velocity must be determined to convert the transit time to a physical length. The sound velocity can be selected from the material chart in the manual, or manually adjusted using a single, or multiple, known reference point(s) until the TI-25SX correctly measuring the reference point(s). The later will result in greater precision overall. To enter a common velocity from a table of velocities, look up the material on the chart in the appendix of this manual. Refer to the section below on Material Calibration for instructions on manually adjusting the velocity using a reference point(s)/standard(s). To determine the velocity of a single sample, refer to the Velocity Calibration section 5.2. The TI-25SX can also be calibrated by selecting a common material type from a short list of materials. To select a common material type to use for calibration, refer the Basic Material Type section 5.3.

5.1 Probe zero

Setting the zero point of the TI-25SX is important for the same reason that setting the zero on a mechanical micrometer is important. It must be done prior to calibration, and should be done throughout the day to account for any temperature changes in the probe. If the TI-25SX is not zeroed correctly, all the measurements taken may be in error by some fixed value.

The "on block" zero procedure is outlined below:

1. Apply a drop of couplant on the transducer and place the transducer in steady contact with the disk (battery cover) located at the top of the unit to obtain a measurement.

2. Be sure all six repeatability/stability bars in the top left corner of the display are fully illuminated and stable, and last digit of the measurement is toggling only +/- .001" (.01mm

3. Press the 

key to perform the manual zero. "PRB0" will briefly be displayed on the screen, indicating the zero calculation is being performed.

5.2 Velocity Calibration

In order for the TI-25SX to make accurate measurements, it must be set to the correct sound velocity of the material being measured. Different types of materials have different inherent sound velocities. For example, the velocity of sound through steel is about 0.233 inches per microsecond, versus that of aluminum, which is about 0.248

inches per microsecond. If the gauge is not set to the correct sound velocity, all of the measurements the gauge makes will be erroneous by some amount.

If the material velocity is known, it can be manually entered into the TI-25SX. If the exact material velocity is unknown, a common velocity can initially be entered to set the TI-25SX close to the unknown target velocity, followed by multiple fine adjustments to the velocity value until the target velocity is discovered.

The steps for entering/editing the velocity value are outlined below:

1. With the transducer free from contact with the material, press the VEL key to display the current velocity.
2. Use the + and - keys to scroll the velocity to the known target value.

NOTE: The longer the keys are pressed and held, the faster the value will increment/decrement.

NOTE: Pressing the VEL key prior to pressing the ON/OFF key will abort the cal routine without saving any changes.

3. Press the ON/OFF key to set the velocity value and return to the measurement screen. The new velocity value will be shown at the top of the display.

CHECK YOUR CALIBRATION! Place the transducer back on the calibration point and verify the thickness. If the thickness is not correct, repeat the steps above.

5.3 Basic Material Type

If the material velocity is unknown, a sample thickness cannot be taken directly from the material, but the general type of material is known, selecting a basic material type from the common material (MATL) list in the TI-25SX would offer a reasonable approximation of the thickness. There are 9 common materials and 2 user programmable settings available. It's important to note that these velocities will not always be an exact representation of the material being tested. Use these values only if a close approximation is acceptable. Follow the steps below to select a basic material type:

Selecting a Basic Material Type

1. Press the MATL key to access the material list. The edit icon will be illuminated and flashing.
2. Use the + and - keys to scroll through the material options.

		in/µs	m/s
ALU	ALUMINUM (2024)	0.250	6350
StL	STEEL (4340)	0.233	5918
StSt	STAINLESS (303)	0.223	5664
Iron	CAST IRON	0.180	4572
PLE	PLEXIGLASS	0.106	2692
PVC	PVC	0.094	2388
PLSt	POLYSTYRENE	0.092	2337
PLUr	POLYURETHANE	0.070	1778
USr1	USER PROGRAMMABLE		
USr2			

3. When the desired MATL setting is displayed, press the MATL key to set the material velocity and return to the measurement screen.

NOTE: Pressing the CAL key prior to pressing the ON/OFF key will abort to the measurement screen without saving any changes.

4. If USR1 or USR2 were selected, the velocity edit screen will be displayed and edit icon illuminated and flashing.

5. Use the + and - keys to scroll to the desired material velocity.

NOTE: The longer these keys are held, the faster the velocity value is incremented.

6. When the desired velocity setting is displayed, press the key to set the material velocity and return to the measurement screen.

NOTE: Pressing the MATL key prior to pressing the ON/OFF key will abort to the measurement screen without saving changes.

6.0 ADDITIONAL FEATURES

6.1 Units

The TI-25SX will operate in both English (inches) or Metric (millimeters) units.

1. Press the UNITS key to toggle inches/millimeters (IN/MM).

6.2 Light

The TI-25SX uses a custom glass segmented display that is equipped with a backlight for use in low light conditions. The options are on/off/auto, where the auto setting only lights the display when the gauge is coupled to the material and receiving a measurement.

The steps below outline how to toggle the backlite:

1. Press the LIGHT key to access the menu items/features.
2. Use the + and - keys to toggle the status on/off/auto/

NOTE: Pressing the LIGHT key prior to pressing the ON/OFF key will abort to the measurement screen without saving changes.

3. When the desired LITE setting is displayed, press the ON/OFF key to set the status and edit the BRT (brightness) option.
4. Use the + and - keys to scroll through the BRT (LO, MED, HI options.
5. When the desired BRT setting is displayed, press the ON/OFF key to set the brightness and return to the measurement screen.

6.3 Lock

The lock feature was built into the TI-25SX for the purpose of locking the operators out of editing any of the gauge settings, for purposes of consistency between operators. When the lock feature is enabled, the gauge calibration functionality cannot be altered, as well as any of the individual features in the gauge. The only keys that are always unlocked are the power and probe zero keys, as these must remain unlocked for measurement functionality.

The procedure to enable/disable the lock feature is outlined below:

1. With the TI-25SX powered off, press and hold down the key while powering the TI-25SX on . The lock icon will be illuminated on the display.
2. To unlock the TI-25SX repeat step one, but hold down the key while powering the TI-25SX on.

6.8 Factory Defaults

The TI-25SX can be reset to factory defaults at any time to restore the original gauge settings. This should only be used if the gauge is not functioning properly, or perhaps multiple features have been enabled and a clean start is needed.

The procedure to reset the gauge is outlined below:

1. With the TI-25SX powered off, press and hold down the and keys while powering the TI-25SX on.

NOTE: Once the measurement screen is displayed the keys can be released.

7.0 APPENDIX A – SOUND VELOCITY TABLE

Material	Sound Velocity in/us		Sound Velocity m/s
Aluminum	0.2510		6375
Beryllium	0.5080		12903
Brass	0.1730		4394
Bronze	0.1390		3531
Cadmium	0.1090		2769
Columbium	0.1940		4928
Copper	0.1830		4648
Glass (plate)	0.2270		5766
Glycerine	0.0760		1930
Gold	0.1280		3251
Inconel	0.2290		5817
Iron	0.2320		5893
Cast Iron	0.1800	(approx)	4572
Lead	0.0850		2159
Magnesium	0.2300		5842
Mercury	0.0570		1448
Molybdenum	0.2460		6248
Monel	0.2110		5359
Nickel	0.2220		5639
Nylon	0.1060	(approx)	2692
Platinum	0.1560		3962
Plexiglas	0.1060		2692
Polystyrene	0.0920		2337
PVC	0.0940		2388
Quartz glass	0.2260		5740
Rubber vulcanized	0.0910		2311
Silver	0.1420		3607
Steel (1020)	0.2320		5893
Steel (4340)	0.2330		5918
Teflon	0.0540		1372
Tim	0.1310		3327
Titanium	0.2400		6096
Tungsten	0.2040		5182
Uranium	0.1130		3378
Water	0.0580		1473
Zinc	0.1660		4216
Zirconium	0.1830		4648

8.0 APPENDIX B – APPLICATION NOTES

Measuring pipe and tubing

When measuring a piece of pipe to determine the thickness of the pipe wall, orientation of the transducers is important. The transducer should be oriented so that the gap (sound barrier) in the wear face is perpendicular (at a right angle) to the length (long axis) of the tubing, allowing both sides of the transducer to make the same amount of contact. The transducer orientation can either be parallel or perpendicular for large diameter piping, as it's much easier to ensure both sides are making similar contact.

Measuring hot surfaces

The velocity of sound through a substance is dependent on its temperature. As materials heat up, the velocity of sound through them decreases. In most applications with surface temperatures less than about 200°F (100°C), no special procedures must be observed. At temperatures above this point, the change in sound velocity of the material being measured starts to have a noticeable effect upon ultrasonic measurement.

At such elevated temperatures, it is recommended that the user perform calibration on a sample piece of known thickness, which is at or near the temperature of the material to be measured. This will allow the TI-25SX to correctly calculate the velocity of sound through the hot material.

Expansion and contraction of the transducer based on temperature, and a varying temperature gradient, will also affect the measurement in a pulse-echo (P-E) measurement mode. It is recommended that a "transducer zero" be performed often to account for the delay line changing length and adversely affecting the accuracy of the measurements.

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 (intermittent contact) to acquire a stable measurement.

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. The only way to reliably measure such materials is by performing a calibration procedure on a sample piece of known thickness. Ideally, this sample material should be a part of the same piece being measured, or at least from the same lamination batch. By calibrating to each test piece individually, the effects of variation of sound-velocity will be minimized. If the variation is relatively close, averaging the sound velocities to minimize error is another option.

An additional important consideration when measuring laminates is that many included air gaps or pockets which will cause an early reflection of the ultrasound beam. This effect will be noticed as a sudden decrease in thickness in an otherwise regular surface. While this may impede accurate measurement of total material thickness, it does provide the user with positive indication of air gaps in the laminate.

Measuring through paint & coatings

Measuring through paints and coatings are also unique, in that the velocity of the paint/coating will be significantly different from the actual material being measured. A perfect example of this would be a mild steel pipe with .025" of coating on the surface. Where the velocity of the steel pipe is .2330 in/µsec, and the velocity of the paint is .0850 in/µsec. If the user is calibrated for mild steel pipe and measures through both materials, the actual coating thickness will appear to be approximately 3 times thicker than it actually is, as a result of the differences in velocity.

9.0 WARRANTY

ELECTROMATIC Equipment Co., Inc. (ELECTROMATIC) warrants to the original purchaser that this product is of merchantable quality and confirms in kind and quality with the descriptions and specifications thereof. Product failure or malfunction arising out of any defect in workmanship or material in the product existing at the time of delivery thereof which manifests itself within one year from the sale of such product, shall be remedied by repair or replacement of such product, at ELECTROMATIC's option, except where unauthorized repair, disassembly, tampering, abuse or misapplication has taken place, as determined by ELECTROMATIC. All returnsfor warranty or non-warranty repairs and/or replacement must be authorized by ELECTROMATIC, in advance, with all repacking and shipping expenses to the address below to be borne by the purchaser.

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ELECTROMATIC Equipment Co., Inc.
600 Oakland Ave. Cedarhurst, NY 11516—USA
Tel: 1-800-645-4330/ Tel: 516-295-4300/ Fax: 516-295-4399