TI-25PX Adjustable Velocity Ultrasonic Wall Thickness Gauge

NOTES

TABLE OF CONTENTS

IMPORTANT NOTE:
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 rests solely with the user of the instrument.

1.0 Introduction

The TI-25P is a precision Ultrasonic Micrometer. Based on the same operating principles as SONAR, the TI-25P 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.

Notes

13.0 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 returns for 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.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE WARRANTY OF MERCHANTABILITY AND FITNESS FOR ANY PARTICULAR PURPOSE OR APPLICATION. ELECTROMATIC SHALL NOT BE RESPONSIBLE NOR LIABLE FOR ANY CONSEQUENTIAL DAMAGE, OF ANY KIND OR NATURE, RESULTING FROM THE USE OF SUPPLIED EQUIPMENT, WHETHER SUCH DAMAGE OCCURS OR IS DISCOVERED BEFORE, UPON OR AFTER REPLACEMENT OR REPAIR, AND WHETHER OR NOT SUCH DAMAGE IS CAUSED BY MANUFACTURER'S OR SUPPLIER'S NEGLIGENCE WITHIN ONE YEAR FROM INVOICE DATE.

Some State jurisdictions or States do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation may not apply to you. The duration of any implied warranty, including, without limitation, fitness for any particular purpose and merchantability with respect to this product, is limited to the duration of the foregoing warranty. Some states do not allow limitations on how long an implied warranty lasts but, not withstanding, this warranty, in the absence of such limitations, shall extend for one year from the date of invoice.

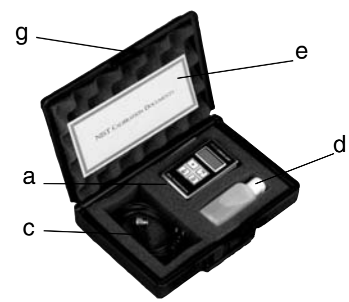
2.0 Overview

2.1 Gauge

2.2 Complete Kit

The TI-25P is supplied as a complete kit with the following:

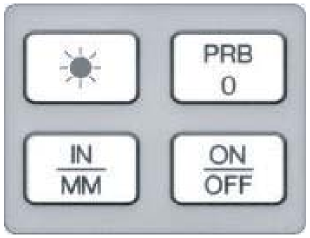
a. Gauge
b. Two (2) AA batteries (installed in gauge)
c. Probe/cable assembly
d. 4 oz. Bottle of coupling fluid
e. NIST-traceable calibration certificate
f. Operating instruction manual
g. Foam-filled carrying case



3.0 Operating Elements

The TI-25P interacts with the operator through the membrane keypad and the LCD display. The functions of the various keys on the keypad are detailed below, followed by an explanation of the display and its various symbols.

3.1 The Keypad



ON / OFF

This **ON/OFF key i**s used to turn the TI-25P on and off. When the gauge is turned ON, it will first perform a brief display test by illuminating all of the segments in the display. After one second, the gauge will display the internal software version number. After displaying the version number, the display will show "0.000" (or "0.00" if using metric units), indicating the gauge is ready for use.

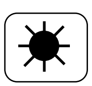
The TI-25P is turned OFF by pressing the ON/OFF key. The gauge has a special memory that retains all of its settings even when the power is off. The gauge also features an auto-powerdown mode designed to conserve battery life. If the gauge is idle for 5 minutes, it will turn itself off.

PRB 0

The **PRB-0 key** is used to “zero” the TI-25P 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 page 8 for an explanation of this important procedure.

IN / MM

The **IN/MM key** is used to switch back and forth between English and Metric units. This key may be used at any time, whether the gauge is displaying a thickness (IN or MM) or a velocity value (IN/µs or M/s)



The **BACKLIGHT key** switches the display backlight between three available settings. OFF will be displayed when the backlight is switched off. AUTO will be displayed when the backlight is set to automatic mode, and ON will be displayed when the backlight is set to stay on. In the AUTO setting, the backlight will illuminate when the TI-25P is actually making a measurement.

12.0 Material Safety Data Sheet (MSDA)

Section 1— Product Identification

Product Name: TI-25M
Generic Name: Ultrasonic Couplant
Manufacturer: Electromatic Equpt. Co.
NFPA Hazardous Materials Identification System (est)
Health 0 Flammability 0 Reactivity 0

Section 2— Hazardous Ingredients

This material does not contain any ingredients having known health hazards in concentrations greater than 1%. This material does not contain any known or suspected carcinogens.

Section 3 — Physical Data (nominal)

Boiling Point: >220°F
Freezing Point: <20°F
Vapor Pressure: N/A
Evaporation Rate: N/A
Specific Gravity: >1.0Z
Solubility in Water: complete
pH: 7.35 – 7.9
Acoustic Imp.: 1.726×10^6
Vapor Density: N/A
Appearance and Odor: water white, opaque gel; bland odor

Section 4 — Fire and Explosive Hazard Data

Flash Point: none
Upper Exposure Limit: none
Lower Exposure Limit: none
Special Fire Fighting Procedures: N/A
Extinguishing media: N/A
Unusual Fire and Explosion Hazards: none

Section 5 — Reactive Data

Stability: Stable
Conditions to Avoid: none
Incompatibility (Materials to Avoid): none known
Hazardous Polymerization: will not occur
Hazardous Decomposition or Byproducts: none known

Section 6 —- Health Hazard and First Aid Data

Routes of Entry[1]:
Skin: not likely
Ingestion: not normally
Eyes: not normally
Inhalation: no

Effects of Overexposure:
Acute: May cause temporary eye irritation
Chronic: none expected

First Aid Procedures:
Skin: Remove with water if desired.
Eyes: Flush with water for 15 minutes.
Ingestion: For large quantities, induce vomiting and call a physician
Inhalation: N/A

Section 7 - Storage and Handling Information

Precautions to be taken in handling and storage: Store between 20 °F and 120 °F. Spills are slippery and should be cleaned up immediately. Steps to be taken in case material is released or spilled: Pick up excess for disposal. Clean with water. Waste disposal method: Dispose of in accordance with federal, state, and local regulations.

Section 8 — Control Measures

Respiratory Protection: not required
Ventilation: not required
Protective Gloves: on individuals demonstrating sensitivity to TI-25M
Eye Protection: as required by working conditions
Other Protective Equipment: not required

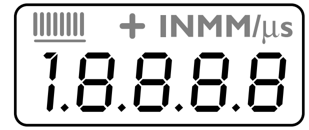
1. TI-25M contains only food grade and cosmetic grade ingredients.

11.0 Appendix B: Sound Velocities of Common Materials

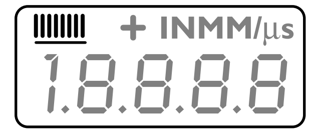
Material Type	Velocity Inches/µs	Velocity Meters/s
Aluminum	0.2500	6350
Bismuth	0.8600	2184
Brass	0.1730	4394
Cadmium	0.1090	2769
Cast Iron	0.18000	4572
Constantan	0.2060	5232
Copper	0.1840	4674
Epoxy resin	0.1000	2540
German silver	0.1870	4750
Glass, crown	0.2230	5664
Glass, flint	0.1680	4267
Gold	0.1280	3251
Ice	0.1570	3988
Iron	0.2320	5898
Lead	0.8500	2159
Magnesium	0.2280	5791
Nickel	0.2220	5639
Nylon	0.1020	2591
Paraffin	0.0870	2210
Platinum	0.1560	3962
Plexiglass	0.1060	2692
Polystyrene	0.0920	2337
Porcelain	0.2300	5842
PVC	0.0940	2388
Quartz glass	0.2220	5639
Rubber, vulcanized	0.0910	2311
Silver	0.1420	3607
✔ Steel, common	0.2330	5920
Steel, stainless	0.2230	5664
Stellite	0.2750	6985
Tin	0.1310	3327
Titanium	0.2400	6096
Tungsten	0.2100	5334
Zinc	0.1660	4216
Water	0.058	1473

Notes: 1. These values are to be used only when a suitable sample of known thickness is not available for calibrating, as slight variations in material composition, finishing (hardening, polishing, etc.) or shape can affect the acoustic velocity.
2. "✔ "denotes the factory default setting for acoustic velocity.

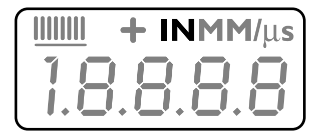
3.2 The Display



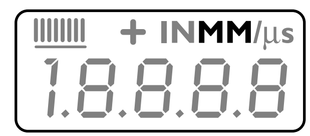
Numerals: The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of various settings. When the TI-25P is displaying thickness measurements, the display will hold the last value measured, until a new measurement is made. Additionally, when the battery voltage is low, the entire display will begin to flash. When this occurs, the batteries should be replaced.



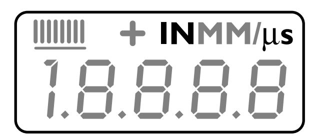
Stability Indicator: These 8 vertical bars form the Stability Indicator. When the TI-25P is idle, only the left-most bar and the underline will be on. When the gauge is making a measurement, six or seven of the bars should be on. If fewer than five bars are on, the TI-25P is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.



IN Symbol: When the IN symbol is on, the TI-25P is displaying a thickness value in inches. The maximum thickness that can be displayed is 19.999 inches.

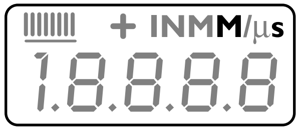


MM Symbol: When the MM symbol is on, the TI-25P is displaying a thickness value in millimeters. If the displayed thickness exceeds 199.99 millimeters, the decimal point will shift automatically to the right, allowing values up to 1999.9 millimeters to be displayed.



IN/µs Symbol: When the IN symbol is on, in conjunction with the /µs symbol, the TI-25P is displaying a sound-velocity value in inches-per-microsecond.

M Symbol: When the M symbol is on, in conjunction with the /s symbol, the TI-25P is displaying a sound-velocity value in meters-per-second.

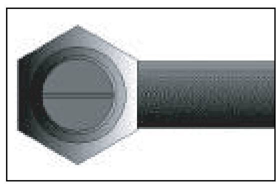


3.3 The Transducer

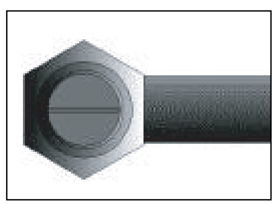
The transducer is the "business end"of the TI-25P. It transmits and receives the ultrasonic sound waves which the TI-25P uses to calculate the thickness of the material being measured. The transducer connects to the TI-25P via the attached cable and two coaxial connectors. When using the transducer,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

The transducer must be used correctly in order for the TI-25P 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 wearface 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 wearface 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 wearface seated flat against the surface of the material being measured.



An additional important consideration when measuring laminates is that any included air gaps or pockets 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.

10.0 Appendix A: Application Notes

Measuring pipe and tubing

Perpendicular Parallel

When measuring a piece of pipe to determine the thickness of the pipe wall, orientation of the transducers is important. If the diameter of the pipe is larger than approximately four 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.

Measuring hot surfaces

The velocity of sound through a substance is dependent upon 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 a calibration procedure (refer to page 9) 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-25P to correctly calculate the velocity of sound through the hot material.

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 itself, and through thermal expansion and other effects, may begin to adversely affect the accuracy of measurements.

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.

4.0 Condition and Preparation of Measuring Surface

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 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.

Extremely rough surfaces, such as the pebble-like finish of some cast irons, will prove most difficult to measure. These kinds of surfaces act on the sound beam like frosted glass on light, the beam becomes diffused and scattered in all directions.

In addition to posing obstacles to measurement, rough surfaces contribute to excessive wear of the transducer, particularly in situations where the transducer is “scrubbed” along the surface. Transducers should be inspected on a regular basis, for signs of uneven wear of the wearface. If the wearface is worn on one side more than another, the sound beam penetrating the test material may no longer be perpendicular to the material surface. In this case, it will be difficult to exactly locate tiny irregularities in the material being measured, as the focus of the soundbeam no longer lies directly beneath the transducer.

5.0 Zeroing The Probe

Setting the Zero Point of the TI-25P is important for the same reason that setting the zero on a mechanical micrometer is important. If the gauge is not "zeroed" correctly, all of the measurements the gauge makes will be in error by some fixed number. When the TI-25P is "zeroed", this fixed error value is measured and automatically corrected for in all subsequent measurements. The TI-25P may be "zeroed" by performing the following procedure:

1. Make sure the TI-25P is on.
2. Plug the transducer into the TI-25P. Make sure that the connectors are fully engaged. Check that the wearface of the transducer is clean and free of any debris.
3. On the top of the TI-25P, above the display, is the metal probe-disc. Apply a single droplet of ultrasonic couplant to the face of this disc.
4. Press the transducer against the probe-disc, making sure that the transducer sits flat against the surface of the probe-disc. The display should show some thickness value, and the Stability Indicator should have nearly all its bars illuminated.
5. While the transducer is firmly coupled to the probe-disc, press the PRB-0 key on the keypad. The TI-25P will display "Prb0" while it is calculating its zero point.
6. Remove the transducer from the probe-disc.

At this point, the TI-25P has successfully calculated it's internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the TI-25P will always use the sound-velocity value of the built-in probe-disc, even if some other velocity value has been entered for making actual measurements. Though the TI-25P 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.

9.0 Specifications

Measuring Range	0.025 to 19.999 inches *(0.63 to 500 millimeters)*
Resolution:	0.001 inch *(0.01 millimeter)*
Accuracy	±0.001 inch *(0.01 millimeter)*, depends on material and conditions
Sound Velocity Range	0.0492 to 0.3930 in/µs *(1250 to 10000µ/s)*
Keypad	Sealed membrane, resistant to water and petroleum products.
Display	Liquid-Crystal-Display, 4.5 digits, 0.500 inch high numerals. LED
Power Source	Two AA size, 1.5 volt alkaline or 1.2 volt NiCad cells.
Battery Life	200 hours typical operating time using alkaline, 120 hours typical operating time using NiCad.
Weight	10 ounces
Size	2.5W x 4.75H x 1.25D inches *(63.5W x 120.7H x 31.8D mm).*
Operating Temperature	–20 to 120 °F *(–20 to 50 °C)*
Case	Extruded aluminum body nickel plated aluminum end caps.

8.0 Taking Measurements

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 transmit, 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 Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the TI-25P has been properly “zeroed” (see page 8) and set to the correct sound velocity (see page 9), 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 page 10 for information on transducer selection.

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

IMPORTANT: 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 TI-25P 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.

6.0 Calibration Procedure

In order for the TI-25P 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. 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 fixed percentage.

6.1 Programming the Sound Velocity

Since the TI-25P is a fixed velocity gauge, the correct sound velocity for the material being measured must be programmed into the gauge via the serial port on the bottom of the unit. Approximate sound velocities for common materials can be found in appendix C.

1. Connect the serial cable (Part No. N-306-0010) to a COM port on a computer and to the RS232 connector located on the bottom of the TI-25P. Remove and replace the rubber plug before and after programming.
2. Assuming that DakView2 PC software is installed and running, select the TI-25P icon from the DakView2 gauge selector icons. A window will appear with the title “TI-25P Velocity Upload Utility”.
3. Under the Preset Velocity heading are two options. The first option is a test box with a velocity number displayed. The text box is editable. To change the velocity, click in the text field and type in the appropriate velocity number. The second option is a list box with a material type displayed. To change the material type, click the down arrow located to the right of the list box. Use the arrows or slider bar to scroll through the available material types. Click on a material to select it.
4. To select the units (english or metric), click on the radio button located to the left of the units title. A black dot will appear in th button when selected.
5. Click on the Program Gauge button located in the top right of the window. A pop up window will be display with the following message “Turn on gauge power”. Press the ON/OFF button on the TI-25P to download the velocity. The TI-25P will display the new velocity.

7.0 Transducer Selection

The TI-25P is inherently 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 measurements. The following paragraphs highlight the important properties of transducers, which should be considered when selecting a transducer for a specific job.

Generally speaking, the best transducer for a job is one that sends sufficient ultrasonic energy into the material being measured such that a strong, stable echo is received by the TI-25P. Several factors affect the strength of ultrasound as it travels. These are outlined below:

Initial Signal Strength

The stronger a signal is to begin with, the stronger its return echo will be. Initial signal strength is largely a factor of the size of the ultrasound emitter in the transducer. A large emitting area will send more energy into the material being measured than a small emitting area. Thus, a so-called "1/2-inch" transducer will emit a stronger signal than a "1/4-inch" transducer.

Absorption and Scattering

As ultrasound travels through any material, it is partly absorbed. If the material through which it travels has any grain structure, the sound waves will also experience scattering. Both of these effects reduce the strength of the waves, and thus, the TI-25P's ability to detect the returning echo.

Higher frequency ultrasound is absorbed and scattered more than ultrasound of a lower frequency. While it may seem that using a lower frequency transducer might be better in every instance, low frequencies are less directional than high frequencies. Thus, a higher frequency transducer would be a better choice for detecting the exact location of small pits or flaws in the material being measured.

Geometry of the Transducer

The physical constraints of the measuring environment sometimes determine a transducer's suitability for a given job. Some transducers may simply be too large to be used in tightly confined areas. Also, the surface area available for contacting with the transducer may be limited, requiring the use of a transducer with a small wearface. Measuring on a curved surface, such as an engine cylinder wall, may require the use of a transducer with a matching curved wearface.

Temperature of the Material

When it is necessary to measure on surfaces that are exceedingly hot, high temperature transducers must be used. These transducers are built using special materials and techniques that allow them to withstand high temperatures without damage. Additionally, care must be taken when performing a "Probe-Zero" or "Calibration to Known Thickness" with a high temperature transducer. See Appendix B for more information on measuring materials with a high temperature transducer.

NOTE: Selection of the proper transducer is often a matter of tradeoffs between various characteristics. It may be necessary to experiment with a variety of transducers in order to find one that works well for a given job. Electromatic can provide assistance in choosing a transducer, and offers a broad selection of transducers for evaluation in specialized applications.