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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

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1.0 INTRODUCTION

The TI-25M-MMX is a multi-mode Ultrasonic thickness gauge that 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. The multi-mode feature of the TI-25M-MMX allows the user to toggle between pulse-echo mode (flaw and pit detection), and echo-echo mode (eliminate paint or coating thickness).

2.0 PRECAUTIONS

Do not use the standard probe in applications where material temperatures exceed 200 °F (100 °C) as the probe will be damaged. Special *High Temperature Probes* should be used. Consult factory.

Keep the gauge free of dust (especially metal powders, carbon, etc.) as they will damage the gauge. Use a damp cloth to clean the gauge after use. **DO NOT USE CHEMICAL SOLVENTS OF ANY KIND.**

Note—Very Important!

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.

In addition, measurements through very thick paint or coatings while using echo-echo mode, 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 type of phenomenon's rest solely with the user of the instrument.

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.

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.

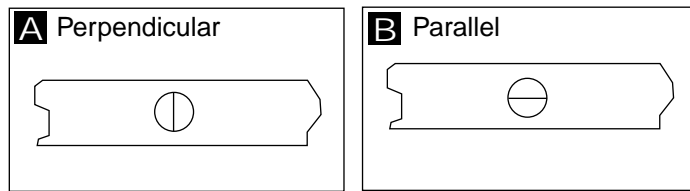
Measuring Through Paint & Coatings

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 approximately .025" of coating on the surface. Where the velocity of the pipe is .2330 in/msec, and the velocity of the paint is .0900 in/msec. 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.

18.0 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. 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.



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 12) 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-25DL-MMX 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, and through thermal expansion and other effects, may begin to adversely affect the accuracy of measurements.

3.0 OVERVIEW OF GAUGE

3.1 Gauge



16.0 SPECIFICATIONS

Range	
<i>TI-25DL-MMX*</i>	Pulse-Echo Mode (Pit & Flaw Detection): 0.040–6.000" (1.01–152 mm) Echo-Echo Mode (Through Paint & Coatings): 0.100–1.0" (2.54–25.4 mm). With up to 0.040" of coating.
<i>TI-25DL-MMX-EXT*</i>	Pulse-Echo Mode (Pit & Flaw Detection): 0.100–10.000" (2.54–254 mm) Echo-Echo Mode (Through Paint & Coatings): 0.200–5.0" (5–127 mm). With up to 0.080" of coating.
Resolution	.001" (0.01 mm)
Display	4 ½ -Digit, 0.5" Backlit LCD
Velocity Range	0.0492 to .3937 in./μs. (1250 to 10,000 meters/second)
Probe	
<i>TI-25DL-MMX</i>	5 MHz, 0.25" Dia. (6.35 mm), High Damp
<i>TI-25DL-MMX-EXT</i>	3.5 MHz, 0.5" Dia. (12.70 mm), High Damp
Probe Wearface	PEEK (Polyethylenekeytone)
Cable	4 ft. (1.2 m) waterproof cable with non-polarized, quick-disconnect connectors. Optional lengths up to 100 ft. (30 m).
Probe Zero Test Plate	Steel plate built into battery cover, approximate thickness of 0.416" (10.57mm)
Temp. Limits	<u>Ambient:</u> –20 to 120 °F (–30 to 50 °C) <u>Material:</u> 0 to 200 °F (–20 to 100 °C) Special high temperature probes are optionally available.
Battery Type	Two AA batteries
Battery Life	200 hours
Weight	7 ounces (196 g)
Size	2.4 x 4.5 x 1.25" (65 x 114 x 35 mm)
Accessories Included	Probe/cable assembly, 4oz. bottle of coupling fluid, NIST Calibration Certificate, 2 AA batteries, operating instructions, hard-plastic carrying case.
Warranty	<u>Gauge:</u> 5 years <u>Probe:</u> 90 days

*Measuring Range indicated is for steel. Actual range for other materials will vary based upon the material's sonic velocity and attenuation.

3.4 The Keypad



The TI-25DL-MMX 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.



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

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



The **PRB-0** key is used to "zero" the TI-25DL-MMX in much the same way that a mechanical micrometer is zeroed. If the tool is not zeroed correctly, all of the measurements that the tool makes may be in error by some fixed value. Refer to page 10 for an explanation of this important procedure.



The **CAL** key is used to enter and exit the TI-25DL-MMX's calibration mode. This mode is used to adjust the sound-velocity value that the TI-25DL-MMX will use when calculating thickness. The tool will either calculate the sound-velocity from a sample of the material being measured, or allow a known velocity value to be entered directly. Refer to page 12 for an explanation of the two CAL functions available.



The **MODE** key is used to toggle through the various features and settings of the TI-25DL-MMX (gate, alarm mode, beeper, back light, units, scan mode, and differential mode). The MODE key is used in conjunction with the arrow and send keys to enable/disable the features and settings.



The **UP** arrow key has three functions. When the TI-25DL-MMX is in calibration mode, this key is used to increase numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will increment at an increasing rate. When MODE is activated, the UP arrow key scrolls through the various features and settings of the instrument. When the data logging feature has been activated by pressing the MEM key, the

UP arrow is used to scroll through the various files, storage locations, and functions of the data logger. Refer to page 22 for further information regarding the use of the UP arrow key and the data logger.



The **DOWN** arrow key has three functions. When the TI-25DL-MMX is in the CAL mode, this key is used to decrease numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will decrement at an increasing rate. When MODE is activated, the DOWN arrow scrolls through the various features and settings of the TI-25DL-MMX. When the data logging feature has been activated by pressing the MEM key, the UP arrow is used to scroll through the various files, storage locations, and functions of the data logger. Refer to page 20 for further information regarding the use of the DOWN arrow key and the data logger.



The **MEM** key enables/disables the data logging feature of the TI-25DL-MMX. This key is used in conjunction with the UP/DOWN arrows, SEND, AND CLR keys (hi-lighted in green). The combination of these keys control the data logging features of the TI-25DL-MMX. Refer to the section on data logging page 20

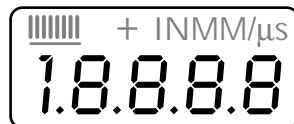


The **CLR** key is specifically used with the data logging feature of the TI-25DL-MMX. This key clears the contents of an entire file, or individual storage locations. The CLR key is also used to send an obstruct (ObSt) to an individual storage location. The ObSt symbol would indicate that a the user was unable to take a reading at a particular location. Refer to the section on data logging on page 20.



The **SEND** key is used for sending data to internal storage locations, and external peripheral devices (serial printer/computer). The SEND key is also used to select data logging functions in the TI-25DL-MMX. Refer to page 20.

3.5 LCD Display



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-25DL-MMX 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 flash.

When this occurs, the batteries should be replaced.

15.2 Acoustic Velocity Table

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

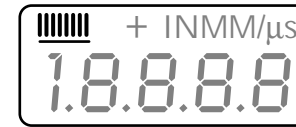
Notes: 1. These values are to be used only when a suitable sample of known thickness is not available for calibrating, as slight variations in material composition, finishing (hardening, polishing, etc.) or shape can affect the acoustic velocity.

2. “✓” denotes the factory default setting for acoustic velocity.

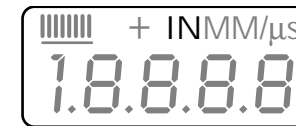
7. Press the CAL key again and the acoustic velocity units indicator “IN/μs” or “M/s” will be flashing showing the acoustic velocity value that was calculated for this sample. If desired, record this value so it can be re-entered easily in the future.

8. Press the CAL key again to exit the calibration mode and return to the measurement mode.

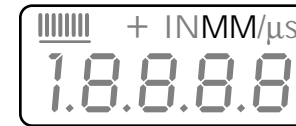
Note: If the CAL key is pressed while in the calibration mode, the TI-25DL-MMX will be reset to the factory default calibration for common steel (0.2330 IN/μs or 5920 M/s).



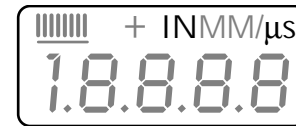
These eight vertical bars form the **Stability Indicator**. When the TI-25DL-MMX is idle, only the left-most bar and the underline will be on. While the gauge is taking a measurement, six or seven of the bars should be on. If fewer than five bars are on, the TI-25DL-MMX is having difficulty achieving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



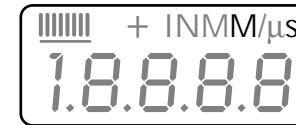
When the **IN** symbol is on, the TI-25DL-MMX is displaying a thickness value in **inches**. The maximum thickness that can be displayed is 19.999 inches.



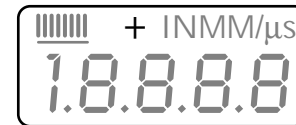
When the **MM** symbol is on, the TI-25DL-MMX is displaying a thickness value in **millimeters**. If the displayed thickness exceeds 199.99 millimeters, the decimal point will shift automatically to the right, allowing values up to 1999.9 millimeters to be displayed.



When the **IN** symbol is on, in conjunction with the **/ms** symbol, the TI-25DL-MMX is displaying a sound-velocity value in inches-per-microsecond.



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



When the **+** symbol is on and blinking, this indicates that the TI-25DL-MMX is currently operating in echo-echo (Thru-paint/coating) mode.

3.6 Probe Zero Plate

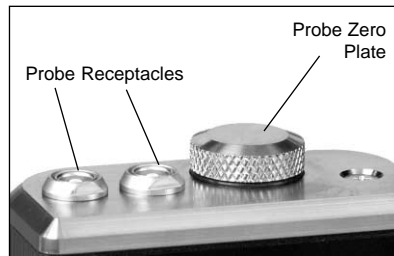
When first connecting the probe supplied with the TI-25DL-MMX, the user should perform a “Probe Zero” as described in Section 4.2. The Probe Zero Test Plate is used for this task. It is located on the top edge of the gauge as shown in the photo below. It also serves as the battery compartment cover

Note: The thickness of this plate is not important, and it should not be used as a Calibration Test Plate. A precision 4-step Test Block is optionally available for this purpose.

3.7 Probe Connector Receptacle

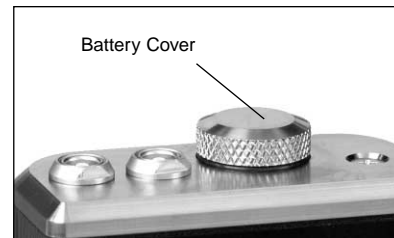
Located on the top edge of the TI-25M-MMX housing are the receptacles for the probe and the probe zero plate.

The connectors for the probe are non-polarized so the connector at the end of the probe cable can be inserted into this receptacle in either orientation. Make sure the connector is “well seated” in the receptacle.



3.8 Battery Compartment (Changing The Battery)

The battery compartment is located under the probe zero test plate. To open the battery compartment, unscrew the probe zero plate by rotating it counterclockwise. The TI-25DL-MMX operates on two (2) AA Batteries (1.5 V). If desired, rechargeable batteries may be used.



The TI-25DL-MMX is shipped with the batteries installed. Insert batteries in the polarity indicated on the rear label.

Note: When the display elements begin to flash off and on repeatedly, the batteries are low and should be replaced.

15.0 CALIBRATION FOR MEASURING THICKNESS OF MATERIALS OTHER THAN STEEL

Ultrasonic Thickness Gauges use sound waves to measure wall thickness. Different types of materials have different inherent acoustic velocities. For instance, the acoustic velocity of steel is 0.2330 IN/ μ s (inches-per-microsecond), versus that of aluminum, which is about 0.2500 IN/ μ s. It is critical that the TI-25DL-MMX be set for the correct acoustic velocity depending upon the material to be measured.

The TI-25DL-MMX is shipped from the factory calibrated for steel with an acoustic velocity of 0.2330 IN/ μ s (5920 M/s). To measure the thickness of any other material, the calibration will have to be changed by adjusting the acoustic velocity to the appropriate value for the specific material being measured.

To determine the proper acoustic velocity for the non-steel material, refer to the Acoustic Velocity Table, section 10.1. After determining the proper acoustic velocity, the gauge must be re-calibrated for this new value.

If you do not know the type of material to be measured or if the material type is not listed in the Acoustic Velocity Table follow the following procedure.

15.1 Changing Calibration - Acoustic Velocity Is Not Known

In applications where the type of material is not known or the material is not listed in the Acoustic Velocity Table, the following procedure can be used to calibrate the gauge for highest accuracy.

1. Obtain a sample of the material with a known thickness or use a micrometer, caliper or similar device to accurately measure it.
2. Turn on the gauge by pressing the ON/OFF key.
3. Place a small amount of coupling fluid on the sample of known thickness and place the probe on the sample. The Stability Indicator should have nearly all its bars illuminated. Having achieved a stable reading remove the probe from the sample.
4. Press the CAL key.
5. The units of measure indicator “IN” or “MM” will be flashing indicating that you are in the *Measurement Calibration* mode.
6. Use the UP and DOWN arrow keys to adjust the displayed measurement value to match the thickness of the known sample. By pressing and holding the key, the numbers will change more rapidly.

“Calibration to Known Thickness” with a high temperature transducer. See Appendix B for more information on measuring materials with a high temperature transducer.

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.

Through Paint & Coatings

The TI-25DL-MMX has the ability to measure through and eliminate the thickness of paint or coatings on the surface of metals. While this is a very convenient feature, it must be used with the proper transducers in order to produce favorable results. Special high damped alpha style transducers must be used in order to achieve optimal results. Consult Electromatic directly for assistance in choosing the proper transducer for use with the Multi-Mode feature.

4.0 MAKING 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 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 Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the TI-25DL-MMX has been properly “zeroed” (see page 10) and set to the correct sound velocity (see page 13), 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 25 for information on transducer selection.

While the transducer is in contact with the material that is being measured, the TI-25DL-MMX 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-25DL-MMX 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’s, rest solely with the user of the instrument.

4.1 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 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 iron, 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 sound-beam no longer lies directly beneath the transducer.

Setting the Zero Point of the TI-25DL-MMX is important for the same reason that setting the zero on a mechanical micrometer is important. If the tool is not “zeroed” correctly, all of the measurements the tool makes will be in error by some fixed number. When the TI-25DL-MMX is “zeroed”, this fixed error value is measured and automatically corrected for in all subsequent measurements. The TI-25DL-MMX may be “zeroed” as follows:

4.2 Performing a Probe-Zero

1. Make sure the TI-25DL-MMX is on.
2. Plug the transducer into the TI-25DL-MMXL. Make sure that the connectors are fully engaged. Check that the wearface of the transducer is clean and free of any debris.
3. The metal probe-disc is on the top end of the TI-25DL-MMX DL. Apply a single droplet of ultrasonic couplant to the face of this disc.
4. Make sure that the TI-25DL-MMX is in P-E (pulse-echo mode) by pressing the Dual-Multi key to toggle the modes.

Note: The Probe-Zero feature is not used in Echo-Echo Thru-Paint mode, and has been disabled. If the PRB-0 key is pressed, while in this mode, “nO” followed by “Prb0” will be displayed.

14.0 TRANSDUCER SELECTION

The TI-25DL-MMX 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-25DL-MMX. 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 the sound travels has any grain structure, the sound waves will experience scattering. Both of these effects reduce the strength of the waves, and thus, the TI-25DL-MMX’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 a

13.4 Sending All Files to a Computer

At the end of the inspection process, or end of the day, the user may require the readings be transferred to a computer. The following steps outline this procedure:

1. Refer to the section on Connecting to a Computer, page 19, before proceeding.
2. Press the ON/OFF key to power up the TI-25DL-MMX.
3. Press the MEM key to activate the data logging functions and settings.
4. Press the UP / DOWN arrow keys to scroll to the SEND / ALL symbol flashing on the display.
5. Press the SEND key to send all data files to the computer.
6. Press the MEM key to exit the data logging functions and return to measurement mode.

13.5 Printing a File

The user may wish to print an individual file to a serial printer or computer. A file can, very simply, be printed to a communications program on a PC (i.e. Windows 3.1 -Terminal, Window 95/98/Me/XP-HyperTerminal), and then printed. The procedure for printing a file is outlined below:

1. Refer to the section on Connecting to a Computer, page 21, before proceeding.
2. Press the ON/OFF key to power up the TI-25DL-MMX.
3. Press the MEM key to activate the data logging functions and settings.
4. Press the SEND key to enter file setup.
5. Press the UP / DOWN arrow keys to scroll to the file to be printed (F-01, F-05, etc.).
6. Press SEND, once again, to select the file to be printed. The display will flash the FILE / F-05 (The file selected) symbol.
7. Press the UP / DOWN arrow keys to scroll to the flashing Prn /F-05 (The file chosen), or LISt (tape printer) symbol.
8. Press the SEND key to print the contents of the file.
9. Press the MEM key, at any time, to exit the data logging functions and return to measurement mode.

5. Press the transducer against the probe-disc, making sure that the transducer sits flat against the surface. The display should show some thickness value, and the Stability Indicator should have nearly all its bars illuminated.
6. While the transducer is firmly coupled to the probe-disc, press the PRB-0 key on the keypad. The TI-25DL-MMX will display "Prb0" while it is calculating its zero point.
7. Remove the transducer from the probe-disc.

At this point, the TI-25DL-MMX has successfully calculated its internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the TI-25DL-MMX 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-25DL-MMX will remember the last "probe-zero" performed, it is generally a good idea to perform a "probe-zero" whenever the tool is turned on, as well as any time a different transducer is used. This will ensure that the instrument is always correctly zeroed.

5.0 CALIBRATION

In order for the TI-25DL-MMX 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 tool is not set to the correct sound-velocity, all of the measurements the tool 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. The TI-25DL-MMX provides three simple methods for setting the sound-velocity, described in the following pages.

5.1 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. Make sure the TI-25DL-MMX is on and switched to P-E (pulse-echo) mode. Press the Dual-Multi key to toggle modes.

Note: The calibration function has been disabled in E-E (echo-echo) mode. If the CAL key is pressed while in E-E mode, “nO” followed by “CAL” will be displayed.

2. Perform a Probe-Zero (refer to page 10)
3. Apply couplant to the sample piece.
4. 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 (probably incorrect) thickness value, and the Stability Indicator should have nearly all its bars on.
5. Having achieved a stable reading, remove the transducer. If the displayed thickness changes from the value shown while the transducer was coupled, repeat step 4.
6. Press the CAL key. The IN (or MM) symbol should begin flashing.
7. Use the UP and DOWN arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.
8. Press the CAL key again. The IN/ms (or M/s) symbols should begin flashing. The TI-25DL-MMX is displaying the sound velocity value it has calculated based on the thickness value that was entered in step 7.
9. Press the CAL key once more to exit the calibration mode.

The TI-25DL-MMX is now ready to perform measurements.

Note: Assuming the steps in Using The Data Logger have been completed, and step 8 is being repeated.

1. Press the UP / DOWN arrow keys to move to the location to be over written.

Note: If the user attempts to write to a location that is currently full, the display will flash the FuLL symbol.

2. Press the CLR key to delete the contents of the storage location. The display will flash the storage location (L011, L099, etc.) and the CLR symbol.
3. Take another measurement, and press the SEND key to write to the same storage location just cleared.

13.2 Clearing an Entire File

The user may require the contents of an entire file be completely cleared of all measurements. This would allow the user to start a new list of measurements starting at storage location L001. The procedure is outlined in the following steps:

1. Press the ON/OFF key to power up the TI-25DL-MMX.
2. Press the MEM key to activate the data logging functions and settings.
3. Press the SEND key to enter file setup.
4. Press the UP / DOWN arrow keys to scroll to the file that will be cleared of all measurements.
5. Press the SEND key once again to select the file.

Note: The display will flash the FILE / F-05 (The file selected by the user) symbol.

6. Press the UP / DOWN arrow keys to scroll to the flashing CLr / F-05 (The file selected by the user) symbol.
7. Press the SEND key to select the clear file option. The symbol (CLr?) will be displayed.
8. Press the CLR key to confirm and clear the contents of the entire file.
9. Press the MEM key, at any time, to exit the data logging functions and return to measurement mode.

13.3 Clearing all Files

1. Press the ON/OFF key to power up the TI-25DL-MMX.
2. Immediately press the CLR key. CLr? Will be displayed.
3. Press the CLR key once again to clear all files.

13.0 USING THE DATA LOGGER

The TI-25DL-MMX is equipped with an on board data logging feature. This will prove to be a valuable reporting tool for inspection purposes. It will increase efficiency by reducing the time it takes to manually record the measurements during the inspection process. The TI-25DL-MMX can then be connected to a computer or serial printer to save and print the results of the inspection.

The TI-25DL-MMX has a storage capacity of 1000 measurements. The TI-25DL-MMX has 10 files consisting of 100 sequential storage locations in each file. The procedure for using the data logger is outlined in the following steps:

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press the MEM key to activate the data logger.

Note: The display will flash FILE / F-01 (or the last file used) symbol. Remember, there are 10 files F-01 thru F-10.

3. Press the SEND key to enter file setup.

Note: The current file will be displayed (F-01, F-03, etc.)

4. Press the UP / DOWN arrow keys to scroll to the file (1-10) that will be used to record the measurements.
5. Press the SEND key once again to select the file.

Note: The display will flash the FILE / F-04 (The selected file)symbol.

6. Press the MEM key, once again, to advance to the storage locations in the file selected.

Note: The display will flash the current storage location (L007, L039, etc.), followed by the status of the location. The storage location can contain one of three possible things: a) A measurement that was previously stored. b) A clear location, indicated by the CLr symbol. c) Obstruct (ObSt), indicating that a measurement could not be obtained.

7. Press the UP / DOWN arrow keys to advance to the desired cell location.
8. Take a measurement and press the SEND key to store a reading in the desired location.

Note: The data logger will automatically advance to the next storage location in sequential order.

9. Repeat step 8 as required.

13.1 Clearing a Storage Location

The user may require a storage location, that is currently full, be over written. This procedure is outlined in the following steps:

5.2 Calibration to a known velocity

Note: This procedure requires that the operator know the sound-velocity of the material to be measured. A table of common materials and their sound-velocities can be found in on page 27.

1. Make sure the TI-25DL-MMX is on and switched to P-E (pulse-echo) mode. Press the Dual-Multi key to toggle modes.

Note: The calibration function has been disabled in E-E (echo-echo) mode. If the CAL key is pressed while in E-E mode, “nO” followed by “CAL” will be displayed.

2. Press the CAL key to enter calibration mode. If the IN (or MM) symbol is flashing, press the CAL key again, so that the IN/ms (or M/s) symbols are flashing.
3. Use the UP and DOWN arrow keys to adjust the displayed velocity up or down, until it matches the sound-velocity of the material to be measured.
4. Press the CAL key once more to exit the calibration mode.

The TI-25DL-MMX is now ready to perform measurements.

Note: At any time during the calibration procedure (IN, MM, IN/ms, or M/s flashing in the display), pressing the PRB-0 key will restore the tool to the factory default sound-velocity for steel (0.233 IN/ms).

To achieve the most accurate measurements possible, it is generally advisable to always calibrate the TI-25DL-MMX 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 tool is set as closely as possible to the sound velocity of the material to be measured.

5.3 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. Make sure the TI-25DL-MMX is on and switched to P-E (pulse-echo) mode. Press the Dual-Multi key to toggle modes.

Note: The calibration function has been disabled in E-E (echo-echo) mode. If the CAL key is pressed while in E-E mode, “nO” followed by “CAL” will be displayed.

2. Perform a Probe-Zero (refer to page 10)
3. Apply couplant to the sample piece.

-
-
4. 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 Stability Indicator should have nearly all its bars on.
 5. Having achieved a stable reading, remove the transducer. If the displayed thickness changes from the value shown while the transducer was coupled, repeat step 4.
 6. Press the CAL key. The IN (or MM) symbol should begin flashing.
 7. Use the UP and DOWN arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.
 8. Press the PROBE key. The display will flash 1OF2. Repeat steps 3 through 7 on the second calibration point. The TI-25DL-MMX will now display the sound velocity value it has calculated based on the thickness values that were entered in step 7.

The TI-25DL-MMX is now ready to perform measurements within this range.

12.0 RS232 SERIAL PORT

The TI-25DL-MMX is equipped with an RS232 serial port. Using the accessory cable (part# N-306-0010), the TI-25DL-MMX has the ability to connect to a computer, or external storage device. The following section outlines the procedure for connecting the TI-25DL-MMX to a computer, and how to collect data using any standard communications program:

12.1 Connecting To a Computer

1. Connect the accessory cable (part# N-306-0010) to the 2-pin jack located on the bottom of the TI-25DL-MMX, and the 9-pin connector to a serial port on the computer.
2. Start the communications software that will be used to collect the measurements (i.e. Microsoft Windows 3.1 -Terminal, or 95, 98, Me, XP— HyperTerminal).
3. Setup the communications software using the following parameters:
Data Bits -8, Parity -None, Stop Bits -1, Baud Rate 1200 (to print a report), or 9600 to transfer data file.

Note: A report can be printed to a communications program (i.e. HyperTerminal), or printed to a serial printer using 8.5” x 11” paper.

4. Set the communications software COMM port to the port number that the TI-25DL-MMX is connected — direct comm1, comm 2, etc.
5. Proceed to the section 13.0 Data Logger.

Note: Communications software packages generally have the ability to capture the screen data to a common text file. This text file, containing the measurements, can then be imported into any common spreadsheet program (i.e. Excel, Quattro Pro, Lotus123) for further reporting requirements.

11.0 DUAL-MULTI 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. An A-Scan scope with a special echo-echo mode is generally used in order to accurately perform measurements through paints and coatings. However, In order to inspect for blind wall pitting and internal flaws, both echo-echo (thru-paint / coatings), and pulse-echo (locate flaws & pits) modes are needed. Special high damped dual element transducers are also a must when performing inspections using both modes without an a-scan scope for verification. A highly damped transducer rings for a much shorter time, allowing the TI-25DL-MMX to measure thinner material thicknesses in echo-echo mode. This same transducer is equally effective when used in pulse-echo mode, eliminating the need to use different transducers for each mode. The new

TI-25DL-MMX gives you all these features in a simple to use, one button toggle, digital thickness gauge. The following steps outline the procedure for setting up this feature:

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press MODE key to activate features and settings.
3. Press the UP or DOWN arrow keys to scroll to GAtE.
4. Press the SEND key to toggle between modes (E-E, P-E).
5. Press the MODE key once again to return to measurement mode.

6.0 QUICK START INSTRUCTIONS — STEEL THICKNESS

These Quick Start procedures are intended for those applications where the thickness of steel is to be measured. If a material other than steel will be measured, the gauge must be calibrated for use on this particular material. Refer to Sections 5.0 for additional details.

Quick Start Instructions

1. Turn on the power by pressing the ON/OFF key.
2. Plug the probe cable into the receptacle at the top of the gauge.
3. Place a drop of coupling fluid on the built-in Probe Zero Plate.
4. Grasp the probe and place it on top of the Probe Zero Plate. Apply moderate pressure to the top surface of the probe with your index finger or thumb to stabilize the probe and to keep the wearface seated flat against the measurement surface.
5. The display will show some thickness value and the Stability Indicator will have most of its bars illuminated.
6. While keeping the probe on the Probe Zero Plate, press the PROBE 0 key. The display will show a value that can be recorded for future use.
7. Remove the probe from the Probe Zero Plate. The gauge is now ready to perform thickness readings on steel samples.
8. Place a small amount of coupling fluid on the steel surface to be measured and proceed as explained in step #4 above.
9. The gauge will display the thickness of the steel wall along with the Stability Indicator showing the relative stability of the reading. If fewer than five (5) bars are illuminated, the thickness reading displayed is most likely inaccurate.

Notes

- a. When the probe is removed from the sample after a measurement, the last reading will be retained on the display.
- b. Occasionally, a small film of couplant will be drawn out between the probe and the surface as the probe is removed. When this happens, the TI-25DL-MMX may perform a measurement that is larger or smaller than it should be. This phenomenon is obvious when one thickness value is observed while the probe is in contact with the material, and another value after the probe is removed.
- c. The gauge will automatically power off after 5 minutes of non-use.

7.0 CHANGING UNITS (IN/MM)

The TI-25DL-MMX has the ability to display measurements in both the English (IN) and Metric (MM) systems. The following steps outline the procedure for changing units:

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press the MODE key to activate features and settings.
3. Press the UP or Down arrow keys to scroll to the unit symbol.
4. Press the SEND key to toggle the status of the units— IN / MM.
5. Press the MODE key once again to return to measurement mode.

8.0 THE BACK LIGHT

The back light of the TI-25DL-MMX can be set to three different positions on/off/auto. The following steps outline the procedure for changing the settings of the back light:

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press the MODE key to activate features and settings.
3. Press the UP / Down arrow keys to scroll to the LIte symbol.
4. Press the SEND key to toggle the status of the back light on/off/auto.
5. Press the MODE key once again to return to measurement mode.

9.0 SCAN MODE

While the TI-25DL-MMX excels at making single point measurements, it is sometimes desirable to examine a larger region, searching for the thinnest point. The TI-25DL-MMX includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the TI-25DL-MMX performs and displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the tool performs sixteen measurements every second. While the transducer is in contact with the material being measured, the TI-25DL-MMX 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 a second, the TI-25DL-MMX will display the smallest measurement it found.

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press the MODE key to activate features and settings.
3. Press the UP / Down arrow keys to scroll to the SCAN symbol.
4. Press the SEND key to toggle the scan mode on/off. of the back light on/off/auto.
5. Press the MODE key once again to return to measurement mode.

10.0 ALARM MODE

The Alarm Mode feature of the TI-25DL-MMX allows the user to set an audible and visual parameter when taking measurements. If the measurement falls below a nominal value, set by the user, a red light will be illuminated on the front panel of the gauge and the beeper sounded. This improves the speed and efficiency of the inspection process by eliminating constant viewing of the actual reading displayed. The following procedures outline how to enable and set up this feature:

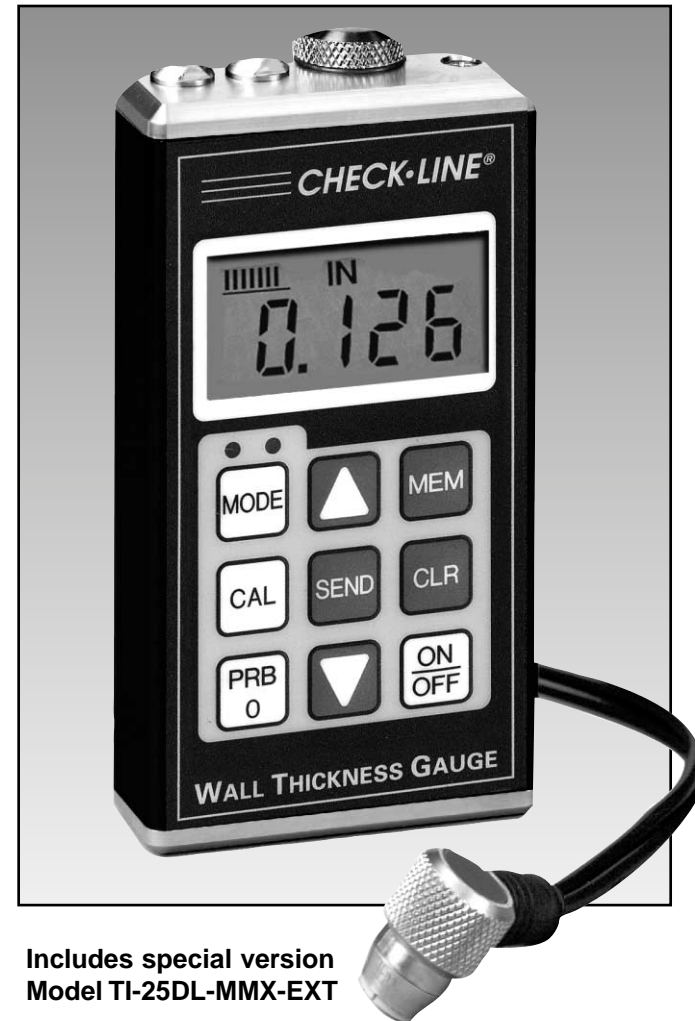
Using the Beeper

1. Press ON/OFF key to power up the unit.
2. Press MODE key to activate features and settings.
3. Press the UP or DOWN arrow keys to scroll to bEEP.
4. Press the SEND key to toggle the status of the beeper on/off.
5. Press the MODE key once again to return to measurement mode.

Alarm Mode

1. Press ON/OFF key to power up the TI-25DL-MMX.
2. Press the MODE key to activate features and settings.
3. Press the UP / Down arrow keys to scroll to the ALAr symbol.
4. Press send key to toggle ALAr status on/off.
5. Status ON -A nominal value will be displayed with the units IN/MM flashing.
6. Press the UP or DOWN arrow keys to scroll to the desired nominal thickness value.
7. Press the SEND key to select the desired nominal value and return to mode menu.
8. Press the MODE key once again to return to measurement mode.

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