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1.0 INTRODUCTION

The Electromatic TI-CMX is an ultrasonic thickness gauge that measures with extreme versatility. It has the ability to simultaneously measure coatings and material thicknesses while maintaining the ability to locate pits, flaws and defects in the material. Based on the same operating principles as SONAR, the TI-CMX 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.

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 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.

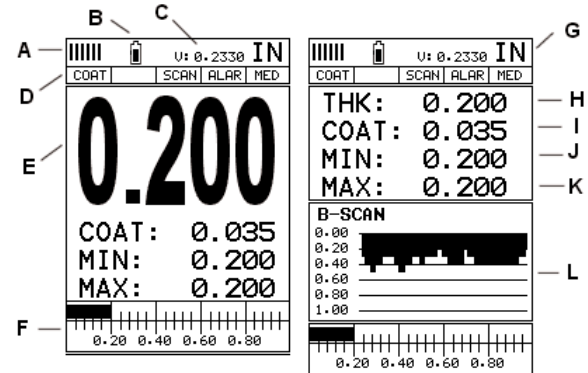
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2.0 QUICK-START GUIDE

Turn the TI-CMX on and off using the switch located on the bottom right corner of the keypad. When TI-CMX is initially turned on, a flash logo and blinking lights are displayed. Then the gauge attempts to identify the currently attached transducer (probe). The TI-CMX has an “Auto Probe Recognition” feature that attempts to identify special transducers with feature built in. If the TI-CMX doesn’t find a transducer so equipped, the user must select a transducer from the Probe Type list. The following sections outline each scenario.

NOTE: This section is primarily written as a basic startup guide only.



CMX SERIES SCREEN SHOTS

2.1 TI-CMX Overview

In order to understand how to operate the TI-CMX, it’s best to start off with an understanding of what it is we’re looking at exactly. The TI-CMX has a lot of great features and tools that will prove to be a huge benefit for the variety of applications you’re constantly facing on a continual basis. Let’s have a brief look at the screens you’ll be looking at most often:

- A. Repeatability/Stability Indicator** – This indicator should be commonly used in conjunction with the digital thickness values displayed. When all the vertical bars are fully illuminated and the last digit on the digital thickness value is stable, the TI-CMX is reliably measuring the same value 3 to 200 times per second, depending on which measurement mode and features are enabled.
- B. Battery Icon** – Indicates the amount of battery life the TI-CMX has remaining.
- C. Velocity** – The material velocity value the TI-CMX is currently using or calibrated for. Displayed in English or Metric units, depending on the what units the gauge is set for.
- D. Feature Status Bar** – Indicates the features currently enabled and in use in the following order:
 - Measurement Mode
 - Differential Mode
 - High Speed Scan Mode
 - Alarm Mode
 - Gain Setting
- E. Digital Material Thickness Value** – Extra large font size for viewing ease.

- F. **Scan Bar** – Another view of material thickness in a deflection style horizontal bar. This visual tool enables the user the ability to see thickness changes during high speed scans from flaws and pits.
- G. **Units** – The current measurement units being used (English, Metric).
- H. **Digital Material Thickness Value** – Smaller font size when the B-Scan display view is enabled.
- I. **Coating Thickness Value** – Displays the actual thickness of any coating adhered to a metallic material surface (PECT Mode), or a coating adhered to a non-metallic surface (CT Mode).
- J. **Minimum Material Thickness** – Part of the Alarm feature. Displays the minimum thickness value found during a scan.
- K. **Maximum Material Thickness** – Part of the Alarm feature. Displays the maximum thickness value found during a scan.
- L. **B-Scan Display** – Cross section view of the material. Provides the user with graphical view of the opposite/blind surface (i.e. inside pipe wall surface), to give the user some idea of the condition, or integrity of the material being tested.

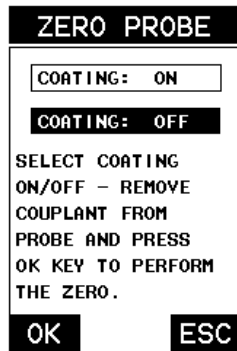
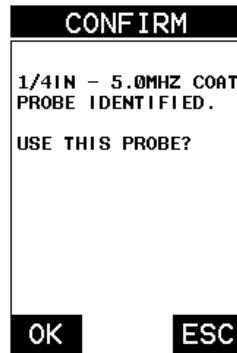
2.2 Auto Probe Recognition

When the TI-CMX is initially powered up, the gauge will automatically check to see if the transducer plugged into the gauge can be recognized. The steps that follow assume the TI-CMX recognized the probe type:

1. Press the **OK key** once to use the identified probe, or **ESC** to display a list of optional transducers.

NOTE: If the TI-CMX recognizes a specific transducer, the user should always select OK to use the identified probe. The only time an alternative probe should be selected from a list is if the user switched probes following initial power up and recognition.

2. Assuming the TI-CMX recognized the probe and the **OK key** was pressed, the TI-CMX will advance to a Zero Probe menu. If the transducer was identified as a special transducer capable of measuring coating thickness, a menu will be displayed allowing the user the ability to toggle the coating thickness display on/off as follows:
3. Press the **UP** and **DOWN** arrow keys to toggle the coating option on/off.
4. Wipe all couplant from the transducer face and advance to the Probe Zero & Calibration section, 6.0.



NOTES

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, notwithstanding, this warranty, in the absence of such limitations, shall extend for one year from the date of invoice.

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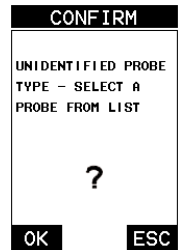
Every precaution has been taken in the preparation of this manual. Electromatic Equipment Co., Inc., assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of information contained herein. Any brand or product names mentioned herein are used for identification purposes only, and are trademarks or registered trademarks of their respective holders.

2.3 Selecting the Transducer Type

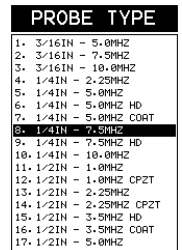
If the TI-CMX does not identify a specific transducer type on initial power up, the user will be required to select a type from a predefined list of types by diameter and frequency. By selecting a transducer type from a predefined list, the TI-CMX can recall specific properties about the transducer.

NOTE: Once the transducer has been selected, the TI-CMX will store and recall this transducer type every time the TI-CMX is powered on/off. The type will only change if the user physically selects another transducer type from the list, or selects a previously saved setup. However, the TI-CMX will continue to take you through these steps each time the gauge is powered up. You'll notice that the probe type previously selected will be highlighted every time the probe type screen is displayed. Use the following steps to select your transducer type:

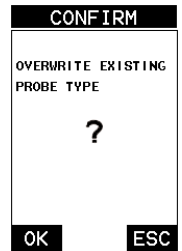
1. Press the OK or ESC keys to display the factory list of transducer types (by diameter and frequency).



2. Press the UP and DOWN arrow keys to scroll through the transducer list until the appropriate type is highlighted.



3. Press the ENTER key to select the transducer type and display over write existing probe screen.
4. Press the OK key to overwrite the existing probe type with the newly selected probe type. The zero probe screen will be displayed. Proceed to the zero probe section that follows.



2.4 Probe Zero & One Point Calibration

The next steps are to perform a probe zero and calibrate the TI-CMX to the material and transducer being used. If the sound velocity is unknown, the TI-CMX can be calibrated to a known thickness sample. This demo will briefly explain both of these techniques.

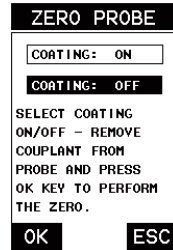
The TI-CMX is equipped with two zero options:

- **Off Block Zero (Automatic Probe Zero)** – When this feature is enabled the TI-CMX will do an electronic zero automatically, eliminating the need for a zero disk or block.
- **On Block Zero (Manual Probe Zero)** – When this feature is enabled the transducer must be placed on the probe zero disk (battery cover located on the top of the unit).

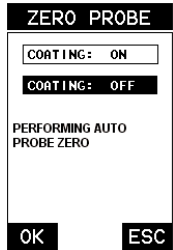
Both zero procedures are outlined as follows:

Off Block Zero (Automatic Probe Zero)

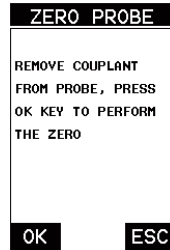
1. Be sure all couplant has been removed from the face of the transducer.
2. Press the **OK** key to perform the automatic probe zero, or **ESC** key to cancel the zero operation.
3. The screens illustrated at the right will be briefly displayed followed by the main measurement screen. The TI-CMX is ready to be calibrated.



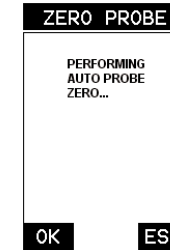
Coating Probe Identified



Coating Probe Identified



Coating Probe Not Identified

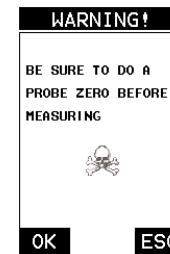


Coating Probe Not Identified

Performing a Manual Probe Zero (On Block)

NOTE: When the zero probe option is set to manual, the probe zero disk (battery cap) located on the top of the gauge, will be used as a zero standard and the warning screen illustrated above will be displayed.

1. Press the **OK** or **ESC** keys to enter the main measurement screen and begin the manual zero process.
2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the probe zero disk, and obtain a steady reading.



APPENDIX A: 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
Steel Stainless"	0.2230		5664
Teflon	0.0540		1372
Tin	0.1310		3327
Titanium	0.2400		6096
Tungsten	0.2040		5182
Uranium	0.1330		3378
Water	0.0580		1473
Zinc	0.1660		4216
Zirconium	0.1830		4648

12.0 USING THE UTILITY SOFTWARE

12.1 Computer System Requirements

Datacomm will run on many different operating systems: Windows 98 (1st or 2nd edition), Windows NT 4.0 with Service Pack 5, Windows ME, Windows XP, Windows 2000 Professional, Windows 2000 Server, or Windows 2000 Advanced Server operating systems running on Intel or AMD hardware.

A Pentium 166MHz or faster processor with at least 32 megabytes of physical RAM is required. You should have 40 megabytes of free disk space before attempting to install Datacomm.

Datacomm requires an available communications port in order to transfer data to and from the TI-CMX. Datacomm supports COM1, COM2, COM3, and COM4.

USB to Serial Converter

Some newer laptop computers do not have standard serial ports. In this case it is possible to use a USB to Serial converter. If a serial to USB cable is needed, contact Electromatic

12.2 Installing Datacomm

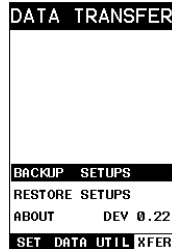
Datacomm comes on a CD-ROM with an automatic installer program. Place the CD in your computer's CD tray and close the door. Open the CD-ROM by double clicking on the My Computer ICON, then double click on the CD. Finally, double click on the SETUP icon to begin the installation.

Refer to the help section in Datacomm software for the complete operating manual, setup, and operation.

12.3 Using the XFER menu (TI-CMX)

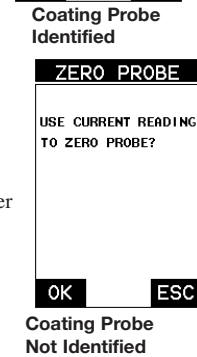
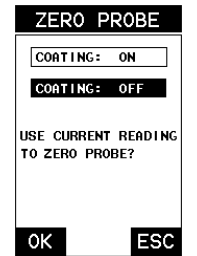
The XFER menu of the TI-CMX will be used in conjunction with the Datacomm PC software. The steps below outline the procedure for accessing the XFER menu and basic operation as follows:

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the XFER menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until the desired option is highlighted.
3. Press the **ENTER** key to activate the option selected.
4. Once the Backup or Restore function has been completed, press the **MEAS** key once to return to the menu items, or twice to return to the measurement mode.



3. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **PRB** menu is highlighted and displaying the submenu items.
4. Press the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **ZERO PROBE** is highlighted.
5. Press the **ENTER** key to display the confirmation screen.
6. If a coating transducer was identified use the **UP** and **DOWN** arrow keys to toggle coating on/off.
7. Press the **OK** key to complete the probe zero function, or **ESC** key to cancel the probe zero function.
8. Remove the transducer from the probe zero disk, and proceed to the calibration section.

NOTE: The value that is displayed will change depending on the current velocity setting in the TI-CMX. Disregard the number that is displayed. It is not important. What is important is accurately performing the steps outlined above to insure reliability of the probe zero calculation.

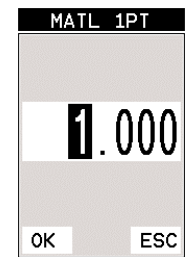
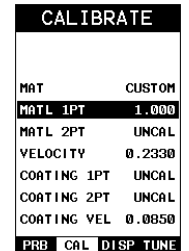


One Point Material Calibration

For the purposes of this quick start section, we'll only be covering the most common one point calibration option to determine the sound velocity of the test material. It would be very handy to carry a set of mechanical calipers to use in conjunction with the TI-CMX for calibration in the field:

NOTE: Be sure that the probe zero procedure has been performed prior to performing this calibration procedure.

1. Physically measure an exact sample of the material or a location directly on the material to be measured using a set of calipers or a digital micrometer.
2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the sample or actual test material. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
3. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **MATL 1PT** is highlighted.
4. Press the **ENTER** key to display the Digits Edit Box.
5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.



7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.
8. Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the one point calibration.
9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

NOTE: CHECK YOUR CALIBRATION! Place the transducer back on the calibration point. The thickness reading should now match the known thickness. If the thickness is not correct, repeat the steps above.

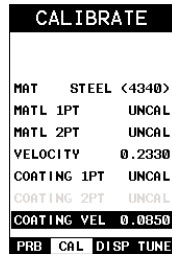
2.5 Coating Calibration

The TI-CMX has been preset to a default coating velocity of 0.0850 in/μsec (2159 m/sec). This will be very close to the most common coating material velocities used in the field. If the velocity of the coating is known, and different than the above default setting, the user can simply enter the coating velocity into the TI-CMX. However, if the velocity is unknown, the TI-CMX can also be calibrated to a specific coating sample/type using the 1pt calibration option in PECT (pulse-echo coating) mode, or a two point calibration is CT (coating only) mode. For the purpose of this quick start section only the 1pt option PECT (pulse-echo coating) mode will be covered. Refer to the calibration section of the manual for a complete explanation on the coating calibration options. The following steps below outline the necessary steps to either set the velocity of the coating, or perform a one point calibration to calculate the coating velocity:

Known Coating Velocity

If the coating velocity is known, the user may wish to simply enter the velocity number into the TI-CMX, rather than have the TI-CMX calculate the velocity value using a known thickness on a coating sample. The steps for entering the velocity are outlined below:

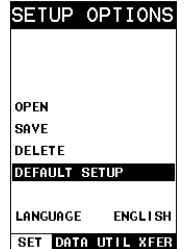
1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **COATING VEL** is highlighted.
3. Press the **ENTER** key to display the Digits Edit Box.
4. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
5. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
6. Repeat steps 4 & 5 until the velocity number is correctly displayed.
7. Press the **OK** key to set the coating velocity and return to the menu screen, or **ESC** to cancel entering the coating velocity.
8. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings



11.5 Using the Default Setup

The default setup feature was added to the CMX to use, as a last resort, if there are no setups stored in the gauge –factory or otherwise. The only time this might possibly occur is if the setup file in the CMX was somehow corrupted, and the user does not have access to a computer to re-load the factory setups back into the CMX. This gives the user the ability to load and modify a basic setup as follows:

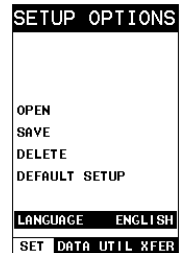
1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **SETUP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **DEFAULT SETUP** is highlighted.



11.6 Selecting a Language

The CMX is equipped with a language option. Currently, the only languages supported are English, Spanish, and German. The steps to select one of these languages are outlined as follows:

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **SETUP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **LANGUAGE** is highlighted.
3. Press the **LEFT** and **RIGHT** arrow keys to toggle the language options.
4. Once the desired language is displayed, press the **MEAS** key to return to the measurement screen.



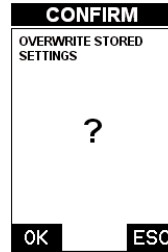
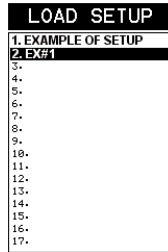
10. Press the **ENTER** key to activate the Setup List Box.

11. Use the **UP** and **DOWN** arrow keys to scroll through the setups until the target location to save the Setup is highlighted.

12. Press the **OK** key to activate the confirmation screen.

13. Press the **OK** key to save the Setup, or **ESC** to cancel saving the Setup.

14. Finally, press the **MEAS** key to return to the measurement screen.



NOTE: The Name and Comments of the Setup can be edited at any time by simply repeating the Save Setup routine described above. Therefore, the Save Setup function can also be considered an Edit Function.

11.4 Deleting a Saved Setup

This option allows a user to delete setup files that were previously saved and no longer needed. It's a simple feature to allow the user to do a bit of "house cleaning".

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **SETUP** menu is highlighted and displaying the submenu items.

2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **DELETE** is highlighted.

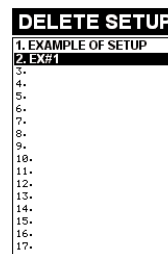
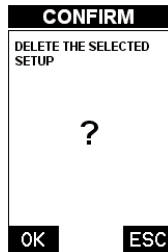
3. Press the **ENTER** key to display the Setups List.

4. Press the **UP** and **DOWN** arrow keys to scroll to the Setup Name.

5. When the Setup Name is highlighted, press the **ENTER** key to display the confirmation screen.

6. Press the **OK** key to delete the Setup File.

7. Finally, press the **MEAS** key to return to the measurement screen.



Known Coating Thickness

When the exact velocity of a coating is unknown, the user has the option of performing a one point calibration on a sample of the coating with a known thickness to determine the sound velocity. It would be very handy to carry a set of mechanical calipers to use in conjunction with the TI-CMX for calibration in the field:

1. Physically measure a location on a coating sample using a set of calipers or a digital micrometer.

IMPORTANT NOTE: In PECT (pulse-echo coating) mode, the coating sample must be coupled to metal in order to calibrate successfully. Simply place a drop of couplant on a piece of metal, lay the coating sample over the couplant on the metal and proceed to step 2.

2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the coating (on metal) sample or actual test material. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the sub menu items.

3. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **COATING 1PT** is highlighted.

4. Press the **ENTER** key to display the Digits Edit Box.

5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.

6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.

7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.

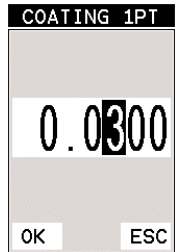
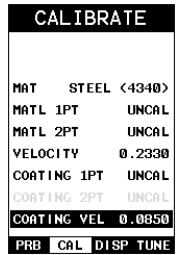
8. Press the **OK** key to calculate the coating velocity and return to the menu screen, or **ESC** to cancel the one point calibration.

9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

NOTE: CHECK YOUR CALIBRATION! Place the transducer back on the calibration point. The coating thickness reading should now match the known coating thickness sample. If the thickness is not correct, repeat the steps above.

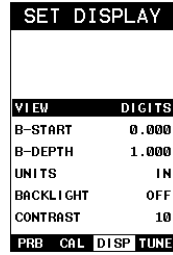
2.6 Measure

The TI-CMX is now ready to measure. There are two different measurement view options, each with a specific purpose – Digits & B-Scan. The steps below outline how to toggle between the different view mode options:



Selecting the Measurement View Option

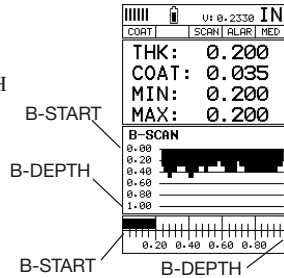
1. Press the **MEU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **DISP** menu is highlighted and displaying the sub menu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **VIEW** is high lighted.
3. Use the **LEFT** and **RIGHT** arrow keys to scroll the view options.
4. Once the view is displayed, press the **MEAS** key to return to measurement mode.



DIGITS: Displays the digital thickness value using a large font size. This view is useful when the TI-CMX is being used as a basic thickness gauge.

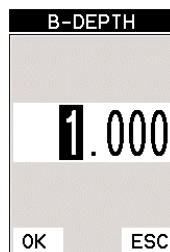
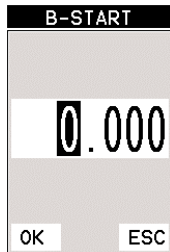
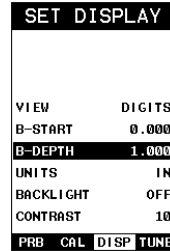
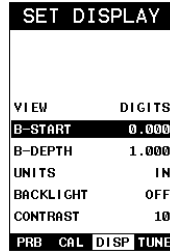
B-SCAN: The Time Based B-Scan provides the user with a cross sectional view of the material being tested. This mode is useful when there is concern regarding the profile of the blind surface. This can also be a useful view when scanning for pits and flaws.

Once the view has been selected according to the application requirements, the B-START and B-DEPTH of the screen will potentially need to be adjusted if the view has been set to B-SCAN. Use the following steps to adjust these as follows:



Adjusting B-START and B-DEPTH

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **DISP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until B-START or B-DEPTH is highlighted.
3. Use the **LEFT** or **RIGHT** arrow keys to increase/decrease the start or depth values in coarse increments/decrements.
4. Repeat steps 2 & 3 until the range is correctly being displayed.

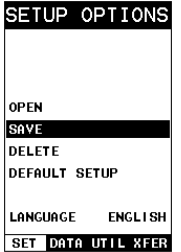


11.3 Saving a Setup

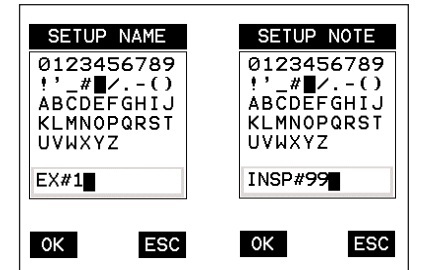
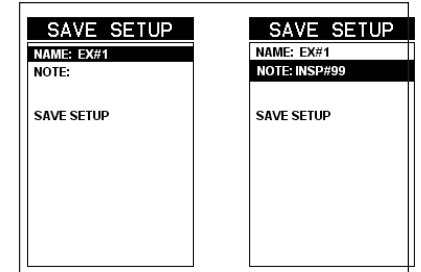
Once the TI-CMX parameters and features have been adjusted for an application, the user may elect to save these settings to a specific setup location for future use. This can potentially save time and reduce error between users.

It is sometimes necessary to rename a previously saved setup, or add additional comments about a particular setup. The setup name may have been entered incorrectly, or the user needs to use the setup for a completely different project. An inspector's name or other comments about the project may also be required for additional documentation purposes. The following procedures outline the necessary steps for saving and editing a setup:

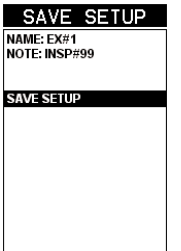
1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **SETUP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **SAVE** is highlighted.
3. Press the **ENTER** key to display the Save Setup Parameters List Box.



4. Press the **UP** and **DOWN** arrow keys to scroll the Name and Note
5. When the parameter to edit is highlighted, press the **ENTER** key to activate the Alpha Edit Box.
6. Use the **UP**, **DOWN**, **LEFT**, and **RIGHT** arrow keys to scroll through the characters, the **ENTER** key to select characters, and the **CLR** key to backspace through the characters, until the Name or Note fields have been edited.
7. Press the **OK** key to return to the Save Setup Parameters List Box.
8. If both parameters will be edited, repeat steps 4 - 7.



9. Use the **UP** and **DOWN** arrow keys to scroll to and highlight **SAVE SETUP**.



11.0 SETUPS, CREATE, STORE, EDIT & RECALL

11.1 Introduction to Setups

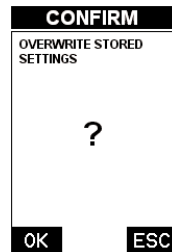
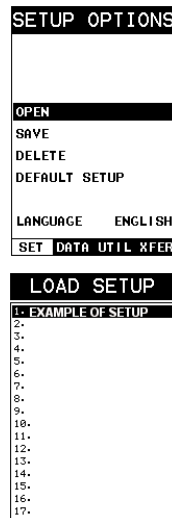
Often times, users are faced with a variety of tasks and applications that are sometimes similar, but often times very different. With a standard thickness gauge, the user would have to recalibrate for each individual application respectively. With all the features of the TI-CMX, the number of potential applications also increases based on ability alone. This is primarily in reference to the addition of those very difficult applications, where a standard thickness gauge would not be feasible, or capable of accomplishing the tasks.

The increased number of features and parameters also adds to the overall setup time, or amount of time to set up marginal applications with perfection and understanding. Because of the additional time involved, the TI-CMX has been equipped with the ability to save these setups to memory and be recalled at any time. The TI-CMX can store up to 64 custom setups. These setups can be bi-directionally transferred to and from a PC. Therefore, the user can save as many setups as necessary for all their individual applications requirements. This saves a great deal of time and knowledge for future inspections of the same job or project. This feature also eliminates error between two or more users during the setup and calibration process.

11.2 Opening a Setup

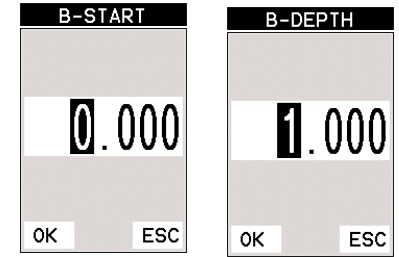
Once user setups are saved (refer to Section 11.3, p. 47), they are opened (recalled for use) using the following procedure. Please make sure that the correct probe is connected and matches the probe selection stored in this setup.

1. Press the **MENU** key once to activate the menu items tab.
Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **SETUP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **OPEN** is highlighted.
3. Press the **ENTER** key to display the Setup List Box.
4. Use the **UP** and **DOWN** arrow keys to scroll through the setups until the target setup is highlighted.
5. Press the **ENTER** key to activate the confirmation screen.
6. Press the **OK** key to load the setup from memory.
7. Press the **MEAS** key to return to the measure screen.



Alternatively, the B-START and B-DEPTH values can be changed using the Digit Edit Box as follows:

1. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until B-START or B-DEPTH is highlighted.
2. Press the **ENTER** key to display the digits edit box.
3. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
4. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
5. Repeat steps 3 & 4 until the B-START or B-DEPTH value is correctly displayed.
6. Press the **OK** key to set the B-START or B-DEPTH value and return to the DISP menu, or **ESC** to cancel entering the B-START or B-DEPTH value.

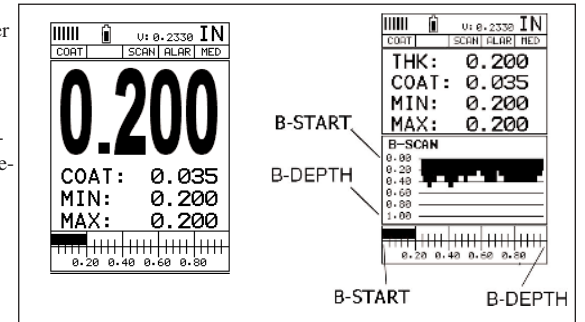


NOTE: The adjusted value will appear next to the B-START or B-DEPTH menu labels.

7. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

In the upper left corner of each of the display photos at the right, is the repeatability indicator. The repeatability indicator is represented by six vertical bars and represents how repeatable the measurements are. In regular measurement mode, the TI-CMX makes eight measurements

a second. In scan mode, the TI-CMX makes 200 measurements a second. If the coating mode option is activated, the TI-CMX makes three measurements a second in regular measurement mode and 65 measurements a second in scan mode. When the TI-CMX is idle, only the left vertical bar and the underline will be displayed. However, when the TI-CMX is making a measurement, five or six of the bars should be displayed on the repeatability indicator. If fewer than five bars are showing, the TI-CMX is having difficulty achieving a stable measurement and the thickness value displayed is potentially unstable.



3.0 KEYBOARD, MENU & CONNECTOR REFERENCE

3.1 Menu Key (Operation & Sub Menus)

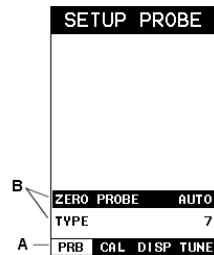
MENU The Menu key activates the primary menu structure containing 8 menu tab groups. These tab groups then contain sub menu items, or functions. The sub menu items have been organized in tab groups according to how closely they are related to the individual tab group names. Let's first get familiar with how to move around in these tabs before continuing on to the sub menu functions. This procedure is outlined below:



Activating and Getting Around in the Menu Items

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left until the desired tab group is highlighted and displaying the submenu items. The tab groups are illustrated above (A).

Now that you're familiar with activating and moving amongst the tab groups, let's have a look at how to move around in the sub menu items as follows:

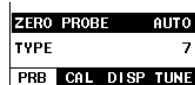


Getting Around in the Sub Menu Items

1. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until the desired function is highlighted. The sub menu items are illustrated in the diagram above (B).
2. Depending on which function is highlighted, use the **LEFT**, **RIGHT**, and **ENTER** keys to scroll the options or activate the Digit Edit and List Box options.

3.2 Probe – Menu

ZERO PROBE: The TI-CMX is zeroed in much the same way that a mechanical micrometer is zeroed. If the TI-CMX is not zeroed correctly, all of the measurements made using the TI-CMX may be in error by some fixed value. The TI-CMX is equipped with an optional automatic or manual zero feature. Refer to the section 6.3, for an explanation of this important procedure.

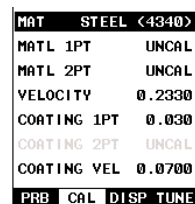


TYPE: Enables the user to select the type of transducer being used from a chart of transducer types. This provides increased linearity between transducers. Refer to section 6.1 for a further explanation.

3.3 CAL – Menu

MAT: Select the material velocity from a chart of basic material types when a known sample thickness, or material velocity cannot be obtained. Refer to section 9.3 for further info.

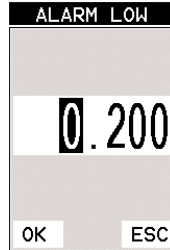
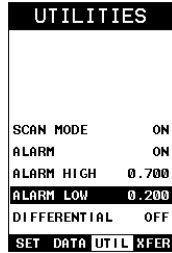
MATL 1PT: Performs a single point calibration. This option allows the user to automatically calculate the velocity by entering a known sample thickness. Refer to section 9.3 for further info.



3. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
4. Repeat steps 2 & 3 until the DIFFERENTIAL value is correctly displayed.
5. Press the OK key to set the DIFFERENTIAL value and return to the menu screen.
6. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

Setting the Alarm Low Limit

1. Assuming the ALARM is ON, use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **ALARM LOW** is highlighted.
2. Press the **LEFT** and **RIGHT** arrow keys to scroll the value. When the correct alarm value is being displayed, proceed to step 7.
3. Alternatively, press the **ENTER** key to display the Digits Edit Box.
4. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
5. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
6. Repeat steps 4 & 5 until the **ALARM LOW** value is correctly displayed.
7. If only one limit will be used, press the **MEAS** key to return to the measurement screen and begin taking readings. Otherwise, continue on to set the **ALARM HIGH** limit.

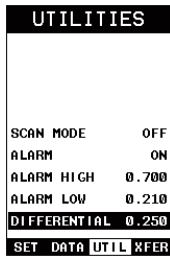


10.3 Differential Mode

The Differential Mode of the TI-CMX provides the user with the ability to set a nominal value, according to what the expected thickness should be, and measure the +/- difference from the nominal value entered. This feature is typically used in QA incoming inspections on pipes, plate stock, coils, etc. The steps below outline how to enable and enter the nominal value to use this feature:

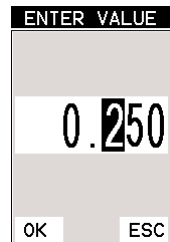
Toggle Differential (on/off)

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the **UTIL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **DIFFERENTIAL** is highlighted.
3. Use the **LEFT** and **RIGHT** arrow keys to toggle the **DIFFERENTIAL** on. A value will appear to the right of **DIFFERENTIAL**.
4. Continue on to the next section "Setting the Differential Value".



Setting the Differential Value

1. Assuming **DIFFERENTIAL** has been enabled and a value is being displayed to the right of the **DIFFERENTIAL** label, press the **ENTER** key to display the Digits Edit Box.
2. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.



MATL 2PT: Performs a two-point calibration. This option allows the user to automatically calculate the velocity by entering a second known sample thickness. Refer to section 6.3 for further info.

VELOCITY: Function is to calibrate the TI-CMX by setting the velocity to a known material velocity. Refer to section 6.3 for further info.

COATING 1PT: Performs a single point coating calibration. This option allows the user to automatically calculate the velocity by measuring a known coating sample thickness. Refer to section 9.5 for further info.

COATING 2PT: Performs a two-point coating calibration. This option allows the user to automatically calculate the velocity by entering a second known coating sample thickness. Refer to section 9.5 for further info.

COATING VEL: Function to calibrate the TI-CMX to a specific coating material type by entering a coating velocity. Refer to section 9.3 for further info.

3.4 DISP (display) – Menu

VIEW: Selectable B-SCAN (cross section), and DIGITS (large digits) views. Refer to section 7.1 for further info.

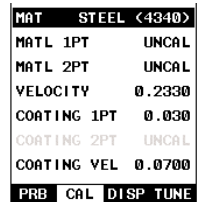
B-START: Provides the user the ability to change the start position of the B-SCAN view. Refer to section 7.3 for further info.

B-DEPTH: Provides the user the ability to change the overall depth of the viewable measurement area. It functions a lot like a zoom on a camera. Refer to section 7.3 for further info.

UNITS: Toggle between English or Metric units. The readout will change from inches to millimeters.

BACKLIGHT: Selectable OFF, ON, AUTO, or INVERT backlight option.

CONTRAST: Adjustable display contrast for variable light conditions.



3.5 TUNE – Menu

MEASURE MODE: Toggles a variety of unique measurement modes for different application requirements. Refer to section 11.2 for further info.

GAIN: A 5 position gain switch in 2 db increments from 40 to 50 dB. Increase for better penetration or punch, and decrease to eliminate unwanted noise or better resolution. Refer to section 11.2 for further info.



3.6 SETUP – Menu

OPEN: Displays a list of factory and user defined setups currently stored in memory. These setups can be recalled and used at any time. Refer to section 11.2 for further info.

SAVE: Provides the user with the ability to save a custom setup that has been modified or created by the user. Refer to section 11.2 for further info.

DELETE: Provides the user with the ability to delete specific setups previously save in memory. Refer to section 11.2 for further info.



DEFAULT SETUP: Loads a basic default setup. Use only as a last resort when the setups in the TI-CMX have been corrupted and a computer is not accessible. Refer to section 11.4 for further info.

LANGUAGE: Provides the user the ability to select different languages for the TI-CMX. Refer to section 11.4 for further info.

3.7 UTIL (utilities) – Menu

SCAN MODE: This function enables a hi speed scan mode that increases the overall sample rate from 65 to 200 measurements per second, depending on the current measurement mode used. Refer to section 10.2 for further info.

ALARM: Toggles alarm mode on, off, or audible. Refer to section 10.3 for further info.

ALARM HIGH: Gives the user the ability to set the HI limit parameter. If the measurement exceeds this value, a red light will illuminate and sound the internal beeper. Refer to section 10.1 for further info.

ALARM LOW: Gives the user the ability to set the LO limit parameter. If the measurement falls below this value, a red light will illuminate and sound the internal beeper. Refer to section 11.4 for further info.

DIFFERENTIAL: Gives the user the ability to set a nominal value and the TI-CMX will display \pm the difference from the nominal value entered. Refer to section 10.2 for further info.

SCAN MODE	OFF
ALARM	OFF
ALARM HIGH	0.700
ALARM LOW	0.210
DIFFERENTIAL	OFF
SET DATA UTIL XFER	

3.8 XFER (transfer) – Menu

BACKUP SETUPS: Enables the user the ability to backup the setups currently stored in the TI-CMX to a PC via RS232 port. Refer the help section of the TI-CMX Datacomm software for a complete electronic manual.

RESTORE SETUPS: Enables the user the ability to restore the setups currently saved on a PC to an TI-CMX via RS232 port. Refer the help section of the TI-CMX Datacomm software for a complete electronic manual.

ABOUT: Provides the user with Dakota Ultrasonics contact information and the TI-CMX software version. Refer the Dakota Ultrasonics web site for information on the latest firmware versions available for download.

BACKUP SETUPS	
RESTORE SETUPS	
ABOUT	DEV 0.21
SET DATA UTIL XFER	

3.9 CLR (clear) Key

CLR The CLR key is used to backspace when entering alpha characters in various save/name modes.

3.10 MEAS (measurement mode) Key

MEAS The MEAS key puts the TI-CMX into it's primary mode of operation. In this mode, the user has a complete view of the LCD.

10.0 ADDITIONAL FEATURES OF THE TI-CMX

10.1 High Speed Scan

The High Speed Scan feature of the TI-CMX increases the overall repetition rate to a maximum of 140Hz with a high speed screen refresh rate of 25 times a second. This feature enables a user to make scanned passes over an arbitrary length of the test material, while still maintaining a reasonable representation of thickness over the scanned area or region. This feature can be used in conjunction with High and Low alarm limits features

to dynamically keep track of both values. The feature is typically used to provide a better representation of the area scanned, by taking more readings at a faster rate repetition rate.

The procedure to use the SCAN MODE feature is outlined below:

Using the Scan Mode

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **UTIL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **SCAN MODE** is highlighted.
3. Use the **LEFT** and **RIGHT** arrow keys to toggle the **SCAN MODE** on/off.
4. Press the **MEAS** key to return to the measurement screen.

UTILITIES	
SCAN MODE	ON
ALARM	ON
ALARM HIGH	0.700
ALARM LOW	0.210
DIFFERENTIAL	OFF
SET DATA UTIL XFER	

10.2 Alarm Mode

The Alarm Mode feature of the TI-CMX provides the user with a method of setting tolerances, or limits, for a particular application requirement. This feature may be used for a variety of applications to verify the material is within the manufacturer specifications. There are two limits, or alarm values, that can be setup in the TI-CMX – ALARM LOW and ALARM HIGH limits. However, the user may choose to activate and utilize only one of the limit values, depending on their specific application requirements. The procedures to use the ALARM MODE feature are outlined below:

Toggle Alarm (on/off)

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the **UTIL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until ALARM is highlighted.
3. Use the **LEFT** and **RIGHT** arrow keys to toggle the **ALARM** on/off/audible.
4. Continue on to the next section "Setting the Alarm Low Limit".

UTILITIES	
SCAN MODE	ON
ALARM	ON
ALARM HIGH	0.700
ALARM LOW	0.200
DIFFERENTIAL	OFF
SET DATA UTIL XFER	

- Apply a drop of couplant on the transducer and place the transducer in steady contact with the thinner of the two coating and samples. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.

- Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **COATING 2PT** is highlighted.

- Press the **ENTER** key to display the Digits Edit Box.

- Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.

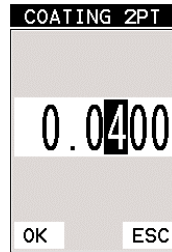
- Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.

- Repeat steps 5 & 6 until the known thickness value is correctly displayed.

- Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the coating one point calibration.

- Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

NOTE: CHECK YOUR CALIBRATION! Place the transducer back on both calibration points. The coating thickness readings should now match the known thickness values of each sample. If the thickness is not correct, repeat the steps above.



3.11 OK Key



The primary function of the OK key is confirmation of a change or selection.

3.12 ESC Key



The **ESC** key is used in the MENU, MEAS, and EDIT functions as a back or escape function.

3.13 Arrow Keys

The Arrow Keys are used to navigate through the menus, increase/decrease values, and toggle specific function keys.



3.14 ENTER key



The **ENTER** key is used in the menu navigation process to activate lists as well as edit boxes.

3.15 MULTI MODE Key



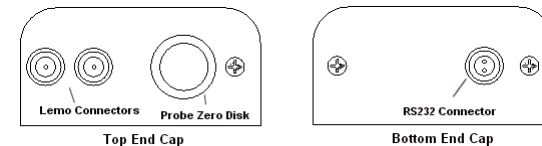
The **MULTI MODE** key opens a measurement mode screen listing all the modes that are available to the transducer specifically selected. The modes can be all or a combination of the entire set of modes the TI-CMX offers, depending on which transducer is being used as follows: Coating Off (P-E), Coating On (PECT), Temp Comp (PETP), Thru-Coat (E-E), and Coating Only (CT).

3.16 ON/OFF Key



The **ON/OFF** key simply powers the unit either ON or OFF. Note: Unit will automatically power off when idle for 5 minutes. All current settings are automatically saved prior to powering off.

3.17 Top & Bottom End Caps



The top & bottom end panels are where all connections are made to the TI-CMX. The diagram above shows the layout and description of the connectors:

Transducer Connectors

Refer to Diagram: The transducer connectors, and battery cover/probe zero disk are located on the TI-CMX'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-CMX.

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 disk. Simply remove the cover when replacing the batteries (3 AA cells). When performing a manual probe zero function, simply place the transducer on disk making firm contact.

IMPORTANT: Be sure to follow the polarity labels located on the back label of the TI-CMX.

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

RS-232 Connector

Refer to Diagram: The RS-232 connector, located on the bottom end cap, is a 2 pin female Lemo connector. It is designed to connect directly from the TI-CMX to a standard AT serial port on a PC. The cable supplied with the TI-CMX is a Lemo to 9 pin serial cable. Note: This connector is also used to upgrade the TI-CMX with the latest version of firmware.

USB Serial to USB Converter Cable

A converter cable can be attached to the 9 pin serial cable in needed (part no. N-402-0510).

One Point Calibration

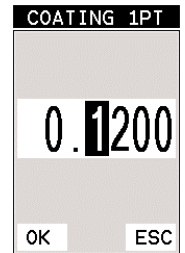
NOTE: Use the maximum coating sample for the one point calibration first.

1. Physically measure the thicker of the two samples of coating, as close as possible to the maximum expected coating measurement range, using a set of calipers or a digital micrometer.

Very Important: If coating measurements will be made with the coating applied to a metal surface, the calibration must be done in the same manner, with the samples coupled to a metal surface. However, if the coating will be measured as a stand alone material, the calibration must be performed the same way.

2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the thicker of the two coating and samples fist. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.

3. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **COATING 1PT** is highlighted.
4. Press the **ENTER** key to display the Digits Edit Box.
5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.
8. Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the coating one point calibration.
9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

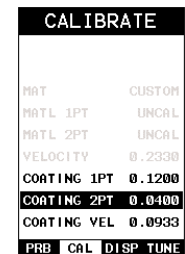


Two Point Calibration

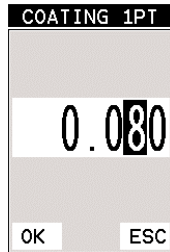
NOTE: Use the minimum coating sample for the two point calibration.

1. Physically measure the thinnest of the two samples of the coating, as close as possible to the minimum expected coating measurement range, using a set of calipers or a digital micrometer.

Very Important: If coating measurements will be made with the coating applied to a metal surface, the calibration must be done in the same manner, with the samples coupled to a metal surface. However, if the coating will be measured as a stand alone material, the calibration must be performed the same way.



2. Apply a drop of couplant on a piece of metal and place the coating sample on the metal over the couplant. Apply a drop of couplant on the transducer and place the transducer in steady contact with the coating and sample or actual test material. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the ESC key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
3. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until COATING 1PT is highlighted.
4. Press the **ENTER** key to display the Digits Edit Box.
5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.
8. Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the coating one point calibration.
9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.



NOTE: CHECK YOUR CALIBRATION! Place the transducer back on the calibration point. The coating thickness reading should now match the known thickness. If the thickness is not correct, repeat the steps above.

9.4 Introduction to Coating Measurement (CT)

In the previous sections we've discussed how to setup and use the coating feature for use in conjunction with material thickness and flaw and pit detection. The TI-CMX also has the capability to be used for general coating measurements. This measurement mode is called Coating (CT) and can be enabled using the same methods as described in a previous section above.

When the Coating Only (CT) mode is enabled, a two point calibration on the coating samples must be performed. This is to ensure linearity over the coating measurement range will be achieved. Important note: If coating measurements will be made with the coating applied to a metal surface, the calibration must be done in the same manner, with the samples coupled to a metal surface. However, if the coating will be measured as a stand alone material, the calibration must be performed the same way.

9.5 Two Point Coating Calibration (CT)

Known Thickness

The following section will demonstrate the two point coating calibration procedure. This example demonstrates a coating thickness range of .040" - .120" (1 – 3 mm) as follows:

NOTE: It's always handy to carry a set of mechanical calipers to use in conjunction with the TI-CMX for calibration in the field:

4.0 PRINCIPLES OF ULTRASONIC MEASUREMENT

4.1 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.

4.2 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.

4.3 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, the technique being used and the type of transducer. Thickness measurements can be made from a minimum of 0.010 inch to 9.999" in steel. However, the maximum attainable thickness is much less for more attenuative materials (materials that absorb sound).

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%.

4.4 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.

4.5 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 180°F.

High temperature measurements

Special transducers and couplants are available for temperatures above 180°F up to 650°F with intermittent contact. It is necessary to cool the transducer, by submerging the transducer in water between readings, when measuring high temperatures.

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 mode has larger errors due to changes in temperature of the delay line. However, in multi-echo techniques, auto temperature helps to minimize these errors.

4.6 Measurement Modes

In this section we will discuss the different measurements modes the TI-CMX is capable of operating in, the transducers required, and the reasons for using specific modes:

Pulse-Echo Mode (Flaw & Pit detection) – Coating Off (P-E)

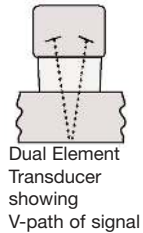
Pulse-echo mode measures from the initial pulse (sometimes referred to as an artificial zero) to the first echo (reflection). In this mode, either an automatic or manual zero can be performed depending on the zero probe function setting. If the manual mode has been selected, the transducer is placed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

In this mode errors result from surface coatings and temperature variations.

Since pulse-echo only requires one reflection, it is the most sensitive mode for measuring weak reflections (flaws) typically found when measuring heavily corroded metals.

V-Path Correction

Dual element delay line transducers have two piezoelectric elements mounted at an angle on one end of the delay line. One element is used for transmitting sound, while the other element only receives sound. The two elements and their delay lines are packaged in a single housing but acoustically isolated from each other with a 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 usable over a range of 0.025 inches to 20 inches 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.

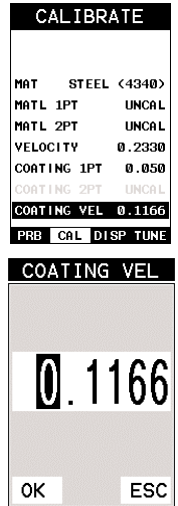
9.3 Coating Calibration (PECT)

Known Velocity

If the coating velocity is known, the user may wish to simply enter the velocity number into the TI-CMX, rather than have the TI-CMX calculate the velocity value using a known thickness on a coating sample(s). The steps for entering the velocity are outlined below:

Using a Known Material Velocity

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **COATING VEL** is highlighted.
3. Press the **ENTER** key to display the Digits Edit Box.
4. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
5. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
6. Repeat steps 4 & 5 until the velocity number is correctly displayed.
7. Press the **OK** key to set the velocity and return to the menu screen, or **ESC** to cancel entering the velocity.
8. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.



Known Thickness

Sometimes the sound velocity of a coating material is unknown. In this case a sample with a known thickness can be used to determine the sound velocity of the coating. As previously discussed, the TI-CMX offers a one point calibration option for coating in PECT measurement mode. It is also important to reiterate that the coating sample must be coupled to a metallic material in order to perform the calibration. The calibration should also consider calibrating on high side of the intended measurement range, when using the one point option, minimize overall error. For example, if the measurement range of the coating will be from .040" - .080" (1.0mm 2.3mm), a coating closest to .080 (2.0mm) should be used.

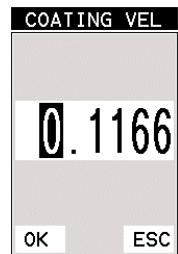
NOTE: It's always handy to carry a set of mechanical calipers to use in conjunction with the TI-CMX for calibration in the field:

One Point Calibration

NOTE: Be sure that the probe zero procedure has been performed prior to performing this calibration procedure.

1. Physically measure an exact sample of the coating using a set of calipers or a digital micrometer.

NOTE: The coating sample must be coupled to a metallic material in order to be calibrated.



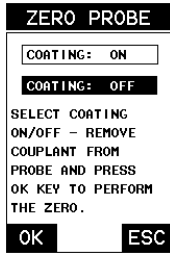
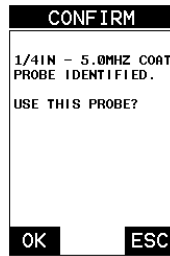
Probe Automatically Recognized (PECT only)

1. Press the OK key once to use the identified probe, or **ESC** to display a list of optional transducers.

NOTE: If the TI-CMX recognizes a specific transducer, the user should always select OK to use the identified probe. The only time an alternative probe should be selected from a list is if the user switched probes following initial power up and recognition.

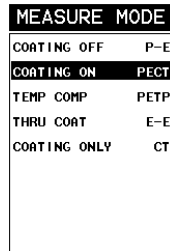
2. Assuming the TI-CMX recognized the probe and the **OK** key was pressed, the TI-CMX will advance to a Zero Probe menu. If the transducer was identified as a special transducer capable of measuring coating thickness, a menu will be displayed allowing the user the ability to toggle the coating thickness display on/off as follows:

3. Press the **UP** and **DOWN** arrow keys to toggle the coating option on/off.



Multi Mode Key Pressed (PECT & CT)

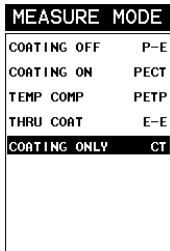
1. Press the **MULTI MODE** key located on bottom left of the keypad to display the MEASURE MODE options menu.



Applied to Metals

2. Press the **UP** and **DOWN** arrow keys to highlight the COATING ON (PECT) or COATING ONLY (CT) menu option.

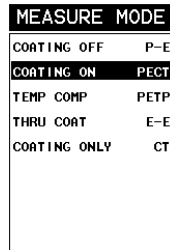
3. Press the **ENTER** key to enable the coating option, or **ESC** to cancel changing the measure mode, and return to the main measurement screen.



Not Applied to Metals

Measure Mode (Tabbed Menus) – (PECT & CT)

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the **TUNE** menu is highlighted and displaying the submenu items.

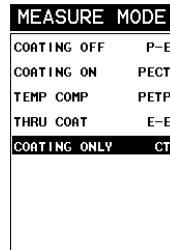


Applied to Metals

2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **MEASURE MODE** is highlighted.

3. Press the **LEFT** and **RIGHT** arrow keys to scroll the modes.

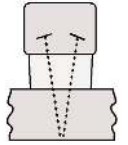
4. When the correct **MODE** is being displayed, press the **MEAS** key to return to the measurement screen and begin taking readings.



Not Applied to Metals

Searching for small defects

Dual element delay line transducers are especially useful in searching for small defects. In the pulse-echo mode with high amplifier gain, very small defects can be measured. This is very useful during corrosion inspections overall. The dual element style transducer will find wall deterioration, pits, and any porosity pockets during tank and pipeline inspections.



Dual Element Transducer in Echo to Echo mode

Echo-Echo Mode – Thru-Paint (E-E)

The echo-echo mode measures between two reflections. This technique is commonly used to eliminate errors from surface coatings and also to make measurements in multiple layered materials. The disadvantage is that two echoes are needed which requires a much stronger echo (reflection).

Pulse Echo Coating Mode – Coating On (PECT)

A custom hybrid combination mode using properties from the basic modes along with a group of special techniques and theoretical wave phenomena's to measure coating and material thicknesses at the same time, while still retaining the ability to locate flaws and pits in materials. Therefore, the best description for this hybrid mode is Pulse-Echo Coating mode.

Coating Mode – Coating Only (CT)

Once again, this is a custom hybrid combination mode using special techniques to effectively measure the thickness of coatings that are either adhered to metallic surfaces or in stand alone form. In this mode a two point calibration must be performed. If the user will be measuring coating that has been applied to a metal surface, the calibration must be performed using coating samples coupled to a metal surface when calibrating. To explain further, a drop of couplant must be applied in between the coating samples and metal surface. If the coating has not been applied to a metal surface, the calibration should be performed accordingly.

Pulse-Echo Temperature Compensated Mode – Temp Comp (PETP)

This is a custom mode that combines pulse-echo and electronic zero techniques to automatically adjust for temperature changes in the transducer as a result of an increasing/decreasing temperature gradient in the test material.

NOTE: Rough surface conditions can have an effect on the overall accuracy in this mode. If the surface condition is in question, the pulse-echo mode should be used in conjunction with performing an off block automatic zero as the temperature gradient changes.

5.0 SELECTING THE MEASUREMENT MODE

5.1 The setup library

The TI-CMX contains 64 user configurable preset locations to store custom setups for easy recall. These setups can be optimized for the user's specific application needs and can also be stored on a PC and transferred bi-directionally using Dakota's PC interface software included with the instrument.

5.2 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. The TI-CMX has been optimized for cast materials. Cast iron applications require 1 - 5MHz frequencies, and cast aluminum requires a 10MHz frequency. Plastics typically require lower frequencies depending on the thickness and make-up of the material. Larger diameters offer greater penetration power because of the crystal size, for difficult to measure materials.

Corrosion & Pit Detection in steel and cast materials

Use pulse-echo mode whenever attempting to locate pits and flaws. 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 2.5 times slower than that of steel, pulse-echo mode will induce error if the coating or paint is not completely removed. By using echo-echo mode, the user is able to successfully measure through both, the coating and steel, and completely eliminate the thickness of the paint or coating. Therefore, the steel can be measured without having to remove the coating prior to measuring. Users will often use pulse-echo mode and echo-echo mode in conjunction when performing inspections on coated materials.

Thru coating measurements require special high damped transducers. The most common transducers are the 3.5, 5, and 7.5MHz hi damped transducers. These transducers are suitable for use in both pulse-echo and echo-echo modes. This conveniently enables the user to accurately measure overall material thickness using the thru Coating mode, and then conveniently switch to pit detection mode without changing transducers. The " 5MHz Hi damped transducer is the most commonly used transducer for standard thru coating applications.

9.0 PULSE-ECHO COATING & COATING TECHNIQUES

9.1 Introduction to Pulse-Echo Coating Measurement (PECT)

In the previous sections we've discussed the need for detecting pits and flaws (pulse-echo) in materials, along with the requirement to measure through and eliminate errors caused by coated materials (echo-echo). Until now, both modes were needed in order to accomplish both tasks. Pulse-echo mode was used for flaw detection, and echo-echo mode was used to eliminate the coating thickness and provide a nominal material thickness only. With this in mind, it often became cumbersome toggling between both modes respectively.

In a majority of applications involving coated materials, inspectors are often interested in monitoring both the thickness of the material, as well as the thickness of the coating. Therefore, the TI-CMX has been designed to provide the user with the ability to measure the material and coating thicknesses simultaneously, while maintaining the ability to detect flaws and pits all in a single mode called Pulse-Echo Coating (PECT). This is accomplished by using a custom hybrid combination mode utilizing properties from the basic modes along with a group of special techniques and theoretical wave phenomena's.

The TI-CMX is preset to a coating velocity of 0.0850 in/usec (2159 m/sec) from the factory. This velocity is a very close approximation of the common coating velocities found in the field. However, the TI-CMX also has a built-in one and two point calibration options to calibrate to coating samples with a known thicknesses.

There are two coating modes built into the TI-CMX:

1. **Pulse-Echo Coating (PECT)** – used during inspections where both the material and coating thicknesses are required.
2. **Coating Only (CT)** – used during inspections where only the coating thickness is required.

9.2 Enabling Pulse-Echo Coating Mode (PECT) & Coating (CT)

When the TI-CMX is initially powered up, the gauge will automatically check to see if the transducer plugged into the gauge can be recognized. All Dakota Ultrasonics coating enabled transducers are equipped with the auto recognition feature. If the TI-CMX doesn't recognize that a special coating enabled transducer is plugged into the gauge, the coating feature will be disabled entirely. There are a number of coating enabled transducers available from Dakota. Please contact us with your application requirements for additional information on frequencies and diameters currently offered.

The coating modes can be enabled in three different ways:

1. On Power up and probe recognition.
2. By pressing **MULTI MODE** keypad.
3. From the tabbed menus under TUNE, MEASURE MODE.

The steps that follow will demonstrate all three methods in the order listed above.

8.0 THRU-PAINT MEASUREMENT TECHNIQUE

8.1 Introduction to Thru Paint Measurement

The principle behind thru paint measurement is by measuring the time between two backwall echoes returning from the test material. Since both of these backwall echoes travel the same path through the paint or coating, the thickness of the coating is subtracted out of the measurement so that only the actual material thickness can be measured. This feature saves the user a great deal of time scraping and removing the coating from tanks and pipes during the inspection process.

The primary purpose of thru paint measurement is to determine actual or overall material thickness by eliminating the coating thickness. Thru paint mode cannot be used for flaw or pit detection. Therefore, inspectors may need to use echo-echo thru paint mode in conjunction with the standard pulse-echo flaw detection mode for some applications. Chassis tubing inspectors and sanctioning bodies will use the echo-echo mode for tubing with powder coatings, and pulse-echo mode for tubing without coating. The combination of using both modes is ideal for the advanced inspectors needs.

8.2 Using Thru Paint Mode

The first thing to note in this section, is that by selecting the transducer type from the list of probes stored in the TI-CMX, a basic echo-echo thru paint configuration is recalled from memory. Each of the transducers in the list contains pre-configured echo-echo settings. The standard transducer that will be used for common steel applications is a 5MHz high damped transducer (1/4IN – 5.0MHZ HD). This is the recommended transducer for this industry and should be used for thru paint applications. Any of the auto recognition coating transducers are also high damped transducers and will work in echo-echo mode as well.

NOTE: When a transducer is selected for use, all of the measurement modes available for use with this transducer can easily be determined by pressing the multi-mode button on the keypad. The TI-CMX has been programmed to identify the modes available to a specific transducer.

Once the transducer type has been selected and the appropriate calibration procedure completed, the TI-CMX can toggle between pulse-echo (flaws & pits), and echo-echo (thru paint) modes by simply pressing the **MULTI MODE** key located on the keypad. Refer to section 6.0 for additional information.

The TI-CMX can also be configured for thru paint applications by selecting a factory setup stored in the list of setups in the TI-CMX. Refer to section 11.0 for information on recalling a setup. Once either the transducer type or setup has been selected, the inspector is ready to begin making measurements.

Coating Only

The coating only mode should be used when the application calls for coating measurements only and the user is not interested in the thickness of the material the coating has been applied to. This mode can also be used as a stand alone coating thickness gauge, where the coating has not been applied to another material surface. An auto identified coating probe must be attached to the TI-CMX in order to enable this mode.

Thin materials

Use pulse echo mode and a high frequency transducer 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

Use and select a special 2.25MHz and 5 MHz High temperature transducer 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 delay line of the transducer.

Noisy Material

Materials such as titanium, stainless steel, and aluminum may have inherent surface noise issues. This is a signal that appears at the surface of the material when using a dual element delay line probe. Select a higher frequency transducer to reduce this noise – 7.5MHz and higher for better resolution.

Restricted access

Measuring materials with extreme curvatures or restricted access, higher frequencies with smaller diameters should be considered. The smallest diameter uses 3/16” crystals with a contact area of .250”. Custom transducers are available on request.

5.3 Factory Setup Chart

There are no standard factory setups provided with the TI-CMX, as the primary reason for the setups is to retain all of the user adjustments made to set the gauge for use on a specific application. Saving a setup allows you to retain all of the settings made to tune the gauge, such as Gain setting, 1 or 2 Point Calibration values for the Material and/or the Coating, Acoustic Velocity setting, Alarm limits, operating mode, B-scan settings and much, much more. Refer to section 11.0 for additional info on Setups.

Acoustic 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
Steel Stainless"	0.2230		5664
Teflon	0.0540		1372
Tin	0.1310		3327
Titanium	0.2400		6096
Tungsten	0.2040		5182
Uranium	0.1330		3378
Water	0.0580		1473
Zinc	0.1660		4216
Zirconium	0.1830		4648

7.4 Gain

The gain, or amplification of the return echoes, can be adjusted in the TI-CMX to accommodate a variety of applications. The setting of the gain is crucial in order to obtain valid readings during the measurement process. Too much gain may result in erroneous measurements, by detecting on noise rather than the actual material back wall itself. Not enough gain may result in intermittent detection. It may also result in lack of detection on internal flaws, pits, or porosity. The gain can easily be compared to the volume control of a home stereo system. If you turn it up too much, you can't hear the music clearly. If it's turned down too much, you can't hear it at all.

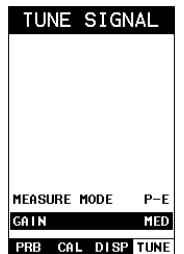
The TI-CMX has five gain settings (VLOW, LOW, MED, HI, VHI). The gain range is 42dB – 50dB in 2dB increments. Note: The TI-CMX has been optimized for the MED gain setting for all common applications. It should be operated in this mode as standard. However, some applications may require the lower or higher gain settings. When? The low settings may be necessary for noisy or granular cast materials. How do I know when to lower the gain? If the reading becomes sporadic and won't settle down or resolve on a thickness value, the user can assume that the material is either very noisy aluminum, or granular cast iron. This would be a good time to change the TI-CMX to lower gain setting and see if the reading settles down and become stable.

How do I know when to increase the gain? Often times the user will be trying to measure a material that is hard to penetrate or pass sound through. This may be due to the material type, or overall thickness of the material. When a material is hard to pass sound through because of the thickness or general make-up, it would be a good time to consider switching the TI-CMX into a higher gain setting. Another example might be the need to increase overall sensitivity for locating fine pits or flaws. In any case, the selectable gain settings offer the user some additional options to resolve and overcome application issues.

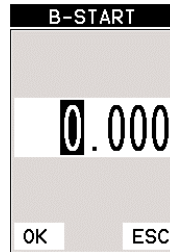
Note: When the echo-echo thru-paint measurement mode is selected, the manual gain feature is disabled and grayed out in the menu items. In this mode, the TI-CMX switches to an automatic gain mode (AGC) that optimizes the gain setting automatically in the hardware of the TI-CMX.

The procedures to adjust the Gain are outlined below:

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the TUNE menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **GAIN** is highlighted.
3. Press the **LEFT** and **RIGHT** arrow keys to scroll the value. When the correct Gain is being displayed, press the **MEAS** key to return to the measurement screen and begin taking readings.



- Alternatively, press the **ENTER** key to display the Digits Edit Box.
- Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
- Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
- Repeat steps 5 & 6 until the B-Start value is correctly displayed.
- Press the **OK** key to set the B-Start value and return to the menu screen, or **ESC** to cancel entering the B-Start.
- Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

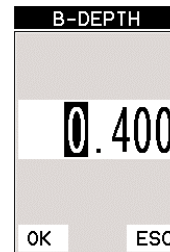
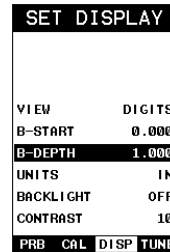


Overall range (B-DEPTH)

Once again, just to reiterate, B-DEPTH is the overall viewable thickness range being tested. This should be set to a value slightly larger than the expected maximum range being measured. The procedures to adjust the overall thickness range viewed (B-DEPTH) are outlined below:

Adjusting the Overall Depth (B-DEPTH)

- Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the **DISP** menu is highlighted and displaying the submenu items.
- Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until B-DEPTH is highlighted.
- Press the **LEFT** and **RIGHT** arrow keys to scroll the value. When the correct width is being displayed, proceed to step 8.
- Alternatively, press the **ENTER** key to display the Digits Edit Box.
- Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
- Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
- Repeat steps 5 & 6 until the B-Scan Depth value is correctly displayed.
- Press the **OK** key to set the B-SCAN Depth and return to the menu screen, or **ESC** to cancel entering the B-Depth.
- Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.



6.0 TAKING MEASUREMENTS

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

An automatic or manual zero must always be performed. The auto zero is an off block electronic zero that does not require a zero reference block. This will most always be the zero option of choice, as it makes the zeroing process very easy and convenient to perform. However, if the manual zero option is enabled, the probe zero must be measured on the reference disk (battery disk) attached to the top of the instrument. The zero compensates for variations in the transducer. In all modes the sound velocity must be determined. The sound velocity is used to convert the transit time to a physical length. The sound velocity can be selected from a material chart in the manual, selected from a material list in the TI-CMX, or for greater precision determined from a sample of the test material that has been mechanically measured. To enter the velocity from a table, look up the material on the chart in the appendix of this manual and refer to the section below on Calibration to a Known Velocity. To determine the velocity of a single sample, refer to the Material Calibration section 6.0

When measuring curved materials, it is more accurate to calibrate from two test points, one at the minimum limit of the target thickness and one at the maximum limit. In this case the reference disk mounted to the TI-CMX is not used. This is called two-point calibration and is described on section 6.0.

6.1 Auto Probe Recognition & Selecting The Transducer Type

The first step in using the TI-CMX is to plug the transducer into the gauge and power the unit up. The TI-CMX has a special built-in automatic probe recognition feature that will check to see if the probe plugged into the gauge is an auto recognized probe type. If so, the TI-CMX will display a message indicating the transducer type and ask the user for confirmation to use the identified probe. If the transducer is not an auto recognized probe, the TI-CMX will display a message indicating the transducer type has not been recognized, and force the user to select a transducer type from a list of transducers according to frequency and diameter. Whether the transducer is auto recognized or selected from a predefined list, the TI-CMX will recall specific properties about the transducer.

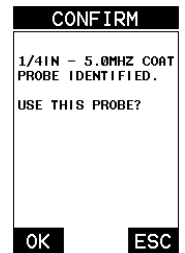
NOTE: Once the transducer has been selected, the TI-CMX will store and recall this transducer type every time the TI-CMX is powered on/off. The type will only change if the user physically selects another type from the list, or selects a previously saved setup. Therefore, if you have previously gone through this section and selected the transducer you are using, proceed to the next section. Use the following steps to select your transducer type.

NOTE: If the transducer is not identified on power up, be sure the transducer type Selected is the same as the transducer plugged into the TI-CMX. Failure to do this will result in erroneous measurements:

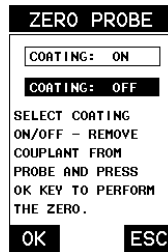
In this first example the transducer was automatically identified:

- Press the **OK** key once to use the identified probe, or **ESC** to display a list of optional transducers.

NOTE: If the TI-CMX recognizes a specific transducer, the user should always select OK to use the identified probe. The only time an alternative probe should be selected from a list is if the user switched probes following initial power up and recognition, or the TI-CMX has somehow identified the probe in error..

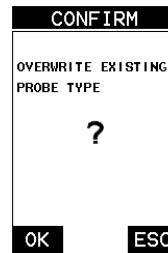
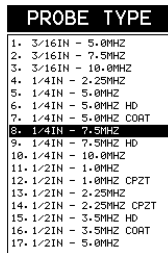


- Assuming the TI-CMX recognized the probe and the **OK** key was pressed, the TI-CMX will advance to a Zero Probe menu. If the transducer was identified as a special transducer capable of measuring coating thickness, a menu will be displayed allowing the user the ability to toggle the coating thickness display on/off as follows:
- Press the **UP** and **DOWN** arrow keys to toggle the coating option on/off.
- Wipe all couplant from the transducer face and proceed to the Probe Zero section that follows.



In this second example the transducer was not identified and will force the user to select the transducer type from a predefined list of transducers:

- Press the **OK** or **ESC** keys to display the factory list of transducer types (by diameter and frequency).
- Press the **UP** and **DOWN** arrow keys to scroll through the transducer list until the appropriate type is highlighted.
- Press the **ENTER** key to select the transducer type and display overwrite existing probe screen.
- Press the **OK** key to overwrite the existing probe type with the newly selected probe type. The zero probe screen will be displayed. Proceed to the zero probe section that follows.



6.2 Probe zero

The next step is to perform a probe zero. The zero function is a very important and necessary function that must be done prior to calibration. It should be done on a regular basis. In fact, the TI-CMX has been programmed to force this issue at regular intervals during operation if it hasn't been done. If the TI-CMX is not zeroed correctly, all the measurements taken may be in error by some fixed value. When the TI-CMX is using the auto zero (electronic zero), the TI-CMX^o can be in any measurement mode. However, when the manual zero is being used, the TI-CMX must be in pulse-echo mode in order to perform the zero. The TI-CMX will also see to it that this occurs by simply forcing the gauge into this mode when zero. Therefore, if the TI-CMX is in the echo-echo measurement mode and a manual zero is being performed, the TI-CMX will put the gauge into pulse-echo mode automatically before performing the zero. While this is a very convenient feature of the TI-CMX, the user should be sure to check the measurement mode following calibration to be sure the TI-CMX is in the desired mode. The following steps outline both of these techniques.

The TI-CMX is equipped with two zero options:

- Off Block Zero (Automatic Probe Zero)** – When this feature is enabled the TI-CMX will do an electronic zero automatically, eliminating the need for a zero disk or block.
- On Block Zero (Manual Probe Zero)** – When this feature is enabled the transducer must be placed on the probe zero disk (battery cover located on the top of the unit).

Both zero procedures are outlined as follows

- Press the **LEFT** and **RIGHT** arrow keys to toggle DIGITS or **B-SCAN**. When the correct view is being displayed continue on to setting the B-START or B-DEPTH values, or press the **MEAS** key to return to the measurement screen and begin taking readings.

7.3 Adjusting the B-Scan Start (B-START) & Depth (B-DEPTH)

In order to use the B-Scan and Scan Bar features of the TI-CMX effectively, the starting depth and overall depth must be setup correctly. This can be adjusted using the B-START and the B-DEPTH features of the TI-CMX. The B-START refers to the starting depth or thickness value displayed. Example: If you want your B-Scan or Scan Bar to start at a zero thickness value, then B-START must be set to 0.000". If you want the B-Scan and Scan Bar to start displaying at .125", then B-START must be set to .125". B-DEPTH represents overall viewable thickness range being tested. Example: If your measuring tank walls with a total thickness of .300", and your B-START has been set to 0.000", you might consider setting your B-DEPTH value to something like 0.400" to cover the entire thickness range being tested. You might also consider B-DEPTH as a zoom feature for both the B-Scan and Scan Bar. Why? Because the larger the overall thickness range view (B-DEPTH), the smaller the noticeable shifts in the Scan Bar and B-Scan presentation. Therefore, it's best to set the B-START and B-DEPTH to reasonable values that zoom in and optimize your graphic presentation.

Starting depth (B-START)

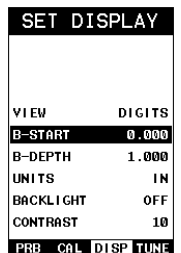
The starting B-START, or starting depth, is the starting thickness value. Often times this value will simply be set to zero in order to start measuring at 0.000". The only time this value will be set to something other than zero, is if the user needs to zoom in even closer. When will this be the case? If the user is testing a material that's 1 inch in thickness and knows that the potential corrosion is only on the back surface of the material and not possibly deeper than .200". In this case, the user may wish to set the B-ST at .700" to zoom in closer to the actual area being tested. In turn, the B-DEP might be set at 1.100" in order to cover the entire range respectively. This will offer the user better resolution for both the B-Scan and Scan Bar graphical presentations.

NOTE: Once the range is set, it will remain the same for all the views respectively.

The procedures to adjust the starting depth (B-START) are outlined below:

Adjusting the Starting Depth (B-START)

- Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the DISP menu is highlighted and displaying the submenu items.
- Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until B-START is highlighted.
- Press the LEFT and RIGHT arrow keys to scroll the value. When the correct B-Start value is being displayed, proceed to step 8.



The following is a list of the viewable features on the display:

- A. **Repeatability/Stability Indicator** – This indicator should be commonly used in conjunction with the digital thickness values displayed. When all the vertical bars are fully illuminated and the last digit on the digital thickness value is stable, the TI-CMX is reliably measuring the same value 3 to 200 times per second, depending on which measurement mode and features are enabled.
- B. **Battery Icon** – Indicates the amount of battery life the TI-CMX has remaining.
- C. **Velocity** – The material velocity value the TI-CMX is currently using or calibrated for. Displayed in either English or Metric units, depending on the what units the gauge is set for.
- D. **Feature Status Bar** – Indicates the features currently enabled and in use in the following order:
 - Measurement Mode (P-E, PECT, PETP, E-E, COAT)
 - Differential Mode (ON/OFF)
 - High Speed Scan Mode (ON/OFF)
 - Alarm Mode (ON/OFF/AUDIBLE)
 - Gain Setting (VLOW, LOW, MED, HI, VHI)
- E. **Digital Material Thickness Value** – Smaller font size when the B-Scan display view is enabled.
- F. **Scan Bar** – Another view of material thickness in a deflection style horizontal bar. This is another visual tool that would enable the user the ability to see thickness changes during high speed scans from flaws and pits.
- G. **Units** – The current measurement units being used (English, Metric).
- H. **Coating Thickness Value** – Displays the actual thickness of any coating adhered to a metallic material surface (PECT Mode), or a coating adhered to a non-metallic surface (CT Mode).
- I. **Minimum Material Thickness** – Part of the Alarm feature. Displays the minimum thickness value found during a scan.
- J. **Maximum Material Thickness** – Part of the Alarm feature. Displays the maximum thickness value found during a scan.
- K. **B-Scan Display** – Cross section view of the material. Provides the user with graphical view of the opposite/blind surface (i.e. inside pipe wall surface), to give the user some idea of the condition, or integrity of the material being tested.

7.2 Activating B-Scan View

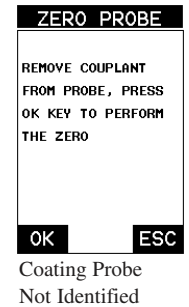
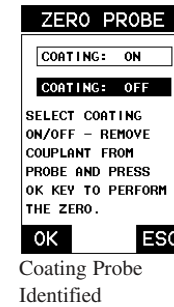
To use the B-Scan feature it must be enabled in the display menu. The following steps will help you do just that:

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right, and the **ESC** key multiple times to tab left, until the **DISP** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **VIEW** is highlighted.

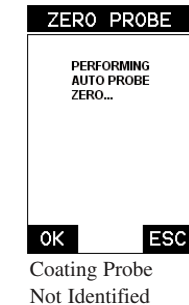
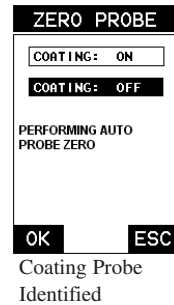
SET DISPLAY	
VIEW	BSCAN
B-START	0.000
B-DEPTH	0.400
UNITS	IN
BACKLIGHT	OFF
CONTRAST	10
PRB	CAL
DISP	TUNE

Performing an Auto Probe Zero (Off Block)

1. Be sure all couplant has been removed from the face of the transducer.
2. Press the OK key to perform the automatic probe zero, or ESC key to cancel the zero operation.



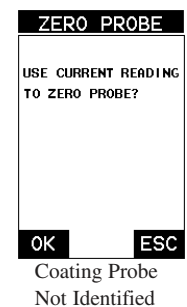
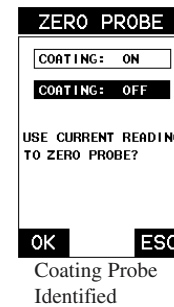
3. The screens illustrated at right will be briefly displayed followed by the main measurement screen. The CMX is ready to be calibrated.



Performing a Manual Probe Zero (On Block)

NOTE: When the zero probe option is set to manual, the probe zero disk (battery cap) located on the top of the gauge will be used as a zero standard and the warning screen illustrated above will be displayed.

1. Press the **OK** or **ESC** keys to enter the main measurement screen and begin the manual zero process.
2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the probe zero disk and obtain a steady reading.
3. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **PRB** menu is highlighted and displaying the submenu items.
4. Press the **UP** and **DOWN** arrow keys to scroll through the sub menu items until **ZERO PROBE** is highlighted.
5. Press the **ENTER** key to display the confirmation screen.
6. If a coating transducer was identified use the **UP** and **DOWN** arrow keys to toggle coating on/off.



- Press the **OK** key to complete the probe zero function, or ESC key to cancel the probe zero function.
- Remove the transducer from the probe zero disk, and proceed to the calibration section.

NOTE: The value that is displayed will change depending on the current velocity setting in the TI-CMX. Disregard the number that is displayed. It is not important. What is important is accurately performing the steps outlined above to insure reliability of the probe zero calculation.

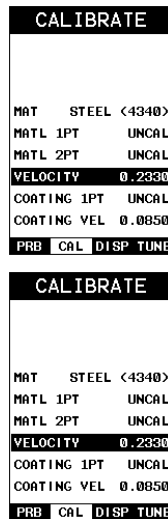
6.3 Material Calibration

In order for the TI-CMX 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 fixed percentage.

The One Point calibration is the simplest and most commonly used calibration method—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-CMX provides four simple methods for setting the sound-velocity outlined below:

Using A Known Velocity

- Press the MENU key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
- Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **VELOCITY** is highlighted.
- Press the **ENTER** key to display the Digits Edit Box.
- Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
- Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
- Repeat steps 4 & 5 until the velocity number is correctly displayed.
- Press the **OK** key to set the velocity and return to the menu screen, or **ESC** to cancel entering the velocity.
- Press the **MEAS** key to return to the measurement screen and begin taking readings.



Using A Known Thickness

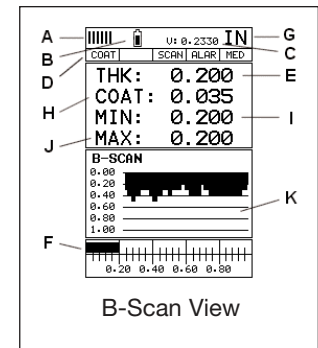
Sometimes the sound velocity of a material is unknown. In this case a sample with one or two known thicknesses can be used to determine the sound velocity. As previously discussed, the TI-CMX has a one or two point calibration option. The one point calibration option is most suited for linearity over large ranges, as noted above. The user should also consider calibrating on high side of the intended measurement range, when using the one point option, minimize overall error. For example, if the measurement range is .100"

- Velocity** – The material velocity value the TI-CMX is currently using or calibrated for. Displayed in English or Metric units, depending on the what units the gauge is set for.
- Feature Status Bar** – Indicates the features currently enabled and in use in the following order:
 - Measurement Mode
 - Differential Mode
 - High Speed Scan Mode
 - Alarm Mode
 - Gain Setting
- Digital Material Thickness Value** – Extra large font size for viewing ease.
- Scan Bar** – Another view of material thickness in a deflection style horizontal bar. This is another visual tool that would enable the user the ability to see thickness changes during high speed scans from flaws and pits.
- Units** – The current measurement units being used (English, Metric).
- Coating Thickness Value** – Displays the actual thickness of any coating adhered to a metallic material surface (PECT Mode), or a coating adhered to a non-metallic surface (CT Mode).
- Minimum Material Thickness – Part of the Alarm feature.** Displays the minimum thickness value found during a scan.
- Maximum Material Thickness – Part of the Alarm feature.** Displays the maximum thickness value found during a scan.

B-Scan

The B-Scan displays a time based cross section view of test material. This is a visual tool that enables the user to see the contour of the blind, or underside, surface of a pipe or tank application. It is very similar to a fish finder. If a flaw or pit is located during a scan, the B-Scan will draw the pit on the screen.

The solid black rectangle in the diagram at location K represents the cross section, or side view of the material. The B-Scan view draws at a rate of 7 seconds per screen from right to left. Also notice at location K, the pits and corroded bottom surface of the material.



It's important to note that the measurement range on the display be set wide enough, so that the maximum thickness of the material can be viewed on the display. Using the diagram above, if the material thickness was actually 1.75", the underside of the material would not be viewable according to the current range at 0.00" – 1.00". All the user would see is a black screen from 0.00" – 1.00" with no view of the bottom contour at 1.75".

7.0 USING THE DIGITS AND B-SCAN DISPLAYS

A key feature of the TI-CMX is the ability to toggle between two different display options, Digits and B-Scan. The Digits view provides the user with a large digital readout of the thickness. Both views also include a scan bar features that uses a bar graph to indicate thickness. The Scan bar can be very handy while scanning a tank or pipe wall by graphically displaying deflections from pits or internal flaws, rather than having to constantly watch for changes in the digital readout. It's just another visual aid to alarm the user when something out of the ordinary has been detected.

The B-Scan display is also very useful when scanning surfaces and viewing the cross section of the test material. It provides a convenient way of visually profiling, or drawing a picture of, the blind surfaces during a scan. The B-Scan display is also equipped with a scan bar representing the overall thickness. Once again, the scan bar gives the user a visual indication when a flaw or defect has been passed over during the scan process. The scan bar will deflect off of the defect and return back to the overall thickness. In this chapter we'll outline some of the fine adjustment features of the TI-CMX. We'll take a better look at these options in this chapter.

NOTE: In order to recall and use the new adjustments made to the TI-CMX at a later time, the user must save the modified settings in one of the setup locations. Refer section 11.0 for more information on setups.

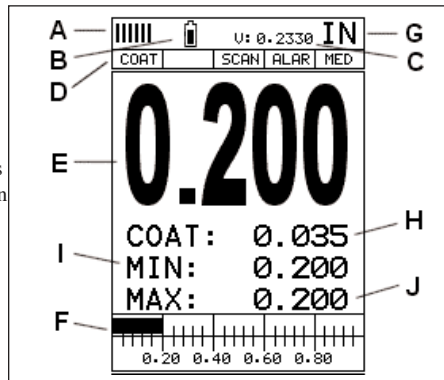
7.1 Display Views

DIGITS

The Digits view is a basic digital thickness gauge look and feel. The larger digits make it much easier for the operator to monitor the thickness readings. The Scan Bar has also been added to the Digits view to provide the user with yet another visual tool for easily monitoring changes in thickness readings due to internal flaws or defects.

The following is a list of the viewable features on the display:

- A. **Repeatability/Stability Indicator** – This indicator should be commonly used in conjunction with the digital thickness values displayed. When all the vertical bars are fully illuminated and the last digit on the digital thickness value is stable, the TI-CMX is reliably measuring the same value 3 to 200 times per second, depending on which measurement mode and features are enabled.
- B. **Battery Icon** – Indicates the amount of battery life the TI-CMX has remaining.



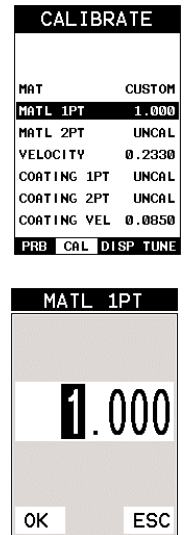
(2.54mm) to 1.0" (25.4mm), the user should calibrate on a known thickness sample close to 1.0" (25.4mm).

NOTE: It's always handy to carry a set of mechanical calipers to use in conjunction with the TI-CMX for calibration in the field:

One Point Calibration

NOTE: Be sure that the probe zero procedure has been performed prior to performing this calibration procedure.

1. Physically measure an exact sample of the material or a location directly on the material to be measured using a set of calipers or a digital micrometer.
2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the sample or actual test material. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
3. Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **MATL 1PT** is highlighted.
4. Press the **ENTER** key to display the Digits Edit Box.
5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.
8. Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the one point calibration.
9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.



NOTE: CHECK YOUR CALIBRATION! Place the transducer back on the calibration point. The thickness reading should now match the known thickness. If the thickness is not correct, repeat the steps above.

At some point there may become a requirement for improved accuracy over a smaller measurement range. In this case, a two point calibration would be most suited for the job. For example, if the measurement range was .080" (2.03mm) to .250" (6.35mm), the user would perform a one point calibration on a known thickness sample close to .250" (6.35mm), followed by a two point calibration close to .080" (2.03mm). When a two point calibration is performed, the TI-CMX calculates the zero and the velocity.

The following steps outline this procedure:

Two Point Calibration

1. Physically measure an exact sample of the material or a location directly on the material to be measured using a set of calipers or a digital micrometer.
2. Apply a drop of couplant on the transducer and place the transducer in steady contact with the sample or actual test material. Be sure that the reading is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the ESC key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
3. Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **MATL 2PT** is highlighted.
4. Press the **ENTER** key to display the Digits Edit Box.
5. Press the **UP** and **DOWN** arrow keys to scroll the highlighted value.
6. Press the **LEFT** and **RIGHT** arrow keys to scroll the digit locations.
7. Repeat steps 5 & 6 until the known thickness value is correctly displayed.
8. Press the **OK** key to calculate the velocity and return to the menu screen, or **ESC** to cancel the one point calibration.
9. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

NOTE: CHECK YOUR CALIBRATION! Place the transducer back on the calibration point. The thickness reading should now match the known thickness. If the thickness is not correct, repeat the steps above.

Basic Material Type

If the material velocity is unknown, and a sample thickness cannot be taken from the material, the user may opt to choose a basic material type from a list with approximate velocity values according to various material types. 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:

1. Press the **MENU** key once to activate the menu items tab. Press the **MENU** key multiple times to tab right and the **ESC** key multiple times to tab left until the **CAL** menu is highlighted and displaying the submenu items.
2. Use the **UP** and **DOWN** arrow keys to scroll through the submenu items until **MAT** is highlighted.

CALIBRATE	
MAT	CUSTOM
MATL 1PT	0.250
MATL 2PT	0.080
VELOCITY	0.1865
COATING 1PT	UNCAL
COATING 2PT	UNCAL
COATING VEL	0.0850
PRB	CAL DISP TUNE

MATL 2PT	
0.080	
OK	ESC

MATL 2PT	
0.080	
OK	ESC

3. Press the **ENTER** key to display the list of material types.

MATL TYPE	
18. MONEL	0.2110
19. NICKEL	0.2220
20. NYLON	0.1060
21. PLATINUM	0.1560
22. PLEXIGLASS	0.1060
23. POLYSTYRENE	0.0920
24. PUC	0.0940
25. QUARTZ GLASS	0.2260
26. RUBBER, UULCAN	0.0910
27. SILVER	0.1420
28. STEEL (1020)	0.2320
29. STEEL (4340)	0.2330
30. STEEL, STAIN.	0.2230
31. TEFLON	0.0540
32. TIN	0.1310
33. TITANIUM	0.2400
34. TUNGSTEN	0.2040

4. Press the **UP** and **DOWN** arrow keys to scroll through the material list until the appropriate material is highlighted.
5. Press the **ENTER** key to overwrite the material type and display the menu items with the new material type selected.
6. Finally, press the **MEAS** key to return to the measurement screen and begin taking readings.

To calibrate the TI-CMX for a specific type of coating using samples with known thicknesses, please refer to the chapter 9 – Pulse-Echo Coating (PECT) or Coating (CT) for a complete explanation of using the TI-CMX for coating measurements.

CALIBRATE	
MAT	STEEL (4340)
MATL 1PT	1.000
MATL 2PT	UNCAL
VELOCITY	0.2330
COATING 1PT	UNCAL
COATING 2PT	UNCAL
COATING VEL	0.0850
PRB	CAL DISP TUNE

Ultrasonic THICKNESS GAUGE

Model TI-CMX



OPERATING MANUAL



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