OPERATION MANUAL

DAKOTA ULTRASONICS

MMX-6 DL MULTI-MODE ULTRASONIC THICKNESS GAUGE

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DISCLAIMER – Very Important!

Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the back surface of the material being measured while in standard pulse-echo mode. This may result in a thickness reading that is TWICE what it should be.

In addition, measurements through very thick paint or coatings while using echo-echo mode, may result in the paint or coating being measured rather than the actual material intended. The Responsibility for proper use of the instrument and recognition of these types phenomenons rest solely with the user of the instrument.

INTRODUCTION

The Dakota Ultrasonics model ***MMX-6 DL*** is a precision Ultrasonic Micrometer. Based on the same operating principles as SONAR, the ***MMX-6 DL*** 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.

This manual is presented in three sections. The first section covers operation of the ***MMX-6 DL***, and explains the keypad controls and display. The second section provides guidelines in selecting a transducer for a specific application. The last section provides application notes and a table of sound velocity values for various materials.

Dakota Ultrasonics maintains a customer support resource in order to assist users with questions or difficulties not covered in this manual. Customer support may be reached at any of the following:

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OPERATION

The ***MMX-6 DL*** interacts with the operator through the membrane keypad and the LCD display. The functions of the various keys on the keypad are detailed below, followed by an explanation of the display and its various symbols.

The Keypad

This key is used to turn the ***MMX-6 DL*** on and off. When the tool is turned ON, it will first perform a brief display test by illuminating all of the segments in the display. After one second, the tool will display the internal software version number and the current file location and status. After displaying the version number, the display will show "0.000" (or "0.00" if using metric units), indicating the tool is ready for use.

The ***MMX-6 DL*** is turned OFF by pressing the **ON/OFF** key. The tool has a special memory that retains all of its settings even when the power is off. The tool also features an auto-powerdown mode designed to conserve battery life. If the tool is idle for 5 minutes, it will turn itself off.

The **PRB-0** key is used to "zero" the ***MMX-6 DL*** in much the same way that a mechanical micrometer is zeroed. If the tool is not zeroed correctly, all of the measurements that the tool makes may be in error by some fixed value. Refer to page 14 for an explanation of this important procedure.

The **CAL** key is used to enter and exit the ***MMX-6 DL***'s calibration mode. This mode is used to adjust the sound-velocity value that the ***MMX-6 DL*** will use when calculating thickness. The tool will either calculate the sound-velocity from a sample of the material being measured, or allow a known velocity value to be entered directly. Refer to page 15 for an explanation of the two **CAL** functions available.

The **MODE** key is used to toggle through the various features and settings of the ***MMX-6 DL*** (gate, alarm mode, beeper, back light, units, scan mode, and differential mode). The **MODE** key is used in conjunction with the arrow and send keys to enable/disable the features and settings.

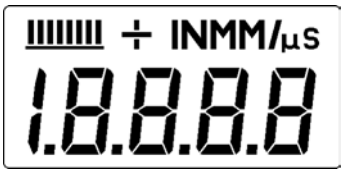
The **UP** arrow key has three functions. When the ***MMX-6 DL*** is in calibration mode, this key is used to increase numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will increment at an increasing rate. When MODE is activated, the **UP** arrow key scrolls through the various features and settings of the ***MMX-6 DL***. When the data logging feature has been activated by pressing the **MEM** key, the **UP** arrow is used to scroll through the various files, storage locations, and functions of the data logger. Refer to page 28 for further information regarding the use of the **UP** arrow key and the data logger.

The **DOWN** arrow key has three functions. When the ***MMX-6 DL*** is in the **CAL** mode, this key is used to decrease numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will decrement at an increasing rate. When **MODE** is activated, the **DOWN** arrow scrolls through the various features and settings of the ***MMX-6 DL***. When the data logging feature has been activated by pressing the **MEM** key, the **UP** arrow is used to scroll through the various files, storage locations, and functions of the data logger. Refer to page 28 for further information regarding the use of the **DOWN** arrow key and the data logger.

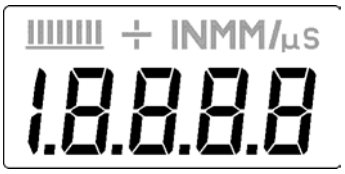
The **MEM** key enables/disables the data logging feature of the MMX-6 DL. This key is used in conjunction with the UP/DOWN arrows, SEND, AND CLR keys (hi-lighted in green). The combination of these keys control the data logging features of the ***MMX-6 DL***. Refer to the section on data logging page 28.

The **CLR** key is specifically used with the data logging feature of the ***MMX-6 DL***. This key clears the contents of an entire file, or individual storage locations. The **CLR** key is also used to send an obstruct (**ObSt**) to an individual storage location. The **ObSt** symbol would indicate that a the user was unable to take a reading at a particular location. Refer to the section on data logging page 28.

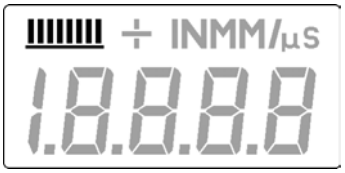
The **SEND** key is used for sending data to internal storage locations, and external peripheral devices (serial printer / computer). The **SEND** key is also used to select data logging functions in the ***MMX-6 DL*** page 28.



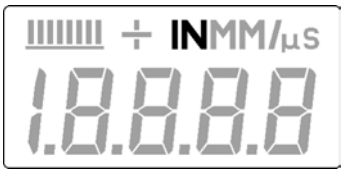
The Display



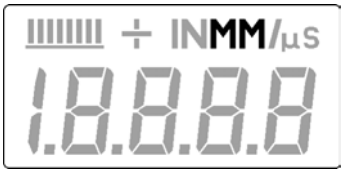
The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of various settings. When the ***MMX-6 DL*** is displaying thickness measurements, the display will hold the last value measured, until a new measurement is made. Additionally, when the battery voltage is low, the entire display will begin to flash. When this occurs, the batteries should be replaced.



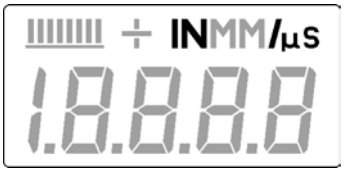
These eight vertical bars form the Stability Indicator. When the ***MMX-6 DL*** is idle, only the left-most bar and the underline will be on. While the gauge is taking a measurement, six or seven of the bars should be on. If fewer than five bars are on, the ***MMX-6 DL*** is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.

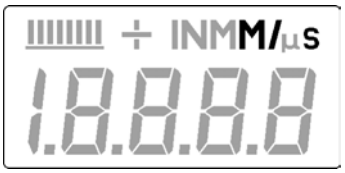


When the **IN** symbol is on, the ***MMX-6 DL*** is displaying a thickness value in inches. The maximum thickness that can be displayed is 19.999 inches.



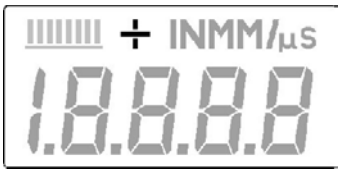
When the **MM** symbol is on, the ***MMX-6 DL*** is displaying a thickness value in millimeters. If the displayed thickness exceeds 199.99 millimeters, the decimal point will shift automatically to the right, allowing values up to 1999.9 millimeters to be displayed.





When the **IN** symbol is on, in conjunction with the **/µs** symbol, the ***MMX-6 DL*** is displaying a sound-velocity value in **inches-per-microsecond.**

When the **M** symbol is on, in conjunction with the **/s** symbol, the ***MMX-6 DL*** is displaying a sound-velocity value in **meters-per-second**.



When the **+** symbol is on and blinking, this indicates that the ***MMX-6 DL*** is currently operating in **echo-echo (Thru-paint/coating) mode**.

The Transducer

The transducer is the "business end" of the ***MMX-6 DL***. It transmits and receives ultrasonic sound waves that the ***MMX-6 DL*** uses to calculate the thickness of the material being measured. The transducer connects to the ***MMX-6 DL*** via the attached cable, and two coaxial connectors. When using transducers manufactured by Dakota Ultrasonics, the orientation of the dual coaxial connectors is not critical: either plug may be fitted to either socket in the ***MMX-6 DL***.

The transducer must be used correctly in order for the ***MMX-6 DL*** to produce accurate, reliable measurements. Below is a short description of the transducer, followed by instructions for its use.

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

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

Making Measurements

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

After applying couplant, press the transducer (wearface down) firmly against the area to be measured. The Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the ***MMX-6 DL*** has been properly "zeroed" (see page 14) and set to the correct sound velocity (see page 15), the number in the display will indicate the actual thickness of the material directly beneath the transducer.

If the Stability Indicator has fewer than five bars darkened, or the numbers on the display seem erratic, first check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the material. If the condition persists, it may be necessary to select a different transducer (size or frequency) for the material being measured. See page 30 for information on transducer selection.

While the transducer is in contact with the material that is being measured, the ***MMX-6 DL*** will perform four measurements every second, updating its display as it does so. When the transducer is removed from the surface, the display will hold the last measurement made.

IMPORTANT

Occasionally, a small film of couplant will be drawn out between the transducer and the surface as the transducer is removed. When this happens, the ***MMX-6 DL*** may perform a measurement through this couplant film, resulting in a measurement that is larger or smaller than it should be. This phenomenon is obvious when one thickness value is observed while the transducer is in place, and another value is observed after the transducer is removed.

In addition, measurements through very thick paint or coatings may result in the paint or coating being measured rather than the actual material intended. The responsibility for proper use of the instrument, and recognition of these types of phenomenon's, rest solely with the user of the instrument.

Condition and Preparation of Surfaces

In any ultrasonic measurement scenario, the shape and roughness of the test surface are of paramount importance. Rough, uneven surfaces may limit the penetration of ultrasound through the material, and result in unstable, and therefore unreliable, measurements. The surface being measured should be clean, and free of any small particulate matter, rust, or scale. The presence of such obstructions will prevent the transducer from seating properly against the surface. Often, a wire brush or scraper will be helpful in cleaning surfaces. In more extreme cases, rotary sanders or grinding wheels may be used, though care must be taken to prevent surface gouging, which will inhibit proper transducer coupling.

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

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

Probe Zero

Setting the Zero Point of the ***MMX-6 DL*** is important for the same reason that setting the zero on a mechanical micrometer is important. If the tool is not "zeroed" correctly, all of the measurements the tool makes will be in error by some fixed number. When the ***MMX-6 DL*** is "zeroed", this fixed error value is measured and automatically corrected for in all subsequent measurements. The ***MMX-6 DL*** may be "zeroed" as follows:

Performing a Probe-Zero

1) Make sure the ***MMX-6 DL*** is on.
2) Plug the transducer into the ***MMX-6 DL***. Make sure that the connectors are fully engaged. Check that the wearface of the transducer is clean and free of any debris.
3) The metal probe-disc is on the top end of the ***MMX-6 DL***. Apply a single droplet of ultrasonic couplant to the face of this disc.
4) Make sure that the ***MMX-6 DL*** is in **P-E** (pulse-echo mode) by pressing the **Dual-Multi** key to toggle the modes.

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

5) Press the transducer against the probe-disc, making sure that the transducer sits flat against the surface. The display should show some thickness value, and the Stability Indicator should have nearly all its bars illuminated.

6) While the transducer is firmly coupled to the probe-disc, press the **PRB-0** key on the keypad. The ***MMX-6 DL*** will display **"Prb0"** while it is calculating its zero point.
7) Remove the transducer from the probe-disc.

At this point, the ***MMX-6 DL*** has successfully calculated it's internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the ***MMX-6 DL*** will always use the sound-velocity value of the built-in probe-disc, even if some other velocity value has been entered for making actual measurements. Though the ***MMX-6 DL*** will remember the last "probe-zero" performed, it is generally a good idea to perform a "probe-zero" whenever the tool is turned on, as well as any time a different transducer is used. This will ensure that the instrument is always correctly zeroed.

Calibration

In order for the ***MMX-6 DL*** to make accurate measurements, it must be set to the correct sound-velocity for the material being measured. Different types of material have different inherent sound-velocities. For example, the velocity of sound through steel is about 0.233 inches-per-microsecond, versus that of aluminum, which is about 0.248 inches-per-microsecond. If the tool is not set to the correct sound-velocity, all of the measurements the tool makes will be erroneous by some fixed percentage. The **one point**

calibration is the simplest and most commonly used calibration procedure - optimizing linearity over large ranges. The **two point** calibration allows for greater accuracy over small ranges by calculating the probe zero and velocity. The ***MMX-6 DL*** provides three simple methods for setting the sound-velocity, described in the following pages.

Calibration to a known thickness

Note: This procedure requires a sample piece of the specific material to be measured, the exact thickness of which is known, e.g. from having been measured by some other means.

1) 1) Make sure the ***MMX-6 DL*** is on and switched to **P-E** (pulse-echo) mode. Press the **Dual-Multi** key to toggle modes.

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

2) Perform a Probe-Zero (refer to page 14)

3) Apply couplant to the sample piece.

4) Press the transducer against the sample piece, making sure that the transducer sits flat against the surface of the sample. The display should show some (probably incorrect) thickness value, and the Stability Indicator should have nearly all its bars on.

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

6) Press the **CAL** key. The **IN** (or **MM**) symbol should begin flashing.

7) Use the **UP** and **DOWN** arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.

8) Press the **CAL** key again. The **IN/μs** (or **M/s**) symbols should begin flashing. The ***MMX-6 DL*** is now displaying the sound

velocity value it has calculated based on the thickness value that was entered in step 7.

9) Press the **CAL** key once more to exit the calibration mode. The ***MMX-6 DL*** is now ready to perform measurements.

Calibration to a known velocity

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

1) Make sure the ***MMX-6 DL*** is on and switched to **P-E** (pulse-echo) mode. Press the **Dual-Multi** key to toggle modes.

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

2) Press the **CAL** key to enter calibration mode. If the **IN** (or **MM**) symbol is flashing, press the **CAL** key again, so that the **IN/μs** (or **M/s**) symbols are flashing.

3) Use the **UP** and **DOWN** arrow keys to adjust the displayed velocity up or down, until it matches the sound-velocity of the material to be measured.

4) Press the **CAL** key once more to exit the calibration mode. The ***MMX-6 DL*** is now ready to perform measurements.

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

To achieve the most accurate measurements possible, it is generally advisable to always calibrate the ***MMX-6 DL*** to a sample piece of known thickness. Material composition (and thus, its sound-velocity) sometimes

varies from lot to lot and from manufacturer to manufacturer. Calibration to a sample of known thickness will ensure that the tool is set as closely as possible to the sound velocity of the material to be measured.

Two Point Calibration

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

1) Make sure the ***MMX-6 DL*** is on and switched to **P-E** (pulse-echo) mode. Press the **Dual-Multi** key to toggle modes.

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

2) Perform a Probe-Zero (refer to page 14)

3) Apply couplant to the sample piece.

4) Press the transducer against the sample piece, at the first/second calibration point, making sure that the transducer sits flat against the surface of the sample. The display should show some (probably incorrect) thickness value, and the Stability Indicator should have nearly all its bars on.

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

6) Press the **CAL** key. The **IN** (or **MM**) symbol should begin flashing.

7) Use the **UP** and **DOWN** arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.

8) Press the **Probe** key. The display will flash **1OF2**. **Repeat steps 3 through 7** on the second calibration point. The ***MMX-6 DL*** will now display the sound velocity value it has calculated based on the thickness values that were entered in step 7. The ***MMX-6 DL*** is now ready to perform measurements within this range.

MMX-6 DL Modes

Changing Units IN / MM

The ***MMX-6 DL*** has the ability to display measurements in both the English (IN) and Metric (MM) systems. The following steps outline the procedure for changing units:

Units in/mm

1) Press **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press the **MODE key** to activate features and settings.
3) Press the **UP** or **Down** arrow keys to scroll to the **unIt** symbol.
4) Press the **SEND** key to toggle the status of the units - **IN** / **MM**.
5) Press the **MODE** key once again to return to measurement mode.

The Back light

The back light of the ***MMX-6 DL*** can be set to three different positions on/off/auto. The following steps outline the procedure for changing the settings of the back light:

Using The Back Light

1) Press **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press the **MODE key** to activate features and settings.
3) Press the **UP** / **Down** arrow keys to scroll to the **LItE** symbol.
4) Press the **SEND** key to toggle the status of the back light on/off/auto.
5) Press the **MODE** key once again to return to measurement mode.

Scan Mode

While the ***MMX-6 DL*** excels at making single point measurements, it is sometimes desirable to examine a larger region, searching for the thinnest point. The ***MMX-6 DL*** includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the ***MMX-6 DL*** performs and displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the tool performs sixteen

measurements every second. While the transducer is in contact with the material being measured, the ***MMX-6 DL*** is keeping track of the lowest measurement it finds. The transducer may be "scrubbed" across a surface, and any brief interruptions in the signal will be ignored. When the transducer loses contact with the surface for more than a second, the ***MMX-6 DL*** will display the smallest measurement it found.

Using Scan Mode

1) Press **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press the **MODE key** to activate features and settings.
3) Press the **UP** / **Down** arrow keys to scroll to the **SCAn** symbol.
4) Press the **SEND** key to toggle the scan mode on/off. of the back light on/off/auto.
5) Press the **MODE** key once again to return to measurement mode.

Alarm Mode

The Alarm Mode feature of the ***MMX-6 DL*** allows the user to set an audible and visual parameter when taking measurements. If the measurement falls below a nominal value, set by the user, a red light will be illuminated on the front panel of the gauge and the beeper sounded. This improves the speed and efficiency of the inspection process by eliminating constant viewing of the actual reading displayed. The following procedures outline how to enable and set up this feature:

Using the Beeper

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

Alarm Mode

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

Dual-Multi Mode

Often times users and inspectors in the field are faced with coated materials such as pipes and tanks. Typically inspectors will need to remove the paint or coating prior to measuring, or allow for some fixed amount of error introduced by the paint or coating thickness and velocity. An A-Scan scope with a special echo-echo mode is generally used in order to accurately perform measurements through paints and coatings. However, In order to inspect for blind wall pitting and internal flaws, both echo-echo (thru-paint / coatings), and pulse-echo (locate flaws & pits) modes are needed. Special high damped dual element transducers are also a must when performing inspections using both modes without an a-scan scope for verification. A highly damped transducer rings for a much shorter time, allowing the ***MMX-6DL*** to measure thinner material thicknesses in echo-echo mode. This same transducer is equally effective when used in pulse-echo mode, eliminating the need to use different transducers for each mode. The new ***MMX-6DL*** gives you all these features in a simple to use, one button toggle, digital thickness gauge. The following steps outline the procedure for setting up this feature:

Dual-Multi Mode

1) Press **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press **MODE** key to activate features and settings.
3) Press the **UP** or **DOWN** arrow keys to scroll to **GAtE**.
4) Press the **SEND** key to toggle between modes (**E-E, P-E**).
5) Press the **MODE** key once again to return to measurement mode.

RS232 Serial Port & The Data Logger

The MMX-6 DL is equipped with an RS232 serial port. Using the accessory cable (part# N-306-0010), the MMX-6 DL has the ability to connect to a computer, or external storage device. The following section outlines the procedure for connecting the MMX-6 DL to a computer, and how to collect data using any standard communications program:

Connecting To a Computer

1) Connect the accessory cable (part# N-306-0010) to the 2 pin jack located on the bottom of the ***MMX-6 DL***, and the 9 pin connector to a serial port on the computer.
2) Start the communications software that will be used to collect the measurements (i.e. Microsoft Windows™ 3.1 -Terminal, or 95, 98,Me, XP - HyperTerminal).
3) Setup the communications software using the following parameters: **Data Bits - 8**, **Parity - None**, **Stop Bits - 1**, **Baud Rate 1200 (to print a report), or 9600 to transfer data file**.

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

4) Set the communications software **COMM** port to the port number that the ***MMX-6 DL*** is connected - direct comm1, comm 2, etc.
5) Proceed to the section **USING THE DATA LOGGER**.

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

Using The Data Logger

The ***MMX-6 DL*** is equipped with an on board data logging feature. This will prove to be a valuable reporting tool for inspection purposes. It will increase efficiency by reducing the time it takes to manually record the measurements during the inspection process. The ***MMX-6 DL*** can then be connected to a computer or serial printer to save and print the results of the inspection.

The ***MMX-6 DL*** has a **storage capacity of 1000 measurements**. The ***MMX-6 DL*** has **10 files consisting of 100 sequential storage locations** in each file. The procedure for using the data logger is outlined in the following steps:

1) Press **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press the **MEM** key to activate the data logger.

Note:

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

3) Press the **SEND** key to enter file setup.

Using the Data Logger (con't)

- The current file will be diplayed (F-01, F-03, etc.)

4) Press the **UP** / **DOWN** arrow keys to scroll to the file (1-10) that will be used to record the measurements.

5) Press the **SEND** key once again to select the file.

Note:

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

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

Note:

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

7) Press the **UP** / **DOWN** arrow keys to advance to the desired cell location.

8) Take a measurement and press the **SEND** key to store a reading in the desired location.

Note:

- The data logger will **automatically advance** to the next storage location in sequential order.

9) Repeat **step 8** as required.

Clearing a Storage Location

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

Note:

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

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

Note:

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

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

Clearing an Entire File

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

1) Press the **ON/OFF** key to power up the ***MMX-6 DL***.
2) Press the **MEM** key to activate the data logging functions and settings.
3) Press the **SEND** key to enter file setup.
4) Press the **UP** / **DOWN** arrow keys to scroll to the file that will be cleared of all measurements.
5) Press the **SEND** key once again to select the file.

Note:

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

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

Clearing all Files

1) Press the **ON/OFF** key to power up the ***MMX-6 DL***.
2) Immediately press the **CLR** key. CLr? Will be displayed.
3) Press the **CLR** key once again to clear all files.

Sending All Files to a Computer

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

1) Refer to the section on **Connecting to a Computer**, page 27, before proceeding.
2) Press the **ON/OFF** key to power up the ***MMX-6 DL***.
3) Press the **MEM** key to activate the data logging functions and settings.
4) Press the **UP** / **DOWN** arrow keys to scroll to the **SEnd / ALL** symbol flashing on the display.
5) Press the **SEND** key to send all data files to the computer.
6) Press the **MEM** key to exit the data logging functions and return to measurement mode.

Printing a File

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

1) Refer to the section on **Connecting to a Computer**, page 27, before proceeding.
2) Press the **ON/OFF** key to power up the ***MMX-6 DL***.
3) Press the **MEM** key to activate the data logging functions and settings.
4) Press the **SEND** key to enter file setup.
5) Press the **UP** / **DOWN** arrow keys to scroll to the file to be printed (F-01, F-05, etc.).
6) Press **SEND**, once again, to select the file to be printed. The display will flash the **FILE / F-05** (The file selected) symbol.
7) Press the **UP** / **DOWN** arrow keys to scroll to the flashing **Prnt / F-05** (The file chosen), or **LISt** (tape printer) symbol.
8) Press the **SEND** key to print the contents of the file.
9) Press the **MEM** key, at any time, to exit the data logging functions and return to measurement mode.

TRANSDUCER SELECTION

The ***MMX-6 DL*** is inherently capable of performing measurements on a wide range of materials, from various metals to glass and plastics. Different types of material, however, will require the use of different transducers. Choosing the correct transducer for a job is critical to being able to easily perform accurate and reliable measurements. The following paragraphs highlight the important properties of transducers, which should be considered when selecting a transducer for a specific job.

Generally speaking, the best transducer for a job is one that sends sufficient ultrasonic energy into the material being measured such that a strong, stable echo is received by the ***MMX-6 DL***. Several factors affect the strength of ultrasound as it travels. These are outlined below:

- Initial Signal Strength

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

- Absorption and Scattering

  As ultrasound travels through any material, it is partly absorbed. If the material through which the sound travels has any grain structure, the sound waves will experience scattering. Both of these effects

reduce the strength of the waves, and thus, the ***MMX-6 DL***'s ability to detect the returning echo.

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

- Geometry of the Transducer

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

- Temperature of the Material

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

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

- Through Paint & Coatings

The ***MMX-6 DL*** has the ability to measure through and eliminate the thickness of paint or coatings on the surface of metals. While this is a very convenient feature, it must be used with the proper transducers in order to produce favorable results. Special high damped alpha style transducers must be used in order to achieve optimal results. Consult Dakota Ultrasonics directly for assistance in choosing the proper transducer for use with the Multi-Mode feature.

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APPENDIX A

Product Specifications

Physical

Weight: 10 ounces

Size: 2.5W x 4.75H x 1.25D inches
(63.5W x 120.6H x 31.75D mm).

Operating Temperature: -20 to 120 °F (-20 to 50 °C)

Case: Extruded aluminum body / nickel plated aluminum end caps.

Keypad

Sealed membrane, resistant to water and petroleum products.

Power Source

Two “AA” size, 1.5 volt alkaline or 1.2 volt NiCad cells. 200 hours typical operating time on alkaline, 120 hours on NiCad.

Display

Liquid-Crystal-Display, 4.5 digits, 0.500 inch high numerals. LED backlight.

Measuring

Range: Pulse-Echo mode 0.025 to 19.999 inches (0.63 to 500 millimeters)

Echo-Echo mode 0.100 to 1.0 inches (2.54 to 25.4 millimeters.

Resolution: 0.001 inch (0.01 millimeter)

Accuracy: ±0.001 inch (0.01 millimeter), depends on material and conditions

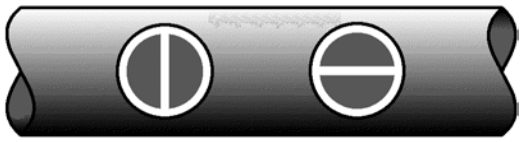
Sound Velocity Range: 0.0492 to 0.3930 in/μs (1250 to 10000 m/s)

APPENDIX B

Application Notes

- **Measuring pipe and tubing**

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



Perpendicular Parallel

- **Measuring hot surfaces**

The velocity of sound through a substance is dependant upon its temperature. As materials heat up, the velocity of sound through them decreases. In most applications with surface temperatures less than about 200°F (100°C), no special procedures must be observed. At temperatures

above this point, the change in sound velocity of the material being measured starts to have a noticeable effect upon ultrasonic measurement.

At such elevated temperatures, it is recommended that the user perform a **calibration** procedure (refer to page 15) on a sample piece of known thickness, which is at or near the temperature of the material to be measured. This will allow the ***MMX-6 DL*** to correctly calculate the velocity of sound through the hot material.

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

- **Measuring laminated materials**

Laminated materials are unique in that their density (and therefore sound-velocity) may vary considerably from one piece to another. Some laminated materials may even exhibit noticeable changes in sound-velocity across a single surface. The only way to reliably measure such materials is by performing a calibration procedure on a sample piece of known thickness. Ideally, this sample material should be a part of the same piece being measured, or at least from the same lamination batch. By calibrating to each test piece individually, the effects of variation of sound-velocity will be minimized.

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

- **Measuring Through Paint & Coatings**

Measuring through paints and coatings are also unique, in that the velocity of the paint / coating will be significantly different from the actual material being measured. A perfect example of this would be a mild steel pipe with approximately .025" of coating on the surface. Where the velocity of the pipe is .2330 in/μsec, and the velocity of the paint is .0900 in/μsec. If the user is calibrated for mild steel pipe and measures through both materials, the actual coating thickness will appear to be 2.5 times thicker than it actually is, as a result of the differences in velocity. This error can be eliminated by using a special echo-echo mode to perform measurements for applications such as these. In echo-echo mode, the paint / coating thickness will be eliminated entirely and the steel will be the only material measured.

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APPENDIX C

Sound Velocities of some Common Materials

Material	sound velocity in/us		sound velocity m/s
Aluminum	0.250		6350
Bismuth	0.086		2184
Brass	0.173		4394
Cadmium	0.109		2769
Cast Iron	0.180	(apprx)	4572
Constantan	0.206		5232
Copper	0.184		4674
Epoxy resin	0.100	(apprx)	2540
German silver	0.187		4750
Glass, crown	0.223		5664
Glass,flint	0.168		4267
Gold	0.128		3251
Ice	0.157		3988
Iron	0.232		5893
Lead	0.085		2159
Magnesium	0.228		5791
Mercury	0.057		1448
Nickel	0.222		5639
Nylon	0.102	(apprx)	2591
Paraffin	0.087		2210
Platinum	0.156		3962
Plexiglass	0.106		2692
Polystyrene	0.092		2337
Porcelain	0.230	(apprx)	5842
PVC	0.094		2388
Quartz glass	0.222		5639
Rubber, vulcanized	0.091		2311
Silver	0.142		3607
Steel, common	0.233		5918
Steel, stainless	0.223		5664
Stellite	0.275	(apprx)	6985
Teflon	0.056		1422
Tin	0.131		3327
Titanium	0.240		6096
Tungsten	0.210		5334
Zinc	0.166		4216
Water	0.058		1473

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WARRANTY INFORMATION

• Warranty Statement •

Dakota Ultrasonics warrants the MMX-6 DL against defects in materials and workmanship for a period of five years from receipt by the end user. Additionally, Dakota Ultrasonics warrants transducers and accessories against such defects for a period of 90 days from receipt by the end user. If Dakota Ultrasonics receives notice of such defects during the warranty period, Dakota Ultrasonics will either, at its option, repair or replace products that prove to be defective.

Should Dakota Ultrasonics be unable to repair or replace the product within a reasonable amount of time, the customer's alternative exclusive remedy shall be refund of the purchase price upon return of the product.

• Exclusions •

The above warranty shall not apply to defects resulting from: improper or inadequate maintenance by the customer; unauthorized modification or misuse; or operation outside the environmental specifications for the product.

Dakota Ultrasonics makes no other warranty, either express or implied, with respect to this product. Dakota Ultrasonics specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. Some states or provinces do not allow limitations on the duration of an implied warranty, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the five-year duration of this written warranty.

This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state or province to province.

• Obtaining Service During Warranty Period •

If your hardware should fail during the warranty period, contact Dakota Ultrasonics and arrange for servicing of the product. Retain proof of purchase in order to obtain warranty service.

For products that require servicing, Dakota Ultrasonics may use one of the following methods:

- Repair the product
- Replace the product with a re-manufactured unit
- Replace the product with a product of equal or greater performance
- Refund the purchase price.

• After the Warranty Period •

If your hardware should fail after the warranty period, contact Dakota Ultrasonics for details of the services available, and to arrange for non-warranty service.