

OPERATION MANUAL

DAKOTA ULTRASONICS - MMX-6 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 of phenomenon's rest solely with the user of the instrument.

INTRODUCTION

The Dakota Ultrasonics model **MMX-6** is a multi-mode Ultrasonic thickness gauge. Based on the same operating principles as SONAR, the **MMX-6** is capable of measuring the thickness of various materials with accuracy as high as ± 0.001 inches, or ± 0.01 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only one side of the material being measured. The multi-mode feature of the **MMX-6** allows the user to toggle between pulse-echo mode (flaw and pit detection), and echo-echo mode (eliminate paint or coating thickness).

This manual is presented in three sections. The first section covers operation of the **MMX-6**, 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:

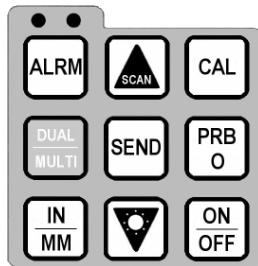
Dakota Ultrasonics, 1500 Green Hills Road, #107
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OPERATION

The **MMX-6** 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** on and off. When the gauge is turned ON, it will first perform a brief display test by illuminating all of the segments in the display. After one second, the gauge will display the internal software version number. After displaying the version number, the display will show "0.000" (or "0.00" if using metric units), indicating the gauge is ready for use.

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



The **PRB-0** key is used to "zero" the **MMX-6** in much the same way that a mechanical micrometer is zeroed. If the gauge is not zeroed correctly, all of the measurements that the gauge makes may be in error by some fixed value. Refer to page 12 for an explanation of this important procedure.



The **CAL** key is used to enter and exit the **MMX-6**'s calibration mode. This mode is used to adjust the sound-velocity value that the **MMX-6** will use when calculating thickness. The gauge 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 13 for an explanation of the two **CAL** functions available.



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



The **UP** arrow key has two functions. When the **MMX-6** 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 the **MMX-6** is not in calibration mode, the **UP** arrow key switches the **SCAN** measurement mode on and off. Refer to page 18 for an explanation of the **SCAN** measurement mode.



The **DOWN** arrow key has two functions. When the **MMX-6** 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 the **MMX-6** is not in calibration mode, the **DOWN** arrow key switches the display backlight between three available settings. **OFF** will be displayed when the backlight is switched off. **AUTO** will be displayed when the backlight is set to automatic mode, and **ON** will be displayed when the backlight is set to stay on. In the **AUTO** setting, the backlight will illuminate while the **MMX-6** is making a measurement and turn off after several seconds to conserve battery life.



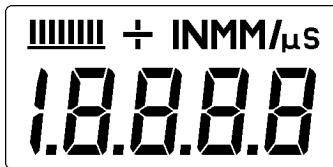
The **ALRM** key has two functions. By holding down the **ALRM** key when powering up the **MMX-6**, the audible beeper will be turned on or off accordingly. After the unit has been turned on, pressing the **ALRM** key will toggle the alarm mode to the on/off positions and allow the user to enter a nominal thickness value. Refer to page 19 for details on how to use the alarm feature.



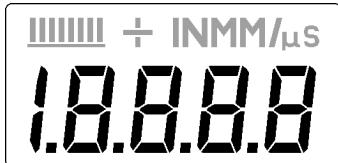
The **DUAL-MULTI** key is used to toggle **pulse-echo** (flaw & pit detection), and **echo-echo** (eliminate paint & coating thickness). This enables the user to very conveniently switch between modes depending on application requirements. Refer to page 20 for a complete explanation of this feature.



The **SEND** key is used to send the currently displayed thickness measurement to an external storage device via the **MMX-6's** RS232 port. Refer to page 22 for an explanation of how to use this feature.



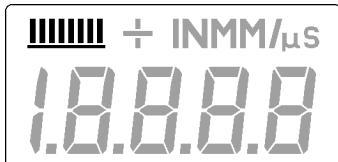
The Display



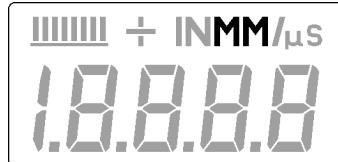
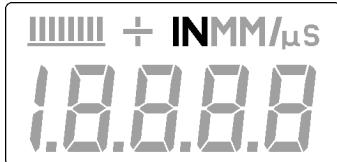
The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of various settings.

When the **MMX-6** 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.

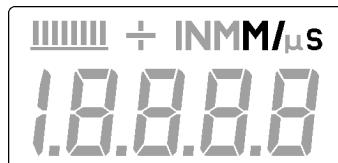
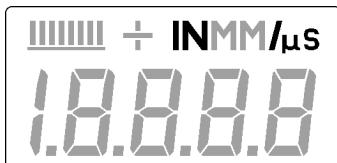


These eight vertical bars form the Stability Indicator. When the **MMX-6** is idle, only the left-most bar and the underline will be on. While the gauge is taking a measurement, six or seven of the bars should be on. If fewer than five bars are on, the **MMX-6** is having difficulty achieving a stable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



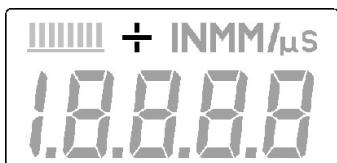
When the **IN** symbol is on, the **MMX-6** is displaying a thickness value in inches. The maximum thickness that can be displayed is 19.999 inches.

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



When the **IN** symbol is on, in conjunction with the **ms** symbol, the **MMX-6** 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** is displaying a sound-velocity value in **meters-per-second**.



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



The Transducer

The transducer is the "business end" of the **MMX-6**. It transmits and receives ultrasonic sound waves that the **MMX-6** uses to calculate the thickness of the material being measured. The transducer connects to the **MMX-6** 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**.

The transducer must be used correctly in order for the **MMX-6** 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** has been properly "zeroed" (see page 12) and set to the correct sound velocity (see page 13), the number in the display will indicate the actual thickness of the material directly beneath the transducer.

If the Stability Indicator has fewer than five bars darkened, or the numbers on the display seem erratic, first check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the material. If the condition persists, it may be necessary to select a different transducer (size or frequency) for the material being measured. See page 24.

While the transducer is in contact with the material that is being measured, the **MMX-6** 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** 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** is important for the same reason that setting the zero on a mechanical micrometer is important. If the gauge is not "zeroed" correctly, all of the measurements the gauge makes will be in error by some fixed number. When the **MMX-6** is "zeroed", this fixed error value is measured and automatically corrected for in all subsequent measurements. The **MMX-6** may be "zeroed" by performing the following procedure:

Performing a Probe-Zero

- 1) Make sure the **MMX-6** is on.
- 2) Plug the transducer into the **MMX-6**. 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**. Apply a single droplet of ultrasonic couplant to the face of this disc.
- 4) Make sure that the **MMX-6** 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** will display "Prb0" while it is calculating its zero point.
- 7) Remove the transducer from the probe-disc.

At this point, the **MMX-6** has successfully calculated its internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the **MMX-6** 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** will remember the last "probe-zero" performed, it is generally a good idea to perform a "probe-zero" whenever the gauge is turned on, as well as any time a different transducer is used. This will ensure that the instrument is always correctly zeroed.

Calibration

In order for the **MMX-6** to make accurate measurements, it must be set to the correct sound-velocity for the material being measured. Different types of material have different inherent sound-velocities. For example, the velocity of sound through steel is about 0.233 inches-per-microsecond, versus that of aluminum, which is about 0.248 inches-per-microsecond. If the gauge is not set to the correct sound-velocity, all of the measurements the gauge makes will be erroneous by some fixed percentage. 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** provides three simple methods for setting the sound-velocity, described in the following pages.

Note: Although the **MMX-6** has a thru-paint/coating feature, **one** and **two** point calibrations must be performed on material with the paint or coating removed. Failure to remove the paint or coating prior to calibration, will result in a multi material velocity calculation that may be different from the actual material velocity intended to be measured.

Calibration to a known thickness

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

- 1) Make sure the **MMX-6** 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 12)
- 3) Apply couplant to the sample piece.
- 4) Press the transducer against the sample piece, making sure that the transducer sits flat against the surface of the sample. The

display should show some (probably incorrect) thickness value, and the Stability Indicator should have nearly all its bars on.

- 5) Having achieved a stable reading, remove the transducer. If the displayed thickness changes from the value shown while the transducer was coupled, repeat step 4.
- 6) Press the **CAL** key. The **IN** (or **MM**) symbol should begin flashing.
- 7) Use the **UP** and **DOWN** arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.
- 8) Press the **CAL** key again. The **IN/ms** (or **M/s**) symbols should begin flashing. The **MMX-6** 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** 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** is on and switched to **P-E** (pulse-echo) mode. Press the **Dual-Multi** key to toggle modes.

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

- 2) Press the **CAL** key to enter calibration mode. If the **IN** (or **MM**) symbol is flashing, press the **CAL** key again, so that the **IN/ms** (or **M/s**) symbols are flashing.
- 3) Use the **UP** and **DOWN** arrow keys to adjust the displayed velocity up or down, until it matches the sound-velocity of the material to be measured.
- 4) Press the **CAL** key once more to exit the calibration mode. The **MMX-6** is now ready to perform measurements.

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

To achieve the most accurate measurements possible, it is generally advisable to always calibrate the **MMX-6** 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 gauge 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** 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 12)
- 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 8 on the second calibration point. The **MMX-6** will now display the sound velocity value it has calculated based on the thickness values that were entered in step 7.
- 9) The **MMX-6** is now ready to perform measurements within this range.

Scan Mode

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

In normal operation, the **MMX-6** performs and displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the gauge performs sixteen measurements every second, and displays the readings while scanning. While the transducer is in contact with the material being measured, the **MMX-6** 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** will display the smallest measurement it found.

When the **MMX-6** is not in calibration mode, press the **UP** arrow key to turn Scan Mode on and off. A brief message will appear in the display confirming the operation. When the transducer is removed from the material being scanned, the **MMX-6** will (after a brief pause) display the smallest measurement it found.

Alarm Mode

The Alarm Mode feature of the MMX-6 allows the user to set an audible and visual parameter when taking measurements. When the Alarm Mode is on, the green LED is illuminated. If a measurement falls below a nominal value, set by the user, the red LED will illuminate and the beeper will sound, if enabled. This improves the speed and efficiency of the inspection process by eliminating constant viewing of the actual reading displayed. The following pages outline how to enable and set up this feature:

Using the Beeper

- 1) While the unit is off, press and hold down the **ALRM** key.
- 2) Press **ON/OFF** key to power up the unit.
- 3) Release the **ALRM** key - **BEEP ON** or **BEEP OFF** will be displayed enabling or disabling the beeper.
- 4) **Repeat steps 1 through 3** to toggle between **BEEP ON** or **BEEP OFF**.

Alarm Mode

- 1) Press **ON/OFF** key to power up the **MMX-6**.
- 2) Press the **ALRM** key. **ALAr OFF**, or **ALAr** followed by a thickness value and flashing **IN** (or **MM**) symbol will be displayed - indicating the alarm mode is enabled.
- 3) Repeat step 2 to toggle between **ALAr OFF** or **ALAr value** and flashing **IN / MM** symbol (On).
- 4) Assuming **ALAr** value flashing **IN** is displayed, use the **UP** and **DOWN** arrow keys to scroll to the desired nominal alarm value.
- 5) Press the **ALRM** key once again to select the nominal value entered.
- 6) The **MMX-6** is now ready to perform measurements using the Alarm feature.

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-6** 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-6** 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**.
- 2) Press the **DUAL-MULTI** key to toggle between **E-E** (echo-echo) thru-paint/coatings mode and **P-E** (pulse-echo) flaw and pit mode.
- 3) The **MMX-6** is now ready to perform measurements in the current mode setting.

RS232 Serial Port

The **MMX-6** is equipped with an RS232 serial port. Using the accessory cable (part# N-306-0010), the **MMX-6** has the ability to connect to a computer, or external storage device. The following section outlines the procedure for connecting the **MMX-6** 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**, 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**.
- 4) Set the communications software **COMM** port to the port number that the **MMX-6** is connected.
- 5) After taking a measurement, press the **SEND** key to send the measurement to the computer. The measurement will be displayed on the computer screen.

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.

TRANSDUCER SELECTION

The **MMX-6** 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**. 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**'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** 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 120.7H x 31.8D 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.
Flashing display indicates low battery voltage.

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 10000m/s)

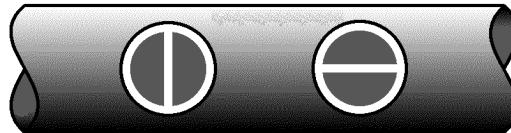
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APPENDIX B

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.



- **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 13) 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** 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/ μ sec, and the velocity of the paint is .0900 in/ μ sec. 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	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 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.

MATERIAL SAFETY DATA SHEET

N/A = not applicable or not available

(To comply with 29 CFR 1910.1200)

SECTION 1 – PRODUCT IDENTIFICATION

Product Name: **SOUNDSAFE®**
Generic Name: Ultrasonic Couplant
Manufacturer: Sonotech, Inc.
774 Marine Dr., Bellingham, WA 98225
(360) 671-9121

NFPA Hazardous Materials
Identification System (est)
Health.....0
Flammability.....0
Reactivity.....0

SECTION 2 – HAZARDOUS INGREDIENTS

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

SECTION 3 – PHYSICAL DATA (nominal)

Boiling Point: >220°F pH: 7.35 – 7.9
Freezing Point: <20°F Acoustic Imp.: 1.726x10⁶
Vapor Pressure: N/A Vapor Density: N/A
Evaporation Rate: N/A Specific Gravity: >1.02
Solubility in Water: complete
Appearance and Odor: water white, opaque gel;
bland odor

SECTION 4 – FIRE AND EXPLOSION HAZARD DATA

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

SECTION 5 – REACTIVITY DATA

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

SECTION 6 – HEALTH HAZARD AND FIRST AID DATA

Routes of Entry:¹
Skin: not likely Ingestion: not normally
Eyes: not normally Inhalation: no
Effects of Overexposure: *Acute:* May cause temporary eye irritation
Chronic: none expected

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

SECTION 7 – STORAGE AND HANDLING INFORMATION

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

SECTION 8 – CONTROL MEASURES

Respiratory Protection: not required
Ventilation: not required
Protective Gloves: on individuals demonstrating sensitivity to SOUNDSAFE®
Eye Protection: as required by working conditions
Other Protective Equipment: not required

¹SOUNDSAFE® contains only food grade and cosmetic grade ingredients.

SONOTECH, INC.

Toll Free: 1-800-458-4254

774 Marine Dr., Bellingham, WA 98225
Telephone: (360) 671-9121

Fax: (360) 671-9024

