OPERATION MANUAL

DAKOTA ULTRASONICS MODEL PX-7 DL PRECISION THICKNESS GAUGE

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INTRODUCTION

The Dakota Ultrasonics model **PX-7 DL** is a precision Ultrasonic Micrometer. Based on the same operating principles as SONAR, the **PX-7 DL** is capable of measuring the thickness of various materials with accuracy as high as ± 0.0001 inches, or ± 0.001 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only <u>one side</u> of the material being measured.

This manual is presented in three sections. The first section covers operation of the **PX-7 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:

- Dakota Ultrasonics, 1500 Green Hills Road, #107
  Scotts Valley, CA 95066 USA

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- www.dakotaultrasonics.com

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OPERATION

The **PX-7 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
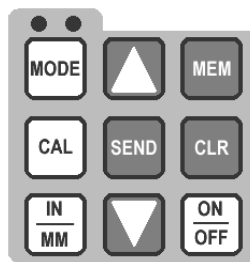
This key is used to turn the **PX-7 DL** on and off. When the tool is turned ON, it will first perform a brief display test by illuminating all of the segments in the display. After one second, the tool will display the internal software version number and the current file location and status. After displaying the version number, the display will show ".0000" (or "0.000" if using metric units), indicating the tool is ready for use.

The **PX-7 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.

$$\boxed{\frac{\text{IN}}{\text{MM}}}$$

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

$$\boxed{\text{CAL}}$$

The **CAL** key is used to enter and exit the *PX-7 DL*'s calibration mode. This mode is used to adjust the sound-velocity value that the *PX-7 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 13 for an explanation of the two **CAL** functions available.

$$\boxed{\text{MODE}}$$

The **MODE** key is used to toggle through the various features and settings of the *PX-7 DL* (alarm, diff, scan, gate, back light, and beeper). The **MODE** key is used in conjunction with the arrow and send keys to enable/disable the features and settings. Refer to page 16 for a further explanation of the different modes.

The **UP** arrow key has three functions. When the *PX-7 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 *PX-7 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 22 for further information regarding the use of the **UP** arrow key and the data logger.

The **DOWN** arrow key has three functions. When the *PX-7 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 *PX-7 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 22 for further information regarding the use of the **DOWN** arrow key and the data logger.

MEM

The **MEM** key enables/disables the data logging feature of the PX-7 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 *PX-7 DL*. Refer to the section on data logging page 22.

CLR

The **CLR** key is specifically used with the data logging feature of the *PX-7 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 22.

SEND

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 *PX-7 DL* page 22.

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IIIIIIII ÷ INMM/μS
I.8.8.8.8

The Display

IIIIIIII ÷ INMM/μS
I.8.8.8.8
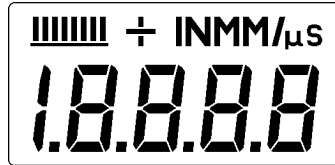
The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of various settings. When the *PX-7 DL* is displaying thickness measurements, the dis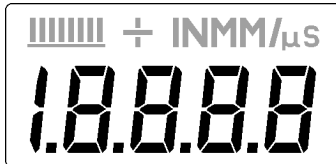play will hold the last value measured, until a new measurement is made. Additionally, when the battery voltage is low, the entire display will begin to flash. When this occurs, the batteries should be replaced.

IIIIIIII ÷ INMM/μS
I.8.8.8.8
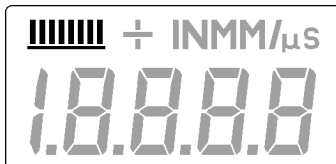
These eight vertical bars form the Stability Indicator. When the *PX-7 DL* is idle, only the left-most bar and the underline will be on. While the gauge is taking a measurement, six or seven of the bars should be on. If fewer than five bars are on, the *PX-7 DL* is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.

IIIIIIII ÷ INMM/μs
1.8.8.8.8
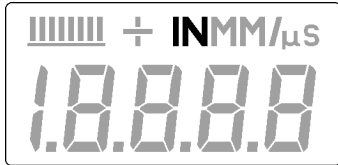
When the **IN** symbol is on, the *PX-7 DL* is displaying a thickness value in inches. The maximum thickness that can be displayed is 1.999 inches.

IIIIIIII ÷ IN MM/μs
1.8.8.8.8
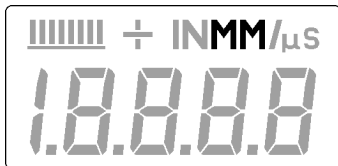
When the **MM** symbol is on, the *PX-7 DL* is displaying a thickness value in millimeters. If the displayed thickness exceeds 19.999 millimeters, the decimal point will shift automatically to the right, allowing values up to 99.99 millimeters to be displayed.

IIIIIIII ÷ INMM**/μs**
1.8.8.8.8
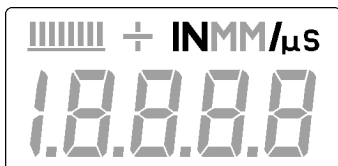
When the **IN** symbol is on, in conjunction with the **/μs** symbol, the *PX-7 DL* is displaying a sound-velocity value in **inches-per-microsecond.**

IIIIIIII ÷ INM**/**μs
1.8.8.8.8
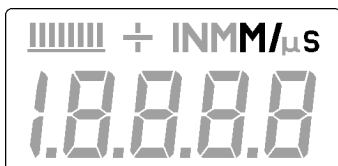
When the **M** symbol is on, in conjunction with the **/s** symbol, the *PX-7 DL* is displaying a sound-velocity value in **meters-per-second**.

Transducer
Identification

Transducer Body ——

Microdot Connector

Retaining Ring ——

Replaceable Delay Line ——
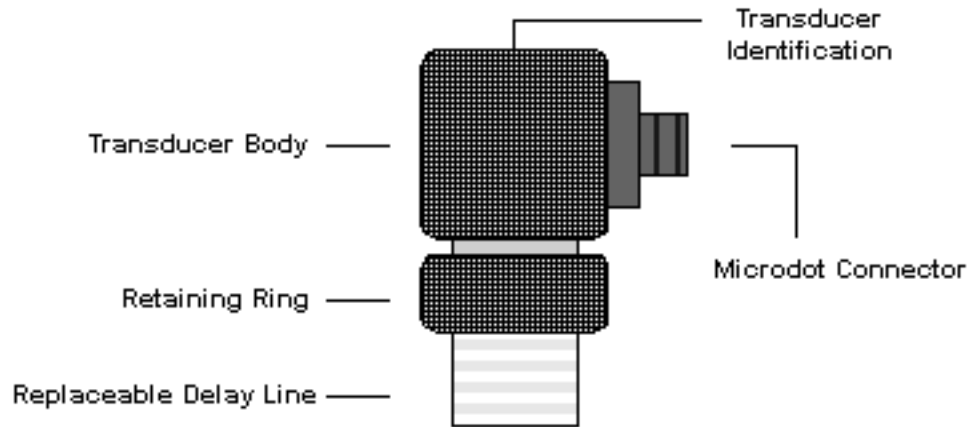
The Transducer

The transducer is the "business end" of the **PX-7**. It transmits and receives ultrasonic sound waves that the **PX-7** uses to calculate the thickness of the material being measured. The transducer connects to the **PX-7** via the attached cable, and one coaxial connector.

The transducer must be used correctly in order for the **PX-7** to produce accurate, reliable measurements. Below is a short description of the transducer, followed by instructions for its use.

The diagram above is a side view of a typical single element delay line transducer. This delay line is fastened to the transducer with a retainer ring. A drop of couplant is applied between the delay line and transducer body. The transducer body contains one crystal element that is responsible for conducting ultrasonic sound into and back from the material being measured. When the transducer is placed against the material being measured, it is the area directly beneath the delay line that is being measured.

When measuring, press against the top of the transducer 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 delay line 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 **PX-7** has been 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 28 for information on transducer selection.

While the transducer is in contact with the material that is being measured, the **PX-7** 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 **PX-7 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.

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.

Calibration

In order for the **PX-7 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 <u>large</u> ranges. The **PX-7 DL** provides two 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) Make sure the *PX-7 DL* is on.

2) Apply couplant to the sample piece.

3) 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.

4) Having achieved a stable reading, remove the transducer. If the
displayed thickness changes from the value shown while the
transducer was coupled, repeat step 3.

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

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

7) Press the **CAL** key again. The **IN/ms** (or **M/s**) symbols should
begin flashing. The *PX-7 DL* is now displaying the sound velocity
value it has calculated based on the thickness value that was
entered in step 6.

8) Press the **CAL** key once more to exit the calibration mode. The
PX-7 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 *PX-7 DL* is on.

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 *PX-7 DL* 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* **CLR** *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 *PX-7 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.

PX-7 DL Modes & Features

The Back light

The back light of the **PX-7 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:

1) Press **ON/OFF** key to power up the **PX-7 DL**.

1) Press the **MODE key** to activate features and settings.

2) Press the **UP** / **Down** arrow keys to scroll to the **LItE** symbol.

3) Press the **SEND** key to toggle the status of the back light on/off/auto.

4) Press the **MODE** key once again to return to measurement mode.

Scan Mode

While the **PX-7 DL** excels at making single point measurements, it is sometimes desirable to examine a larger region, searching for the thinnest point. The **PX-7 DL** includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the **PX-7 DL** performs and displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the tool performs eight measurements every second, but does not display them. While the transducer is in contact with the material being measured, the **PX-7 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 **PX-7 DL** will display the smallest measurement it found.

When the **PX-7 DL** is in measurement mode, press the **MODE** key to activate the features and settings. The display will begin flashing **ALAr** (alarm), followed by the status - on/off. Use the **UP** and **DOWN** arrow keys to scroll to **SCAn** mode. Press the **SEND** key to toggle scan mode on/off. While scanning, the display will show a moving series of dashes instead of a thickness value. When the transducer is removed from the material being scanned, the **PX-7 DL** will (after a brief pause) display the smallest measurement it found.

Alarm Mode

The Alarm Mode feature of the PX-7 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 *PX-7 DL*.

2) Press the **MODE key** to activate features and settings.

3) Mode will start with **ALAr** feature and current status.

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.

Measurement Modes

The PX-7 is equipped with three measurement mode options (echo-echo, interface-echo, or auto). In echo-echo mode, the gauge has the ability to read thin metals down to .006 inches (.15 millimeters). The echo-echo mode also allows the user to measure the thickness of metals that have been previously coated or painted on the surface. This enables the user to determine the thickness of the metal without having to remove the paint. In interface-echo mode, the gauge has the ability to read plastics and thicker materials. The PX-7's auto mode will automatically switch between modes according to the different materials being measured. Finally, the plas mod can be used to measure thin plastics using a special graphite tip. The following section outlines how to switch between measurement modes:

Measurement Modes

1) Press **ON/OFF** key to power up the *PX-7 DL*.

2) Press the **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 the different measurement modes (**E-E, I-E, AutO, and PLAS**).

5) Press the **MODE** key once again to return to measurement mode.

Differential Mode

In the Quality Control environment, it is sometimes necessary to know the difference between a nominal (target) thickness value and an actual thickness value.   This feature is also included in the PX-7 DL. With the Differential Mode enabled, the PX-7 DL will display the positive or negative difference from an entered nominal value. The following steps outline the procedure for setting up this feature:

Differential Mode

6) Press **ON/OFF** key to power up the *PX-7 DL*.

7) Press the **MODE** key to activate features and settings.

8) Press the **UP** or **DOWN** arrow keys to scroll to **dIFF**.

9) Press the **SEND** key to toggle the staus of the differential mode on/off.

10) **Status ON** - A nominal value will be displayed with the units IN/MM flashing.

11) Press the **UP** or **DOWN** arrow keys to scroll to the desired nominal thickness value.

12) Press the **SEND** key to select the desired nominal value and return to mode menu.

13) Press the **MODE** key once again to return to measurement mode.

RS232 Serial Port & The Data Logger

The PX-7 DL is equipped with an RS232 serial port. Using the accessory cable (part# N-306-0010), the PX-7 DL has the ability to connect to a computer, or external storage device. The following section outlines the procedure for connecting the PX-7 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 **PX-7 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. Dakota Ultrasonics DakView, Microsoft Windows™ 3.1 -Terminal, or 95/98 - 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: Step 3 is not required when Using DakView software.

▪ 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 **PX-7 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 **PX-7 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 **PX-7 DL** can then be connected to a computer or serial printer to save and print the results of the inspection.

The **PX-7 DL** has a **storage capacity of 1000 measurements**. The **PX-7 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 **PX-7 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.

- 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.

<u>Clearing an Entire File</u>

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 *PX-7 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.

<u>Clearing all Files</u>

1) Press the **ON/OFF** key to power up the *PX-7 DL*.

2) Immediately press the **CLR** key. CLr? Will be displayed.

3) Press the **CLR** key once again to clear all files.

<u>Sending All Files to a Computer</u>

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 21, before proceeding.

2) Press the **ON/OFF** key to power up the *PX-7 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.

5) 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. Dakota Ultrasonics DakView, Windows 3.1 - Terminal, Window 95/98 - HyperTerminal), and then printed. The procedure for printing a file is outlined below:

1) Refer to the section on **Connecting to a Computer**, page 21, before proceeding.

2) Press the **ON/OFF** key to power up the *PX-7 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 **PX-7** 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 **PX-7**. 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 "1/4-inch" transducer will emit a stronger signal than a "1/8-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 **PX-7**'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.

- 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 cone tipped delay line. Measuring on a curved surface, 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, special delay lines may be neccessary. Additionally, care must be taken when performing a "Calibration to Known Thickness" with a high temperature application. See **Appendix B** for more information on measuring materials with a high temperatures.

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.

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APPENDIX A

Product Specifications

Physical

Weight: 10 ounces(with batteries).

Size: 2.5W x 4.5 H x 1.24 D inches

(63.5W x 114.3 H x 31.5 D mm).

Operating Temperature: -20 to 120 °F (-30 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. 150 hours typical operating time on alkaline, 100 hours on NiCad.

Display

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

Measuring

Range: 0.0060 to 1.0000 inches (0.15 to 25.40 millimeters) - Steel

Resolution: 0.0001 inch (0.001 millimeter)

Accuracy: ±0.0001 inch (0.001 millimeter), depends on material

and conditions

Sound Velocity Range: 0.0492 to 0.3937 in/µs (1250 to 10000m/s)

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APPENDIX B

Application Notes

- ### <u>Measuring tubing</u>

When measuring a piece of tubing for wall thickness, it may prove beneficial to have multiple delay lines with different radiuses for different tubing diameters. The delay lines can be easily radiused by placing a piece of emery cloth around the tubing and moving the transducer back and forth until a radius has formed on the tip of the delay line.

- ### <u>Measuring hot surfaces</u>

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 *PX-7* 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 delay line. 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.

- **<u>Measuring laminated materials</u>**

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.

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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 PX-7 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.

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
<u>Identification System (est)</u>
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.: 1.726×10^6
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

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

<u>First Aid Procedures</u>:
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

<u>Precautions to be taken in handling and storage</u>: Store between 20°F and 120°F. Spills are slippery and should be cleaned up immediately.
<u>Steps to be taken in case material is released or spilled</u>: Pick up excess for disposal. Clean with water.
<u>Waste disposal method</u>: 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

[1]**SOUNDSAFE**® contains only food grade and cosmetic grade ingredients.

SONOTECH, INC.

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

Toll Free: 1-800-458-4254   **Fax: (360) 671-9024**