OPERATION MANUAL

DAKOTA ULTRASONICS

PR-9

Sonic Thickness Tester - Racing

P/N P-309-0002 Rev 1.11, November 2019

CONTENTS

CHAPTER ONE
INTRODUCTION

The Dakota Ultrasonics model ***PR-9*** is a basic dual element sonic tester with the ability to locate blind surface pitting and internal defects/flaws in materials. Based on the same operating principles as SONAR, the ***PR-9*** is capable of measuring the thickness of various materials with accuracy as high as $\pm$ 0.001 inches, or $\pm$ 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.

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:

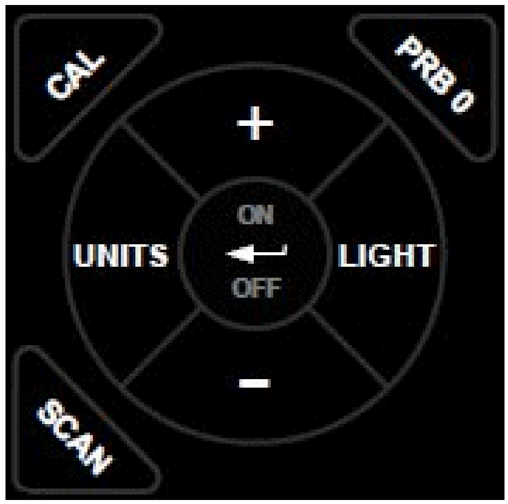
Dakota Ultrasonics Corporation
1500 Green Hills Road, #107
Scotts Valley, CA 95066
Tel: (831) 431-9722
Fax: (831) 431-9723
www.dakotaultrasonics.com

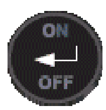
1.1 Disclaimer

Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the back surface of the material being measured. This may result in a thickness reading that is TWICE what it should be. Responsibility for proper use of the instrument and recognition of this phenomenon rest solely with the user of the instrument. Other errors may occur from measuring coated materials where the coating is insufficiently bonded to the material surface. Irregular and inaccurate readings may result. Again, the user is responsible for proper use and interpretation of the measurements acquired.

CHAPTER TWO
KEYPAD, MENU, DISPLAY & CONNECTORS

The Keypad

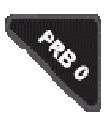


2.1 ON/OFF/ENTER Key 

The **ON/OFF/ENTER** key powers the unit **ON** or **OFF**. Since the same key is also used as an **ENTER** key, the gauge is powered off by pressing and holding down the key until the unit powers off.

Once the gauge is initially powered on, this key will function as the **ENTER** key, similar to a computer keyboard. This key will be used to select or set a menu option.

Note: *Unit will automatically power off when idle for 5 minutes. All current settings are automatically saved prior to powering off.*

2.2 PRB 0 Key 

The **PRB 0** key is used to "zero" the ***PR-9*** 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 13 for a further explanation of this important feature.

2.3 CAL Key

The **CAL** key is used to enter and exit the ***PR-9***'s calibration mode. This mode is used to adjust the sound velocity value that the ***PR-9*** 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. This provides increased linearity between transducers. Refer to page 14 for an explanation on the various calibration options.

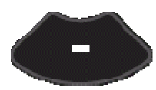
2.4 LIGHT Key

The **LIGHT** key accesses the backlight setting of the LCD display. The backlight has three setting options; ON, OFF, AUTO. The auto option will only illuminate the display when the ***PR-9*** is measuring, or receiving an echo. If either ON or AUTO are selected, there are three brightness options, LO, MED, HI, to select a preferred overall brightness of the display. Refer to page 20 for an explanation on how to enable and set the brightness.

2.5 UNITS Key

The **UNITS** key is used to select either English or Metric units. Refer to page 20 for an explanation of how to select the units.

2.6 +/- Increment/Decrement Key's

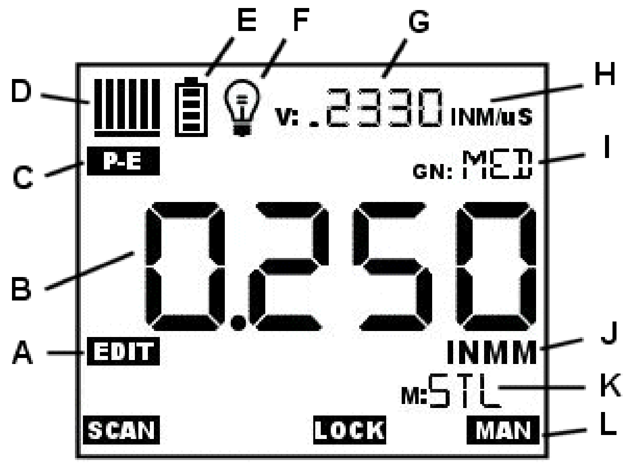


The **+/-** Keys are used to increment/decrement values, navigate menus, and select menu options.

2.7 SCAN Key

The ***PR-9*** offers a high speed scan feature. This feature allows for scanning larger areas on a given test material, while still offering reasonable representation of thickness over the area scanned. Refer to page 20 for an explanation on the scan feature.

2.8 The Display



The ***PR-9*** uses a custom glass LCD backlit low temperature display for use in a variety of climate conditions. It contains graphic icons, as well as both 7 and 14 segment display areas. Let's take a closer look and what all these things are telling us:

Note: *This display is used for multiple gauge models in the* ***ZX*** *&* ***PZX*** *series. As a result, some of the icons and segments that are illuminated during boot up, may not be applicable to your specific model, and will never be illuminated during operation. The icons and segments that will be used with the* ***PR-9*** *are shown in the diagram above.*

- **A.** **Edit:** This icon will be displayed, and blinking, to let a user know when they are in an edit mode to change a value or setting.
- **B.** **Large 7 segment:** The thickness measurement, velocity or alpha message will be displayed in this area.
- **C.** **Measurement Modes:** This icon indicates the measurement mode. The ***PR-9*** operates exclusively in pulse-echo (P-E) mode only.
- **D.** **Stability/Repeatability Indicator:** This is used in conjunction with the thickness measurement as a reference for the validity of the measurement. The ***PR-9*** takes multiple measurements per second, and when all the vertical bars are illuminated, it's a reference that the same thickness value is reliably being measured multiple times per second.
- **E.** **Battery:** Indicates the amount of battery life the ***PR-9*** has remaining.
- **F.** **Backlight :** When this icon is illuminated, it indicates the backlight is on.
- **G.** **Small 7 Segment:** The material velocity, speed the sound wave travels through a given medium/material, is displayed in this area, informing the user what material the ***PR-9*** is currently calibrated too. This area is also used for alpha messages in the menu and edit modes.

H. **Units:** This combination of icons are illuminated in different sequences to inform the user what measurement units are currently being displayed in the small 7 segment area.

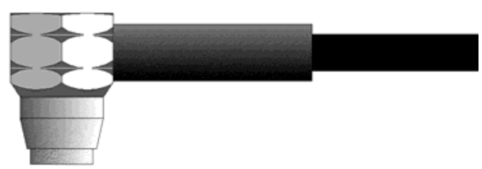
I. **Small 14 Segment:** Displays the current gain setting of the ***PR-9*** which will always display medium (MED).

J. **Units:** This combination of icons are illuminated in different sequences to inform the user what measurement units are currently being displayed in the large 7 segment area.

K. **Small 14 Segment:** The material type is displayed in this area. If it is set to a value of one of the materials in our material list, it will be displayed in alpha characters indicating the material type. Otherwise it will be set to CUST, indicating custom material type.

L. **Features:** The icons illuminated in this row across the bottom of the LCD display which features are currently enabled. For a complete list refer to page 20. The ***PR-9*** can be locked once calibrated, to avoid accidently changing the calibration. When this icon is illuminated, the ***PR-9*** is in lock mode. Refer to page 21 for an explanation on locking the ***PR-9***.

2.9 The Transducer



The Transducer is the "business end" of the ***PR-9***. It transmits and receives ultrasonic sound waves that the ***PR-9*** uses to calculate the thickness of the material being measured. The transducer connects to the ***PR-9*** 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 ***PR-9***.

The transducer must be used correctly in order for the ***PR-9*** 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 wear face 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 wear face 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 wear face seated flat against the surface of the material being measured.

Measuring

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.

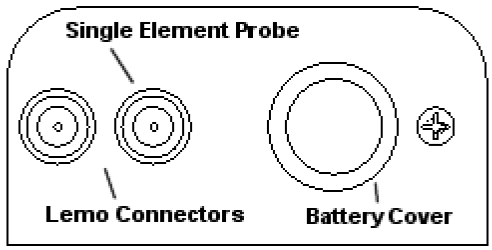
After applying couplant, press the transducer (wear face down) firmly against the area to be measured. The Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the ***PR-9*** has been properly "zeroed" (see page 13) and set to the correct sound velocity (see page 14), 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 11 for information on transducer selection.

While the transducer is in contact with the material that is being measured, the ***PR-9*** 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.

2.10 Top End Cap



Top End Cap

The top end cap is where all connections are made to the ***PR-9***. The diagram above shows the layout and description of the connectors:

Transducer Connectors

Refer to Diagram: The transducer connectors and battery cover/probe zero disk are located on the ***PR-9's*** top end cap. The transducer connectors are of type Lemo "00".

Note: *There is no polarity associated with connecting the transducer to the **PR-9**, it can be plugged into the gauge in either direction.*

Probe Zero Disk & Battery Cover

Refer to Diagram: The Battery cover is the large round disk shown in the diagram.

Note: *This same disk is also used as a probe zero reference disk. Simply remove the cover when replacing the batteries (2 AA cells). When performing a manual probe zero function, simply place the transducer on disk making firm contact.* ***Important:*** *Be sure the battery polarity is correct, which can be found on the back label of the **PR-9**.*

Note: *Rechargeable batteries can be used, however they must be recharged outside of the unit in a standalone battery charger.*

CHAPTER THREE
PRINCIPALS OF ULTRASONIC MEASUREMENT

3.1 Time versus thickness relationship

Ultrasonic thickness measurements depend on measuring the length of time it takes for sound to travel through the material being tested. The ratio of the thickness versus the time is known as the sound velocity. In order to make accurate measurements, a sound velocity must be determined and entered into the instrument.

The accuracy of a thickness measurement therefore depends on having a consistent sound velocity. Some materials are not as consistent as others and accuracy will be marginal. For example, some cast materials are very granular and porous and as a result have inconsistent sound velocities.

While there are many different ultrasonic techniques to measure thickness, which will be discussed below, all of them rely on using the sound velocity to convert from time to thickness.

3.2 Suitability of materials

Ultrasonic thickness measurements rely on passing a sound wave through the material being measured. Not all materials are good at transmitting sound. Ultrasonic thickness measurement is practical in a wide variety of materials including metals, plastics, and glass. Materials that are difficult include some cast materials, concrete, wood, fiberglass, and some rubber.

3.3 Range of measurement and accuracy

The overall measurement capabilities, based on the wide variety of materials, is determined by the consistency of the material being measured

The range of thickness that can be measured ultrasonically depends on the material type and surface, as well as the technique being used and the type of transducer. The range will vary depending on the type of material being measured.

Accuracy, is determined by how consistent the sound velocity is through the sound path being measured, and is a function of the overall thickness of the material. For example, the velocity in steel is typically within 0.5% while the velocity in cast iron can vary by 4%.

3.4 Couplant

All ultrasonic applications require some medium to couple the sound from the transducer to the test piece. Typically a high viscosity liquid is used as the medium. The sound frequencies used in ultrasonic thickness measurement do not travel through air efficiently. By using a liquid couplant between the transducer and test piece the amount of ultrasound entering the test piece is much greater.

3.5 Temperature

Temperature has an effect on sound velocity. The higher the temperature, the slower sound travels in a material. High temperatures can also damage transducers and present a problem for various liquid couplants.

Since the sound velocity varies with temperature it is important to calibrate at the same temperature as the material being measured.

Normal temperature range

Most standard transducers will operate from 0°F to 250°F.

High temperature measurements

Special transducers and couplants are available for temperatures above 250°F up to 1000°F with intermittent contact. It is necessary to cool the transducer by submerging it in water between measurements.

Modes and temperature errors

In addition to errors caused by velocity changing with temperature, some modes (measurement techniques) are affected more than others. For example, dual element pulse-echo mode has larger errors due to changes in the temperature of the transducer. However, multi-echo techniques offer temperature compensation help to minimize these errors.

3.6 Measurement Modes

This section will cover the different measurements modes of the ***PR-9***, the transducers required, and the reasons for using specific modes:

Pulse-Echo (P-E) Mode:

Pulse-echo mode measures from the initial pulse (sometimes referred to as an artificial zero) to the first echo (reflection). In this mode, either an automatic or manual zero can be performed depending on the zero probe setting. If the manual mode has been selected, the transducer is placed on the reference disk located on top of the ***PR-9***, and the **PRB 0** key pressed to establish a zero point for the transducer connected. If the Auto Zero feature is enabled, simply pressing the PRB 0 key will perform an electronic zero to establish the same zero point.

In pulse-echo mode, errors can result from surface coatings and temperature variations. Since pulse-echo only requires one reflection, it is the most sensitive mode for measuring flaw/defects when measuring heavily corroded metals.

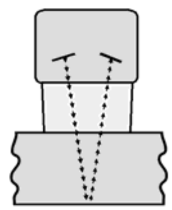
V-Path Correction

Dual element delay line transducers have two piezoelectric elements focused towards one another at a slight angle, mounted on a delay line. One element is used for transmitting sound, while the other element receives the sound reflection. The two elements and their delay lines are packaged in a single housing but acoustically isolated from each other with an insulated sound barrier. This allows the transducer the ability to achieve very high sensitivity for detecting small defects. Also, the surface of the test material does not have to be as flat in order to obtain good measurements.

Dual element transducers are normally used in pulse-echo mode for finding defects, and in echo-echo mode for through coating measurements.

Dual element delay line transducers are have a usable range of 0.025" and up, depending on the material, frequency, and diameter.

A limitation of dual element delay-line transducers is the V shaped sound path. Because the sound travels from one element to another, the time versus thickness relationship is non-linear. Therefore, a correction table in the instruments software is used to compensate for this error.



Dual Element Transducer showing V-path of signal

Searching for small defects

Dual element delay line transducers are especially useful in searching for small defects. In pulse-echo mode with high amplifier gain, very small defects can be located. As a result, this configuration is commonly used for corrosion inspections. The dual element style transducer will find wall deterioration, pits, cracks, and any porosity pockets during tank and pipeline inspections.

CHAPTER FOUR
SELECTING THE MEASUREMENT MODE

4.1 Which mode & transducer do I use for my application?

High penetration plastics and castings

The most common mode for these types of applications is pulse-echo. Cast iron applications require 1 - 5MHz frequencies, and cast aluminum requires a 7 - 10MHz frequency depending on the thickness. Plastics typically require lower frequencies depending on the thickness and make-up of the material as well. Larger diameters offer greater penetration power based on the size of the crystal.

Corrosion & Pit Detection in steel and cast materials

Pulse-echo mode is commonly used for locating pits and defects. Typically a 5MHz transducer, or higher, will be used for these types of applications. Use low frequencies for greater penetration and use higher frequencies for better resolution.

Measuring Material & Coatings

The pulse-echo coating mode should be used when both material and coating thickness are required, while still requiring the ability to detect flaws and pits. A special coating style transducer is required for use in this mode. There are a variety of coating transducers in various frequencies available from Dakota.

Thru Paint & Coatings

Often times, users will be faced with applications where the material will be coated with paint or some other type of epoxy material. Since the velocity of the coating is approximately 3 times slower than that of steel, pulse-echo mode will result in an error if the coating or paint is not completely removed.

Thin materials

Pulse echo mode and a high frequency transducer is commonly used for these types of applications. The most common transducers are the 7.5MHz and 10MHz models with extra resolution. The higher frequencies provide greater resolution and a lower minimum thickness rating overall.

High temperature

Special 5 MHz High temperature transducers are available for these types of applications. Both pulse-echo and echo-echo modes will also work for these applications. However, echo-echo mode will eliminate error caused by temperature variations in the transducer.

Noisy Material

Materials such as titanium, stainless steel, and aluminum may have inherent surface noise issues or mirroring effect. Higher frequency transducers 7 – 10MHz offer improved resolution to avoid erroneous measurements.

Restricted access

Measuring materials with extreme curvatures or restricted access are best suited for higher frequencies and smaller diameter transducers.

CHAPTER FIVE
MAKING MEASUREMENTS

The steps involved in making measurements are detailed in this section. The following sections outline how to setup and prepare your ***PR-9*** for field use.

An automatic or manual zero must always be performed. The auto zero is an 'off block' electronic zero that does not require a zero reference standard. This will most always be the zero option of choice, as it makes the zeroing process very easy and convenient to perform. However, the manual zero option offers better accuracy in terms of a reference point. If the manual zero option is enabled, the probe zero must be measured on the reference disk (battery disk) attached to the top of the instrument. The zero compensates for variations in the transducer. In either mode the sound velocity must be determined, and is used to convert the transit time to a physical length. The sound velocity can be selected from a material chart in the manual, selected from a short list of common materials in the ***PR-9***, or for greater precision determined from a sample of the test material that has been mechanically measured. To enter the velocity from a table, look up the material on the chart in the appendix of this manual and refer to the section below on Calibration to a Known Velocity. To determine the velocity of a single sample, refer to the Material Calibration section on page 14.

When measuring curved materials, it's more accurate to calibrate from two test points, one at the minimum limit of the target thickness and one at the maximum limit. In this case the reference disk mounted to the ***PR-9*** is not used. This is called two-point calibration and is described on page 17.

5.1 Probe zero

Setting the zero point of the ***PR-9*** is important for the same reason that setting the zero on a mechanical micrometer is important. It must be done prior to calibration, and should be done throughout the day to account for any temperature changes in the probe. If the ***PR-9*** is not zeroed correctly, all the measurements taken may be in error by some fixed value.

The procedure is outlined below as follows:

Performing a Probe Zero

1) Apply a drop of couplant on the transducer and place the transducer in steady contact with the disk (battery cover) located at the top of the unit to obtain a measurement.
2) Be sure all six repeatability/stability bars in the top left corner of the display are fully illuminated and stable, and last digit of the measurement is toggling only +/- .001" (.01mm).
3) Press the 

key to perform the zero. "PRB0" will briefly be displayed on the screen, indicating the zero calculation was performed.

5.2 Material Calibration

In order for the ***PR-9*** to make accurate measurements, it must be set to the correct sound velocity of the material being measured. Different types of materials have different inherent sound velocities. For example, the velocity of sound through steel is about 0.233 inches per microsecond, versus that of aluminum, which is about 0.248 inches per microsecond. If the gauge is not set to the correct sound velocity, all of the measurements the gauge makes will be erroneous by some amount.

The **One Point** calibration is the simplest and most commonly used calibration method - optimizing linearity over large ranges. The **Two Point** calibration allows for greater accuracy over small ranges by calculating both the probe zero, as well as the material velocity. The ***PR-9*** provides three simple methods for setting the sound-velocity outlined below:

Known Velocity

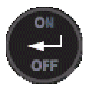
If the material velocity is known, it can be manually entered into the ***PR-9***, rather than have the ***PR-9*** calculate the velocity value using a known thickness of the same material type. The steps for entering the velocity are outlined below:

Using a Known Material Velocity

1) With the transducer free from contact with the material, press the  key to display the current velocity.
2) Use the   keys to scroll the velocity to the known target value.

Note: *The longer the keys are pressed and held, the faster the value will increment/decrement.*

Note: *Pressing the*  *key prior to pressing the*  *key will abort the cal routine without saving any changes.*

3) Press the  key to set the velocity value and return to the measurement screen. The new velocity value will be shown at the top of the display.

Known Thickness

Often times the exact sound velocity of a material is unknown. However, a sample with one or two known thicknesses can be used to determine the sound velocity. As previously discussed, the ***PR-9*** has a one or two point calibration option. The one point calibration option is most suited for linearity over large ranges. When using the one point option, the calibration should be perform on the thickest side of the measurement range for the best linearity for that range. For example, if the measurement range is .100” (2.54mm) to 1.0” (25.4mm), the user should calibrate on a known thickness sample close to 1.0” (25.4mm). **Note:** *It’s always handy to carry a set of mechanical calipers to use in conjunction with the **PR-9** for calibration of various materials in the field:*

<u>One Point Calibration</u>

Note: *Be sure that a probe zero has been performed prior to performing this calibration procedure.*

1) Physically measure an exact sample of the material, or a location directly on the material to be measured, using a set of calipers or a digital micrometer.

Note: *A sample or location on the test piece should be used as close to the maximum thickness of the test range to minimize error.*

2) Apply a drop of couplant on the transducer and place the transducer in steady contact with the sample or actual test material. Be sure that the reading is stable and the repeatability indicator in the top left corner of the display is fully lit and stable.

3) Press the 

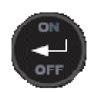
key to enter the calibration edit screen displaying the current measurement value.

4) Use the 

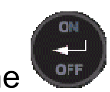
keys to scroll to the known thickness value.

Note: *The longer the keys are pressed and held, the faster the value will increment/decrement.*

Note: *Pressing the* 

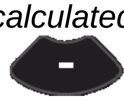
key prior to pressing the 

key will abort the cal routine without saving any changes.

5) Once the known thickness value is being displayed, press the 

key to display the calculated material velocity edit screen.

Note: *The calculated velocity can be edited, if needed, by pressing the* 



keys to scroll and edit the velocity value.

6) Press the 

key to set the calculated material velocity and return to the measurement screen.

CHECK YOUR CALIBRATION! Place the transducer back on the calibration point and verify the thickness. If the thickness is not correct, repeat the steps above.

Two Known Thicknesses

The two point calibration should be considered when an application requires improved accuracy over a small measurement range based on tolerance requirements. This calibration option calculates both the 'probe zero' and 'velocity value. If the two point option is used, a probe zero is not required. For example, if the measurement range was .080" (2.03mm) to .250" (6.35mm), two known samples or locations on the test material would be needed for the minimum and maximum boundaries of the test range. Using the range above, a one point calibration would be performed at .250" (6.35mm) and a two point calibration at .080" (2.03mm), or something close to the min/max values of the measurement range.

Note: *The **PR-9** also offers the capability of setting the 'probe zero' to use any reference standard as the 'probe zero' standard. For clarification, if it's desired to use a one inch reference of a specific material type as the 'zero' reference, performing the first point of a two-point calibration sets the internal zero of the **PR-9**.*

The following steps outline this procedure:

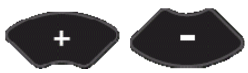
Two Point Calibration

1) Physically measure a **minimum** and **maximum** calibration point of the exact sample material, or locations directly on the material to be measured, using a set of calipers or a digital micrometer.

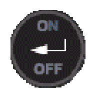
Note: *A sample or location on the test piece should be used as close to the **minimum** and **maximum** thickness of the test range to minimize error and improve linearity.*

2) Apply a drop of couplant on the transducer and place the transducer in steady contact with either the **minimum** or **maximum** sample or actual test material. Be sure that the reading is stable and the repeatability indicator in the top left corner of the display is fully lit and stable.

3) Press the  key to enter the calibration edit screen displaying the current measurement value.

4) Use the  keys to scroll to the known thickness value.

Note: *The longer the keys are pressed and held, the faster the value will increment/decrement.*

Note: *Pressing the*  *key prior to pressing the*  *key will abort the cal routine without saving any changes.*

5) Once the known thickness value is being displayed, press the  key to display "**1 of 2"**, which sets the zero value and returns to the measurement screen.

Note: *The internal zero of the **PR-9** is now set. The procedure above can be used to set the internal zero of the **PR-9** to use any reference standard as the 'probe zero' standard if desired.*

6) Repeat steps 2-4 on the second test point/location.

7) Press the  key to display the calculated velocity edit screen.

Note: *The calculated velocity can be edited, if needed, by pressing the*  *keys to scroll and edit the velocity value.*

8) Press the  key to set the calculated material velocity and return to the measurement screen.

Note: ***CHECK YOUR CALIBRATION!*** *Place the transducer back on the calibration points. The thickness readings should now match the known thickness values with minimal error. If the thicknesses are not correct, repeat the steps above.*

CHAPTER SIX
ADDITIONAL FEATURES

6.1 High Speed Scan

The High Speed Scan feature of the ***PR-9*** increases the overall repetition rate to a maximum of 140Hz with a high speed screen refresh rate of 25 times a second. This allows for making scanned passes over an arbitrary length of the test material, while still maintaining a reasonable representation of thickness over the area or region scanned.

The procedure to use the scan feature is outlined below:

High Speed Scan

1) Press the 

key to toggle **SCAN** on/off. The display will briefly display the status and return to the measurement screen.

6.2 Units

The ***PR-9*** will operate in both English (inches) or Metric (millimeters) units.

The procedure to select the units is outlined as below:

Units

1) Press the 

key to toggle inches/millimeters (IN/MM).

6.3 Light

The ***PR-9*** uses a custom glass segmented display that is equipped with a backlight for use in low light conditions. The options are on/off/auto, where the auto setting only lights the display when the gauge is coupled to the material and receiving a measurement.

The steps below outline how to toggle the options:

Backlight

1) Press the key to access the backlight status options. The edit icon will be illuminated and flashing.
2) Use the keys to toggle status on/off/auto.

Note: *Pressing the key prior to pressing the key will abort to the measurement screen without saving changes.*

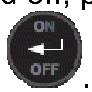
3) When the desired **LITE** setting is displayed, press the key to set the status and edit the **BRT** (brightness) option.
4) Use the keys to scroll through the **BRT** (LO, MED, HI) options.
5) When the desired **BRT** setting is displayed, press the key to set the brightness and return to the measurement screen.

6.4 Lock

The lock feature was built into the ***PR-9*** for the purpose of locking the operators out of editing any of the gauge settings, for purposes of consistency between operators. When the lock feature is enabled, the gauge calibration functionality cannot be altered, as well as any of the individual features in the gauge. The only keys that are always unlocked are the power and probe zero keys, as these must remain unlocked for measurement functionality.

The procedure to enable/disable the lock feature is outlined below:

Lock

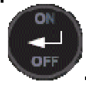
1) With the ***PR-9*** powered off, press and hold down the  key while powering the ***PR-9*** on . The lock icon will be illuminated on the display.
2) To unlock the ***PR-9*** repeat step one, but hold down the  key while powering the ***PR-9*** on .

6.5 Factory Defaults

The ***PR-9*** can be reset to factory defaults at any time to restore the original gauge settings. This should only be used if the gauge is not functioning properly, or perhaps multiple features have been enabled and a clean start is needed.

The procedure to reset the gauge is outlined below:

Factory Reset

1) With the ***PR-9*** powered off, press and hold down the  and  keys while powering the ***PR-9*** on .

Note: *Once the measurement screen is displayed the* 

and 

can be released.

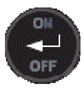
2) Press the 

keys to scroll through the factory setting options.

3) Make a note of the “MEDI” & “ZERO” settings prior to performing a reset. These values will need to be entered back in the gauge following the reset.

4) Press the 

keys to scroll “REST” (reset).

5) Press the 

key to edit the reset option.

6) Press the 

keys to toggle YES, followed by pressing 

to reset the gauge.

7) Repeat the steps above to set “MEDI” & “ZERO” back to their original settings noted in step three above.

APPENDIX A - VELOCITY TABLE

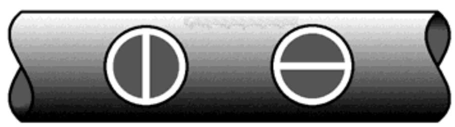
Material	sound velocity in/us		sound velocity m/s
Aluminum	0.2510		6375
Beryllium	0.5080		12903
Brass	0.1730		4394
Bronze	0.1390		3531
Cadmium	0.1090		2769
Columbium	0.1940		4928
Copper	0.1830		4648
Glass (plate)	0.2270		5766
Glycerine	0.0760		1930
Gold	0.1280		3251
Inconel	0.2290		5817
Iron	0.2320		5893
Cast Iron	0.1800	(approx)	4572
Lead	0.0850		2159
Magnesium	0.2300		5842
Mercury	0.0570		1448
Molybdenum	0.2460		6248
Monel	0.2110		5359
Nickel	0.2220		5639
Nylon	0.1060	(approx)	2692
Platinum	0.1560		3962
Plexiglas	0.1060		2692
Polystyrene	0.0920		2337
PVC	0.0940		2388
Quartz glass	0.2260		5740
Rubber vulcanized	0.0910		2311
Silver	0.1420		3607
Steel (1020)	0.2320		5893
Steel (4340)	0.2330		5918
Steel Stainless"	0.2230		5664
Teflon	0.0540		1372

Tin	**0.1310**		**3327**
Titanium	**0.2400**		**6096**
Tungsten	**0.2040**		**5182**
Uranium	**0.1330**		**3378**
Water	**0.0580**		**1473**
Zinc	**0.1660**		**4216**
Zirconium	**0.1830**		**4648**

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. The transducer should be oriented so that the gap (sound barrier) in the wear face is perpendicular (at a right angle) to the length (long axis) of the tubing, allowing both sides of the transducer to make the same amount of contact. The transducer orientation can either be parallel or perpendicular for large diameter piping, as it’s much easier to ensure both sides are making similar contact.



Measuring hot surfaces

The velocity of sound through a substance is dependent on 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 calibration on a sample piece of known thickness, which is at or near the temperature of the material to be measured. This will allow the ***PR-9*** to correctly calculate the velocity of sound through the hot material.

Expansion and contraction of the transducer based on temperature, and a varying temperature gradient, will also affect the measurement in a pulse-echo (P-E) measurement mode. It is recommended that a “transducer zero” be performed often to account for the delay line changing length and adversely affecting the accuracy of the measurements.

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 (intermittent contact) to acquire a stable measurement.

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. If the variation is relatively close, averaging the sound velocities to minimize error is another option.

An additional important consideration when measuring laminates is that many included air gaps or pockets which 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 .025” of coating on the surface. Where the velocity of the steel pipe is .2330 in/μsec, and the velocity of the paint is .0850 in/μsec. If the user is calibrated for mild steel pipe and measures through both materials, the actual coating thickness will appear to be approximately 3 times thicker than it actually is, as a result of the differences in velocity.

WARRANTY INFORMATION

• Warranty Statement •

Dakota Ultrasonics warrants the ***PR-9*** 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.