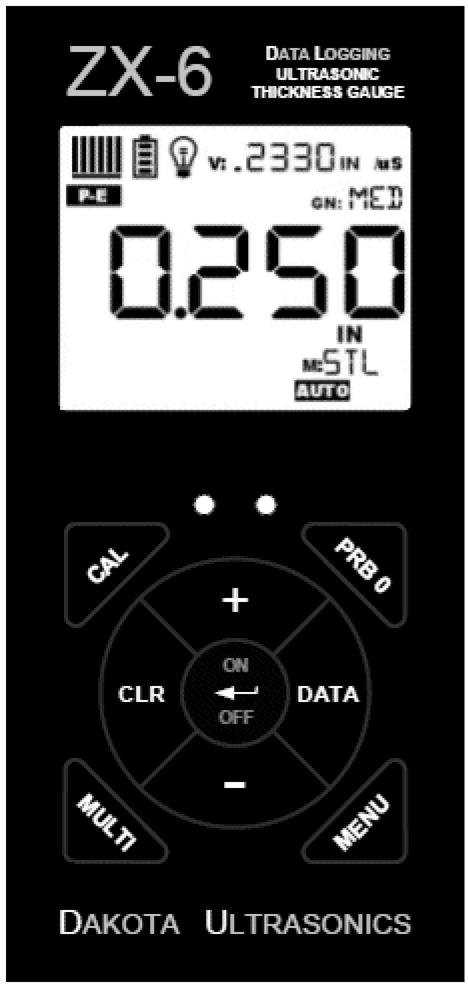
OPERATION MANUAL

DAKOTA ULTRASONICS

ZX-6 DL

Ultrasonic Multi-Echo Data
Logging Thickness Gauge



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CHAPTER ONE
INTRODUCTION

The Dakota Ultrasonics model ***ZX-6 DL*** is a basic dual element thickness gauge with through paint measurement capability, and the ability to locate blind surface pitting and internal defects/flaws in materials. Based on the same operating principles as SONAR, the ***ZX-6 DL*** is capable of measuring the thickness of various materials with accuracy as high as ± 0.001 inches, or ± 0.01 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only one side of the material being measured.

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:

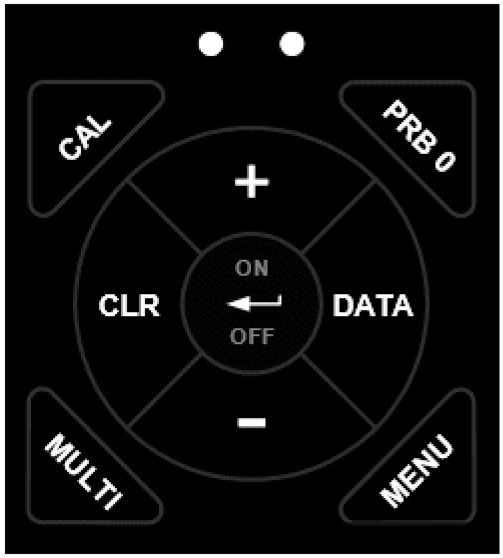
Dakota Ultrasonics Corporation
1500 Green Hills Road, #107
Scotts Valley, CA 95066
Tel: (831) 431-9722
Fax: (831) 431-9723
www.dakotaultrasonics.com

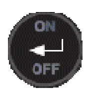
1.1 Disclaimer

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

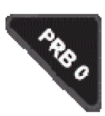


2.1 ON/OFF/ENTER Key 

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 ***ZX-6 DL*** 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 38 for a further explanation of this important feature.

2.3 CAL Key

The **CAL** key is used to enter and exit the ***ZX-6 DL***'s calibration mode. This mode is used to adjust the sound velocity value that the ***ZX-6 DL*** will use when calculating thickness. The tool will either calculate the sound-velocity from a sample of the material being measured, or allow a known velocity value to be entered directly. This provides increased linearity between transducers. Refer to page 19 for an explanation on the various calibration options.

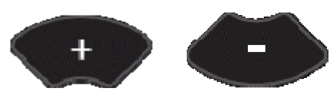
2.4 DATA Key

The **DATA** key accesses the data logging section of the ***ZX-6 DL***, which consists of 50 sequential (single column) files with 250 storage locations per file. Refer to page 43 for an explanation on the various calibration options.

2.5 CLR Key

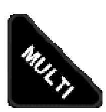
The **CLR** key is used in conjunction with the data logging section to clear a single stored memory location. Refer to page 43 for an explanation on the various calibration options.

2.6 +/- Increment/Decrement Key's



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

2.7 MULTI Key



The **MULTI** key toggles between pulse-echo (P-E) and echo-echo (E-E) measurement modes. (P-E) is used primarily for flaw and pit detection, while (E-E) is used for through paint and coatings measurement without having to remove the paint/coating and eliminating any error as a result of the paint/coating. Refer to page 25 for an explanation on the various calibration options.

2.8 MENU Key

The **MENU** key is used to access and set all of the additional features of the ***ZX-6 DL*** that are not at the top level of the keypad with a dedicated key. The features and setting are outlined in the table below:

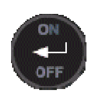
Menu Feature Items:

Gain	Matl	Scan	Alarm	Diff	Unit	Lite	Beep	Zero	VX	Probe
VLOW	Aluminum	On	On	On	English	On	On	Manual	On	.18 5
LOW	Steel	Off	Off	Off	Metric	Off	Off	Auto	Off	.18 5
MED	Stainless		**Options**	**Options**		**Options**				.25 5
HIGH	Iron		Set Lo	Set Nominal		Lo				.25 7
VHI	Plexiglass		Set Hi			Med				.50 3
	PVC					High				.50 5
	Plastic									
	Poly Urea									
	User 1									
	User 2									

Here's a quick overview of navigating through the various features in **MENU**:

Navigating the Features in Menu

1) Press the 

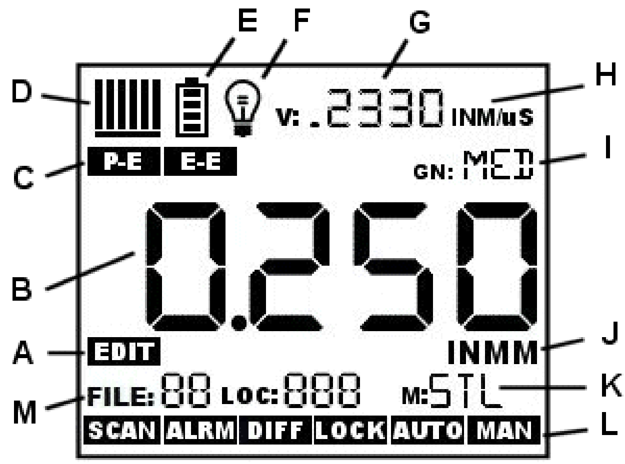
key once to enter the sub menu items.
2) Press the   keys to toggle through the features.
3) To enable or edit the status of any feature, press the 

key.
4) The edit icon will start blinking to indicate that the ***ZX-6*** is currently in **EDIT** mode.
5) Press the   keys to toggle through the setting options.
6) Press the 

key to accept changes and return to the top level of features, or the 

key at any time to abort changes and return the measurement screen.

2.9 The Display



The ***ZX-6 DL*** 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:

- **A. <u>Edit:</u>** 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. <u>Large 7 segment:</u>** The thickness measurement, velocity or alpha message will be displayed in this area.
- **C. <u>Measurement Modes:</u>** This group of icons indicates which measurement mode the ***ZX-6 DL*** is currently using. The modes are pulse-echo, for flaw and pit detection, and echo-echo for through paint and coating measurements.
- **D. <u>Stability/Repeatability Indicator:</u>** This is used in conjunction with the thickness measurement as a reference for the validity of the measurement. The ***ZX-6 DL*** 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. <u>Battery:</u>** Indicates the amount of battery life the ***ZX-6 DL*** has remaining.
- **F. <u>Backlight :</u>** When this icon is illuminated, it indicates the backlight is on.
- **G. <u>Small 7 Segment:</u>** The material velocity, speed the sound wave travels through a given medium/material, is displayed in this area, informing the user what material the ***ZX-6 DL*** is currently calibrated too. This area is also used for alpha messages in the menu and edit modes.
- **H. <u>Units:</u>** 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 ***ZX-6 DL***. MED is the default, with the options of VLOW, LOW, MED, HIGH, VHI (40dB to 52db gain range with MED at 46dB).

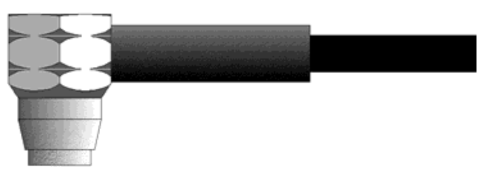
J. **Units:** This combination of icons are illuminated in different sequences to inform the user what measurement units are currently being displayed in the large 7 segment area. The plus/minus icon is illuminated when the DIFF (differential) feature is activated.

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 of the menu features in the ***ZX-6 DL***, Refer to page 4 for a list. The ***ZX-6 DL*** can be locked once calibrated, to avoid accidently changing the calibration. When this icon is illuminated, the ***ZX-6 DL*** is in lock mode. Refer to page 41 for an explanation on locking the ***ZX-6 DL***.

M. **File/Loc:** This area is exclusively for the data storage section of the ***ZX-6 DL***. The icons and segment fields represent the current file open, and the current storage location in the file. Refer to page 43 for an explanation of the data storage feature in the ***ZX-6 DL***.

2.10 The Transducer



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

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

This is a bottom view of a typical transducer. The two semicircles of the 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

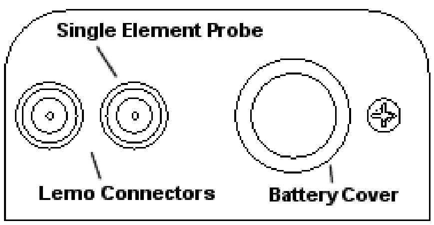
In order for the transducer to do its job, there must be no air gaps between the wear-face and the surface of the material being measured. This is accomplished with the use of a "coupling" fluid, commonly called "couplant". This fluid serves to "couple", or transfer, the ultrasonic sound waves from the 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 ***ZX-6 DL*** has been properly "zeroed" (see page 16) and set to the correct sound velocity (see page 18), 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 14 for information on transducer selection.

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

2.11 Top & Bottom End Caps



Top End Cap

Bottom End Cap

The top & bottom end panels are where all connections are made to the ***ZX-6 DL***. 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 ***ZX-6 DL's*** top end cap. The transducer connectors are of type Lemo "00".

Note: *There is no polarity associated with connecting the transducer to the **ZX-6 DL**, 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 disk when the zero feature is set to the 'manual' option. 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 **ZX-6 DL**.*

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

USB-C Connector

Refer to Diagram: The **USB-C** connector, located on the bottom end cap, is a mini type C female connector. It is designed to connect directly from the ***ZX-6 DL*** to a standard USB type A port on a PC. The cable supplied with the ***ZX-6 DL*** is a USB type C to a USB type A (pt# N-003-0330). See page 48 for information on connectivity.

Note: *This connector is also used to upgrade the **ZX-6 DL** with the latest version of firmware.*

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 ***ZX-6 DL***, 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 ***ZX-6 DL***, 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.

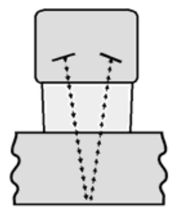
V-Path Correction

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.



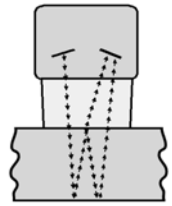
Dual Element Transducer showing V-path of signal

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.

Echo-Echo (E-E) Mode – Through Paint

The echo-echo mode measures between the first and second return echoes/reflections. This technique is commonly used when measuring through a surface coating and measuring only the second layer of material. Tanks and pipes commonly have a protective coating applied to the surface. Echo-echo mode will enable the user to measure just the steel without having to remove the coating. The disadvantage is that two return echoes are required to effectively measure the test material. Additionally, echo-echo mode does not have the capability to find defects. Therefore, both modes will commonly be used; echo-echo mode to find the nominal thickness of the material without removing the coating, and pulse-echo to locate defects.



Dual Element Transducer in Echo to Echo mode

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. By using echo-echo mode, the user is able to successfully measure through both the coating and steel, and completely eliminate the thickness of the paint or coating. Therefore, the steel can be measured without having to remove the coating prior to measuring. Users will often use pulse-echo mode and echo-echo mode in conjunction when performing inspections on coated materials.

Thru coating measurements require special high damped transducers. The most common transducers are the 3.5, 5, and 7.5MHz hi damped transducers. These transducers are suitable for use in both pulse-echo and echo-echo modes. This conveniently enables the user to accurately measure overall material thickness using the thru Coating mode, and then conveniently switch to pit detection mode without changing transducers. The ¼” 5MHz Hi damped transducer is the most commonly used transducer for standard thru coating applications.

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 ***ZX-6 DL*** 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 ***ZX-6 DL***, 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 18.

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 ***ZX-6 DL*** is not used. This is called two-point calibration and is described on page 21.

5.1 Probe zero

Setting the zero point of the ***ZX-6 DL*** 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 ***ZX-6 DL*** is not zeroed correctly, all the measurements taken may be in error by some fixed value. The zero can only be performed with the measurement mode set to pulse-echo (P-E). Therefore, if the ***ZX-6 DL*** is to use the echo-echo (E-E) measurement mode and a manual zero is being performed, the ***ZX-6 DL*** will argue by briefly displaying the message "NO PRB0".

Important note: The internal zero setting of the ***ZX-6 DL***, used for the auto zero mode, can be reset at anytime by performing a "manual zero", and immediately followed by performing an "auto zero".

The ***ZX-6 DL*** is equipped with two zero options:

1) **Off Block Zero (Automatic Probe Zero)** – When this feature is enabled the ***ZX-6 DL*** will do an electronic zero automatically, eliminating the need for a zero disk or reference standard.

2) **On Block Zero (Manual Probe Zero)** – When this feature is enabled the transducer must be placed on the probe zero disk (battery cover) located on the top of the unit.

Both zero procedures are outlined as follows:

Performing an Auto Probe Zero (Off Block)

1) Be sure all couplant has been removed from the face of the transducer.

2) Press the 

key to perform the auto zero. **"AUTO ZERO"** will briefly be displayed on the screen, indicating the zero calculation is being performed.

Performing a Manual Probe Zero (On Block)

Note: *When the zero probe option is set to manual, the probe zero disk (battery cap) located on the top of the gauge will be used as a zero standard.*

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 manual zero. “PRB0” will briefly be displayed on the screen, indicating the zero calculation is being performed.

5.2 Material Calibration

In order for the ***ZX-6 DL*** 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 <u>large</u> ranges. The **Two Point** calibration allows for greater accuracy over <u>small</u> ranges by calculating both the probe zero, as well as the material velocity. The ***ZX-6 DL*** 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 ***ZX-6 DL***, rather than have the ***ZX-6 DL*** calculate the velocity value using a known thickness of the same material type. The steps for entering the velocity are outlined below:

<u>Using a Known Material Velocity</u>

1) With the transducer free from contact with the material, press the 

key to display the current velocity.

2) Use the 

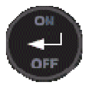
keys to scroll the velocity to the known target value.

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 ***ZX-6 DL*** 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* ***ZX-6 DL*** *for calibration of various materials in the field:*

One Point Calibration

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.

Note: ***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 **ZX-6 DL** 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 **ZX-6 DL**. This should be used only in manual probe zero mode “on block”.*

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 **ZX-6** is now set. The procedure above can be used to set the internal zero of the **ZX-6** 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.*

Basic Material Type

If the material velocity is unknown, a sample thickness cannot be taken directly from the material, but the general type of material is known, selecting a basic material type from the common material **(MATL)** list in the ***ZX-6 DL*** would offer a reasonable approximation of the thickness. There are 9 common materials and 2 user programmable settings available. It's important to note that these velocities will not always be an exact representation of the material being tested. Use these values only if a close approximation is acceptable. Follow the steps below to select a basic material type:

<u>Selecting a Basic Material Type</u>

1) Press the key to access the menu items/features.
2) Use the keys to scroll through the items/features until the **MATL** feature is being displayed.
3) Press the key to edit the material setting. The edit icon will be illuminated and flashing.

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

4) Use the keys to scroll through the material options.

		in/µs	m/s
ALU	ALUMINUM (2024)	0.250	6350
StL	STEEL (4340)	0.233	5918
StSt	STAINLESS (303)	0.223	5664
Iron	CAST IRON	0.180	4572
PLE	PLEXIGLASS	0.106	2692
PVC	PVC	0.094	2388
PLSt	POLYSTYRENE	0.092	2337
PLUr	POLYURETHANE	0.070	1778
USr1	USER PROGRAMMABLE		
USr2			

5) When the desired **MATL** setting is displayed, press the key to set the material velocity and return to the measurement screen.

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

6) If **USR1** or **USR2** were selected, the velocity edit screen will be displayed and edit icon illuminated and flashing.

7) Use the keys to scroll to the desired material velocity.

Note: *The longer these keys are held, the faster the velocity value is incremented.*

8) When the desired velocity setting is displayed, press the key to set the material velocity and return to the measurement screen.

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

CHAPTER SIX
THROUGH PAINT MEASUREMENT - MULTI MODE

6.1 Introduction

Through paint measurement is accomplished by measuring the time between two repeat echoes from the back surface of the material. Since both of these back wall echoes travel the same path through the paint or coating, the thickness of the coating is subtracted out of the measurement so that only the actual material thickness is measured. This avoids having to scrape or remove the coating from materials prior to inspection. The primary purpose of thru paint measurement is to determine the actual/nominal material thickness without error from the coating.

Through paint mode cannot be used for flaw or pit detection based on the internal gating and thresholds. As a result, inspectors will typically use both echo-echo through paint mode in conjunction with the standard pulse-echo flaw detection mode for coated material and corrosion inspection. Finally, this mode will only work for typical epoxy based coatings.

6.2 Multi Mode Transducers

The multi echo measurement technique does have restrictions on the type of dual element transducers it can use successfully. The key requirement is that the transducers are "high damped", which refers to the duration of how long the transducer rings. In order to improve the low end measurement range, being able to measure thin materials, the cycles of ring must be limited so they don't interfere with the internal gating.

Since the ***ZX-6 DL*** is a basic easy to operate gauge without the adjustability you'd get using an advanced A-Scan scope, specific diameter and frequency options can be selected as an option in the menu items. The factory default setting is (.25 5) or 0.250" 5MHz, as the most commonly requested transducer. Refer to page 4 for a list of available high damped transducer diameters and frequencies.

The procedure for activating the through paint (E-E) measurement mode is outlined as follows:

<u>Echo-Echo Multi Mode</u>

Note: *Be sure that a probe zero and "one point calibration", or a "two point calibration" has been performed prior to this procedure.*

1) Press the 

key to toggle between the measurement modes; pulse-echo (P-E) and echo-echo (E-E) at any time.

Note: *An icon will be illuminated in the top left portion of the display to indicate the measurement mode the **ZX-6 DL** is currently using.*

CHAPTER SEVEN
VELOCITY GAUGE

7.1 Velocity Gauge (VX)

The ***ZX-6 DL*** includes a function to convert the unit into a dedicated velocity gauge. With this feature enabled, the ***ZX-6 DL*** will display all measurements in terms of velocity, inches per microsecond (**IN /μs**) or meters per second (**M /s**), rather than dimensional inches or millimeters. This is primarily useful for rudimentary “nodularity” testing, as the velocity can be associated with density and used to determine the hardness/strength of a given material. A casting manufacturer would typically use this feature to control their processes and make sure the density/hardness is sufficient for each part and batch within a specified tolerance.

Using this feature will require calibration on a “known” thickness that will remain consistent at a specific location on a group of parts. The test will always be performed at the same location for all parts in the group. The velocity will be determined, and either accepted or rejected depending on the specified tolerances.

The procedure for enabling this feature is outlined below:

<u>Velocity Gauge Option</u>

1) Press the  key to access the menu items/features.
2) Use the  keys to scroll through the items/features until the **VX** feature is being displayed.
3) Press the  key to edit the velocity gauge setting. The edit icon will be illuminated and flashing.
4) Use the  keys to toggle velocity on/off.

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

5) When the desired **VX** setting is displayed, press the  key to set the status and return to the measurement screen.

7.2 Calibration to a known thickness

In order to calibrate the ***ZX-6 DL*** a ‘known thickness’ on the material or part will be used. The same location will be used for all the other parts in the group/batch to determine the velocity.

The procedure is outlined as follows:

<u>Calibration – Known Thickness</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.

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.

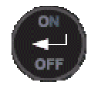
3) Press the  key to enter the calibration edit screen displaying the current velocity **IN /μs** (**M /s**) value. The edit icon will be illuminated and flashing.

4) Press the  key again to edit the known thickness value. The edit icon will be illuminated and flashing and the units will be **IN** or **MM**, indicating thickness.

5) 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.*

6) Once the known thickness value is being displayed, press the  key to return to the measurement screen and display the calculated material velocity.

Note: *The known thickness value that was used to calibrate will be displayed in the top right corner of the display for confirmation.*

7.3 Calibration to a known velocity

The velocity can also be directly edited and set to a target velocity value that was previously determined from a reference standard at an earlier time.

The procedure for directly entering the velocity is outlined below:

Calibration – Known Velocity

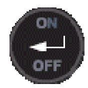
Note: Be sure that a probe zero has been performed prior to performing this calibration procedure.

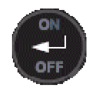
Note: This procedure requires that the operator know the sound-velocity of the material to be measured. A table of common materials and their sound-velocities can be found in **Appendix A**.

1) 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 velocity measurement is stable and the repeatability indicator, in the top left corner of the display, is fully lit and stable.

2) Press the  key to enter the calibration edit screen displaying the current velocity **IN /μs** (**M /s**) value. The edit icon will be illuminated and flashing.

3) Use the   keys to scroll to the known velocity value.

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

4) Once the known velocity value is being displayed, press the  key to display the calculated thickness based on known velocity.

5) Press the  key to return to the measurement screen and begin making measurements.

Note: *The known velocity value that was entered will be displayed, and the thickness value calculated will appear in the top right corner of the display for confirmation.*

CHAPTER EIGHT
ADDITIONAL FEATURES

8.1 Gain

The gain, or amplification of the return echoes, can be adjusted in the **ZX-6 DL** to accommodate a variety of materials and applications. The setting of the gain is crucial in order to obtain valid readings during the measurement process. Too much gain may result in erroneous measurements, detecting on noise rather than the actual material back wall surface. Not enough gain may result in intermittent detection. It could also result in lack of detection on internal flaws, pits, or porosity. The gain can be compared to the volume control of a home stereo system. If you turn it up too much, you can't hear the music clearly. If it's turned down too much, you can't hear it at all.

The ***ZX-6 DL*** has five gain settings **(VLOW, LOW, MED, HIGH, VHI)**. The gain range is 40dB – 52dB in 3dB increments. The ***ZX-6 DL*** has been optimized for the **MED** gain setting at 46dB for all common applications. It should be operated in this mode as standard. However, some applications may require the lower or higher gain settings. When? The low settings may be necessary for noisy or granular cast materials. How do I know when to lower the gain? If the reading becomes sporadic and won't settle down or resolve on a thickness value because the material is either very noisy or granular. Setting the gain to a lower less sensitive level, would potentially offer improved stability.

How do I know when to increase the gain? When a material is difficult to penetrate or pass sound through. This could be due to the material type, overall thickness, the transducer diameter and frequency, or a combination of all the above. Turning the gain up for additional output could improve the ability to obtain a successful measurement. Another example would be the need to increase overall sensitivity for locating fine pits or flaws. In any case, the selectable gain settings offer improved versatility to resolve and overcome potential application issues.

Note: *When the echo-echo through paint measurement mode is selected, the automatic gain control (AGC) is enabled. The dynamic range of the AGC can be adjusted with the following options (LOW, MED, HIGH), with* ***MED*** *still being the optimized standard setting as above.*

The procedure for editing the gain is outlined as follows:

GAIN

1) Press the 

key to access the menu items/features.

2) Use the 

keys to scroll through the items/features until the **GAIN** feature is being displayed.

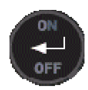
3) Press the 

key to edit the gain setting. The edit icon will be illuminated and flashing.

4) Use the 

keys to scroll through the gain settings in **P-E** (VLOW, LOW, MED, HIGH, VHI), or **E-E** (LOW, MED, HIGH) until the desired setting is being displayed.

Note: *Pressing the* 

key prior to pressing the 

key will abort to the measurement screen without saving changes.

5) Press the 

key to set the gain and return to the measurement screen.

Note: *Pressing the* 

key prior to pressing the 

key will abort to the measurement screen without saving changes.

8.2 High Speed Scan

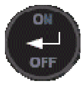
The High Speed Scan feature of the ***ZX-6 DL*** increases the overall repetition rate to a maximum of 140Hz with a high speed screen refresh rate of 25 times a second. This allows for making scanned passes over an arbitrary length of the test material, while still maintaining a reasonable representation of thickness over the area or region scanned. The alarm (ALRM) feature, with high and low limits, can be used in conjunction with high speed scan.

The procedure to use the scan feature is outlined below:

High Speed Scan

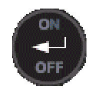
1) Press the  key to access the menu items/features.

2) Use the   keys to scroll through the items/features until the **SCAN** feature is being displayed.

3) Press the  key to edit the scan setting. The edit icon will be illuminated and flashing.

4) Use the   keys to toggle scan on/off.

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

5) When the desired **SCAN** setting is displayed, press the  key to set the status and return to the measurement screen.

8.3 Alarm

The **Alarm** feature of the ***ZX-6 DL*** provides a method of setting tolerances, or limits, for a particular application requirement. This feature may be used for a variety of applications to verify the material thickness is within the manufacturer specifications. The settings available are **ON/OFF/BEEP**, where beep enables the audible beeper. Both the on and beep settings will illuminate the led alarm lights above the keys on the keypad. There are two limit values **HI/LO**, that can be set according to specified tolerances.

The procedure to use the alarm feature is outlined below:

ALARM

1) Press the  key to access the menu items/features.

2) Use the keys to scroll through the items/features until the **ALRM** feature is being displayed.

3) Press the key to edit the alarm status. The edit icon will be illuminated and flashing.

4) Use the keys to toggle alarm on/off/beep.

5) When the desired **ALRM** status is displayed, press the key to set the status and edit the **LO** limit option.

6) Use the keys to scroll the **LO** limit value to the target value.

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

7) When the target **LO** limit is displayed, press the key to set the value and advance to setting **HI** limit option.

8) Use the keys to scroll the **HI** limit value to the target value.

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

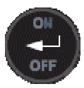
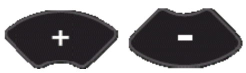
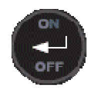
9) When the target **HI** limit is displayed, press the key to set the value and return to the measurement screen.

8.4 Differential

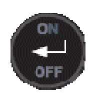
The **Differential Mode** of the ***ZX-6 DL*** provides the user with the ability to set a nominal value, according to what the expected thickness should be, and measure the +/- difference from the nominal value entered. This feature is typically used in QA incoming inspections on pipes, plate stock, coils, etc.

The steps below outline how to enable and enter the nominal value to use this feature:

Differential

1) Press the  key to access the menu items/features.
2) Use the  keys to scroll through the items/features until the **DIFF** feature is being displayed.
3) Press the  key to edit the differential status. The edit icon will be illuminated and flashing.
4) Use the  keys to toggle differential on/off.
5) When the desired **DIFF** setting is displayed, press the  key to set the status and edit the **NOMINAL** value.
6) Use the  keys to scroll the **NOMINAL** value to the target value.

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

7) When the target value is displayed, press the  key to set the value and return to the measurement screen.

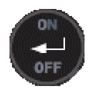
8.5 Units

The ***ZX-6 DL*** 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 access the menu items/features.
2) Use the   keys to scroll through the items/features until the **UNIT** feature is being displayed.
3) Press the  key to edit the units setting. The edit icon will be illuminated and flashing.
4) Use the   keys to toggle English or Metric units.

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

5) When the desired **UNIT** setting is displayed, press the  key to set the units and return to the measurement screen.

8.6 Lite

The ***ZX-6 DL*** 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 menu items/features.

2) Use the keys to scroll through the items/features until the **LITE** feature is being displayed.

3) Press the key to edit the light setting. The edit icon will be illuminated and flashing.

4) 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.*

5) When the desired **LITE** setting is displayed, press the key to set the status and edit the **BRT** (brightness) option.

6) Use the keys to scroll through the **BRT** (LO, MED, HI) options.

7) When the desired **BRT** setting is displayed, press the key to set the brightness and return to the measurement screen.

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

8.7 Beep

The ***ZX-6 DL*** also has a feature to use the internal beeper, most commonly used with the alarm feature, for the key strokes on the keypad. When enabled, pressing any of the keys on the keypad will sound the beeper.

The procedure to enable the keyboard beeper feature is outlined below:

Beeper

1) Press the key to access the menu items/features.
2) Use the keys to scroll through the items/features until the **BEEPER** feature is being displayed.
3) Press the key to edit the beeper setting. The edit icon will be illuminated and flashing.
4) Use the keys to toggle the beeper on/off.

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

5) When the desired **BEEP** setting is displayed, press the key to set the status and return to the measurement screen.

8.8 Zero

There are two transducer zeroing options available in the ***ZX-6 DL***; auto and manual. The AUTO zero can be performed automatically without using a reference standard to zero the gauge, while the MANUAL option requires a reference standard like the battery disk at the top of the gauge. Additionally, the gauge can be set to use another reference standard if needed. Refer to page 38 for a complete explanation of the probe zero options.

The procedure to select the zero option only, is outlined below:

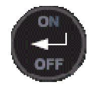
Zero (Auto/Manual)

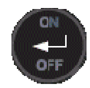
1) Press the  key to access the menu items/features.

2) Use the   keys to scroll through the items/features until the **ZERO** feature is being displayed.

3) Press the  key to edit the zero setting. The edit icon will be illuminated and flashing.

4) Use the   keys to select the auto/man option.

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

5) When the desired **ZERO** setting is displayed, press the  key to set the status and return to the measurement screen.

8.9 Velocity (VX)

When the velocity setting (**VX**) is enabled, the ***ZX-6 DL*** will display the material velocity as the primary measurement quantity instead of dimensional thickness. The feature is generally used for basic “nodularity” testing, as velocity is a key part of density for determining hardness. An example might be casting manufacturers where the density/hardness will determine the strength of the material.

When this feature is enabled, the ***ZX-6 DL*** is operating in reverse to the standard option of the gauge. Only the ‘one point’ calibration can be used with this feature active, and a manual or auto zero is still required. The ***ZX-6 DL*** can be calibrated by entering the known velocity or entering the know thickness of the material at a given position on the test material. Refer to the ‘making measurements’ section on page 27 for a complete explanation of the zero and one point calibration procedure.

The procedure to enable the velocity feature is outlined below:

<u>Velocity Gauge</u>

1) Press the key to access the menu items/features.

2) Use the keys to scroll through the items/features until the **VX** feature is being displayed.

3) Press the key to edit the setting. The edit icon will be illuminated and flashing.

4) Use the keys to select the on/off option.

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

5) When the desired **VX** setting is displayed, press the key to set the status and return to the measurement screen.

8.10 Probe Diameter & Frequency

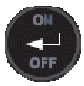
The **PROB** feature was added to improve linearity when using a specific probe diameter and frequency. The default standard setting is **(.25 5)** *0.250" 5MHz Hi Damped*, and works reasonably well using a general correction curve for all of our dual element transducers in the range. However, selecting the exact diameter and frequency of the transducer will offer additional linearity (accuracy). The five options found in our range of transducers are (.18 5, .18 7, .25 5, .25 7, .50 3, .50 5), diameter followed by frequency (inches). All of our transducer diameters and frequencies are marked on top of the transducer housing.

The procedure to select the probe/transducer diameter and frequency is outlined below:

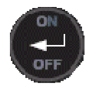
Probe

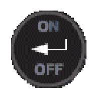
1) Press the  key to access the menu items/features.

2) Use the   keys to scroll through the items/features until the **PROB** feature is being displayed.

3) Press the  key to edit the diameter/frequency setting. The edit icon will be illuminated and flashing.

4) Use the   keys to select the diameter/frequency option.

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

5) When the desired **PROB** setting is displayed, press the  key to select the probe type and return to the measurement screen.

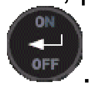
8.11 Lock

The lock feature was built into the ***ZX-6 DL*** 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 ***ZX-6 DL*** powered off, press and hold down the 

key while powering the ***ZX-6 DL*** on 

. The lock icon will be illuminated on the display.

2) To unlock the ***ZX-6 DL*** repeat step one, but hold down the 

key while powering the ***ZX-6 DL*** on 

.

8.12 Factory Defaults

The ***ZX-6 DL*** 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 ***ZX-6 DL*** powered off, press and hold down the 

and 

keys while powering the ***ZX-6 DL*** on 

.

Note: *Once the measurement screen is displayed the* 

and 

can be released.

CHAPTER NINE
DATA STORAGE

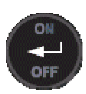
9.1 Introduction

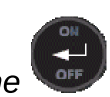
The ***ZX-6 DL*** is equipped with a basic and convenient sequential style data logger that's intuitive to operate. By 'sequential' meaning a single column of 250 measurements and a total of 40 individual files, for a total storage capacity of 10,000 measurements. These files can then be transferred to a PC using the USB-C to USB type A cable included in the kit. When ***ZX-6 DL*** is connected to a PC, it will show up in the list of drives as an external hard drive, or "thumb" drive. Open the external gauge drive, and copy the files to and from the gauge and PC.

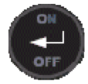
The file format is **.csv** (comma separated) and can be opened using any text editor, spreadsheet editor, or Dakota's proprietary PC software supplied with the gauges. Only files with at least one measurement stored in the file will appear in the external drive folder.

9.2 Opening a Data File

Open Data File

1) Press the  key to access the data files and display the current file open.
2) Press the  key to edit which file to open. The edit icon will be illuminated and flashing.
3) Use the   keys to scroll through the files.

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

4) When the desired **FILE** is displayed, press the 

key to open the file and return to the measurement screen.

Note: *The **FILE** and **LOC** (location) will be displayed in lower left portion of the measurement screen.*

9.3 Storing a Measurement

Now that a file has been selected and opened, the ***ZX-6 DL*** is ready to store measurements.

The following procedure outlines this process:

<u>Storing Data</u>

1) Use the 

keys to scroll to the desired location to store a measurement.

2) Press the 

key to store a measurement and advance to the next location (**LOC**).

3) Repeat steps 1 and 2 as needed.

Note: If an area exists where a measurement cannot be obtained successfully, press the 

key to store **OBST** (obstruction) in the location. Pressing the 

again will clear the location.

Note: *If a measurement has been previously stored in a location, scrolling to that location will display the measurement currently stored, and show **MEM***

(memory) in the top right corner of the display. If the key is pressed to store another measurement at that location, ***FULL*** *will briefly be displayed on the screen indicating a measurement has already been stored at that location. Pressing the key will clear the previously stored measurement from the location. Pressing the key will now store the new measurement.*

9.4 Clearing a File

If a file contains a large number of previously stored measurements, and has already been downloaded, the file will need to be cleared of its measurements.

The following procedure outlines this process:

Clear File

1) Press the key to access the data files and display the current file open.
2) Press the key to edit which file will be cleared. The edit icon will be illuminated and flashing.
3) Use the keys to scroll to the file that will be cleared.
4) When the desired **FILE** is being displayed, press the key to select the file to be cleared.
5) Use the keys to scroll to **CLR** (clear).

6) Press the key to display the confirmation screen. **CLR?** will be displayed, as well as a flashing **Yes/No** option.

7) Press the key for **YES**, and the key for **NO**. The edit icon will be illuminated and flashing.

Note: *Pressing the key prior to pressing the key will abort to the measurement screen without clearing the file.*

8) Press the key to confirm **Yes/No** selection and return to the measurement screen.

Note: *If **Yes** was selected a **BUSY** message will briefly be displayed confirming the file is being cleared.*

9.5 Clear All Files

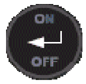
If a number of files in the ***ZX-6 DL*** contain old data, or data that has been previously downloaded, clearing all the files might prove an efficient option.

The following procedure outlines this process:

Clear Files

1) Press the key to access the data files and display the current file open.

2) Use the keys to scroll to the **CLR ALL** option.

3) Press the 

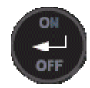
key to display the confirmation screen. **CLR ALL** is displayed, as well as a flashing **Yes/No** option.

4) Press the 

key for **YES**, and the 

key for **NO**. The edit icon will be illuminated and flashing.

Note: *Pressing the* 

key prior to pressing the 

key will abort to the measurement screen without clearing the files.

5) Press the 

key to confirm **Yes/No** selection and return to the measurement screen.

Note: *If **Yes** was selected a **BUSY** message will briefly be displayed confirming the files are being cleared.*

CHAPTER TEN
DATA TRANSFER & POWER OPTIONS

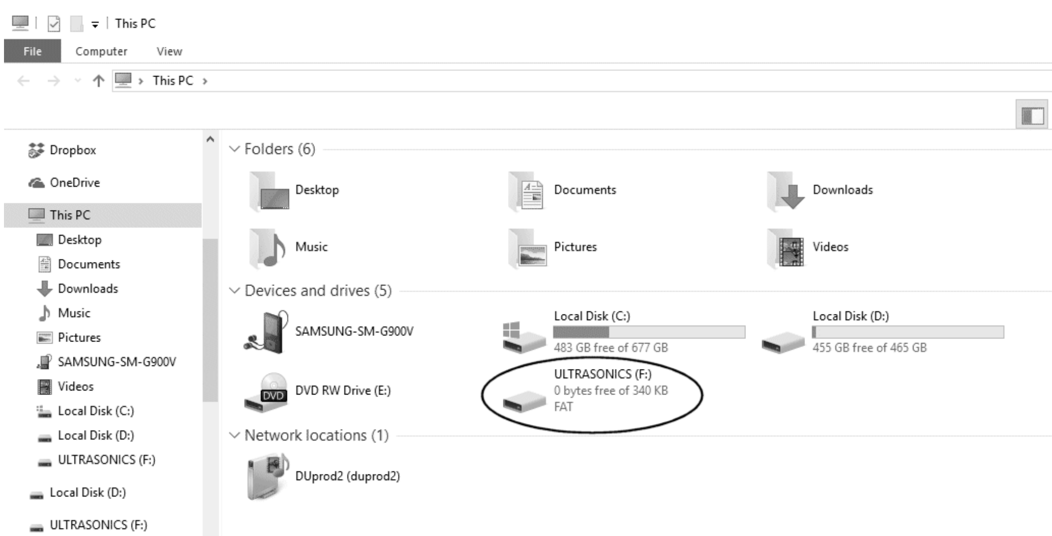
10.1 Connectivity

The ***ZX-6 DL*** is connected to a PC with a USB-C to USB Type A cable, supplied with the kit (part# N-003-0330). The gauge has a file system and the PC will recognize it as an external hard disk, or thumb drive. It functions very similar to a cell phone or camera. Opening the external disk folder will display only the files that currently have data stored in them, and while the other files are physically in the directory, they are hidden until they contain data. The ***ZX-6 DL*** has a maximum of 40 total files with 250 sequential readings per file.

10.2 Opening a File

The data files are stored as a .CVS (comma separated) text file, which is a very basic generic text file structure. It can be conveniently opened using any standard text editor, spreadsheet or database program. The data can easily be copied, moved or imported into reports created by a variety of software packages.

With the gauge turned on and connected to your PC a drive called “ultrasonics” will appear in your list of devices:

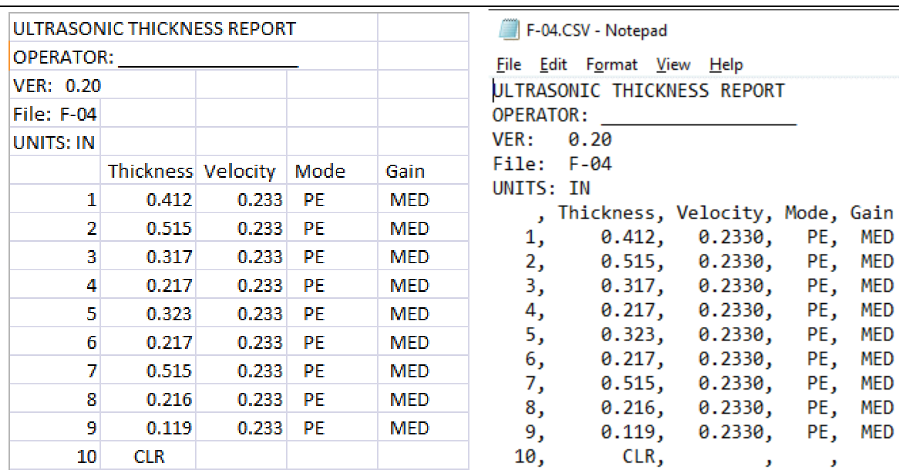


Open the external drive to view the files.

10.3 Copying/Opening Files

Now that the files have been located and are accessible, they can either be opened from the ***ZX-6 DL***'s memory, or copied to another location/folder on your PC. To accomplish this, simply 'drag and drop' files in a new folder on your PC, or on your desktop.

If you have a specific software package associated with .CSV files, like a spreadsheet editor, they can automatically be opened by 'double clicking' one of the active files in the folder. Alternatively, you can specify what software package you'd like them opened with by 'right clicking' on a specific file and using the 'open with' option in the menu.



ULTRASONIC THICKNESS REPORT				
OPERATOR: ________________				
VER: 0.20				
File: F-04				
UNITS: IN				
	Thickness	Velocity	Mode	Gain
1	0.412	0.233	PE	MED
2	0.515	0.233	PE	MED
3	0.317	0.233	PE	MED
4	0.217	0.233	PE	MED
5	0.323	0.233	PE	MED
6	0.217	0.233	PE	MED
7	0.515	0.233	PE	MED
8	0.216	0.233	PE	MED
9	0.119	0.233	PE	MED
10	CLR			

F-04.CSV - Notepad

File Edit Format View Help

```
ULTRASONIC THICKNESS REPORT
OPERATOR: ________________
VER:   0.20
File:  F-04
UNITS: IN
    , Thickness, Velocity, Mode, Gain
  1,     0.412,   0.2330,   PE,  MED
  2,     0.515,   0.2330,   PE,  MED
  3,     0.317,   0.2330,   PE,  MED
  4,     0.217,   0.2330,   PE,  MED
  5,     0.323,   0.2330,   PE,  MED
  6,     0.217,   0.2330,   PE,  MED
  7,     0.515,   0.2330,   PE,  MED
  8,     0.216,   0.2330,   PE,  MED
  9,     0.119,   0.2330,   PE,  MED
 10,       CLR,         ,     ,
```

Spreadsheet **Text Editor**

10.4 Line Power

The ***ZX-6 DL*** can be powered using the standard USB-C to USB-A data cable (N-003-0330), by connecting directly to a USB port on your computer, or using a standard cell phone power adapter directly to an outlet. This is a convenient way to power the gauge for specific bench top applications in a factory line environment.

Note: *If USB is being displayed on the display, the **ZX-6 DL** is currently in download/transfer mode. This can be bypassed by pressing any key to abort the transfer mode, and return to actively measuring and using line power.*

APPENDIX A - VELOCITY TABLE

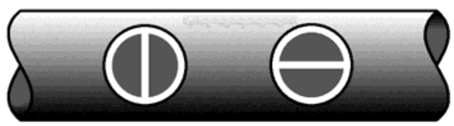
Material	sound velocity in/us		sound velocity m/s
Aluminum	0.2510		6375
Beryllium	0.5080		12903
Brass	0.1730		4394
Bronze	0.1390		3531
Cadmium	0.1090		2769
Columbium	0.1940		4928
Copper	0.1830		4648
Glass (plate)	0.2270		5766
Glycerine	0.0760		1930
Gold	0.1280		3251
Inconel	0.2290		5817
Iron	0.2320		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 ***ZX-6 DL*** 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. This error can be eliminated by using a special echo-echo (E-E) mode to perform measurements for applications such as these. In echo-echo mode, the paint/coating thickness will be eliminated entirely and only the steel or base metal measured.

WARRANTY INFORMATION

• Warranty Statement •

Dakota Ultrasonics warrants the ***ZX-6 DL*** against defects in materials and workmanship for a period of two 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.