# ULTRASONIC THICKNESS GAUGE

# ExScan1000


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# CONTENTS

# 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 rests solely with the user of the instrument.

# INTRODUCTION

The NDT Experts model ExScan1000 is a precision Ultrasonic Micrometer. Based on the same operating principles as SONAR, the ExScan1000 is capable of measuring the thickness of various materials with accuracy as high as ± 0.001 inches, or ± 0.01 millimeters. The principle advantage of ultrasonic measurement over traditional methods is that ultrasonic measurements can be performed with access to only one side of the material being measured.

This manual is presented in three sections. The first section covers operation of the ExScan1000, and explains the keypad controls and display. The second section provides guidelines in selecting a transducer for a specific application. The last section provides application notes and a table of sound velocity values for various materials.

NDT Experts 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:

2718 Westside Drive

Pasadena, TX 77502

USA

# OPERATION

The ExScan1000 interacts with the operator through the membrane keypad and the LCD display. The functions of the various keys on the keypad are detailed below, followed by an explanation of the display and its various symbols.


The Keypad


This key is used to turn the ExScan1000 on and off. When the gauge is turned ON, it will first perform a brief display test by illuminating all of the segments in the display. After one second, the gauge will display the internal software version number. After displaying the version number, the display will show "0.000" (or "0.00" if using metric units), indicating the gauge is ready for use.

The ExScan1000 is turned OFF by pressing the ON/OFF key. The gauge has a special memory that retains all of its settings even when the power is off. The gauge also features an auto-power down mode designed to conserve battery life. If the gauge is idle for 5 minutes, it will turn itself off.


The PRB-0 key is used to "zero" the ExScan1000 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 27 for an explanation of this important procedure.

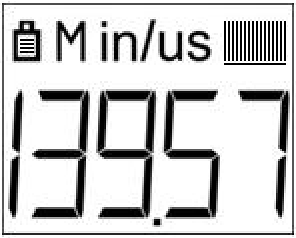

The IN/MM key is used to switch back and forth between English and metric units. This key may be used at any time, whether the gauge is displaying a thickness (in or mm) or a velocity value (IN/µs or m/s).


The CAL key is used to enter and exit the ExScan1000's calibration mode.

This mode is used to adjust the sound-velocity value that the ExScan1000 will use when calculating thickness. The gauge will either calculate the sound-velocity from a sample of the material being measured, or allow a known velocity value to be entered directly. Refer to page 29 for an explanation of the two CAL functions available.


The UP arrow key has two functions. When the ExScan1000 is in calibration mode, this key is used to increase numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will increment at an increasing rate. When the ExScan1000 is not in calibration mode, the UP arrow key switches the SCAN measurement mode on and off. Refer to page 35 for an explanation of the SCAN measurement mode.

The DOWN arrow key has two functions. When the ExScan1000 is in the CAL mode, this key is used to decrease numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will decrement at an increasing rate. When the ExScan1000 is not in calibration mode, the DOWN arrow key switches the display backlight between three available settings. OFF will be displayed when the backlight is switched off. AUTO will be displayed when the backlight is set to automatic mode, and ON will be displayed when the backlight is set to stay on. In the AUTO setting, the backlight will illuminate when the ExScan1000 is actually making a measurement.



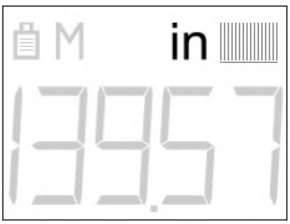

**The Display**


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

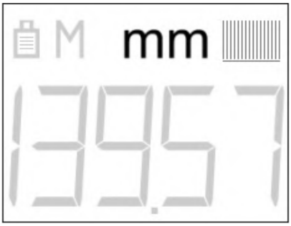
When the ExScan1000 is displaying thickness measurements, the display will hold the last value measured, until a new measurement is made.


These sixteen vertical bars form the Stability Indicator. When the ExScan1000 is idle, only the left-most bar and the underline will be on.

When the gauge is making a measurement, ten or twelve of the bars should be on. If fewer than five bars are on, the ExScan1000 is having difficulty achieving a stable measurement, and the thickness value displayed will most likely be erroneous.

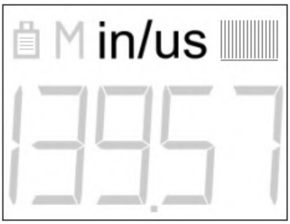



When the IN symbol is on, the ExScan1000 is displaying a thickness value in inches. The maximum thickness that can be displayed is 19.999 inches

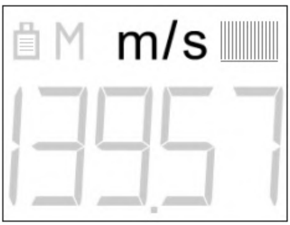



When the MM symbol is on, the ExScan1000 is displaying a thickness value in millimeters.

If the displayed thickness exceeds 199.99 millimeters, the decimal point will shift automatically to the right, allowing values up to 1999.9 millimeters to be displayed.



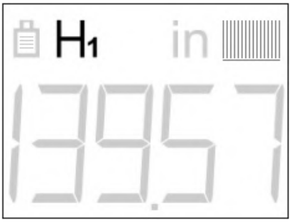

When the in/us symbol is on, the ExScan1000 is displaying a sound-velocity value in inches-per-microsecond.




When the m/s symbol is on, the ExScan1000 is displaying a sound-velocity value in meters-per-second.

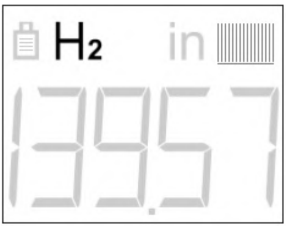

When performing the manual thickness measurement, the M symbol is illuminated on the display.


When switching on the scanning mode, the S symbol is illuminated on the display.



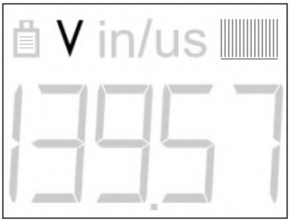

The $H_1$ symbol is appeared after pressing 

button – calibrating the sound velocity at a known thickness (1 point calibration).



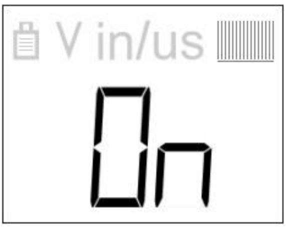

When the $H_2$ symbol is on, the ExScan1000 is performing the 2 point calibration.


When the Z symbol is on, the ExScan1000 is performing the probe zero calibration.

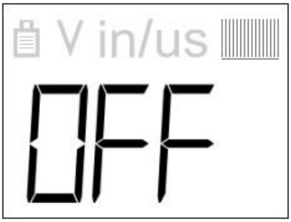



When the V symbol is on, the ExScan1000 is performing the calibration by the known sound velocity in a test block.


When the Prb0 symbol is on, the ExScan1000 is finishing the probe zero calibration. The symbol for switching on the mode of auto display illumination.




When the On symbol is on, the ExScan1000 is switching on the mode of constant display illumination.

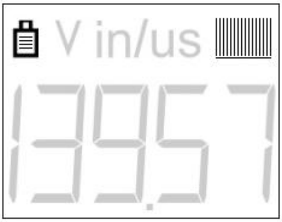



When the OFF symbol is on, the ExScan1000 is switching off the display illumination.

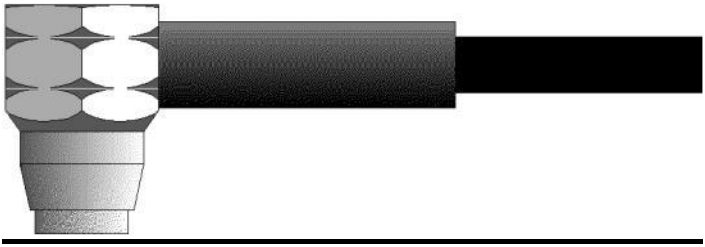

When the Auto symbol is on, the ExScan1000 is switching on the auto mode display illumination with direct measurements.


When the 1-OK symbol is on, the ExScan1000 is performing the 2 point calibration, the calibration of the 1st point.


When the 2-OK symbol is on, the ExScan1000 is perfor-ming the 2 point calibration, the calibration of the 2nd point




This symbol indicates the battery charge status. When the battery needs to be charged this symbol start flashing.

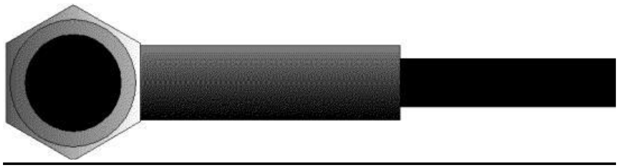


## The Transducer

The transducer is the "business end" of the ExScan1000. It transmits and receives the ultrasonic sound waves which the ExScan1000 uses to calculate the thickness of the material being measured. The transducer connects to the ExScan1000 via the attached cable, and two coaxial connectors. When using transducers manufactured by NDT Experts, the orientation of the dual coaxial connectors is not critical: either plug may be fitted to either socket in the ExScan1000.

The transducer must be used correctly in order for the ExScan1000 to produce accurate, reliable measurements. Below is a short description of the transducer, followed by instructions for its use.

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



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

## **Making Measurements**

In order for the transducer to do its job, there must be no air gaps between the wear-face and the surface of the material being measured.

This is accomplished with the use of a "coupling" fluid, commonly called "couplant". This fluid serves to "couple", or transmit, the ultrasonic sound waves from the transducer, into the material, and back again. Before attempting to make a measurement, a small amount of couplant should be applied to the surface of the material being measured. Typically, a single droplet of couplant is sufficient.

After applying couplant, press the transducer (wearface down) firmly against the area to be measured. The Stability Indicator should have six or seven bars darkened, and a number should appear in the display. If the ExScan1000 has been properly "zeroed" (see page 12) and set to the correct sound velocity (see page 13), the number in the display will indicate the actual thickness of the material directly beneath the transducer.

If the Stability Indicator has fewer than five bars darkened, or the numbers on the display seem erratic, first check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the material. If the condition persists, it may be necessary to select a different transducer (size or frequency) for the material being measured. See page 18 for information on transducer selection.

While the transducer is in contact with the material being measured, the ExScan1000 will perform four measurements every second, updating its display as it does so. When the transducer is removed from the surface, the display will hold the last measurement made.

# IMPORTANT

Occasionally, a small film of couplant will be drawn out between the transducer and the surface as the transducer is removed. When this happens, the ExScan1000 may perform a measurement through this couplant film, resulting in a measurement that is larger or smaller than it should be. This phenomenon is obvious when one thickness value is observed while the transducer is in place, and another value is observed after the transducer is removed.

## Condition and Preparation of Surfaces

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

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

In addition to posing obstacles to measurement, rough surfaces contribute to excessive wear of the transducer, particularly in situations where the transducer is "scrubbed" along the surface. Transducers should be inspected on a regular basis, for signs of uneven wear of the wearface.

If the wearface is worn on one side more than another, the sound beam penetrating the test material may no longer be perpendicular to the material surface. In this case, it will be difficult to exactly locate tiny irregularities in the material being measured, as the focus of the soundbeam no longer lies directly beneath the transducer.

## Probe Zero

Setting the Zero Point of the ExScan1000 is important for the same reason that setting the zero on a mechanical micrometer is important. If the gauge is not "zeroed" correctly, all of the measurements the gauge makes will be in error by some fixed number. When the ExScan1000 is "zeroed", this fixed error value is measured and automatically corrected for in all subsequent measurements. The ExScan1000 may be "zeroed" by performing the following procedure:

## Performing a Probe-Zero

**1)** Make sure the ExScan1000 is on.

**2)** Plug the transducer into the ExScan1000. Make sure that the connectors are fully engaged. Check that the wearface of the transducer is clean and free of any debris.

**3)** On the top of the ExScan1000, above the display, is the metal probe-disc. Apply a single droplet of ultrasonic couplant to the face of this disc.

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

**5)** While the transducer is firmly coupled to the probe-disc, press the PRB-0 key on the keypad. The ExScan1000 will display "Prb0" while it is calculating its zero point.

**6)** Remove the transducer from the probe-disc.

At this point, the ExScan1000 has successfully calculated it's internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the ExScan1000 will always use the sound-velocity value of the built-in probe-disc, even if some other velocity value has been entered for making actual measurements. Though the ExScan1000 will remember the last "probe-zero" performed, it is generally a good idea to perform a "probe-zero" whenever the gauge is turned on, as well as any time a different transducer is used. This will ensure that the instrument is always correctly zeroed.

## Calibration

In order for the ExScan1000 to make accurate measurements, it must be set to the correct sound-velocity for the material being measured. Different types of material have different inherent sound-velocities. For example, the velocity of sound through steel is about 0.233 inches-per-microsecond, versus that of aluminum, which is about 0.248 inches-per-microsecond. If the gauge is not set to the correct sound-velocity, all of the measurements the gauge makes will be erroneous by some fixed percentage. The one- point calibration is the simplest and most commonly used calibration procedure - optimizing linearity over large ranges. The two- point calibration allows for greater accuracy over small ranges by calculating the probe zero and velocity. The ExScan1000 provides three simple methods for setting the sound-velocity, described in the following pages.

## Calibration to a known thickness

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

**1)** Make sure the ExScan1000 is on.

**2)** Perform a Probe-Zero (refer to page 27).

**3)** Apply couplant to the sample piece.

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

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

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

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

**8)** Press the CAL key again. The in/µs (or m/s) symbols should begin flashing. The ExScan1000 is now displaying the sound velocity value it has calculated based on the thickness value that was entered in step 7.

**9)** Press the CAL key once more to exit the calibration mode. The ExScan1000 is now ready to perform measurements.

## Calibration to a known velocity

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

**1)** Make sure the ExScan1000 is on.

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

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

**4)** Press the CAL key once more to exit the calibration mode. The ExScan1000 is now ready to perform measurements.

To achieve the most accurate measurements possible, it is generally advisable to always calibrate the ExScan1000 to a sample piece of known thickness. Material composition (and thus, its sound-velocity) sometimes varies from lot to lot and from manufacturer to manufacturer. Calibration to a sample of known thickness will ensure that the gauge is set as closely as possible to the sound velocity of the material to be measured.

## Two Point Calibration

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

**1)** Make sure the ExScan1000 is on.

**2)** Perform a Probe-Zero (refer to page 27).

**3)** Apply couplant to the sample piece.

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

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

**6)** Press the CAL key. The in/ms (or m/s) symbol should begin flashing.

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

**8)** Press the Probe key. The display will flash 1-OK. Repeat steps 3 through 8 on the second calibration point. The ExScan1000 will now display the sound velocity value it has calculated based on the thickness values that were entered in step 7.

**9)** The ExScan1000 is now ready to perform measurements.

## Scan Mode

While the ExScan1000 excels at making single point measurements, it is sometimes desirable to examine a larger region, searching for the thinnest point. The ExScan1000 includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the ExScan1000 performs and displays four measurements every second, which is quite adequate for single measurements. In Scan Mode, however, the gauge performs sixteen measurements every second. While the transducer is in contact with the material being measured, the ExScan1000 is keeping track of the lowest measurement it finds. The transducer may be "scrubbed" across a surface, and any brief interruptions in the signal will be ignored. When the transducer loses contact with the surface for more than a second, the ExScan1000 will display the smallest measurement it found.

When the ExScan1000 is not in calibration mode, press the UP arrow key to turn Scan Mode on and off. A brief message will appear in the display confirming the operation. When the transducer is removed from the material being scanned, the ExScan1000 will (after a brief pause) display the smallest measurement it found.

# APPENDIX A

## Product Specifications

### Physical

Weight: 10.58 (300 g)

Size:

4.62 W x 2.34H x 1.36 D inch

(117.5 W x 59.6H x 34.6D mm)

Operating Temperature:

-20 to 120 °F

(-20 to 50 °C)

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

### Keypad

Sealed membrane, resistant to water and petroleum products.

**Power Source**

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

**Display**

FSNT/POSITIVE Liquid-Crystal-Display, size 30 mm (Height) x 25 mm (Width).

**Measuring**

Range:

0.025 to 19.999 inches

(0.63 to 500 millimeters)

Resolution: 0.001 inch (0.01 millimeter)

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

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

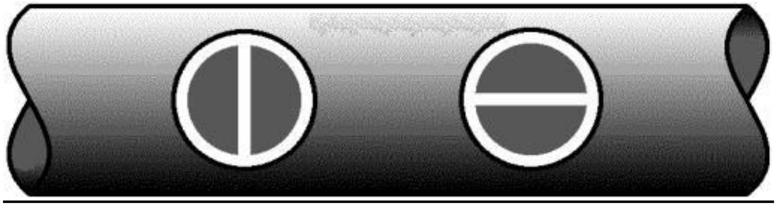
# APPENDIX B

## Application Notes

### Measuring pipe and tubing

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

The smaller of the two displayed values should then be taken as the thickness at that point.



Perpendicular Parallel

**Measuring laminated materials**

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

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

# APPENDIX C

## Sound Velocities of some Common Materials

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