OPERATION MANUAL

DAKOTA ULTRASONICS MODEL VX ULTRASONIC VELOCITY GAUGE

P/N P-138-0002

Rev 1.9, January 2008

DAKOTA ULTRASONICS

CONTENTS

DISCLAIMER

Inherent in ultrasonic 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 reading that is TWICE what it should be. This typically occurs when the material being measured is thinner than the minimum capability of the transducer being used. Responsibility for proper use of the instrument and recognition of this phenomenon rests solely with the user of the instrument.

INTRODUCTION

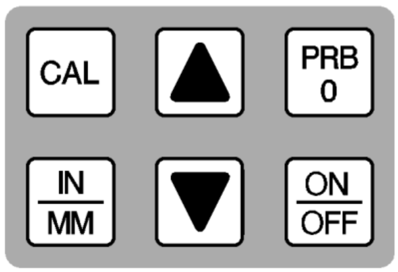
The Dakota Ultrasonics model ***VX*** is an Ultrasonic Velocity Gauge. A velocity gauge displays the speed of sound through materials of a known thickness by measuring one-half the time-of-flight of a sound wave transmitted and received at a single point. The sound velocity is represented in units of Inches-per-microsecond or Meters-per-second. A velocity gauge is useful when a material type or consistency is not known.

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

Dakota Ultrasonics maintains a customer support resource in order to assist users with questions or difficulties not covered in this manual. Customer support may be reached at any of the following:

OPERATION

The ***VX*** 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 ***VX*** 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 **.0000 IN /ms** (or **0000 M /s** if using metric units), indicating the gauge is ready for use.

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

PRB 0

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

CAL

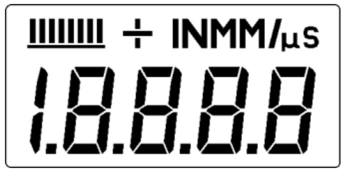
The **CAL** key is used to enter and exit the ***VX***'s calibration mode. This mode is used to adjust the material thickness value that the ***VX*** will use when calculating sound velocity. The gauge will either calculate the sound-velocity from a sample of the material being measured, or allow a known velocity value to be entered directly. Refer to page 13 for an explanation of the two **CAL** functions available.

IN / MM

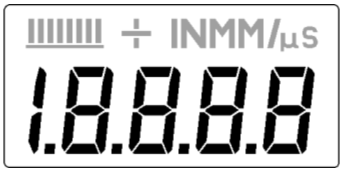
The **IN/MM** key is used to switch back and forth between English and metric units. This key may be used at any time, whether the gauge is displaying a thickness (**IN** or **MM**) or a velocity value (**IN/**μ**s** or **M/s**).

The **UP** arrow key has two functions. When the ***VX*** 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 ***VX*** is not in calibration mode, the **UP** arrow key switches the **SCAN** measurement mode on and off. Refer to page 16 for an explanation of the **SCAN** measurement mode.

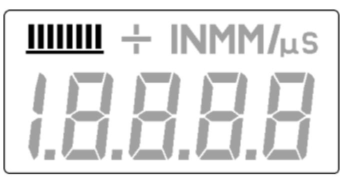
The **DOWN** arrow key has two functions. When the ***VX*** is in the **CAL** mode, this key is used to decrease numeric values on the display. An auto-repeat function is built in, so that when the key is held down, numeric values will decrement at an increasing rate. When the ***VX*** is not in calibration 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 ***VX*** is actually making a measurement.



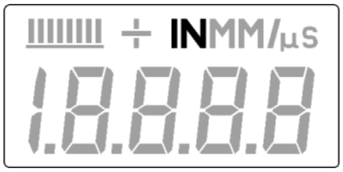
The Display



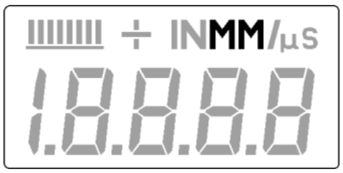
The numeric portion of the display consists of 4 complete digits preceded by a leading "1", and is used to display numeric values, as well as occasional simple words, to indicate the status of various settings. When the ***VX*** is displaying velocity measurements, the display will hold the last value measured, until a new measurement is made. **Additionally, when the battery voltage is low, the entire display will begin to flash. When this occurs, the batteries should be replaced.**



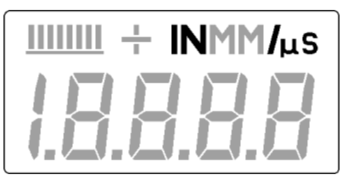
These eight vertical bars form the Stability Indicator. When the ***VX*** is idle, only the left-most bar and the underline will be on. When the gauge is making a measurement, six or seven of the bars should be on. If fewer than five bars are on, the ***VX*** is having difficulty achieving a stable measurement, and the value displayed may not be accurate.



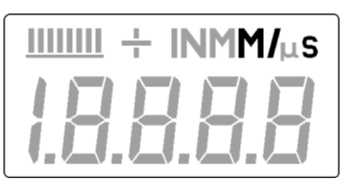
When the **IN** symbol is on, the ***VX*** is displaying a thickness value in inches. The maximum thickness that can be displayed is 19.999 inches.



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



When the **IN** symbol is on, in conjunction with the **/µs** symbol, the ***VX*** is displaying a sound-velocity value in **inches-per-microsecond.**



When the **M** symbol is on, in conjunction with the **/s** symbol, the ***VX*** is displaying a sound-velocity value in **meters-per-second**.

The Transducer

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

The transducer must be used correctly in order for the ***VX*** 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 ***VX*** has been properly "zeroed" (see page 12) and calibrated to a known thickness (see page 13), the number in the display will indicate the actual sound velocity 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 17 for information on transducer selection.

While the transducer is in contact with the material being measured, the ***VX*** 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 ***VX*** 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 value is observed while the transducer is in contact with the material, 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 ***VX*** 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 ***VX*** is "zeroed", this fixed error value is measured and automatically corrected for in all subsequent measurements. The ***VX*** may be "zeroed" by performing the following procedure:

Performing a Probe-Zero

1) Make sure the ***VX*** is on.
2) Plug the transducer into the ***VX***. 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 ***VX***, 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 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 ***VX*** will display "Prb0" while it is calculating its zero point.
6) Remove the transducer from the probe-disc.

At this point, the ***VX*** has successfully calculated it's internal error factor, and will compensate for this value in any subsequent measurements. When performing a "probe-zero", the ***VX*** 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 ***VX*** 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 ***VX*** to make accurate measurements, it must be set to the exact thickness 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 thickness, all of the measurements the gauge makes will be erroneous.

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 ***VX*** is on.
2) Perform a Probe-Zero (refer to page 12)
3) Apply couplant to the sample piece.
4) Press the transducer against the sample piece, making sure that the transducer sits flat against the surface of the sample. The display should show some (probably incorrect) sound velocity value, and the Stability Indicator should have nearly all its bars on.
5) Having achieved a stable reading, remove the transducer. If the displayed value changes from the value shown while the transducer was coupled, repeat step 4.
7) Press the **CAL** key. The **IN /**µ**s** (or **M /s**) symbol should begin flashing.
8) Press the **CAL** key again. The **IN** (or **MM**) symbols should begin flashing and a thickness value is displayed. Use the **UP** and **DOWN** arrow keys to adjust the displayed thickness up or down, until it matches the thickness of the sample piece.
9) Press the **CAL** key once more to exit the calibration mode. The ***VX*** will now display sound velocities of materials of the same thickness as entered.

<u>Calibration to a known velocity</u>

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

1) Place the transducer on the material to be measured and obtain a stable reading.
2) Press the **CAL** key to enter calibration mode. The **IN /ms** (or **M /s**) symbol will begin flashing.
3) Use the **UP** and **DOWN** arrow keys to adjust the displayed velocity up or down, until it matches the known sound-velocity of the material.
4) Press the **CAL** key again and the display will show the thickness value calculated for the material.
4) Press the **CAL** key once more to exit the calibration mode. The ***VX*** is now ready to perform measurements.

NOTE: *During the calibration procedure when* **IN /ms**, *or* **M /s** *is flashing, pressing the* **PRB-0** *key will restore the gauge to the factory default sound-velocity for steel* (.2330 IN /µs or 5920 M /s).

Scan Mode

While the ***VX*** excels at making single point measurements, it is sometimes desirable to examine a larger region to check for material consistency. The ***VX*** includes a feature, called Scan Mode, which allows it to do just that.

In normal operation, the ***VX*** 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, but does not display them. While the transducer is in contact with the material being measured, the ***VX*** is keeping track of the fastest velocity 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 ***VX*** will display the fastest sound velocity it found.

When the ***VX*** 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. While scanning, the display will show a moving series of dashes instead of a sound value.

TRANSDUCER SELECTION

The ***VX*** is inherently capable of performing measurements on a wide range of materials, from various metals to glass and plastics. Different types of material, however, will require the use of different transducers. Choosing the correct transducer for a job is critical to being able to easily perform accurate and reliable measurements. The following paragraphs highlight the important properties of transducers, which should be considered when selecting a transducer for a specific job.

Generally speaking, the best transducer for a job is one that sends sufficient ultrasonic energy into the material being measured such that a strong, stable echo is received by the ***VX***. Several factors affect the strength of ultrasound as it travels. These are outlined below:

- Initial Signal Strength

  The stronger a signal is to begin with, the stronger its return echo will be. Initial signal strength is largely a factor of the size of the ultrasound emitter in the transducer. A large emitting area will send more energy into the material being measured than a small emitting area. Thus, a so-called "1/2-inch" transducer will emit a stronger signal than a "1/4-inch" transducer.

- Absorption and Scattering

  As ultrasound travels through any material, it is partly absorbed. If the material through which it travels has any grain structure, the sound waves will also experience scattering. Both of these effects reduce the strength of the waves, and thus, the ***VX***'s ability to detect the returning echo.

Higher frequency ultrasound is absorbed and scattered more than ultrasound of a lower frequency. While it may seem that using a lower frequency transducer might be better in every instance, low frequencies are less directional than high frequencies. Thus, a higher frequency transducer would be a better choice for detecting the exact location of small pits or flaws in the material being measured.

- Geometry of the Transducer

The physical constraints of the measuring environment sometimes determine a transducer's suitability for a given job. Some transducers may simply be too large to be used in tightly confined areas. Also, the surface area available for contacting with the transducer may be limited, requiring the use of a transducer with a small wearface. Measuring on a curved surface, such as an engine cylinder wall, may require the use of a transducer with a matching curved wearface.

- Temperature of the Material

When it is necessary to measure on surfaces that are exceedingly hot, high temperature transducers must be used. These transducers are built using special materials and techniques that allow them to withstand high temperatures without damage. Additionally, care must be taken when performing a "Probe-Zero" or "Calibration to Known Thickness" with a high temperature transducer. See **Appendix B** for more information on measuring materials with a high temperature transducer.

Selection of the proper transducer is often a matter of tradeoffs between various characteristics. It may be necessary to experiment with a variety of transducers in order to find one that works well for a given job. Dakota Ultrasonics can provide assistance in choosing a transducer, and offers a broad selection of transducers for evaluation in specialized applications.

APPENDIX A

Product Specifications

Physical

Weight: 10 ounces

Size: 2.5W x 4.75H x 1.25D inches
(63.5W x 120.7H x 31.8D mm).

Operating Temperature: -20 to 120 °F (-20 to 50 °C)

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

Keypad

Sealed membrane, resistant to water and petroleum products.

Power Source

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

Display

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

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: .0492 to .3930 IN/µs (1250 to 10000 M/s)

APPENDIX B

Application Notes

· **Measuring hot surfaces**

The velocity of sound through a substance is dependant upon its temperature. As materials heat up, the velocity of sound through them decreases. In most applications with surface temperatures less than about 200°F (100°C), no special procedures must be observed. At temperatures above this point, the change in sound velocity of the material being measured starts to have a noticeable effect upon ultrasonic measurement.

At such elevated temperatures, it is recommended that the user perform a **calibration** procedure (refer to page 11) on a sample piece of known thickness, which is at or near the temperature of the material to be measured. This will allow the ***VX*** to correctly calculate the velocity of sound through the hot material.

When performing measurements on hot surfaces, it may also be necessary to use a specially constructed high-temperature transducer. These transducers are built using materials that can withstand high temperatures. Even so, it is recommended that the probe be left in contact with the surface for as short a time as needed to acquire a stable measurement. While the transducer is in contact with a hot surface, it will begin to heat up itself, and through thermal expansion and other effects may begin to adversely affect the accuracy of measurements.

· **Measuring laminated materials**

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

An additional important consideration when measuring laminates, is that any included air gaps or pockets will cause an early reflection of the ultrasound beam. This effect will be noticed as a sudden increase in sound speed in an otherwise regular surface. While this may impede accurate measurement of the material, 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

WARRANTY INFORMATION

· Warranty Statement ·

Dakota Ultrasonics warrants the VX against defects in materials and workmanship for a period of five years from receipt by the end user. Additionally, Dakota Ultrasonics warrants transducers and accessories against such defects for a period of 90 days from receipt by the end user. If Dakota Ultrasonics receives notice of such defects during the warranty period, Dakota Ultrasonics will either, at its option, repair or replace products that prove to be defective.

Should Dakota Ultrasonics be unable to repair or replace the product within a reasonable amount of time, the customer's alternative exclusive remedy shall be refund of the purchase price upon return of the product.

· Exclusions ·

The above warranty shall not apply to defects resulting from: improper or inadequate maintenance by the customer; unauthorized modification or misuse; or operation outside the environmental specifications for the product.

Dakota Ultrasonics makes no other warranty, either express or implied, with respect to this product. Dakota Ultrasonics specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. Some states or provinces do not allow limitations on the duration of an implied warranty, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the five-year duration of this written warranty.

This warranty gives you specific legal rights, and you may also have other rights, which may vary from state to state or province to province.

· Obtaining Service During Warranty Period ·

If your hardware should fail during the warranty period, contact Dakota Ultrasonics and arrange for servicing of the product. Retain proof of purchase in order to obtain warranty service.

For products that require servicing, Dakota Ultrasonics may use one of the following methods:

- Repair the product
- Replace the product with a re-manufactured unit
- Replace the product with a product of equal or greater performance
- Refund the purchase price.

· After the Warranty Period ·

If your hardware should fail after the warranty period, contact Dakota Ultrasonics for details of the services available, and to arrange for non-warranty service.

MATERIAL SAFETY DATA SHEET

N/A = not applicable or not available (To comply with 29 CFR 1910.1200)

SECTION 1 – PRODUCT IDENTIFICATION

Product Name: **SOUNDSAFE®**
Generic Name: Ultrasonic Couplant
Manufacturer: Sonotech, Inc.

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

SECTION 2 – HAZARDOUS INGREDIENTS

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

This material does not contain any known or suspected carcinogens.

SECTION 3 – PHYSICAL DATA (nominal)

Boiling Point: >220°F
pH: 7.35 – 7.9
Freezing Point: <20°F
Acoustic Imp.: 1.726×10^6
Vapor Pressure: N/A
Vapor Density: N/A
Evaporation Rate: N/A
Specific Gravity: >1.02
Solubility in Water: complete
Appearance and Odor: water white, opaque gel; bland odor

SECTION 4 – FIRE AND EXPLOSION HAZARD DATA

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

SECTION 5 – REACTIVITY DATA

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

SECTION 6 – HEALTH HAZARD AND FIRST AID DATA

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

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

SECTION 7 – STORAGE AND HANDLING INFORMATION

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

SECTION 8 – CONTROL MEASURES

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

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

SONOTECH, INC.

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