

Models BG80DL & BG80TDL

Tension Monitor

Operating Instructions



This product meets the Electromagnetic Compatibility Directive.

The product is Class A, Group 1 ISM equipment according to CISPR 11

Group 1 ISM product: A product in which there is intentionally generated and/or used conductively coupled radio-frequency energy which is necessary for the internal functioning of the equipment itself.

Class A product are suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Note: In the close presence of some radio transmitters, erroneous readings may be given. If this occurs tests should be repeated at another location.



All other trademarks acknowledged.

Material Safety Data Sheets for the ultrasonic couplant supplied with the BG80DL & BG80TDL and available as an accessory, are available to download via our website:

Elcometer NDT Ultrasonic Couplant Material Safety Data Sheet :

www.elcometerndt.com/images/MSDS/elcometer_ultrasonic_couplant.pdf

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Thank you for purchasing this Elcometer NDT product. Welcome to Elcometer NDT.

The Models BG80TD & BG80TDL Tension Monitors are world beating products. With the purchase of either of these gauges you now have access to the worldwide service and support network of Elcometer. For more information visit our website at www.elcometer.com.

1 ABOUT YOUR GAUGE

The Models BG80TD & BG80TDL are tension monitors that measure the change in length of a fastener when a load is applied to the fastener. Within the elastic limit of the fastener, the change of length is proportional to the load applied, and therefore by measuring the change of length and knowing the physical properties of the fastener, the load on the fastener can be calculated.

Based on the same operating principles as SONAR, the Models BG80TD & BG80TDL are capable of measuring the length of fasteners of various materials with accuracy as high as 0.0001 millimetres (0.00001 inches).

Your gauge can measure time, elongation, load, stress or %strain in fasteners of virtually any material from 25.4 mm to 1220mm (1" to 48") in length. By storing the reference waveform and displaying it for comparison while the elongation is being measured, the gauge minimises operator training.

The Models BG80TD & BG80TDL include a data-logging (memory) facility which allows readings to be stored in groups before being downloaded to a computer.

1.1 STANDARDS

Your gauge can be used in accordance with the following Standards and test methods; ASTM E 797, EN 14127 and EN 15317.

1.2 WHAT THIS BOX CONTAINS

Model BG80TD or BG80TDL, Bottle of couplant, Battery (3 x), Carrying case, Test certificate, Operating instructions, CD with software to enable you to transfer your readings and settings to and from a PC, RS232 cable and USB to serial converter.

*Note: The box does **not** include a transducer; these must be ordered separately. To order a transducer, contact Elcometer NDT or your local Elcometer NDT supplier.*

1.3 FEATURES OF THE GAUGE










- Measurement quantities: Time (nanoseconds), Elongation, Load, Stress, and % Strain.
- Display Options: RF, RECTified, Large DIGITS with Limits Bar.
- Display Resolution 1/8" VGA 240 x 160 pixels.
- Stores 8000 readings and waveforms in multiple groups.
- Built-in Linear regression or vector for optimising load measurements.
- Auto Set function which automatically optimises detection and adjusts display.
- Hi/Lo alarm tolerance limits work in conjunction with the data port and external pump shut-off device.
- Alpha numeric measurement data storage. Data can be downloaded to a computer for analysis and storage.

To maximise the benefits of your new Elcometer NDT gauge, please take some time to read these Operating Instructions. Do not hesitate to contact Elcometer NDT or your Elcometer NDT supplier if you have any questions.

1.4 PACKAGING

The gauge is packed inside its carrying case within a cardboard box. Please ensure that the packaging is disposed of in an environmentally sensitive manner. Consult your Local Environmental Authority for further guidance.

2 THE KEYPAD

	Activates the primary menu structure containing menu tab groups. These tab groups then contain sub menu items, or functions.
	Clears a measurement from a group cell location or set obstruct, and backspace in an Alpha Edit Box.
	Press to start taking measurements. Scrolls forward through the Hot Menu.
	Press to confirm a change or selection. If your gauge is displaying a group log, this key advances to a specific bolt number in the group.
	In the MENU, MEAS, and EDIT functions this key acts as a back or escape function. If your gauge is displaying a group log, this key toggles the display options; RF, RECT or DIGITS. Scrolls backward through the Hot Menu functions.
	Navigation Keys.
	In menus this key activates list and edit boxes, displays and saves measurements to bolt group locations. While making measurements, displays the group log file.
	This key has two completely different functions: <ul style="list-style-type: none"> • <i>Reference Lengths</i> - When measuring reference lengths, press to locate automatically the detection point (end of the bolt or target), and optimise the gauge settings. • <i>High Speed Update</i> - When using the Elcometer NDT shut-off box, installed and connected to a pump, press to activate the high speed update mode.
	Switches the gauge ON or OFF. Note: The gauge will automatically switch off when idle for 5 minutes. All current settings are automatically saved prior to switching off.

3 GETTING STARTED

3.1 FITTING BATTERIES

Your gauge may be used with dry cell or rechargeable batteries. 3 x LR6 (AA) alkaline batteries are supplied with this gauge.

When the battery voltage is low the entire display will start to flash. When this occurs the batteries should be replaced.

To fit or replace batteries:

1. Unscrew battery compartment cover.
2. Referring to battery polarity instructions on rear of gauge, insert batteries.
3. Replace battery compartment cover.


Note: Remove the batteries from the gauge if it is to remain unused for a long period of time. This will prevent damage to the gauge in the event of malfunction of the batteries.

3.2 FITTING THE TRANSDUCER

The transducer transmits and receives ultrasonic sound waves that the gauge uses to calculate the thickness of the material being measured. The transducer connects to the gauge via the cable which is connected by screwing to the transducer.



3.3 SWITCHING ON/OFF

To switch on or off, press the on/off key .

The gauge will switch off automatically after 5 minutes of inactivity.



3.4 QUICK START

Follow the steps in this quick start section to set up the gauge in its simplest form to measure elongation. This quick start example uses a preset material type and does not include zeroing the transducer (because the transducer is not zeroed, you will not be able to re-measure the fasteners at a later date - typically to monitor relaxation of a joint over time).

Step	Task	See
1	Load the factory QUICK START setup	"Opening a Setup" on page 34
2	Select units/resolution	"UNITS" on page 40
3	Select bolt material type	"TYPE" on page 40
4	Create a group to save measurements	"Creating a New Data logger Group File" on page 32
5	Set the approximate length of the bolt	"Setting the Approximate Length" on page 30
6	Automatically locate the bolt end	"Conducting an AUTO SET" on page 30
7	Measure and save the unloaded (reference) length in column A of the group	"Measurement - Taking Readings" on page 26 and "Storing readings in a Data Logger Group File" on page 32
8	Apply a load to the bolt	
8	Measure and save the elongation in columns B to ZZ of the group	

Note: When positioning the transducer to measure an elongation, ensure that you place the transducer in exactly the same position on the end of the bolt as used for the measurement of the reference length. This will eliminate any potential sound path error caused by moving the transducer to a different location on the

bolt, thus causing potentially erroneous measurements. To avoid transducer placement errors, be consistent and as methodical in your methods as possible.

Note: Do Not press  while measuring elongation, as this will activate a high speed mode used specifically with the Elcometer NDT shut-off box. The AUTO SET function (see “Auto Set” on page 29) is only used when measuring reference lengths. If  is accidentally pressed, press it again to switch the high speed mode off.

4 ULTRASONICS - OVERVIEW

4.1 ULTRASONIC MEASUREMENT OF BOLTS

Ultrasonic measurement of bolts has proven to be the most reliable and cost effective solution when:

- Variations in friction or joint geometry prevent applied torque from controlling the clamping force produced by the fastener with the required accuracy.
- The clamping force must be monitored over the service life of the bolt.

Ultrasonic measurement of clamping load is obtained through a predictable decrease in the sound velocity within the body of the bolt as the tensile load is increased. By introducing a sonic pulse at one end of the bolt and accurately measuring the time required for the echo to return from the opposite end, the ultrasonic length is determined. As the fastener is tightened, the change in this ultrasonic length is used to calculate and display the clamping force produced.

The physics governing this process are clearly understood, and have been employed for many years in the fields of active sonar, or radar. Send a pulse of energy toward an object (in this case the opposite or reflecting end of the fastener), and then measure the time between the initial pulse and the returning echo. While the concept is comparatively simple and ultrasonic measurement can produce extremely accurate results, the selection of the optimum transducer for the bolt being measured, and their coupling can be difficult. Your gauge minimises these difficulties to the greatest extent possible:

- The variable width pulser system can send the maximum amount of energy to the ultrasonic transducer, allowing the broadest possible range of transducers for a given application.
- The low noise and gain features of the receiver system allow signal detection and measurement in the most difficult applications.
- The digital signal processor optimises the measurement process.

4.2 ULTRASONIC WAVES

Ultrasonic measurement requires the transmission of a suitable quantity of ultrasonic energy through the length of the bolt. The relationship of the energy pulse frequency to its penetration is important in energy transmission:

- Lower frequencies produce longer wavelengths that travel further through a given substance.
- Higher frequencies produce shorter wavelengths.

To use a familiar example: AM radio signals are broadcast at relatively low frequencies and can be received hundreds of miles away, over the horizon. Higher quality FM radio and television signals are broadcast at much higher frequencies, and can only be received within a comparatively short distance. The same phenomenon exists with ultrasonic energy. A low frequency 1 MHz pulse travels much further through metal than a 5 MHz pulse. Therefore, a lower frequency transducer is able to achieve an echo in a longer bolt, or in a bolt made of metal with higher resistance to sound transmission (attenuation). While the lower frequency has more penetration power, it also produces more unwanted noise. Low frequency energy tends to spread, much like an unfocussed beam of light. When low frequency energy is introduced at the end of a bolt, a significant portion is bounced from side to side within the cylindrical shape, producing a noisy and distorted echo. Higher frequency pulses on the other hand tend to travel more directly down and back the centreline of a bolt, with less noise and distortion.

To achieve a good balance between maximum frequency and noise suppression you must use a transducer suitable for measurement of bolts. The diameter of the transducer (which is generally specified by the diameter of the piezoelectric crystal) directly effects energy transmission; larger diameter crystals have

greater ability to send and receive energy, and less of the energy tends to spread laterally. Your gauge is designed to achieve this ideal balance; direct transmission of the strongest possible pulse, with the least amount of noise and distortion, down and back the centreline of the bolt to obtain the most accurate measurement.

5 BOLT PREPARATION

5.1 CORRECT USE OF ULTRASONIC COUPLANT

Sonic energy of the frequency used by this gauge travels well through solid materials and most liquids. It does not travel well through air. This variable resistance to the passage of sonic energy is called sonic impedance. It is the sudden change in impedance which occurs when the sound pulse attempts to cross the metal to air boundary at the end of the bolt which causes most of the energy to be returned as an echo, much like light reflected by the silvered back surface of a mirror.

Any air gap between the face of the transducer and the end of the bolt will prevent the sonic energy from being transmitted into the bolt. The gap must be filled with a suitable coupling fluid. Normally, a liquid ultrasonic couplant is applied between the transducer and the bolt. Since liquid has a sonic impedance closer to the transducer and bolt material than air, it forms a continuous path for the outgoing pulse and the returning echo.

Many liquids can serve as an adequate couplant, however liquids with lower sonic attenuation will produce better results. Liquids containing glycerin offer such low impedance, and couplant manufactured for ultrasonic testing, such as the one supplied with this gauge, produces the best results.

The single purpose of the couplant is to fill the air gap between the transducer and the bolt end. This is accomplished more easily with a liquid that is viscous enough to stay in place. Very viscous substances however can create such a thick layer between the transducer and bolt that measurement errors occur. Also, viscous substances can trap air bubbles, which prevent adequate energy transmission.

The ultrasonic couplant provided with your gauge works best. Apply only the smallest quantity of couplant required to fill the air gap, and carefully place the transducer so that any trapped air or excess couplant is squeezed out of the interface.

5.2 CONTACT BETWEEN THE TRANSDUCER AND THE BOLT

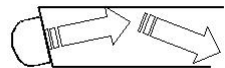
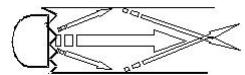
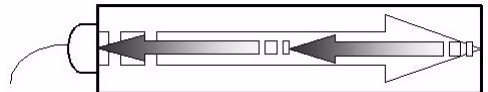
The goal is to transmit as much sonic energy as possible from the transducer into the bolt, and to send that energy, to the greatest extent possible, down the centre of the bolt and back.

In order to transmit sonic energy straight along the axis of the bolt, the transmitting end of the bolt must be smooth, flat and perpendicular to the axis of the bolt and must seat the entire active surface of the transducer with minimum gap. The end of the bolt may need to be cleaned, ground, etc. to achieve the required surface. Typical problems with the transducer contact end of the bolt are listed below:

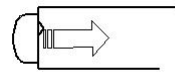
Rough or irregular surfaces. This condition prevents adequate contact with the transducer. Couplant will fill the irregularities in the surface, but energy transmission will be reduced and dispersed causing mode conversions to occur from reflections off the side walls of the bolt.

Bolt ends not perpendicular to the axis of the bolt. Energy will be transmitted toward the side wall and reflect along the bolt, yielding poor signal quality and possible measurement errors. Avoid alignment errors exceeding 2 degrees.

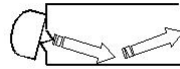
Rusted, dirty, or thick paint-covered bolt ends. These coatings prevent sonic energy from travelling between the transducer and the bolt. Very thin coating or plating is acceptable.



Bolt ends with recessed grademarks Small indentations cause some loss of signal strength, however couplant can be used to fill recessed grademarks and normal measurement is still possible. Large or numerous indentations cause the signal to be too weak for a reliable measurement.



Bolt ends with raised grade marks Raised grade marks or indentations with a raised edge cause the transducer to be seated at an angle to the axis of the bolt, thus preventing adequate contact.



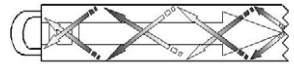
5.3 BOLT END REQUIREMENTS

In order to reflect sonic energy straight back along the axis of the bolt, the reflecting end of the bolt must be smooth, flat and perpendicular to the axis of the bolt. The end of the bolt may need to be cleaned, ground, etc. to achieve the required surface. Typical problems with the reflecting end of the bolt are listed below:

Note: Misalignment exceeding 2 degrees can cause significant errors.

Rough or curved bolt end

Most of the reflected energy will be dispersed and a weak or distorted echo will be received.



Bolt end not perpendicular to bolt axis

Sonic energy will be reflected towards the sidewall of the bolt.



Bent bolt

A curved bolt axis results in sonic energy being reflected towards the sidewall of the bolt.

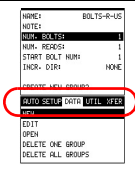
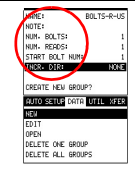
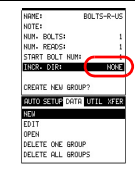


6 THE MENUS

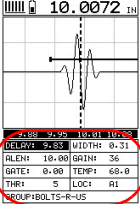
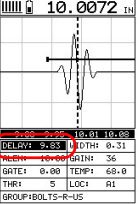
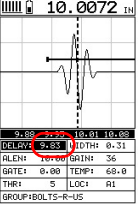
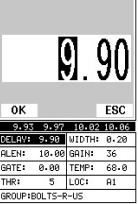
Your gauge has two menu systems:

- Full menu - displays all the functions and settings of the gauge (see also “The Menu Commands” on page 40).
- Hot menu - displays a sub-set of functions and settings related to taking measurements.

6.1 FULL MENU

Press MENU once to access the menus...	then press MENU to scroll to the right along the sub menu bar and ESC to scroll left to the sub menu you want.	Use UP and DOWN to scroll to the function you want within the sub menu...	then use LEFT and RIGHT to scroll to the option you want or to select/unselect
	 <pre> NAME: BOLTS-R-US NOTES MODE: BOLTS: 1 NUM. REDECS: 1 START BOLT NUM: 1 INSTR. OPER: NONE CREATE NEW GROUP? AUTO SETUP DATA UTIL SPEE NEW EDIT OPEN DELETE ONE GROUP DELETE ALL GROUPS </pre>	 <pre> NAME: BOLTS-R-US NOTES NUM. BOLTS: 1 NUM. REDECS: 1 START BOLT NUM: 1 INSTR. OPER: NONE CREATE NEW GROUP? AUTO SETUP DATA UTIL SPEE NEW EDIT OPEN DELETE ONE GROUP DELETE ALL GROUPS </pre>	 <pre> NAME: BOLTS-R-US NOTES NUM. BOLTS: 1 NUM. REDECS: 1 START BOLT NUM: 1 INSTR. OPER: NONE CREATE NEW GROUP? AUTO SETUP DATA UTIL SPEE NEW EDIT OPEN DELETE ONE GROUP DELETE ALL GROUPS </pre>

6.2 HOT KEY MENU

<p>Press MEAS once to access the measurement screen. The hot menu functions are displayed at the bottom of the reading screen.</p>	<p>Press MEAS to scroll right along the hot menu functions and ESC to scroll left.</p>	<p>Use UP, DOWN, LEFT and RIGHT to adjust the value of the function.</p>	<p>Alternatively, adjust values by pressing ENTER then use UP, DOWN, LEFT and RIGHT to scroll and adjust values. Press OK when finished.</p>
			

7 MEASUREMENTS AND THE MEASUREMENT SCREEN

7.1 QUANTITIES OF MEASUREMENT

Your gauge can measure using the following measurement quantities: Time (nanoseconds), Elongation, Load, Stress and % Strain

The easiest and most fail safe of these quantities are Time and Elongation.

Note: If Load, Stress, or % Strain are to be used on a regular basis, a calibration of the bolts for the specific application is required.

The equations which follow outline the factors and constants necessary for each measurement quantity:

Elongation	Load	Stress	% Strain
$X_E = [(S_F)(V_0)]\Delta T$	$P = (X_E)(L_F) + L_o$	$S = \frac{P}{A}$	$S_N = \left(\frac{X_E}{L_E}\right) \times 100$
<p>where: X_E = Elongation S_F = Sonic Stress Factor V_0 = Material Velocity ΔT = Change in Time</p>	<p>where: P = Load X_E = Elongation L_F = Load Factor L_o = Load Offset</p>	<p>where: S = Stress P = Load A = Cross Sectional Area</p>	<p>where: S_N = % Strain X_E = Elongation L_E = Effective Length</p>

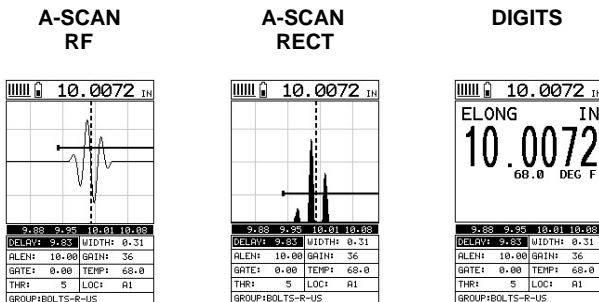
You should be aware of the possibility for errors to occur when using these measurement quantities:

- When measuring in terms of Time and Elongation, very little information is required, as the measurement is simply a difference equation. The stress factor and velocity will typically not vary more than 5%, in total, over the entire range of possible steel fasteners. Therefore the worst case error is 5%.
- When measuring in terms of Load, Stress, or % Strain however, the error can be enormous if errors in effective length, load factor, or cross sectional area are made. These factors will result in proportional errors overall. Therefore, if the load factor is in error by 10%, the load measurement will also be in error by the same 10%.

7.2 THE MEASUREMENT SCREEN

Your gauge has three types of measurement screen:

- A-Scan Waveform, RF
- A-Scan Waveform, RECT
- DIGITS

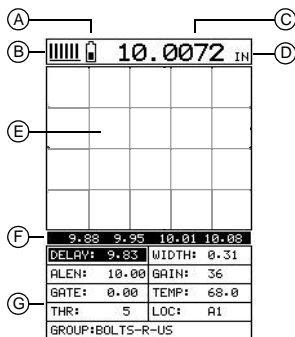


To see the measurement screen, press MEAS.

To select which measurement screen to use, press MENU/DISP/VIEW and then select RF, RECT or DIGITS.

7.3 ITEMS COMMON TO ALL MEASUREMENT SCREENS

A number of items are common to all the measurement screens:

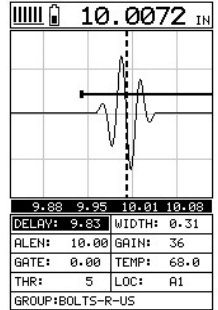


A	Battery Icon	Indicates the battery life remaining.
B	Repeatability/Stability Indicator	When taking readings, this indicator is used in conjunction with the digital thickness values displayed. When all the vertical bars are fully illuminated and the last digit on the digital thickness value is stable, your gauge is reliably measuring the value.
C	Measurement Quantity	Time, Elongation, Load, Stress or % Strain
D	Units	The units of the current measurement quantity.
E	Measurement View Area	RF, RECT or DIGITS view area (type depends upon measurement view).
F	Measurement Labels Bar	The measurement labels display the viewable range and are based on the values of DELAY and WIDTH. <i>Note: The grid of grey lines in the measurement view area divides the display up into 5 segments. The measurement labels correspond to the measurement at each of these lines.</i>

G	Hot Menu	The hot menu contains a selection of the most commonly used options, allowing you to conveniently adjust these to your needs while the graphical display is active
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7.4 RF A-SCAN MEASUREMENT SCREEN

The RF view shows the full sound wave as received by the gauge. The vertical axis indicates the amplitude of the received wave and the horizontal position indicates the time it is received, which is converted into thickness units using the material velocity. The point on the scan that is being used to calculate the bolt length is displayed as the vertical dashed line (see section 9 on gates). The RF screen is used for gauge setup prior to inspection



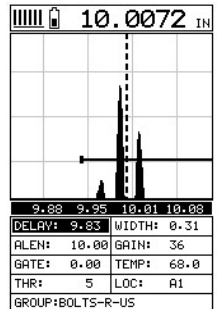
7.5 RECT A-SCAN MEASUREMENT SCREEN

The RECT display is similar to the RF display but shows only half of the waveform.

Either the positive or negative peaks are shown, depending on the polarity selected. The correct polarity is typically determined by first using the RF display to select the optimal phase.

The detection point is indicated by the same vertical dashed line as shown in the RF display.

The gate is indicated by the same solid horizontal line as shown in the RF display. The waveform can be filled or unfilled - see "RECT WAVEFORM" on page 41.

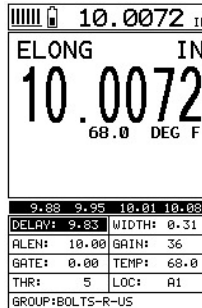


7.6 DIGITS MEASUREMENT SCREEN

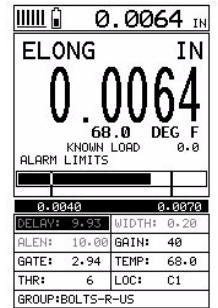
The digits display shows the measurement quantity and its value in a large font size. The current temperature of the bolt is also displayed.

If ALARM STATUS is enabled and you are in a measurement location other than column A of a group data file (column A always contains the bolt reference length), the digits view also shows a limits bar. The limits bar, in conjunction with the alarm lights, allows you to see quickly and easily whether the fastener is within tolerance without having to constantly watch the digital readout for a target value to appear.

This view is used typically once the initial setup of the gauge is complete.



**With
ALARM STATUS
disabled**



**With
ALARM STATUS
enabled**

7.7 CHANGING THE VIEWABLE RANGE

In RF view and RECT view, if the waveform around the detection point is not visible on the display, use one of the following methods to adjust the viewable range of the display:

- Use the Auto Set function - see "Auto Set" on page 29. This is the preferred option and provides a quick and easy method of adjusting the viewable range.
- Change the values of the DELAY and WIDTH functions until the measurement falls inside the viewable range of the display - see instructions below.

Note: Even if the waveform is outside of the viewable range of the display, a measurement can be taken and viewed using the DIGITS view.

7.7.1 DELAY

The DELAY is the starting length value. Under normal circumstances this value should be adjusted to a length slightly shorter than the physical length of the fastener. Adjust DELAY if you need to zoom in on a specific measurement range. If the length of the fastener is unknown, you will have to scroll the DELAY value until the echo is located on the display. However, if the length is known, use the digits edit box to enter the value (and therefore save time).

7.7.2 WIDTH

WIDTH represents the overall viewable thickness range being tested. WIDTH can be thought of as a zoom feature for the RF and RECT measurement screens; the larger the overall thickness range view (WIDTH), the smaller the noticeable shifts in the graphical display. Therefore, it is best to set the DELAY and WIDTH to reasonable values that zoom in and optimise your graphic presentation.

7.7.3 Adjusting DELAY and WIDTH

The DELAY is the thickness value from which the A-Scan display starts on the left of the screen. The WIDTH is used to adjust the value at the right side of the screen. Using these two parameters allows the user to zoom in to a specific measurement range and increase the level of detail on the display. For example, if a wall thickness was nominally 25mm and an operator was assessing for corrosion on this wall they might set the DELAY to 10mm and the WIDTH to 20mm to fit as much relevant information on the display as possible. B-START and B-DEPTH are analogous to DELAY and WIDTH or a B-SCAN display respectively. DELAY and WIDTH or B-START and B-DEPTH may be adjusted in the hot menu or in the DISP section of the main menu.

7.8 GAIN

The GAIN (the amplitude of the received echo) can be adjusted to suit a variety of applications. To obtain valid readings the gain must be set to the correct level to give reliable return echoes:

- Too much gain may result in erroneous measurements by detecting noise rather than the length of the bolt.
- Not enough gain may result in intermittent detection.

The gain setting on your gauge can be compared to the volume control of a home stereo system. If you turn it up too much you cannot hear the music clearly. If it is turned down too much, you cannot hear it at all.

Your gauge has been optimised for a medium gain setting and for the majority of applications it can be used at this setting. Some applications however may require lower or higher gain settings:

- **Lower values** might be necessary if the reading becomes sporadic and will not settle down or resolve on a length value. In this instance, reduce the gain to see if the reading settles down and becomes stable.
- **Higher values** may be necessary when trying to measure a material that is hard to penetrate (due to the material type, or the overall length of the bolt). In these instances, increase the gain to see if the reading settles down and becomes stable.

7.8.1 To Adjust the Gain Value

The quickest way to adjust GAIN is directly from the hot menu. Alternatively, adjust the value using the menus:

1. Select MENU/TUNE/GAIN and adjust using LEFT and RIGHT or press ENTER to use the DIGITS EDIT BOX
2. Press OK to set the value
3. Press MEAS to return to the measurement screen.

7.9 THRESHOLD

The THRESHOLD is the level (sensitivity) of the signal amplitude required to trigger the length reading. This level can be used in conjunction with the GAIN.

An example of when you might need to adjust the THRESHOLD setting is if the gauge is not detecting on the first cycle of the waveform because the amplitude of the first cycle is not large enough to break the current threshold. In this instance either the THRESHOLD can be decreased (lower sensitivity), or the GAIN increased to cause a detection on the first cycle.

This is very important when the reference length is being measured. If the THRESHOLD value is set so that the amplitude of the signal is just barely reaching this value, it should be decreased. If you do not increase it at that time, when the fastener is put under a load, the same peak jumps can occur. Even though the THRESHOLD value can be adjusted at a later time to correct the peak jump, errors can be overlooked during the measurement process. Therefore, it is always best to make these adjustments when initially measuring the reference lengths.

7.9.1 To Adjust the Threshold Value

The quickest way to adjust the THRESHOLD value is directly from the hot menu. Alternatively, adjust the value using the menus:

1. Select MENU/TUNE/THRESHOLD and adjust using LEFT and RIGHT alternatively press ENTER to open the Digits Edit Box.
2. When complete press OK
3. Press MEAS to return to the measurement screen

7.10 THE GATE

Your gauge is equipped with a gate which controls the time measurement process. Using the gate to adjust the time measurement process allows you to measure a specific region on the waveform.

For instructions on how to use the gate, see "Using the Gate" on page 27.

7.11 FRONT PANEL LIGHTS

The green light illuminates when the alarm mode is active and the measured thickness is within limits.

The red light illuminates when the alarm mode is active and the measured thickness is less than the alarm low value, or the measured thickness is greater than the alarm high value.

To set and adjust the alarm, see "Alarm Mode" on page 30.

8 MEASURING SYSTEM ZERO (CALIBRATION)

8.1 INTRODUCTION

System zeroing is the method of calculating the time required for the gauge and transducer combination to detect the echo. When an echo travels back through the bolt to the transducer face, there is an electronic delay before the gauge detects the echo. Because of differences in the electronic parts, or the transducer and cable, the delay is slightly different for each combination of gauge and transducer. The time delay is called the delay factor or zero time offset.

Your gauge is designed for use with two calibration bars having a known ultrasonic velocity and known length. Comparing their known physical length and measured ultrasonic length determines the system delay factor. The system delay factor makes your gauge interchangeable with other calibrated gauges.

Once the delay factor is determined, the gauge automatically subtracts it from the apparent measurement of the time required for the sonic signal to travel through the bolt. Thus, the actual time of signal travel is determined, and compensation is made for the slight difference in each gauge/transducer combination. Since every zeroed gauge makes the same time measurement, the systems give the same result and are interchangeable.

System Zeroing is only required in the following instances:

- More than one gauge or transducer will be used while measuring a set of bolts. If the same gauge and transducer are used, the amount of the delay is constant. If unloaded length measurements were made with one gauge, and the load measurements were made with another, the difference in the delay

factor could cause an error, though in most cases the error would be very small. If it is uncertain that the same unit and transducer will always be used, it is strongly recommended that you conduct a System Zero whenever the gauge is used.

- The application requires that the bolts be monitored over periodic intervals through their service life. In this case, the gauge must be zeroed in order to maintain reliable and accurate measurements. Once again, if a transducer, cable, or gauge is replaced, the delay factor will change, resulting in erroneous measurements.

8.2 CALIBRATION / ZERO MISNOMER

In the past there have been instances where users were under the impression that zeroing the unit was the same as calibrating the unit. If the ultrasonic unit could successfully measure the calibration blocks, the unit was calibrated. However, this is not the case. The linearity of the unit and material type of the bolts are not calibrated following a zero procedure. This is a misnomer.

- Your gauge should be calibrated by Elcometer NDT, or your Elcometer NDT supplier on a periodic basis to verify proper operation of the instrument. Elcometer NDT recommends one-year intervals.
- Depending on the how critical the application is, bolts should be calibrated in a lab against a known load prior to measuring. A temperature bath should also be used to determine the necessary temperature factors required.

The following sections describe typical methods of how to perform and calculate a system zero. The method you choose should be determined by the level of accuracy required and the specifications and conditions of the application itself.

8.3 MEASURING SYSTEM ZERO - USING A STANDARD BOLT

Any bolt that provides a good ultrasonic echo with both ends ground and polished can be used as a simple and effective calibration standard. Although this sounds like an economic method, you should bear in mind that certified calibration standards are usually inclusive of an ultrasonic length, velocity, and temperature coefficient and are certified according to a specific set of standards.

The following procedure outlines how to use a standard bolt.

Create a group in which to store the system zero data

You will save all the values and settings to a cell location in the group for easy recall at a later time. This will allow you to easily verify the zero value and make any necessary changes to the gauge, by adjusting the zero value or temperature depending on the circumstances or conditions.

To create a group, read the notes below and then follow the instructions given in "Creating a New Data logger Group File" on page 32.

- When you create the group, give it a NAME and NOTE which describe and make reference to the System Zero data and bolt.
- A group can contain up to 250 bolts. There must be at least one bolt in a group. If multiple bolts are going to be used to zero the gauge, you will need to create multiple bolts in the group. In some cases you may opt to use a bolt that is a representative bolt from each application, rather than just an arbitrary bolt. This would typically be done in critical applications.
- A bolt can have up to 51 possible measurements and one initial reference length. The initial reference length is saved in a cell of column A of the group and other readings are stored in cells starting at column B. There must be at least one reading per bolt. Since this group is being created to store System Zero data and verify your probe zero periodically, or before starting a new application, consider selecting all 51 measurements locations.

Select the Bolt Material Type

1. Select MENU/MATL/TYPE and press ENTER
2. Select the correct material from the list with ENTER
3. Press OK to confirm or ESC to cancel.

Measure and Record the Ultrasonic Length, Velocity and Temperature Coefficient

You must measure these values and save the length value in the group previously created and make a record of the values of velocity and temperature.

1. Select MENU/CAL/ZERO MODE
2. Use LEFT and RIGHT to adjust the ZERO MODE to FIXED
3. Select Bolt Material Type as detailed above
4. Make a note of the values for the VELOCITY and TEMPERATURE COEFFICIENT displayed next to their respective sub menu items
5. Navigate to MENU/GEOM/QUANTITY
6. Use LEFT and RIGHT to adjust this to ELONG
7. Set the value of ALLEN/APPROX LEN (length of fastener in selected units) and conduct an AUTO SET - see section "Auto Set" on page 29
8. Record the Ultrasonic Length of the bolt along with the velocity and temperature coefficient. These could also be scribed on the bolt for future zero verification
9. Store ultrasonic length value in the group previously created (see "Quick Start" on page 3).

Perform and Save the First System Zero Verification

The next two sections outline two alternative the procedures for performing a system zero calibration by:

- Calculating a zero value.
- Adjusting the temperature value to match the existing System Zero value.

When to use the check zero feature:

The only time the Calc Zero feature should be used is when a different gauge, transducer, or transducer cable is being used, other than the one initially used to obtain the system zero data for the probe zero calibration bolt. In this case, calculating the system zero value forces the new hardware to match with the original. If the hardware has not changed, the user should not use this function. If the hardware has not changed, only the temperature value should be adjusted to match the existing zero values.

Performing a Probe Zero Calibration

1. Select MENU/CAL/ZERO OPTION
2. Use LEFT and RIGHT to adjust ZERO MODE value to ONE POINT
3. Select MEASURE ZERO and press ENTER The ONE POINT ZERO Edit Box is displayed
4. Highlight PHYSICAL LEN, press ENTER and adjust to match the ultrasonic length that was determined in the previous section. This will be considered to be the actual physical length from this point forward. Reminder: This value was stored in the first column of the System Zero group.
5. Press OK to set the value and return to the ONE POINT ZERO Edit Box.
6. Select VELOCITY and adjust to match the velocity of the bolt determined in the previous section. Press OK to confirm
7. Adjust the TEMP COEFF to match the value previously determined.
8. Return to the ONE POINT ZERO edit box
9. Select ULTRASONIC LEN and press ENTER, the value currently being measured is displayed
10. Scroll to CALC ZERO, press OK to set the value and return to the menu.
11. Press MEAS to return to the measurement screen

This completes the Probe Zero Calibration. If the zero value is incorrect and the hardware has not been changed this is typically because the temperature of the bolt has changed. In this case, do not adjust the zero value, but instead adjust the temperature value. This is also a good way to monitor temperature changes in the bolt. The procedures below demonstrate how to adjust the temperature to match the zero value.

Adjusting the temperature value

1. Open the group in which you previously stored the system zero data - see "Opening an Existing Data Logger Group File" on page 32.
2. Press MEAS to return to the measurement screen.
3. Press MEAS again and then highlight LOC in the hot menu.

4. Press ENTER.

The Group View Box is displayed.

5. Scroll the cursor to the next blank cell for the System Zero bolt.

Note: This will always be a cell located in columns B to ZZ.

When you scroll to a blank cell, the gauge will switch into elongation mode and use all the data from the System Zero bolt previously stored.

6. Press MEAS to return to the measurement screen.
7. Press MEAS again and then highlight TEMP in the hot menu.
8. Use UP, DOWN, LEFT and RIGHT to scroll the value of TEMP until the elongation is 0.0000
When the value is at 0.0000 your gauge is zeroed and ready to store or document the zero data prior to taking measurements.
9. Press MEAS to return to the measurement screen.
10. Press MEAS again and then highlight LOC in the hot menu.
11. Press ENTER.
The elongation value of 0.0000 is stored in the cell location previously selected.
As well as storing this elongation value of 0.0000, the adjustment to temperature is also stored, therefore documenting the changes for reporting purposes.
12. Press MEAS to return to the measurement screen.
Your gauge is now ready to take measurements.

	A	B	C
1	10.0072		
2	10.0072		
3			
4			

8.4 MEASURING SYSTEM ZERO - USING CALIBRATION BARS OR TRIPLE SIDED GLASS BLOCK

Historically a set of 3" and 6" mild steel calibration bars, or a triple sided glass block have been used for performing a probe zero. These bars/block are generally measured and certified to a specific set of standards in a professional calibration lab, and the corresponding length, velocity, and temperature coefficient are documented. Elcometer NDT carries a custom set of calibration bars and an optical glass block that are measured and calibrated according to national standards. The primary advantage of using these bars/block versus setting a standard bolt aside, as explained in the previous section, is the possibility of losing the stand alone bolt. Because the factory 3" and 6" bars and glass block are calibrated with documentation, these can be interchanged between units and calibration bars/blocks.

While the 3" and 6" bars provide two specific points to demonstrate linearity, the triple sided glass block has a third reference point. The glass block has a 1", 2", and 3" reference. Generally you will set up the two-point calibration on the 1" and 3" sides first, and use the 2" side for additional verification purposes. This section explains the procedure for using the factory calibration bars and glass block as a means of probe zeroing the gauge.

The first step is to setup a group to document our probe zero data. By doing this, all the values and settings will be saved to the cell location for easy recall at a later time. This will allow the user to easily verify the zero value and make any necessary changes to the gauge, by adjusting the zero value or temperature depending on the circumstances or conditions.

The following procedure outlines how to use the calibration bars or triple sided glass block.

Create a group in which to store the system zero data

You will save all the values and settings to a cell location in the group for easy recall at a later time. This will allow you to easily verify the zero value and make any necessary changes to the gauge, by adjusting the zero value or temperature depending on the circumstances or conditions.

When you create the group, give it a NAME and NOTE which describe and make reference to the System Zero data and calibration apparatus used (3" and 6" bars or triple sided block).

To create a group, follow the instructions given in "Creating a New Data logger Group File" on page 32.

Note: A group can contain up to 250 bolts. In this case, the number of bolts in the group can be thought of as the number of reference points on the calibration standards. If the 3" and 6" calibration bars are being used, then the group should contain two bolts. If the triple sided glass block is being used, then the group should contain three bolts.

Note: A bolt can have up to 51 possible measurements and one unloaded initial length (L-REF). There must be at least one reading per bolt. Since this group is being created to store System Zero data and to verify

your probe zero periodically, or before starting a new application, consider selecting all 51 measurements locations.

Now that the bolt group has been created to document the probe zero data, you are ready start the probe zero process. The first thing to note is, the procedures in the next section demonstrate a Two-Point calibration. However, the same procedures also apply to the One-Point calibration option. If you are conducting a One-Point calibration, follow the same procedures and ignore references to the second point.

1. Select MENU/CAL/ZERO MODE
2. Use LEFT and RIGHT set to TWO POINT

Note: The two-point option allows the user to use two separate points for the probe zero calibration. The one point option can optionally be selected if only one calibration bar is being used. Although the procedures below are described with the two-point option in mind, they will also work in the case of a one-point calibration.

3. Scroll to MEASURE ZERO and press ENTER. The TWO POINT ZERO list box is displayed
4. Highlight PHY LEN 1, press ENTER and input the length of the first (shorter) calibration standard. Note that when using the glass block, the 1" side should be used for PHY LEN 1. Press OK to confirm
5. Press OK and select PHY LEN 2 before inputting the length of the second, longer calibration standard. Press OK to confirm
6. Input the velocity using the same method. If the velocity for each calibration standard is different, use the velocity of the longest bar as it will be the most significant. Press OK to confirm
7. Input the TEMP COEFF

Note: TEMP COEFF should be set to 99 (metric), 55 (English) for the 3" and 6" calibration bars supplied by Elcometer NDT. If the glass block is used, it should be set to 0 (because glass has a very low temperature coefficient).

Press ESC to leave the Two Point Zero list box.

In order for the gauge to display the correct measurement value during calibration, the material velocity and temperature coefficient must be set to the same values as in the calibration section.

1. Select MENU/MATL/VELOCITY
2. Adjust the VELOCITY, and TEMP COEFF to match those used in calibration
3. Set the STRESS FACTOR to 1.000

Before the probe zero is calculated, the calibration bars / glass block needs to be ultrasonically measured. Once the zero value has been calculated, the results should then be documented.

The following steps explain the procedure

Setting up the Gauge for Measurement

Check to see if the system was previously calibrated. You should NOT change the calibration unless the transducer, transducer cable, or instrument has been changed. In any event, the probe zero calibration should always be checked prior to changing it and only changed if it is required, as you can introduce error by uncertainty during the zero procedure. If the gauge has been previously calibrated, open the calibration data saved in the gauge and check the probe zero by simply measuring the bars in an empty location (columns B to ZZ) in the existing probe zero data group. If the zero is slightly off, minor adjustments to the temperature, located in the Main Measure Menu, should be all that is necessary to bring the error between the two bars within a tolerance of 0.0005"

1. Select MENU/GEOM/QUANTITY
2. Use LEFT and RIGHT to adjust the QUANTITY value to ELONG.
3. Press MENU, scroll to the CAL menu and then highlight the MEASURE ZERO function.
4. Couple the transducer to the 3" calibration block (or 1" side of the glass calibration st Select MENU/CAL/MEASURE ZERO and press ENTER. The TWO-POINT Zero list box is displayed
5. Highlight Ultrasonic 1 and press ENTER to store the measured value
6. Couple the transducer to the 6" calibration standard (or 3" side of the glass block) select ULTRASONIC 2 and press ENTER to store the measured value
7. Select CALC ZERO and press ENTER
8. Press OK to confirm overwrite settings

9. Press ENTER to open the DIGITS EDIT BOX.

Evaluate the Error

Calculate the difference between the physical and ultrasonic lengths. If the difference (error) exceeds 0.0005" the temperature must be adjusted, and the CAL procedure repeated for the 3" and 6" calibration bars - see "Setting up the Gauge for Measurement" on page 15.

Note: This should not be necessary when using the glass block as the calibration standard.

Calculating Temperature Adjustment

Use the difference between the physical and ultrasonic lengths of the 6" calibration bar only and multiply the error by 3.

This is the same as OVER correcting the error by 300%

$$[(\text{Ultrasonic Length } 6" \text{ bar}) - (\text{Physical Length } 6" \text{ bar})] \times 3$$

Example using the equation above:

$$[6.0077 - 6.0049] \times 3 = 0.0084$$

The over corrected error must now be subtracted from the physical length of the 6" calibration bar:

$$6.0049 - 0.0084 = 5.9965$$

10. Press MEAS, and then highlight the TEMP field.

11. Use LEFT and RIGHT to adjust the TEMP value to the over corrected value calculated above.

Note: Lower temperatures will make the bolt read longer, and higher temperatures shorter.

12. Repeat steps 4 to 8 above to re-calculate the zero value using the adjusted temperature setting.

Note: The above steps may need to be repeated more than once in order to bring the probe zero calibration into specification (0.0005). This is typically not necessary when using the glass block as a calibration standard.

Once the zero/calibration is within specification, save these initial lengths in column A of the zero group previously created for future reference and verification:

13. Press MEAS to return to the measurement screen.

14. Press MEAS again and then highlight LOC in the hot menu.

15. Press ENTER.

The Group View Box is displayed.

16. Scroll the cursor to the desired storage location.

Note: Since these are the first calibration bar measurements taken, the measurements have to be stored in column A. In fact, the most logical approach would be to store the 3" bar in A1, and the 6" bar in A2. However, if the glass block is the standard, store the 1" side in A1, 2" side in A2, and the 3" side in A3.

	A	B	C
1	18.0072	0.0039	
2	18.0072		
3			
4			

17. Place the transducer on the 3" calibration bar in exactly the same location as before.

18. Press ENTER.

The reading is saved in the storage location selected previously.

19. Repeat steps 17 and 18 for the 6" calibration bar in location A2. If using the glass block, repeat the steps an additional time for the extra point on the glass block.

The gauge is now zeroed.

8.5 VERIFYING PROBE ZERO

This section describes how to go back and verify if the probe zero value is still linear and within specifications at a later time. It is important to note you should never have to change or re-calculate the probe zero value again, unless the gauge, transducer, or cable has been replaced. If the transducer or cable has changed, and the probe zero value re-calculated, the change in the zero value should be very small. Therefore, if the zero is re-calculated and the difference is very large, something may have gone awry and you should become suspicious of how well the probe zero was performed.

If we consider the initial probe zero value constant, as the hardware calibration bars or glass block have not been replaced, any future verifications should always show an elongation value of +/- 0.0001" if they are to be considered as within specification. If the probe zero is out of specification, you should make adjustments only to the physical temperature setting. In other words, the primary reason the probe zero is out of

specification is because the physical temperature of the probe zero calibration standards has changed. If the accessory temperature sensor is being used, the sensor will automatically adjust the physical temperature and the gauge should be within specification and displaying an elongation value of 0.0000" +/- 0.0001".

To verify probe zero:

1. Open the group in which you previously stored the probe zero data - see "Opening an Existing Data Logger Group File" on page 32.

Note: You should always use this group for the zero verification procedure, as it contains the original settings and measurement data of the probe zero calibration standards.

2. Place the transducer with couplant on the calibration standard.
3. Press MEAS to return to the measurement screen.
4. Press MEAS again and then highlight LOC in the hot menu.
5. Press ENTER.

The Group View Box is displayed.

	A	B	C
1	10.0072		
2	10.0072		
3			
4			

6. Scroll the cursor to the next blank cell for the System Zero bolt.

Note: This will always be a cell located in columns B to ZZ. Since this is the first verification following the initial measurement of the Probe Zero Calibration Bars, the cursor should be located on a calibration standard in column B. It is also important to note that the L-REF stored in column A also contains all the gauge settings when the L-REF was initially measured. These settings will automatically be copied to all the columns B to ZZ, for each individual bolt. Therefore, no adjustments to the gauge should be necessary.

7. If the elongation is +/- 0.0001" (and therefore within specification) press ENTER to save the current reading in the highlighted cell location, storing all the current probe zero verification data. If the elongation is greater than +/- 0.0001" (and therefore out of specification) proceed to step 9.
8. Repeat steps 2 to 7 for the other probe zero calibration standards.

If all the elongations are within specification, the probe zero verification procedure is complete.

9. If an elongation is out of specification, press MEAS to return to the measurement screen and then complete steps 10 to 12 below for all elongations out of specification.
10. Press MEAS again and then highlight TEMP in the hot menu.
11. Press ENTER.

The Group View Box is displayed. The ELONGATION value is now within specification.

12. Press ENTER to save the current reading in the highlighted cell location, storing all the current probe zero verification data.

9 TEMPERATURE COMPENSATION

9.1 INTRODUCTION

The temperature of a fastener affects both its physical length (due to thermal expansion) and the velocity of sound in the fastener. As the temperature of a fastener increases, the ultrasonic length increases at a rate greater than the physical change in length.

If you intend to measure the same fastener at different time intervals over the service life of the bolt, it is therefore very important to compensate for changes in temperature in order to produce accurate results.

If, however, a fastener will only be measured once, never to be measured again, temperature compensation is not needed, as long as the reference length and elongation are measured at the same temperature and time.

Although the thermal expansion of the fastener and the ultrasonic change in velocity as a result of temperature are two separate effects, within the gauge, they are combined in a single factor known as the Temperature Coefficient (Tc).

The sections that follow outline the procedures for selecting and using the temperature compensation mode with the accessory temperature sensor when using the BG80TDL. There are three temperature compensation modes:

Manual Mode (BG80DL and BG80TDL): In manual mode, you enter the current temperature into the gauge before carrying out measurements. This is useful to those users that do not require temperature compensation, or those who have an external temperature device measuring the temperature.

Semi Automatic Mode (BG80TDL with temperature sensor only): In semi automatic mode you have an opportunity to initiate when the temperature is read and automatically adjusted. This mode may be useful to those users that want to use the automatic mode but want to retain some control as to when the temperature is changed, rather than take for granted the temperature is automatically changing. Some companies and application procedures may call for manually initiating and physically viewing the change in temperature by adding a manual step to the procedures. The semi automatic mode is designed for requirements such as these.

Automatic Mode (BG80TDL with temperature sensor only): The automatic mode constantly monitors and compensates for temperature when the accessory temperature sensor is attached to the gauge and placed on the joint or fastener being measured. While this mode eliminates the need to manually insert or initiate a temperature measurement, it also requires that the user be very cautious that the sensor is properly attached to the joint or fastener, and not accidentally removed or misplaced during the measurement process.

9.2 TEMPERATURE COMPENSATION - MANUAL MODE

1. Select MENU/UTIL/TEMP MODE and use LEFT and RIGHT to adjust it to MANUAL
2. Press MEAS to return to the measurement screen
3. In the hot menu highlight the TEMP field and adjust to the measured temperature using LEFT and RIGHT or alternatively press ENTER to open the Digits Edit Box
4. Press OK to confirm or ESC to cancel.

9.3 TEMPERATURE COMPENSATION - SEMI AUTOMATIC MODE

1. Select MENU/UTIL/TEMP MODE and use LEFT and RIGHT to scroll the TEMP MODE to SEMI
2. Press MEAS to return to the measurement screen
3. In the hot menu highlight the temperature field, press ENTER and the Digits Edit Box will display the live temperature. Press OK to accept the value or ESC to cancel.

9.4 TEMPERATURE COMPENSATION - AUTOMATIC MODE

1. Select MENU/UTIL/TEMP MODE
2. Use LEFT and RIGHT to scroll TEMP MODE to AUTO
3. Press MEAS to return to the measurement screen.

10 BOLT MATERIAL CALIBRATION

10.1 WHY DO WE NEED TO CALIBRATE

The preset bolt types in the gauge contain average factors for the material type. These are approximate values only. In a tightly controlled application where extreme accuracy is required, it is necessary to obtain all the information possible about the fasteners being measured. By calibrating the fasteners, the ultrasonic and physical lengths of the bolts will match. However, if a field calibration is done, a complete calibration is not necessary. An important thing to note is the fact that everything done in the calibration process results in average values. Since a sample of fasteners will be used in the calibration process, and given the slight differences in material, the result will always be an average value of that sample.

10.2 VELOCITY CALIBRATION

A velocity calibration is generally performed by adjusting the velocity in the gauge to the point where the ultrasonic and physical lengths match. Again, since a sample of fasteners will be used in this process, the velocities will vary by a very small amount, thus resulting in an average velocity value. To accurately calibrate the velocity, a calibrated set of mechanical calipers is required to determine the exact physical lengths of the fasteners. The following procedure outlines this process.

1. Select MENU/GEOM/QUANTITY and scroll the value to ELONG
2. Press MENU/MATL/TYPE and press ENTER
3. Use UP and DOWN to select the correct material type from the list and press ENTER
4. The new bolt type material selected is displayed to the right of the sub menu item.

Note: If the material type is not in the list of types, select a similar type. This step is only to get the velocity value close to the true value. Write down the velocity of the material type selected. This will be considered the Current Velocity.

5. Press OK to set the material type and return to the menu screen, or ESC to cancel.
6. Set the value of ALLEN / APPROX. LEN. to the correct length of the fastener and then conduct an AUTO SET with the transducer attached to one end of the fastener - see "Auto Set" on page 29. The ultrasonic length of the fastener is displayed.

7. Calculate the correct velocity using the following equation:

$$\frac{\text{PhysicalLength}}{\text{UltrasonicLength}} \times \text{CurrentVelocity} = \text{CorrectVelocity}$$

8. Select MENU/MATL/VELOCITY and press ENTER
9. Adjust to the correct value

10.3 STRESS FACTOR CALIBRATION

The sonic stress factor is an empirically determined value for the bolt material or type of bolt being measured. It expresses the ratio of the elongation, or stretch, of the bolt, to the apparent ultrasonic change in length. Since the change in ultrasonic length is approximately 3 times the change in physical length, due to the change in velocity, a stress factor must be applied to correct the ultrasonic length in the gauge.

The Sonic Stress Factor is calculated using the following equation:

$$\text{SonicStressFactor} = \frac{\Delta L_{\text{MECHANICAL}}}{\Delta L_{\text{ULTRASONIC}}} = \frac{L_{M1} - L_{M0}}{L_{U1} - L_{U0}}$$

where:

$$L_{U0} = \text{UltrasonicLengthAtZeroLoad}$$

$$L_{M0} = \text{MechanicalLengthAtZeroLoad}$$

$$L_{U1} = \text{UltrasonicLengthAtLoad}$$

$$L_{M1} = \text{MechanicalLengthAtLoad}$$

The procedure in this section describes how to determine the Sonic Stress Factor for bolts of a specific bolt material and specific geometry by measurement of the change in bolt length.

To complete this procedure you will need the following equipment:

- A laboratory or room in which the temperature can be maintained at 19°C to 21°C (66°F to 70°F).
- A means of applying load to the bolt. Ideally this would be a tensile load machine, capable of measuring the applied load to within 450 N (100 lbs). However, since the actual value of the applied load is not used in calculating the stress factor, any means of applying an approximate load to the bolt will suffice. This includes tightening the bolt against a fixture that simulates the actual joint.
- A mechanical means of traceable measurement of the physical length of the sample fasteners at various tensile loads to an accuracy of plus or minus 2.5 µm (0.0001").

Examples of such devices include the following

- The length measurement function of a sophisticated tensile test machine
- Mechanical or electronic height gauges
- Averaged values of length measurement with mechanical and electronic micrometers.
- A minimum of three sample bolts which are representative of the bolt type and geometry for which the Sonic Stress Factor is to be determined.

10.3.1 Notes

Before you begin:

- Calibrate (zero) the gauge - see “Measuring System Zero - Using Calibration Bars or Triple Sided Glass Block” on page 14.
- Calibrate the velocity - see “Velocity calibration” on page 18.
- Soak the sample bolts in the controlled temperature environment for a period of not less than 24 hours. Care must be taken throughout the measurement process to avoid significant change in the bolt temperature due to handling of the sample bolts, or the process of applying load.
- The mechanical apparatus for measurement of length must be calibrated in accordance with governing quality procedures. The device should be configured so that minimum handling of the sample bolts will be required during the measurement process.

10.3.2 Procedure

Note: The following steps assume that you have performed the steps in the previous section and calibrated the velocity. Therefore, the velocity has been adjusted, approximate length already entered, and the gauge is currently setup and ready to measure in elongation mode.

1. Using the mechanical measuring device, measure and record the Mechanical Length at Zero Load L_{M0} for each sample bolt.
2. Apply the transducer and couplant to the bolt and record the Ultrasonic Length at Zero Load L_{U0} .
3. Repeat step 2 for each sample bolt.
4. Place the first sample bolt in the loading apparatus. Apply approximately 1/3 of the maximum load, which is to be placed on the bolt under actual working conditions. Using the mechanical measuring device, measure and record the Mechanical Length at Load 1 L_{M1} for the current sample bolt.
5. Apply the transducer and couplant to the bolt and measure and record the Ultrasonic Length at Load 1 L_{U1} .
6. Increase the applied load to approximately 2/3 of the maximum load, which is to be placed on the bolt under actual working conditions. Using the mechanical measuring device, measure and record the Mechanical Length at Load 2 L_{M2} for the current sample bolt.
7. Apply the transducer and couplant to the bolt and measure and record the Ultrasonic Length at Load 2 L_{U2} .
8. Increase the applied load to approximately the maximum load, which is to be placed on the bolt under actual working conditions. Using the mechanical measuring device, measure and record the Mechanical Length at Load 3 L_{M3} for the current sample bolt.
9. Apply the transducer and couplant to the bolt and measure and record the Ultrasonic Length at Load 3 L_{U3} .
10. Repeat steps 4 to 9 for the remaining sample bolts.
11. Calculate the value of the Sonic Stress Factor at each load on each sample bolt.

$$SonicStressFactor_{Bolt1L1} = \frac{L_{M1} - L_{M0}}{L_{U1} - L_{U0}}$$

$$SonicStressFactor_{Bolt1L2} = \frac{L_{M2} - L_{M0}}{L_{U2} - L_{U0}}$$

$$SonicStressFactor_{Bolt1L3} = \frac{L_{M3} - L_{M0}}{L_{U3} - L_{U0}}$$

12. Determine the average value of the Sonic Stress Factor by dividing the sum of all Sonic Stress Factor values by the number of bolts sampled.

10.4 TEMPERATURE FACTOR CALIBRATION

The thermal expansion of the fastener and the ultrasonic velocity change with temperature are two separate effects. However, in your gauge they are combined into a single factor known as the Temperature Factor. The important thing to note is that both the thermal expansion and the velocity change with respect to changes in temperature.

Your gauge always measures a fastener at 20°C (68°F). If the temperature of the fastener is currently being measured at 42.2°C (108°F), the gauge will compensate for this and corrects the measurement back to 20°C (68°F).

Note: This is an arbitrary temperature range only. The primary thing to consider is to use a respectable temperature range with at least 5 different temperature points.

The Temperature Factor is calculated using the following equation:

$$T_P = \frac{(L_0 - L_T)}{L_T(T_0 - T)} \times 10^6$$

where:

L_0 = UltrasonicLengthAtBeginningTemperature(T_0)

L_T = UltrasonicLengthAtEndingTemperature(T)

T_0 = BeginningTemperature

T = EndingTemperature

The procedure in this section describes how to determine the Temperature Factor for a bolt made of a specific material type and geometry.

To complete this procedure you will need the following equipment:

- A means of varying and measuring the temperature of the sample bolts between 9°C to 42°C (48°F to 108°F) to an accuracy of +/- 1°C (2°F). The device must allow for a transducer to be connected to one end of the bolt for the purpose of measuring.
Many sophisticated temperature chambers are commercially available, and ideally suited for this function. However, a simple and inexpensive method can be achieved by immersion of the sample bolts in a water bath, which can be heated to boiling or cooled by adding ice. At sea level this will reliably vary the bolt temperature between approximately 9°C to 42°C (48°F to 108°F) depending on water purity and atmospheric pressure. By measuring the temperature of the stirred water bath with a precise mercury thermometer, while reading the ultrasonic length of the bolt, accurate calibration points can be obtained.
- A minimum of three sample bolts which are representative of the bolt type and geometry for which the Temperature Factor is to be determined.
- Your Model BG80TDL gauge.

10.4.1 Notes

Before you begin:

- Calibrate (zero) the gauge - see "Measuring System Zero - Using Calibration Bars or Triple Sided Glass Block" on page 14.
- Soak the sample bolts at the measured temperature points for a period of not less than 20 minutes, to ensure that the temperature is uniform throughout the sample.
- If a water bath is used, care must be taken to avoid immersion of the ultrasonic transducer.

10.4.2 Procedure

Note: The following steps assume that you have performed the steps in the previous section and calibrated the velocity. Therefore, the velocity has been adjusted, approximate length already entered, and the gauge is currently setup and ready to measure in elongation mode.

1. Stabilise the sample bolt at approximately 9°C (48°F). If the water bath method is used this is accomplished in a stirred bath of ice and water. Measure and record this minimum temperature as T_0 .
2. Apply the transducer and couplant to the bolt and record the Ultrasonic Length at Zero Load L_{U0} .
3. Repeat steps 1 and 2 at the target temperatures (T_1 to T_5) 9°C (48°F), 20°C (68°F), 31°C (88°F), and 42°C (108°F) (or some other similar range with 5 temperatures), measuring the ultrasonic lengths (L_1 to L_5) respectively. This process must be done for each of the sample bolts in the experiment.
4. Use the following equation to calculate a linear regression, using the temperatures and lengths recorded for all the sample bolts to determine the temperature factor:

$$TemperatureFactor = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}} \times 10^6$$

where:

x = temperature

y = change in reference length

n = number of sample points per bolt

11 LOAD MEASUREMENT

11.1 CALCULATING A LOAD FACTOR

The load factor is an empirically determined value for the geometry of the bolt. It is the amount of load required to elongate the bolt 0.01 mm in metric units (0.001" in English units). The accurate load factor for the bolts being measured is determined by the Calibrate Bolt function.

An approximate value of this geometry dependent factor can be calculated as follows:

$$L_F = \frac{A_\sigma E}{(C_L + D)} \times 10^{-3}$$

where:

L_F = Load Factor

A_σ = Cross Sectional Area of the Bolt

E = Modulus of Elasticity

C_L = Clamp Length of the Bolt

D = Diameter of the Bolt

Note: If no load factor has been entered, the gauge defaults to zero.

The relationship between load and elongation is a function of the elasticity of the bolt material, and the geometry of the bolt in the application being measured.

Hooke's Law expresses this relationship:

$$P = \frac{\Delta L \times AE}{L_E}$$

where:

P = Load

L_E = Average length under stress

ΔL = Change in length (elongation)

A = Cross sectional area of the bolt

E = Modulus of elasticity (Young's Modulus)

The cross sectional area of the bolt is defined as the average area of a fastener under stress. This factor is only used by the gauge in the calculation of load. It has no effect on stress or elongation, time, or strain, and is directly proportional to the load measured ultrasonically. If the cross sectional area is in error by 5%, the load measurement will also be in error by 5% proportionally. For a cylindrical bolt with the same geometry, the area may be approximated as follows:

$$A = \pi \left(\frac{D}{2} \right)^2$$

where:

A = Area

D = Minor diameter of the bolt allowing for threads

For bolts with complex geometry, the areas should be estimated by averaging each individual area and length. In the case of a hollow fastener, the area of the hole must be subtracted from the overall area. The area of a fastener with complex geometry can be estimated as follows:

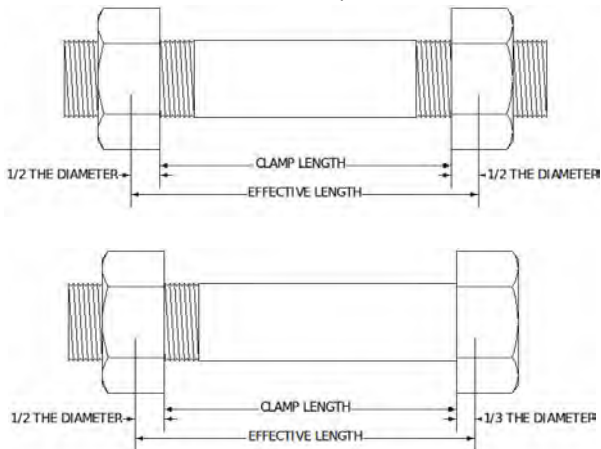
$$A_{AVG} = \frac{\sum AL}{\sum L}$$

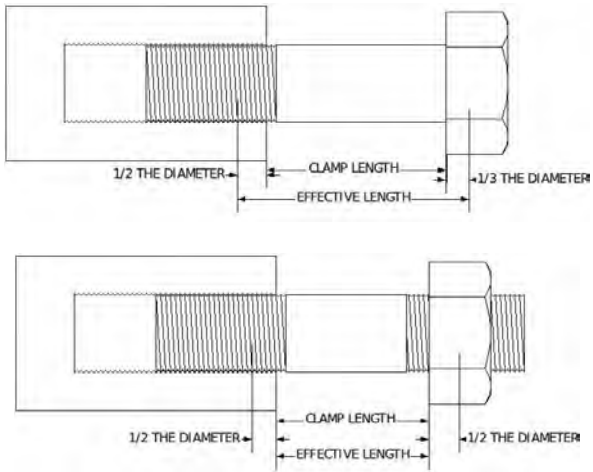
where:

A = Area of a region

L = Length of a region

The value for the Modulus of Elasticity (E), should be provided directly from the manufacturer of the bolts. The effective length is the average length of the fastener under stress when a load is applied. For an applied constant load, the elongation of a fastener is directly proportional to the effective length. Therefore, errors in the effective length will result in load errors by a proportional amount. The effective length of a fastener is a combination of the actual clamp length of the joint being fastened, plus that area of stress found in the head, nut(s), and or blind hole of the fastener - see examples which follow.





$$L_E = C_L + D_X$$

where:

L_E = Average length under stress

C_L = Clamp length

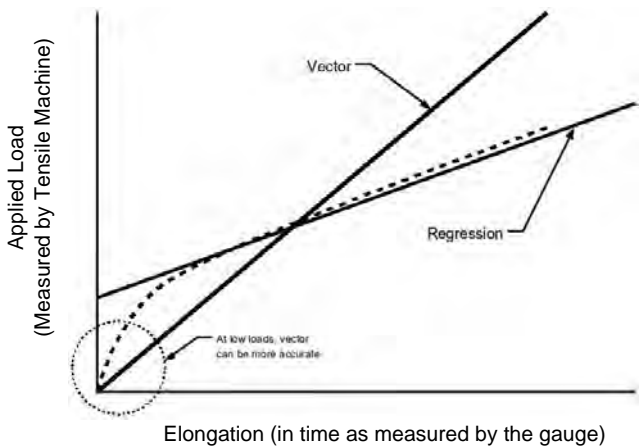
D_X = Additional diameter added for head, nut(s), and or blind hole

Note: A convenient way to perform the above Load Factor calculations is to use the bolt calculator included in the Bolt Link PC software.

It is important to note that performing the calculations above is only a good approximation at best. In all cases, if possible, a field calibration should be performed if you intend to perform measurements in terms of load.

11.2 CALIBRATING A LOAD FACTOR (FIELD CALIBRATION)

Clearly, the most effective way of calibrating the load factor is by performing a field calibration. Material constants are often unknown or cannot be calibrated in a laboratory environment. In cases such as these, a field calibration is the most accurate means of calibration. A field calibration is accomplished using a tensile tester, load cell, or other calibrated load device to compare known loads against ultrasonic elongations. Your gauge is equipped with a self-calibrating feature that uses a linear regression or vector equation to



produce a best-fit line through the known loads, therefore minimising error.

The result is an added load offset (intercept), in the case of regression, and a load factor (slope) to correct the ultrasonic measurements to the known loads. The regression produces a load offset and load factor, while the vector sets the offset to zero and produces only a load factor. Why are both options needed? In applications where a small amount of load is applied to the fastener, thus producing very little elongation, the regression option can potentially produce non-linear results. In cases such as these, a vector may sometimes produce better results as the offset is set at zero. It is recommended to use and compare both results, following a field calibration, to determine which method is most suitable for the application and produces the best results.

11.3 PERFORMING A FIELD CALIBRATION

This section outlines the procedure to perform a field calibration:

1. Create a group in which to store field calibration data
2. Select the calibration mode (vector or regression)
3. Select the bolt material and conduct an auto set.
4. Measure the length at each load and store these values in the group
5. Calculate the load factor

Note: In the calibration procedure below, three sample bolts are used with three loads applied to each bolt (1/3 load, 2/3 load, and maximum load). This should be considered the minimum requirement when performing a field calibration.

11.3.1 Create a group in which to store field calibration data

You will save all the values and settings to a cell location in the group for easy recall at a later time. This will allow you to easily verify the field calibration data.

To create a group, read the notes below and then follow the instructions given in “Creating a New Data logger Group File” on page 32.

- When you create the group, give it a NAME and NOTE which describe and make reference to the Field Calibration data and bolt.
- A group can contain up to 250 bolts. There must be at least one bolt in a group. You should specify a minimum of three bolts in the group (this is the minimum sample size).
- A bolt can have up to 51 possible measurements and one initial reference length. The initial reference length is saved in a cell of column A of the group and other readings are stored in cells starting at column B. There must be at least one reading per bolt. In the example used in this procedure, three loads are applied to each bolt and therefore the measurements for these loads are saved in cells in columns B, C and D.

11.3.2 Select the calibration mode (vector or regression)

Select MENU/CAL/LOAD CAL MODE and use LEFT and RIGHT to scroll between

- OFF
- VECTOR (zero offset)
- REGRESSION
- Press MEAS to return to the measurement screen

11.3.3 Select the bolt material and conduct an auto set

1. Select MENU/GEOM/QUANTITY
2. Use LEFT and RIGHT to change the QUANTITY value to ELONG
3. Select MENU/MATL/TYPE press ENTER and select the material type from the list
4. Press OK to confirm
5. Set the value of ALEN/APPROX. LEN to the correct length of the fastener then conduct on AUTO SET with the transducer attached to the fastener. See “Auto Set” on page 29.

11.3.4 Measure the length at each load and store these values in the group

1. Place the first sample bolt in the load apparatus.

2. Press MEAS.
The measurement screen is displayed.
3. In the hot menu, adjust the value of the LOC function to A1 (row 1 for the first sample bolt, row 2 for the second sample bolt, etc.)
4. Apply the transducer and couplant to the bolt and press ENTER.
The ultrasonic length at no load is measured and saved in cell A1.
5. Use the load apparatus to apply approximately 1/3 of the maximum load which is to be placed on the bolt under actual working conditions.
6. If necessary, in the hot menu, adjust the value of the LOC function to B1 (If the group automatic increment direction function INCR. DIR has been set to EAST, the value of LOC will be adjusted to B1 automatically).
7. Keeping the transducer in exactly the same position, press ENTER.
The ultrasonic length at load 1 is measured and the Digits Edit Box is displayed.
8. Adjust the value in the Digits Edit Box until it matches the known load (from the load apparatus):
 - Press OK to store the known load value and return to the measurement screen, or ESC to cancel.
9. Repeat steps 5 to 8 with the load on the bolt increased to 2/3 of the maximum which is to be placed on the bolt under actual working conditions. Store this known load value in group cell location C1.
10. Repeat steps 5 to 8 with the load on the bolt increased to the maximum which is to be placed on the bolt under actual working conditions. Store this known load value in group cell location D1.
11. Repeat steps 1 to 10 for sample bolt 2. Store the values in group cells A2 to D2.
12. Repeat steps 1 to 10 for sample bolt 3. Store the values in group cells A3 to D3.

11.3.5 Calculate the load factor

1. Select MENU/CAL/LOAD CAL. CALC
2. Press ENTER.
The vector or regression calculation is performed and the coefficient is displayed.
Note: The closer this number is to 1, the better the fit, or least amount of error.
3. Press OK to accept the calculation, or ESC to cancel and return to the CAL menu.
4. Press MEAS to return to the measurement screen.
Calibration is now completed.

Note: The new LOAD FACTOR and LOAD OFFSET values can be reviewed and edited at any time: Press MENU and then scroll to the GEOM menu.

12 MEASUREMENT - TAKING READINGS

Disclaimer: Inherent in ultrasonic thickness measurement is the possibility that the instrument will use the second rather than the first echo from the end of the bolt being measured. This may result in a length 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.

Other errors may occur from measuring coated bolts where the coating is insufficiently bonded to the bolt surface. Irregular and inaccurate readings may result. Again, the user is responsible for proper use and interpretation of the measurements acquired.

12.1 BEFORE YOU START

- Prepare the surface of the bolt - see "Bolt Preparation" on page 5.
- If necessary, set the zero point of the transducer - see "Measuring System Zero (Calibration)" on page 11.
- If necessary, calibrate the gauge - see "Bolt Material Calibration" on page 18.
- Choose the measurement view (RF, RECT or DIGITS) - see "Measurements and The Measurement Screen" on page 7.

12.2 PROCEDURE

1. Apply couplant

For the gauge to work correctly there must be no air gap between the transducer and the surface of the bolt to be measured. This is achieved using a couplant.

Before the transducer is placed on the surface, put a small amount of couplant supplied with the gauge on the surface of the bolt. Typically a single drop is sufficient.

2. Place transducer onto the end of the bolt to be measured

Press the transducer wearface into the couplant. Moderate pressure on the top of the transducer using the thumb or index finger is sufficient; it is only necessary to keep the transducer stationary and the wearface seated flat against the surface of the bolt.

3. Read display

If six or seven bars of the stability indicator are showing, the display will be reading the correct length of the bolt directly beneath the transducer.

If the stability indicator has fewer than five bars showing, or the numbers on the display seem erratic, check to make sure that there is an adequate film of couplant beneath the transducer, and that the transducer is seated flat against the bolt. If the condition persists, it may be necessary to:

- adjust the gain, or
- select a different transducer (size or frequency) for the material being measured.

The gauge will perform a number of measurements every second when the transducer is in contact with the surface of the bolt. The display is updated as each reading is taken.

4. Remove transducer from surface

The display will show the last measurement made.

Note: 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 gauge may perform a measurement through this couplant film, resulting in a measurement that is larger or smaller than it should be. This phenomenon can be seen when one length value is observed while the transducer is in place, and another value is observed after the transducer is removed. If this happens, take the reading again using less couplant.

13 USING THE GATE

Your gauge is equipped with a gate typically used to eliminate noise that may be present prior to the reflection off the end of the bolt, and also to force a detection at or on a specific location or waveform. Often the first reflection off the end of the bolt will produce a poor signal. However, if you look further out in time (length), a reflection from a mode conversion very well may be a better signal to detect on. A mode conversion is simply a reflection of energy that took a longer path, reflecting off the sidewalls of the bolt, resulting in a return echo slightly longer than the overall length of the bolt. Use of a gate allows you to force the gauge to use this signal for measurements.

Another potential problem is general transducer or low frequency noise. In this type of situation, the noise causes interference which is high enough in amplitude to cause the gauge to detect on the noise rather than the true return reflection.

These problems and how to overcome them are explained in the paragraphs which follow.

Note: In order to adjust the gate it must be activated. The gate is only active if the measurement mode is set to P-E GT (Pulse-Echo with Gate). In standard P-E (Pulse-Echo) measurement mode the gate is not active, and it is greyed out in the hot menu and main menu (see "MEASURE MODE" on page 41).

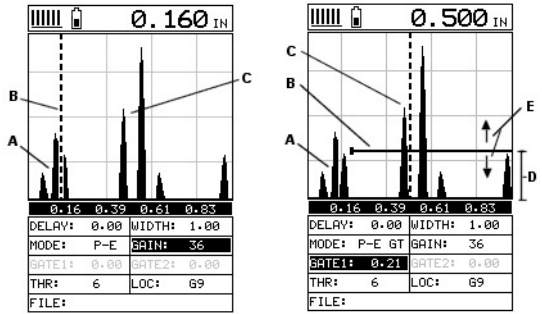
Referring to the noise problem, in the **No Gate** diagram: (A) refers to the noise in front of the true reflection signal (C). Notice that without the gate activated, the gauge is detecting on the noise (A) as shown at point (B). However, the true measurement should be taken at point (C). Given the threshold and gain levels the gauge is currently set to in the no gate diagram, the amplitude from the noise is sufficient enough to cause the gauge to detect, or measure the noise rather than the end of the bolt (C). Therefore, the gauge is making an incorrect reading at point (B).

Now refer to the **With Gate** diagram. The horizontal line at the top of (D), is the value of GATE. The start point of the gate has been adjusted to just beyond the noise (A) so that the gauge ignores the noise and

detects the true end of the bolt (C). Note: the gauge will only detect on signals that are located inside the dimensions of the gate (B). Therefore, the gauge cannot see (A) at all, with respect to the starting point of (B). Also notice, the THR (threshold) level is the height of the distance (D) from the baseline. Zero threshold is indicated by the bottom of the range (D), and a THR (threshold) value of 6 is indicated at the top of the range at (D). Therefore, the vertical height of the gate is the threshold level. The threshold level can be increased to decrease sensitivity, or decreased to increase sensitivity.

If the threshold level was increased in the no gate diagram, so that the level was higher than the amplitude of the noise (A), the gauge would have detected on the correct reflection (C). Alternatively, if the gain level was decreased, the signal amplitude of the noise (A) would have decreased below the threshold level, and the gauge would have also detected the correct reflection (C). This example brings all the fine adjustments into consideration, and demonstrates the versatility of your gauge.

Now, let us look at the diagrams again but in a slightly different way. Let us look at the case of a potential mode conversion problem. In the **No Gate** diagram let us assume that (A) is the true reflection off the end of the bolt, and the gauge is detecting on the echo at (B). However, the signal has a horrible first cycle and is relatively weak. But as we look further out in time or length, the second mode conversion reflection (C) looks like a much cleaner signal to use. Now refer to the **With Gate** diagram. By activating and setting the start time of the GATE (B), we can force the gauge to use the mode conversion reflection (C), instead of (B). Once again, the same gain and threshold tools can be used for fine adjustment and signal optimisation.



No Gate **With Gate**
A typical surface noise problem

13.1 ADJUSTING THE GATE

The quickest way to adjust GATE is directly from the hot menu. Alternatively, adjust the value using the menus:

1. Select MENU/AUTO/GATE
2. Use LEFT and RIGHT to scroll the value
3. Alternatively press ENTER to display the DIGITS EDIT BOX and adjust the value from there
4. Press OK to accept or ESC to cancel
5. Press MEAS to return to the measurement screen

14 INTERPRETING THE WAVEFORM

One of the most important things to consider when using your gauge, is how to interpret the waveform in order to choose the proper polarity (phase) and gain setting. It is also important to understand what is taking place during a basic measurement.

You have the option of selecting the polarity only once during measurement of the reference length. Once the polarity is chosen and the reference measurement taken and stored for a particular bolt, all the elongation and loads taken for that particular bolt will assume the sample polarity.

At first, this might not seem all that critical. In most cases, with well prepared bolts, this might very well be the case. While both polarities may look fine at first sight, during the reference mode, deformations in the joint can occur when a load is applied to the bolt.

When a load is applied on a bolt, the velocity of the fastener decreases. Any deformations in the joint (bending) will disrupt the sound path and potentially cause an overall decrease in signal amplitude. When this occurs, the decrease in amplitude can cause the gauge to lose the first cycle altogether. If the first cycle is lost, the gauge will peak jump to another cycle later in time with greater amplitude. Many transducers have

a very slow ramp up time and the amplitude of the first cycle is lower than the second cycle. For this reason, selecting the proper polarity is very important.

The AUTO SET function in your gauge will do a lot of this work for you. However, it is always a good idea to understand how to interpret the waveform. The following diagrams offer a brief explanation:

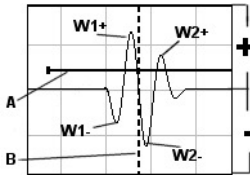


Figure 1
Correct polarity (phase)

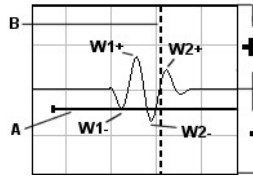


Figure 2
Incorrect polarity (phase)

Refer to the illustrations above. The first thing to note is that the screen shots above are split into positive and negative regions. The centerline is assumed zero, and the two regions in the upper portion of the display are positive, while the two lower halves are negative.

Referring to Fig.1. Notice that the height or amplitude of W1+ is greater than the height of W2+ from the zero crossing (centreline). These are the positive cycles (they are in the upper region). Now consider that the height of W1- is lower in amplitude than W2-. These are the negative cycles (they are in the lower region). With this in mind, the gauge uses a zero crossing (Flank) style of detection. Therefore, the detection will always occur to the right side of the positive or negative cycle being detected. With this said, the detection in Fig.1 (B) is occurring on the zero crossing of the positive first cycle W1+. In this example, the correct (positive) polarity has been selected.

Why? Referring to Fig.2. Notice that when the bolt is tightened, the signal amplitude has decreased due to the applied stress, and a peak jump has occurred from W1- to W2- at (B). If we look at the height of W1- it has a much lower amplitude than W2-. Therefore, when stress was applied to the bolt, the amplitude of W1- was decreased beyond the threshold (A) and the gauge jumped to the next available signal with sufficient amplitude. However, this could never happen in Fig.1. This is because W1+ has more amplitude than W2+, and a peak jump could never occur without losing the signal entirely.

Note: Always look at the height of the positive and negative cycles separately. Ask yourself if the first cycle (from left to right) is greater in height (amplitude) than the second. If so, it is probable that you have selected the correct phase (polarity).

If a situation does occur, as in Fig.2 above, and you are able to notice the peak jump during the process of loading, increasing the gain or lowering the threshold will generally correct the error. However, if it goes unnoticed, all your measurements will be in error. Therefore, it is critical that you take the necessary time to select the proper polarity in the initial setup process.

The AUTO SET function of your gauge will attempt to optimise and select the polarity for you. Use of this feature is further explained in "Auto Set" on page 29.

If you want to adjust the polarity manually, see "Polarity" on page 31.

15 MEASUREMENT - OPTIONS

15.1 AUTO SET

Your gauge includes a function for locating the detection point of a bolt end echo that is not currently in the viewable region of the display. This AUTO SET function uses a variety of algorithms to evaluate the positive and negative cycles and then automatically selects and sets the values of the following functions:

- POLARITY
- GAIN
- DELAY
- WIDTH
- GATE

Use of this function saves you a great deal of time in the measurement process by letting the gauge locate the detection point and bring the waveform signal into view automatically. If necessary, you can then make small adjustments to the range once the signal is displayed on the screen.

In order to use AUTO SET, you must first enter into the gauge the approximate length of the bolt (ALEN / APPROX. LEN.). The approximate length tells the gauge where to start looking for the echo during the AUTO SET; the gauge searches +/- 5% from the value entered.

15.1.1 Setting the Approximate Length

The quickest way to adjust ALEN is directly from the hot menu. Alternatively, adjust the value using the menus:

1. Select MENU/AUTO/APPROX. LEN and press ENTER
2. Adjust to the desired value
3. Press OK to confirm or ESC to cancel
4. Press MEAS to return to the measurement screen

15.1.2 Conducting an AUTO SET

There are two ways to access the AUTO SET function and these are described below. Method A is the preferred method (it is quicker and easier). Before you use either method, ensure that you have previously entered a value for ALEN / APPROX. LEN.

Method A:

1. Apply a drop of couplant to the bolt or transducer, and attach the transducer to one end of the bolt. Rotate the transducer clockwise and counter clockwise applying a small amount of pressure to eliminate any excess couplant between the transducer and the surface of the bolt. Remove and replace the transducer twice in the exact same location on the bolt, rotating it each time to obtain the minimum value measured.
Be sure to always place the transducer in the same location. This will help to eliminate any potential measurement errors caused by changing the sound path.
2. Press AUTO SET.
The display settings are adjusted automatically and the waveform is brought into view on the measurement screen.

Method B:

1. Press MENU, scroll to the UTIL menu and then highlight AUTO SET.
2. Apply a drop of couplant to the bolt or transducer, and attach the transducer to one end of the bolt. Rotate the transducer clockwise and counter clockwise applying a small amount of pressure to eliminate any excess couplant between the transducer and the surface of the bolt.
Be sure to always place the transducer in the same location. This will help to eliminate any potential measurement errors caused by changing the sound path.
3. Press ENTER.
The display settings are adjusted automatically and the waveform is brought into view on the measurement screen.
4. Once the waveform is displayed, press MEAS to return to the measurement screen.

15.2 ALARM MODE

Your gauge includes an Alarm Mode. You set the limits, and if a measurement falls outside of these limits your gauge will signal an alarm (a red light on the front panel of the instrument).

This feature may be used for a variety of applications to verify the material is within the manufacturer specifications.

There are two limit values, ALARM LO LIMIT and ALARM HI LIMIT. You can choose to activate both or just one of these values depending on your requirements.

To enable/disable Alarm Mode:

1. Select MENU/UTIL/ALARM STATUS and use LEFT and RIGHT to toggle the alarm on or off.
2. Press MEAS to return to the measurement screen

To set the Alarm limits

1. Select MENU/UTIL/ALARM LO LIMIT or ALARM HI LIMIT
2. Press ENTER to display the Digits Edit Box and adjust to the desired value
3. Press OK to confirm or ESC to cancel.

15.3 POLARITY

Your gauge is equipped with an option to select the polarity, or phase +/- of the waveform. For instructions on when to adjust the polarity, see "Interpreting the Waveform" on page 28.

To adjust POLARITY:

1. Set the measurement screen view to RF
2. Select MENU/TUNE/POLARITY
3. Use LEFT and RIGHT to toggle POLARITY between NEGATIVE and POSITIVE
4. Press MEAS to return to the measurement screen.

15.4 PULSE WIDTH

Your gauge has an adjustable pulse width option. Pulse width refers to the duration of time the pulser is switched on. Pulse width determines the amount of energy transmitted into the material being tested. There are three pulse width options:

Spike

The Spike option is used for high resolution and general applications and can be considered as the standard setting.

Thin

When additional energy is needed for more penetration, the Thin option may be necessary.

Wide

When even more energy is needed for more penetration, the Wide option may be necessary.

High frequency applications, where resolution is a requirement, may require the Spike or Thin settings to achieve optimal results. Low frequency applications, where more penetration is a requirement, may require the Thin or Wide settings, offering increased penetration. The variety of transducer frequencies and diameters used in conjunction with the pulse width setting, enable you to fine tune the gauge to your application needs.

To adjust the Pulse setting:

1. Press MENU/TUNE/PULSE
2. Use LEFT and RIGHT to adjust the value of PULSE (SPIKE, THIN, WIDE)
3. Press MEAS to return to the measurement screen

16 MEASUREMENT - RECORDING YOUR READINGS

Your gauge is equipped with a data logger - an essential feature for improving the efficiency of product inspection. With a data file open, all your readings values are saved into the file, therefore eliminating the need to manually record measurements during the inspection process. Once all the measurements have been taken, the gauge can then be connected to a computer or serial printer to save and print the results of the inspection.

16.1 ABOUT THE DATA LOGGER

With a data file open, as you take measurements, the measurement data is stored in a group in the gauge memory. A group can have up to 250 bolts, each bolt containing one reference length, and up to 51 elongations. The location in a group is specified by giving a row and column coordinate. The rows are numbered from 1 to 99 and the columns are labelled from A to Z, then AA to ZZ giving a maximum of 52 possible columns. You should always save the reference length in column A.

Data logger filename character sets

Any combination of the following characters can be used for file names and sequential format identifiers:

- Numeric characters: 0 - 9
- Alpha Characters: A - Z
- Special Characters: ! ' _ # space / . - ()

What measurement data is saved

When a measurement is taken, the following information is saved:

- The reading value (Time, Elongation, Load, Stress, and %Strain).
- A screenshot of the measurement screen (RF, RECT, and DIGITS) plus all the gauge settings. The screenshot stored with the reading will depend on what view the gauge was in at the time the reading was taken. For example, if the view was RF, then an RF screenshot will be saved with the reading.

Memory capacity

Your gauge can store a total of 8,000 readings with a corresponding waveform stored with every reading. You can create and save as many group data files as required up to the maximum capacity of the gauge memory (32 Mbit). If you try to create a new file which exceeds the memory capacity, the gauge will display an error message. In this instance, to free some space in memory, you should consider deleting some of the existing files or transferring them to a computer.

16.2 CREATING A NEW DATA LOGGER GROUP FILE

1. Select MENU/DATA/NEW and press ENTER, the Group Edit Box is displayed
2. Scroll to name, press ENTER and use the alphanumeric keypad to name your group.
3. Add a note (e.g inspector name) in the same way if required
4. Scroll to NUM BOLTS then press ENTER to adjust the number of bolts
5. Repeat the method for the NUM READS (number of readings per bolt)
6. Choose the INCR DIR using LEFT and RIGHT Note: Determines the direction the cursor moves when a reading is stored
7. When complete, highlight CREATE NEW GROUP? and press ENTER
8. Press MEAS to return to the measurement screen.
9. The measurement screen is displayed. The name of the group log file is displayed in the lower section of the hot menu area.



16.3 OPENING AN EXISTING DATA LOGGER GROUP FILE

1. Select MENU/DATA/OPEN
2. Press ENTER to display the Group List Box
3. Scroll to the desired data file and press ENTER
4. Press OK to confirm or ESC to cancel

16.4 STORING READINGS IN A DATA LOGGER GROUP FILE

1. Create a new data logger group file (see "Creating a New Data logger Group File" on page 32) or open an existing file (see "Opening an Existing Data Logger Group File" on page 32).
The name of the group log file is displayed in the lower section of the hot menu area.
Note: Once the file is open, it will remain open until another file is opened. If the gauge is switched off, the file will be opened automatically when the gauge is switched on again.
2. Press MEAS, scroll to the hot menu LOC function and then press ENTER.
The Group View Box is displayed.
Note: To abort the Group View Box at any time, press MEAS.
3. To save the reading to a particular cell location, use UP, DOWN, LEFT and RIGHT to scroll to the cell.
Note: The cell location must be empty. If it already contains a reading and you want to save a new reading to the same location, refer to the instructions given in "Viewing and Deleting readings" on page 33.
4. Take a reading and then press ENTER.

The reading value is saved in the file at the location selected and the cursor advances to the next cell according to the INCR. DIR rules set for the data logger group file. If INCR. DIR is set to NORTH, EAST, SOUTH or WEST, the cursor will advance one cell in the chosen direction. When the cursor reaches the last cell in the row or column it will return to the other end of the row or column.

Note: If you try to save a reading into a cell location which already contains a reading value, a warning message is displayed (see Deleting a reading).

16.5 VIEWING AND DELETING READINGS

With a data file open:

1. Use UP, DOWN, LEFT and RIGHT to scroll through the cells in the data file.
As the cursor is moved to a different cell, the display is updated with the display view saved with the reading. Readings stored in memory are indicated by MEM in the top left corner of the measurement screen (in place of the bars of the stability indicator).
2. Press OK and ESC to toggle the measurement quantities TIME, ELONG, LOAD, STRESS, and %STRAIN.
3. To delete a reading, scroll to the cell location, press CLR and then OK (or ESC to cancel).
The reading is deleted and if you wish you can now take another measurement and save the reading in this cell location.

16.6 EDITING A DATA LOGGER FILE

You can edit the following fields of data files: NOTE, and INCRement DIRection

To edit a file:

1. Open the data file.
2. Press MENU, scroll to the EDIT function and press ENTER.
The Edit List Box is displayed. The two fields which can be edited are highlighted (the others are greyed out).
3. To adjust the INCR. DIR field, scroll to the field and then use LEFT and RIGHT to adjust the value.
4. To adjust the NAME field, scroll to the field, press ENTER and then adjust the contents of the field using the techniques previously described to create a data file - see "Creating a New Data logger Group File" on page 32.
5. When finished, scroll to SAVE CHANGES?, press ENTER and then OK (or ESC to cancel).

16.7 DELETING A DATA LOGGER FILE

1. Press MENU, scroll to the DATA menu and then highlight the DELETE ONE GROUP function.
2. Press ENTER.
The Group List Box is displayed and lists all the data files stored in your gauge memory.
3. Scroll through the list until the data file you want to delete is highlighted.
4. Press OK (or ESC to cancel).

The file is deleted.

16.8 DELETING ALL DATA LOGGER FILES

Note: This will delete all the data logger files in gauge memory - use with caution.

1. Press MENU, scroll to the DATA menu and then highlight the DELETE ALL GROUPS function.
2. Press ENTER and then OK to confirm (or ESC to cancel).

The data logger memory is erased - all files are deleted.

17 GAUGE SETUPS

Your gauge contains 64 configurable preset locations in which you can store custom gauge setups, each one optimised for a specific measuring application.

These gauge setups can save time when conducting routine inspections of the same job or project. This feature also helps to eliminate error between two or more users during the setup and calibration process.

The setups store:

- Gain setting
- Alarm settings
- Display type setting

As well as storing the setups in your gauge, you can also store the setups on a computer and transfer them bi-directionally using the PC interface software included with the gauge.

The gauge is supplied with a single factory supplied default setup. This default setup can be recalled, modified, and overwritten to one of 64 setup locations. Although this default setup contains general settings, it can be considered a good starting point to be modified for custom applications.

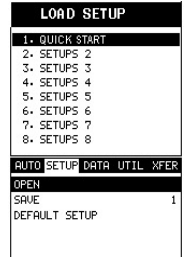
The PC interface software supplied with the gauge includes a copy of this default setup file that can be uploaded to the gauge at any time to restore factory settings. However, you should consider saving modified setups to an empty location rather than overwriting the factory setup in your gauge.

17.1 OPENING A SETUP

1. Select MENU/SETUP/OPEN
2. Press ENTER.

The Setup List Box is displayed (a QUICK START setup is supplied by default by the factory in location 1, although this may be deleted by the user).

3. Scroll through the list of setups until the required setup is highlighted.
4. Press ENTER to activate the confirmation screen.
5. Press OK to load the setup from memory.
6. Press MEAS to return to the measurement screen.



17.2 SAVING AND EDITING A SETUP

Once the parameters and features have been adjusted for an application, you can save these setting to a specific setup location for future use.

It is sometimes necessary to rename a previously saved setup, or add additional comments about a particular setup. The setup name may have been entered incorrectly, or you may need to use the setup for a completely different project. An inspector's name or other comments about the project may also be required for additional documentation purposes.

The following procedures outline the necessary steps for saving and editing a setup:

1. Select MENU/SETUP/SAVE
2. Press ENTER.

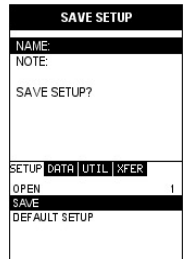
The Save Setup Edit Box is displayed.

3. Scroll to NAME and then press ENTER to edit its value:
 - Use the navigation keys to scroll through the characters press ENTER to select and CLR to backspace.
 - When complete press OK to set

4. If you want to add a note, repeat step 3 for NOTE.
5. When you have finished, scroll to SAVE SETUP and press ENTER.

The Setup List Box is displayed.

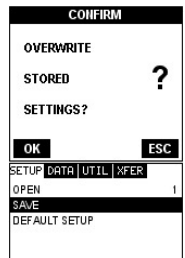
6. Scroll through the list of setups until the required location to save the setup is highlighted.
7. Press OK to activate the confirmation screen.
8. Press OK to save the Setup, or ESC to cancel.
9. Press MEAS to return to the measurement screen.



Note: The Name and Note parameters of a Setup can be edited at any time by repeating the Save Setup routine described above. Therefore, the Save Setup function can also be considered an Edit Function.

17.3 USING THE DEFAULT SETUP

Your gauge includes a default setup which you can use (as a last resort) if there are no other setups stored in the gauge. The only time this might possibly occur is if a



setup file in your gauge was somehow corrupted, and you do not have immediate access to a computer to re-load the factory setup back into the gauge. This gives you the ability to load and modify a basic setup as follows:

1. Press MENU/SETUP/DEFAULT SETUP function.
2. Press ENTER to activate the confirmation screen.
3. Press OK to confirm and to return to the measurement screen.

18 DATA TRANSFER SOFTWARE

Software is available which allows data to be transferred from your gauge to a PC. Presently Elcometer supplies Bolt Link software for this purpose.

To set-up other types of communications software:

1. Start the communications software.
2. Configure the software using the following parameters:
Data Bits - 8, Parity - None, Stop Bits - 1, Baud Rate 1200 (to print a report), or 9600 to transfer data file.
Note: A report can be printed to a communications program (i.e. HyperTerminal), or printed to a serial printer using A4 or 8.5" x 11" paper.
3. Set the communications software COM port to the port number that the gauge is connected to.

18.1 TRANSFERRING MEASUREMENT DATA TO YOUR COMPUTER

18.1.1 RS-232 Connector

The RS-232 connector, located on the bottom end cap of the gauge, is a 2 pin female Lemo connector. It is designed to connect directly from the gauge to a standard AT serial port on a PC. A Lemo to 9 pin serial cable is supplied with the gauge.

Note: This connector is also used to upgrade the gauge with the latest version of firmware.

18.1.2 USB to Serial Converter

Some newer laptop computers do not have standard serial ports. In this case, use the USB to Serial converter supplied with the gauge.

18.1.3 Computer System Requirements

Bolt link requires a PC running Windows 98 or better.

18.1.4 Installing Bolt Link

Bolt Link comes on a CD-ROM with an automatic installer program. Place the CD in your computer's CD tray and close the door. Open the CD-ROM by double clicking on the My Computer ICON, then double click on the CD. Finally, double click on the SETUP icon to begin the installation.

Refer to the help section in Bolt Link software for the complete operating manual, setup, and operation.

18.1.5 Using the XFER menu

The XFER menu of your gauge is used in conjunction with the Bolt Link PC software. The steps below outline the procedure for accessing the XFER menu and basic operation as follows:

1. Press MENU and then scroll to the XFER menu.
2. Use UP and DOWN to scroll through the sub menu items until the desired option is highlighted.
3. Press the ENTER key to activate the option selected.
4. Once the Backup or Restore function has been completed, press MEAS once to return to the menu items, or twice to return to the measurement mode.

19 STORAGE



Your gauge has a Liquid Crystal Display. If the display is heated above 50°C (120°F) it may be damaged. This can happen if the gauge is left in a car parked in strong sunlight.

Always store the gauge in its case when it is not being used.

If the gauge is to remain unused for long periods of time, remove the batteries and store them separately. This will prevent damage to the gauge in the event of malfunction of the batteries.

20 MAINTENANCE

You own one of the finest tension monitors in the world. If looked after, it will last a lifetime.

20.1 FAULTS

Your gauge is designed to give many years reliable service under normal operating and storage conditions. The gauge does not contain any user-serviceable components. In the unlikely event of a fault, the gauge should be returned to your local Elcometer NDT supplier or directly to Elcometer NDT. The warranty will be invalidated if the instrument has been opened.

20.2 TRANSDUCER

The transducer will wear with repeated use. Transducer life depends on the number of measurements taken and the manner in which readings are taken. To extend transducer life, always set the transducer down so that it is perpendicular to the panel surface. Dragging the transducer along the surface will reduce the life of the transducer. Replacement transducers are available from your local Elcometer NDT supplier or directly from Elcometer NDT.

21 TECHNICAL SPECIFICATION

Measurement Rate	4 readings per second
Measuring Range	25.4 mm to 1220 mm (1" to 48")
Measurement Resolution	0.001 mm or 0.0001 mm (0.00001" or 0.0001") - selectable
Velocity Calibration Range	1250 m/s to 10000 m/s (0.0492 in/μs to 0.3937 in/μs)
Weight (including batteries)	380 g (13.5 oz)
Dimensions (W x H x D)	63.5 mm x 165 mm x 31.5 mm (2.5" x 6.5" x 1.24")
Gauge Operating Temperature	-10°C to 60°C (14°F to 140°F)
Case	Aluminium case with gasket sealed end caps and waterproof membrane keypad
PC Connection	RS232 serial port. Windows PC interface software
Display	Backlit VGA greyscale display (240 x 160 pixels). Viewable area 62 mm x 45.7 mm (2.4" x 1.8"). EL backlit (on/off/auto).
Power Source	Three 1.5 V AA alkaline or rechargeable cells. Typically operates for 150 hours on alkaline cells and 100 hours on rechargeable cells (charger not included.)

Note: Alkaline cells must be disposed of carefully to avoid environmental contamination. Please consult your local environmental authority for information on disposal in your region. Do not dispose of any cells in fire.

22 WARRANTY

Elcometer NDT warrants your gauge against defects in materials and workmanship for a period of two years from receipt by the end user.

Additionally, Elcometer NDT warrants transducers and accessories against such defects for a period of 90 days from receipt by the end user. If Elcometer NDT receives notice of such defects during the warranty period, Elcometer NDT will either, at its option, repair or replace products that prove to be defective. The warranty will be invalidated if the instrument has been opened.

22.1 EXCLUSIONS

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

Elcometer NDT makes no other warranty, either express or implied, with respect to this product. Elcometer NDT 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 two-year duration of this written warranty.

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

22.2 OBTAINING SERVICE DURING WARRANTY PERIOD

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

For products that require servicing, Elcometer NDT 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.

22.3 AFTER THE WARRANTY PERIOD

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

23 SPARES & ACCESSORIES

23.1 TRANSDUCERS

Elcometer NDT gauges are **not** supplied with a transducer as standard - this must be ordered separately. The transducers listed below are the most commonly used however, Elcometer NDT offer a wide range of other transducers to suit various applications.

Further information on the transducers available and their applications can be found on the Elcometer NDT Knowledge Centre on www.elcometerndt.com.

Description

2.25 MHz 1/4" Microdot Top Single Element Non-magnetic Transducer
 2.25 MHz 1/4" Microdot Top Single Element Magnetic Transducer
 5 MHz 1/8" Microdot Top Single Element Non-magnetic Transducer
 5 MHz 1/8" Microdot Top Single Element Magnetic Transducer
 10 MHz 1/4" Microdot Top Single Element Non-magnetic Transducer
 10 MHz 1/4" Microdot Top Single Element Magnetic Transducer

Sales Part No.

TX2M25CM-5
 TX2M25CM-6
 TX5M00AM-2
 TX5M00AM-3
 TX10M0CM-4
 TX10M0CM-5

23.2 CALIBRATION BLOCKS

Elcometer NDT offer a comprehensive range of calibration blocks to suit a wide range of applications and standards.

Selecting the correct calibration block for the application is essential to ensure accurate evaluation. The form, shape and material of the calibration block should be appropriate for the material being inspected. Any artificially induced flaw should closely resemble that of the actual flaw being tested for.

The calibration blocks listed below are a selection of those available - details of the full range can be found on www.elcometerndt.com

Description

Glass Calibration Block, 1", 2" and 3"

Calibration Bar, 3", Steel

Calibration Bar, 3" and 6", Steel

Calibration Block: 8 Step; 1 - 8mm

Calibration Block: 10 Step; 2 - 20mm

Calibration Block: 10 Step; 2.5 - 25mm

Replace * with S1018 = 1018 Steel Block;

A = Aluminium Block; SS = Stainless Steel Block; T = Titanium Block.

Sales Part No.

TW-24028

TW-24029-S1

TW-24029-S2

TW-24005-*

TW-24006-*

TW-24007-*

23.3 ULTRASONIC COUPLANT

Each gauge is supplied with a 120ml (4oz) bottle of standard ultrasonic couplant. Replacement bottles and couplant for high temperature applications are available from your local Elcometer NDT supplier or directly from Elcometer NDT.

Description

Ultrasonic Couplant, 120 ml (4 oz)

Ultrasonic Couplant, 360 ml (12 oz)

Sales Part No.

TC-24034-1

TC-24034-2

Note: A wide range of other transducers and accessories is available - see www.elcometerndt.com for details.

23.4 MISCELLANEOUS

Description

RS232 Cable USB to Serial Converter

Sales Part No.

TL-24031

24 TRANSDUCERS

Transducer selection is a very important part of getting the best results from your gauge. The frequency and diameter of transducer should be carefully selected using the following information.

24.1 TRANSDUCER DIAMETER

Select the largest diameter transducer that will seat completely on the end of the bolt. If there are multiple applications and diameters to consider, select a diameter that will work for as many applications as possible, thus reducing the overall number of transducers needed.

24.2 FREQUENCY

When selecting the proper frequency, the following items should be taken into consideration:

- Higher frequencies are typically a better choice when measuring smaller diameter bolts as the sound is better focused resulting in less beam spread and a more direct path.
- Lower frequencies are more forgiving of potential bending and attenuating materials. This is primarily due to the longer wavelength avoiding smearing or distortion of the waveform. Longer wavelengths require more of a phase shift before distortion will occur. Lower frequencies offer an increased amount of dispersion and a less direct path. As this may seem to go against what may typically be considered a good choice, in the case of bending it is actually the best choice overall.

For full details of the Elcometer NDT range of transducers contact your local Elcometer NDT supplier, or visit the Elcometer NDT website www.elcometerndt.com

25 SOUND VELOCITIES OF COMMON MATERIALS

Material	Sound velocity	
	(m/s)	(in/μs)
Aluminium	6350	0.250
Bismuth	2184	0.086
Brass	4394	0.173
Cadmium	2769	0.109
Cast Iron	4572	0.180 (Approx.)
Constantan	5232	0.206
Copper	4674	0.184
Epoxy Resin	2540	0.100 (Approx.)
German Silver	4750	0.187
Glass, Crown	5664	0.223
Glass, Flint	4267	0.168
Gold	3251	0.128
Ice	3988	0.157
Iron	5893	0.232
Lead	2159	0.085
Magnesium	5791	0.228
Mercury	1448	0.057
Nickel	5639	0.222
Nylon	2591	0.102 (Approx.)

Material	Sound velocity	
	(m/s)	(in/μs)
Paraffin	2210	0.087
Platinum	3962	0.156
Plexiglas	2692	0.106
Polystyrene	2337	0.092
Porcelain	5842	0.230 (Approx.)
PVC	2388	0.094
Quartz Glass	5639	0.222
Rubber, Vulcanised	2311	0.091
Silver	3607	0.142
Steel	5918	0.233
Steel, Stainless	5664	0.223
Stellite	6985	0.275 (Approx.)
Teflon	1422	0.056
Tin	3327	0.131
Titanium	6096	0.240
Tungsten	5334	0.210
Water	1473	0.058
Zinc	4216	0.166

26 THE MENU COMMANDS

Menu	Function	Description
CAL (CALIBRATION)	ZERO MODE	Zeros your gauge in much the same way that a mechanical micrometer is zeroed. If your gauge is not zeroed correctly, all of the measurements made may be in error by some fixed value. Choose between FIXED, ONE POINT and TWO POINT.
	ZERO VALUE	Depending on the ZERO MODE selected, the actual zero value will be calculated and displayed in this sub menu item. You can edit this value at any time from this sub menu item.
	MEASURE ZERO	Once the ZERO MODE has been selected, this function displays and calculates the measurement screen containing the known physical length, velocity, and temperature coefficient of the calibration standard versus the ultrasonic length.
	LOAD CAL MODE	Enables and disables the field calibration feature which is used to compare known and ultrasonic loads.
	LOAD CAL CALC	This function calculates a linear regression or vector curve, once the LOAD CAL MODE is enabled and known and ultrasonic loads have been entered and ultrasonically measured. If the REGRESSION option is selected in LOAD CAL MODE, a correction load offset and load factor is calculated. If the VECTOR option is selected, a load factor is calculated and the offset is set to zero.
MATL (material)	UNITS	Toggle between Metric and English units and multiple resolutions for each unit: MM - .001 MMHR - .0001 IN - .0001 INHR - .00001 (HR = High Resolution; HR units are typically used when measuring very short bolts with very little elongation)
	TYPE	Select the bolt material type from a preset list of material types. Each type contains a velocity, stress factor, and temperature factor. When a type is selected, these values are displayed in the next sub menu items.
	VELOCITY	The velocity of sound in the material selected in TYPE. You can edit this value at any time.
	STRESS FACTOR	The stress factor of the material selected in TYPE. You can edit this value at any time.
	TEMP COEFF.	The temperature coefficient of the material selected in TYPE. You can edit this value at any time.

Menu	Function	Description
GEOM (GEOMETRY)	QUANTITY	Select the units of measure: TIME, ELONGATION, LOAD, STRESS or % STRAIN
	LOAD FACTOR	The conversion factor from elongation to Load. This value is typically determined by performing a field calibration and running a regression or vector using the gauge or utility software. Alternatively, the load factor can be determined using the bolt calculator in the Bolt Link software. However, if extreme accuracy is required, you must perform a field calibration. You can edit this value at any time.
	LOAD OFFSET	Normally LOAD OFFSET is set to zero. However, when a field calibration is performed and regression calculated a small offset (y intercept) will result. This value is a constant added or subtracted from the measurement, and will result in correction to the load quantity. You can edit this value at any time.
	AREA	The cross sectional area of the fastener being measured. Used to convert load to stress. Set to zero if QUANTITY is not set to STRESS. You can edit this value at any time.
	EFFECTIVE LEN.	The length of the region of the fastener under stress (the distance between the nut plus some amount of additional stress that occurs in the head and nut(s) of the fastener). You can edit this value at any time.
DISP (display)	VIEW	Choose between RF wave, RECT (rectified) wave and DIGITS (large digits) views.
	BACKLIGHT	Select OFF, ON, AUTO, or INVERT screen backlight.
	CONTRAST	Adjust the screen contrast for variable light conditions.
	DELAY	Adjust where the left side of the display window starts according to time (which is converted to length), in millimetres or inches.
	WIDTH	Set the overall depth of the viewable measurement area. It functions a lot like a zoom on a camera.
TUNE	GAIN	Increases or decreases the overall amplitude of the signal. Gain is similar to the volume control on a stereo receiver.
	THRESHOLD	Sets the sensitivity level of the gauge. The amplitude of the signal must reach or exceed this threshold level before a measurement is detected.
	POLARITY	The gauge operates on a zero crossing detection principle. This feature toggles which stroke of the cycle the crossing detection uses, either positive or negative.
	PULSE	Your gauge has adjustable pulse width for both high penetration and resolution applications. The pulse width refers to the duration of time the pulser is on. The options are SPIKE, THIN, and WIDE.
	RECT WAVEFORM	Toggles between an outlined or filled view option when the display setting is in RECT (rectified) wave mode.
AUTO	AUTO SET	Automatically locates the detection point if the measurement is out of the viewable display area. Used when measuring reference lengths only.
	APPROX. LEN.	To use the AUTO SET function, an approximate length of the bolt must be entered. The approximate length gives the gauge an indication of when to switch on the receiver and look for the detection, or end of the bolt. You can edit this value at any time.
	MEASURE MODE	Select the measurement mode for different application requirements. The mode options are: P-E (pulse-echo) P-E GT (pulse-echo with gate).
	GATE	Sets the start of the gate, according to time/distance. The gate allows you to view areas of the waveform and ignore others. You can edit this value at any time.

Menu	Function	Description
SET (SETUP)	OPEN	Displays a list of factory and user-defined setups currently stored in memory. These setups can be recalled and used at any time. A setup contains all the information about a specific bolting application.
	SAVE	Save a custom setup that you have modified or created.
	DEFAULT SETUP	Loads a basic default setup. Use only as a last resort if the setups in your gauge have been corrupted and a computer is not accessible to restore previously saved setups.
DATA	NEW	Creates a new group with a specified number of bolts and measurements per bolt. A group can contain 250 bolts, 1 reference length, and 51 measurements per bolt, depending on the application requirements.
	EDIT	Modify the NOTE and INCREMENT DIRECTION fields of a group previously saved.
	OPEN	Recalls an existing group from gauge memory.
	DELETE ONE GROUP	Deletes a selected group from memory.
	DELETE ALL GROUPS	Deletes all groups currently stored in memory.
UTIL (utilities)	TEMP. MODE	Selects the automatic temperature compensation mode: MANUAL SEMI-AUTO AUTO
	ALARM STATUS	Toggles alarm mode ON or OFF.
	ALARM LO LIMIT	Sets the LOW limit parameter. If the measurement falls below this value, a red light will illuminate and the alarm will sound.
	ALARM HI LIMIT	Sets the HI limit parameter. If the measurement exceeds this value, a red light will illuminate and the alarm will sound.
XFER (transfer)	BACKUP SETUPS	Allows you to backup the setups currently stored in your gauge to a computer via the RS232 port.
	RESTORE SETUPS	Allows you to restore setups saved on a computer to your gauge via the RS232 port.
	BACKUP GROUP	Allows you to backup groups stored in your gauge to a computer via the RS232 port.
	RESTORE GROUP	Allows you to restore groups saved on a computer to your gauge via the RS232 port.
	ABOUT	Provides Elcometer NDT contact information and your gauge software version. Refer to the help section of your gauge Bolt Link software for a complete electronic manual covering data transfer.