Operating Manual

If it Hasn't Been Inspected Using the CB110 Sidewinder.... It Hasn't Been Inspected

CB110

Sonic Cylinder Bore Inspection Gage

NDT Systems
Automotive Performance Group

17811 Georgetown Lane
Huntington Beach, CA. 92647
PH: 714.893.2438
FAX: 714.897.3840
www.ndtsystems.com

REV 1.0

Table Of Contents

2. INTRODUCTION

NDT Systems would like to thank you for your purchase of the CB110, Miniature Ultrasonic Thickness Gage, an instrument that not only provides the best value and feature set currently available but will also provide you with many years of dependable performance.

The CB110 features the following:

- Membrane-sealed TOUCH-COMMAND control to simplify its setup and use.
- 128 X 64 Pixel high contrast, graphic Liquid Crystal Display (LCD) allows for simple, plain text menus.
- Backlight - Standard
- Ultra-portability available from a pocket-sized instrument incorporating NDT Systems' "*Easy Grip*" Custom Extruded Aluminum Case.
- State-of-the-Art Microprocessor-based design offers unparalleled performance for numerous thickness gaging applications.
- Exclusive adjustable ***ScanBar*** feature permits a simple, analog metered display of thickness for easy & rapid view of thickness trend.
- Scrolling 'B' Scan - Standard. (Pat pending) - Industry First on a handheld
- Auto Probe Recognition (patented) / Legacy Probe Selection via Menu selection. No need to lose previous Nova 100D Transducer investment. This makes upgrading even easier !!
- Fully Adjustable Velocity - Standard
- 50,000 point Data Logger incorporating a scrollable "Spread Sheet" View.
- Single & Dual Point Calibration - Standard
- High & Low Alarm Limits interacting with data logger & high speed scan mode.
- High Speed Scan Mode incorporates Alarm Capture & Hold - Standard
- RS232 Data Transfer Port permits up & download of log as well as user, in-field software upgrades.

3. AREAS OF APPLICATION

The CB110 gages a wide range of thicknesses on metals, plastics, ceramics, glass or virtually any other material which satisfactory conducts ultrasound, and has fairly parallel (or concentric) surfaces. The actual range is material and application dependent.

The durable custom extruded, “Easy Grip” design allows the unit to withstand the rigors of heavier industrial environments, while its accuracy makes it suitable for use in less rigged conditions.

A major application for the CB110 is assessing wall thinning due to corrosion and erosion, Casting condition such as porosity or shrink within a casting and evaluating core shift.

Examples subjects of evaluation:

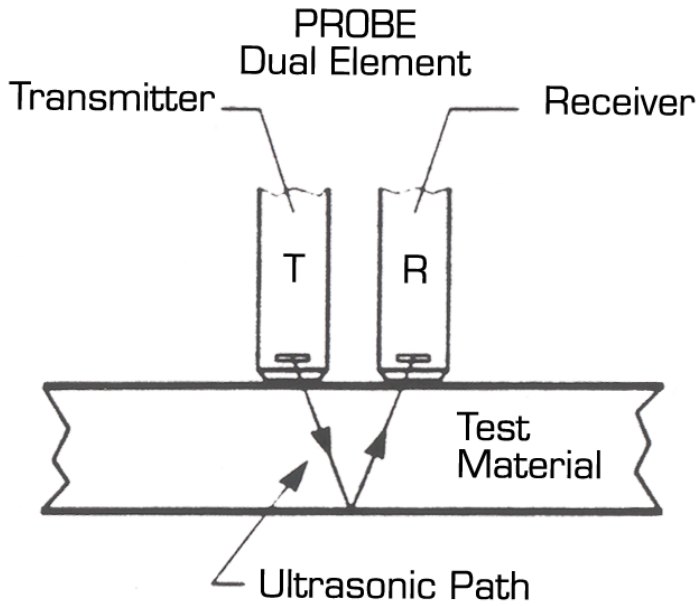
- ✓ Inspection of Steel, Cast Iron Aluminum & Cast Aluminum along with many other materials.
- ✓ Cylinder Wall Thickness
- ✓ Cylinder Wall Porosity
- ✓ Help Determine Shrink within Casting
- ✓ Determine Core Shift within Engine Blocks & Heads
- ✓ Porting of Cylinder Heads
- ✓ Block outer wall to water jacket thickness
- ✓ Roll Cage inspection (Should be inspected unpainted as the paint thickness will add 0.002" to the reading for each 0.001" of paint since the speed of sound in paint & plastics is 1/2 that of steel)

4. PRINCIPLE OF OPERATION

The CB110 operates on a principle similar to sonar, but at much higher frequencies (Megahertz range) and electronic speeds.

Figure 4.1 explains the ultrasonic pulse-echo principle that the CB110 and its dual element probe (transducer) employ. The probe's transmitter element (T) sends a short ultrasonic pulse into the material. The pulse, reflected as an echo from the opposite, parallel surface of the material, subsequently returns to the probe's receiver element.

This round trip time is correlated to the material's thickness (i.e.. the thicker the material, the longer the round trip time). By precisely measuring the round trip time and compensating for the characteristic ultrasonic velocity of the material being gaged (sound velocity differs in various materials), an accurate thickness indication can be obtained.

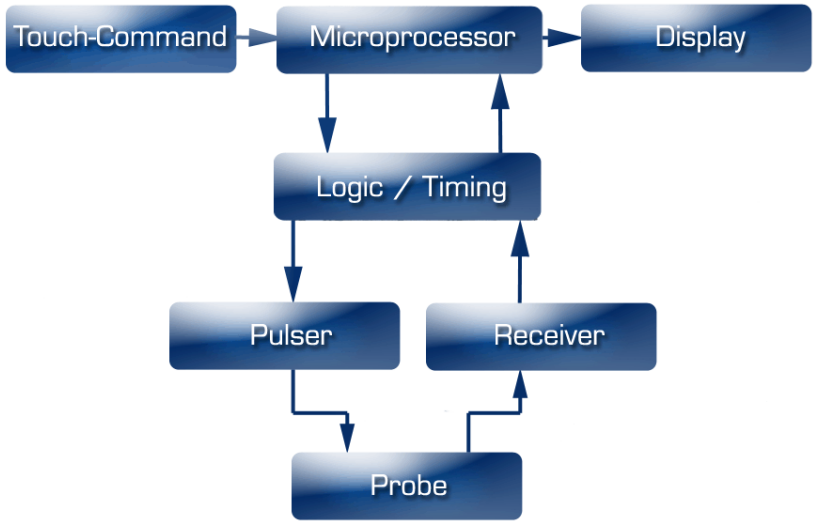


Principal Of Operation

5. BASIC DESIGN

The CB110 incorporates the latest technology available in microprocessor design. Through sophisticated on-chip programming, the microprocessor computes, compensates ('V' Path Compensation), linearizes, and directs numerous operations at high speeds. It also offers simplified setup and operation (gage calibration) via four TOUCH-COMMAND pushbuttons.

The powerful transmitter (pulser), high-sensitivity receiver and informative digital display function in concert with the microprocessor to produce the unparalleled performance offered by the CB110.



Functional Diagram

6. DESCRIPTION OF CONTROLS

1. Battery Level Meter
2. Scan Bar Scale
3. Scan Bar
4. Menu Button
5. Left Arrow & Mode Button
6. Zero Button - compensates for the specific probe in use
7. Up Arrow & Velocity... Velocity or Thickness Increase
8. Enter Function Button
9. Down Arrow & Velocity... Velocity & Thickness Decrease
10. ON / OFF
11. Right Arrow & B-Scan Start
12. Log Access Button
13. Coupling Indicator
14. Auto-Zero Reference Disc: Used with probe during probe zeroing
15. Receiver Input Connector: On the probe cable, it mates with the corresponding connector which has a red plastic boot.
16. Transmitter Output Connector. On the probe cable, it mates with corresponding connector which has a black plastic boot.
17. Bi-Directional RS-232 Connector
18. Battery Cover

PREPARATION FOR USE

The CB110 comes with two AA-size alkaline batteries installed in its battery chamber. To check for satisfactory battery life, press the ON/OFF touch command to turn power on. A Battery Icon appears on the left side of the LCD display indicating the current battery charge state. Approximately 150 hours of typical use remains from a fresh charge. If the display readout fails to register more than 20% scale then the batteries need replacement. When power becomes marginal, the Power-Guard Marginal Cutoff feature automatically turns the power off until the batteries are replaced.

Battery Replacement:
Loosen (counterclockwise) the large captive screw on the bottom of the gage with a small coin or screwdriver. Remove the discharged batteries and replace them with two new AA-size alkaline or NiMH rechargable batteries. Install them with proper polarity as indicated on the bottom of the battery chamber. Replace the endcap battery chamber cover into the gage and tighten the cover cap clockwise. When the batteries are completely discharged, removed or replaced, re-establish the gage calibration setting.

Probe Selection

A variety of probes are available to optimize performance for the broad spectrum of gaging applications that may be encountered. The Standard Probe (TG505R) could be used for most applications and surface temperatures up to about 225ºF.

There is also the HAMMER which is a swivel gimbal Sensor assembly specifically designed to make the inspection of cylinder bores MUCH easier, faster and more accurate by keeping the head assembly and therefore the Sensor center line in axis. This is a very important concept in the inspection of cylindrical surfaces

PORT Probes are smaller sized Mini-Probes with swivel heads mounted on a 6" handle assembly and are available for use on smaller surface radii or for gaging in confined locations such as cylinder ports.

Higher-Power Sensors are available for gaging thicker cast materials with high ultrasonic attenuation or rough surfaces (materials that cannot be penetrated with the Standard Probe).

Select the best probe suited for your application and for best results, use probes manufactured by NDT Systems, Inc whenever possible. If you have any application specific questions please feel free to contact us.

Probe Attachment

Various probes, with the exception of the normal “Mini-Probes”, have a detachable dual cable for connecting to the CB110. Connect the dual cable (LMD1) to the probe using the cable end with the smaller red-sleeved and black-sleeved Microdot screw-on connectors (certain probes may require attaching the red-sleeved and black-sleeved connectors to the correspondingly marked polarized connectors on the probe). Connect the other end of the dual cable with the larger red-sleeved and black-sleeved push-on/pull-off Lemo (silver in color) connectors to the corresponding connectors located on top of the gage. ***Be certain to connect the red-sleeved connector to the gage connector with the adjacent red dot and the black-sleeved connector to the other unmarked gage connector.***

Couplant Selection

A liquid couplant or Gels are always needed to transfer the sonic energy between the probe and the material. Typically, couplant is generously applied to the material surface, although it sometimes can be initially applied to the bottom of the probe (as during some high temperature applications). The type of couplant used is important for optimum performance. In the case of the HAMMER Sensor assembly, a pressurized couplant vessel is supplied to provide a continuous flow of coupling fluid to the sensor head. This permits for quick, easy and smooth section scan views as well as standard thickness readings. VERY little flow is required. Any fluid including water will do but diluted anti freeze would serve further as a rust inhibitor.

Smooth material surfaces require a lower viscosity couplant, such as water, glycerine or grease as necessary.

NDT Systems offers numerous ultrasonic couplants or Gels which cover virtually all application areas for the CB110. These specially formulated couplants should be used whenever possible.

Reference Samples - IMPORTANT!!

To calibrate the CB110, a known thickness or a known ultrasonic velocity for the material is needed. These calibration techniques require, at least initially,

a reference sample representing the material to be gaged. The closer the reference sample matches the actual material, the better the gaging accuracy. To compensate for calibration factors, such as material composition (most important), micro-structure heat treat condition (alloys), grain direction (alloys), thickness ranges, surface roughness and contour, the 'ideal' reference material would come from pieces of the actual material or known measured thicknesses on the part itself. This is perhaps the BEST calibration sample since most cast materials can vary by as much as 6%-12% from lot to lot, year to year or manufacturer to manufacturer.

This type of reference sample is used for critical applications for those requiring maximum gaging accuracy.

For most applications involving mild steel or billet aluminum, satisfactory gaging accuracy can be obtained by using a single reference sample of similar alloy. This sample should have the same composition and same nominal thickness (measured within required tolerances) as the actual materia/product. The material or product itself is often used with a micrometer to accurately measure an accessible representative thickness.

When gaging thin materials that approach the lower performance limits of the gage/probe combination, experiment with reference samples to determine the actual lower limit. Do not gage materials thinner than this limit. See Gaging Very Thin Sections.

If a thickness range is anticipated, then use a reference sample that represents the thicker end of the range.

For exceptionally large thickness ranges, particularly in alloys where micro structure variations occur, use separate samples and calibration setups at selected intervals across the range.

Many wrought and cast metal microstructures exhibit directionality that, depending upon the beam direction. causes a slight variation in ultrasonic velocity. For improved accuracy, reference samples should have the same material or directionality/sound beam orientation as that of the material to be gaged.

A machined step-wedge is a commonly used and convenient reference sample that has thicknesses across the range of interest (flat steps for flat materials or concentric steps for smaller-diameter tubing).

Under certain conditions, the published ultrasonic velocity value for a given material (see velocity table in appendix) can be used instead of a reference sample. Such a procedure is only satisfactory if the material has a known and constant velocity and the intended application does not require relatively high gaging precision. This approach is reasonable for many of the simpler, more-rugged applications involving the gaging of mild steel (plain carbon steel). In some cases. published velocity values will be found to differ appreciably depending upon the source of the publication. This is due to inherent material chemical/physical variations. Published velocity data tend to be useful only where approximate or relatively coarse thickness gaging precision is acceptable.

One of the best locations available on an engine block for instance are the machined flat & parallel crank journal surfaces. Be careful not to place sensor in line with cap bolt holes as this will obstruct the path of the sound to the opposite side. Simply take a standard micrometer and measure the thickness of a section with flat and parallel surfaces and adjust the gage to read that thickness. You are now compensated for that specific block. This will be a far more accurate setup than using anyone's provided or available "Cal Standard" since the likelihood of exact sound velocity match is very slim.

TOUCH COMMAND OPERATION

ON/OFF COMMAND (10)

Turn on the CB110 by momentarily depressing ON/OFF. Once the power is on and no buttons are depressed, the display will display NDT Systems, Inc Logo & contact information. Numeric digits will be displayed once the system boots and is ready for initial calibration.

To display the ultrasonic velocity currently in memory, depress the up or down arrow momentarily. Velocity will be displayed below thickness display area.

Scrolling Commands
The Scroll Commands are active when:
(1) Adjusting the velocity up or down (or)
(2) a thickness reading is displayed while the probe is coupled to a material.

Once the Scroll Commands are operative, scroll the readout by depressing either the up or down arrow to respectively increase or decrease the value. Scrolling initially moves at a slow rate, then, after several seconds. it appreciably increases. Release the scroll command pushbutton to stop the scrolling action and automatically reset it to the initial state. The change in scroll rate is highly advantageous because it readily allows (1) coarse, large numerical display changes in a short period of time by continuous command depression or (2) fine, small numerical display changes - as small as one unit - by quick momentary depression (bumping) of the command.

BATTERY LEVEL METER (1)

The CB110 comes with two AA-size alkaline batteries installed in its battery chamber. To check for satisfactory battery life, press the ON/OFF touch command to turn power on. A Battery Icon appears on the left side of the LCD display indicating the current battery charge state. Approximately 150 hours of typical use remains from a fresh charge. If the display readout fails to register more than 20% scale then the batteries need replacement. When power becomes marginal, the Power-Guard Marginal Cutoff feature automatically turns the power off until the batteries are replaced.

SCAN BAR - ALL NEW & UNIQUE FEATURE

The black bar (3) at the bottom of the display is called a Scan Bar. This feature is unique to hand held thickness gages. It represents a visual representation of the thickness under measurement. As the thickness value changes the bar position across the screen changes proportionate to the thickness being measured. See figures.

.249" reading on a total scale of .500"

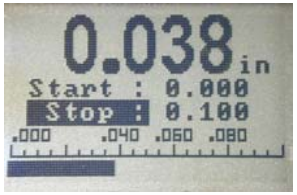
0.093" reading on a total scale of 2.00"

SCAN BAR (3) & SCALE (2)

The Scan Bar Scale is a user adjustable scale value. It can start and end at any value within the CB110 specifications. Suggested scale values might be 10% over the maximum value of expected thickness to be measured. For instance, if the material under test is never expected to exceed 0.500" in thickness then a good starting point would be 0.550" or thereabouts. This will give the greatest amount of visual motion within the range of thickness. If on the other hand, the max thickness were still 0.500" and the scale were set to 5.00" then the range of motion would be a very small proportion of the total scale.

To adjust the Scan Bar, press the left arrow/mode (5) key and select “Adjust Scale” OR press the MENU (4) key and select “Adjust Scale” then press the ENTER (8) key. You will then be presented with the Adjust Scale Screen.

From this point simply set the “Start” value to the appropriate minimum expected thickness using the LEFT and RIGHT ARROW keys. Then use the DOWN ARROW (9) key to select “Stop” and adjust this value to the maximum expected thickness value using the LEFT and RIGHT ARROW keys. Be sure to keep this value within expected thickness range for maximum effectiveness. NOTE: Use of this feature is optional. There is no need to use this feature if you do not choose to do so. It will not effect the value or accuracy of readings regardless of the Scan Bar Scale range. If the Scan Bar Scale is set to low the bar will simply read max thickness value set on scale.

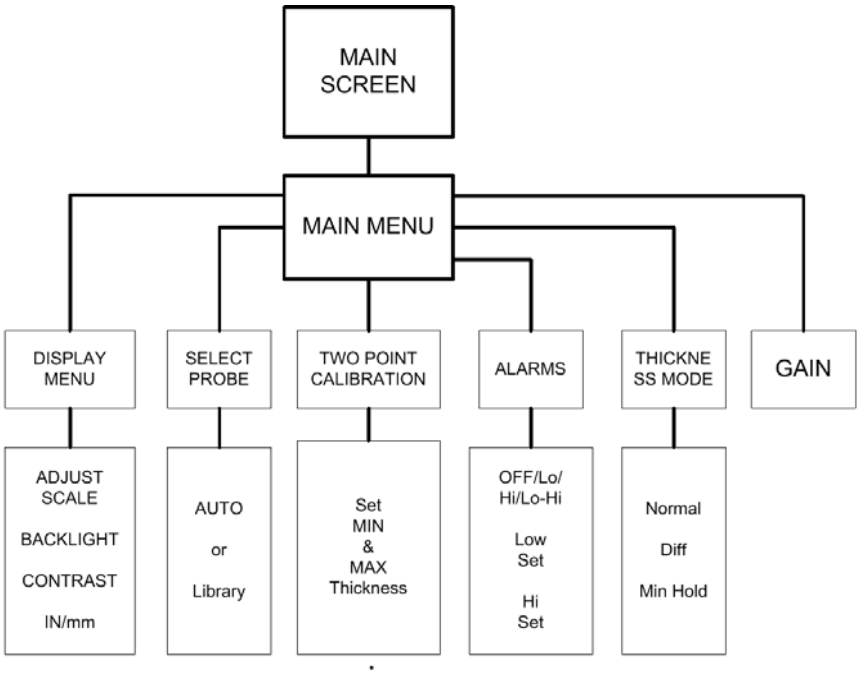


Setting Scan Bar Scale

NOTE: Use of this feature is optional and for you convenience. There is no need to use this feature if you do not choose to do so. It will not effect the value or accuracy of readings regardless of the Scan Bar Scale range. If the Scan Bar Scale is set to low the bar will simply read max thickness value set on scale.

MENU BUTTON (4)

Access to the CB110's special functions are available using this key. The following represents the general Menu Flow discussed more throughout this manual.



LEFT ARROW / MODE BUTTON (5)

This key acts primarily as a shortcut key to the DISPLAY menu for rapid adjustment of the Scan Bar if desired. In several menus the LEFT ARROW acts to decrease associated menu values.

ZERO COMMAND (6) - IMPORTANT STEP IN CALIBRATION!!

During calibration, ZERO compensates for the individual characteristics of the specific probe in use such as wear and other factors.
First couple the probe to the metal Auto Zero Reference Disc located on the right side of the gage (with power on). If you are using a radiused faced sensor, rock it back and forth to obtain the LOWEST" reading.

Next, depress the ZERO button. The display will then instruct you to press the enter key to confirm the request. This two step process is to prevent an inadvertent ZERO request. Note that depressing ZERO without a probe that is coupled does not affect any formerly stored data. When the probe is placed on the Zero Disc and the ZERO is not depressed. the Zero Disc Thickness will display.

DO NOT zero the probe on any other material sample except the Auto Zero Reference Disc, as it will cause substantial gaging errors.

UP ARROW / VEL+ BUTTON (7)

As a direct access to Velocity+ or "High Cal" increase value adjust when in the main measurement screen. Up Arrow also serves to move vertically through other menus of the CB110.

ENTER BUTTON (8)

In Main Screen, will cycle backlight ON if AUTO mode has turned off. Otherwise ENTER serves to activate various other features throughout the CB110's menu structure. ENTER also serves to enter the current value of thickness into the selected cell of a LOG, while in the LOG mode.

UP DOWN / VEL- BUTTON (9)

As a direct access to Velocity- or "High Cal" decrement value adjust when in the main measurement screen. Down Arrow also serves to move vertically through other menus of the CB110.

ON / OFF (10)

Turn on the CB110 by momentarily depressing ON/OFF. Once the power is on and no buttons are depressed, the display will display NDT Systems, Inc Logo & contact information. Numeric digits will be displayed once the system boots and is ready for initial calibration.
Press and hold for 3/4 of a Second to turn off. This delay prevents unintentional turn off of the gage.

LEFT ARROW / SCAN BUTTON (11) - NEW & UNIQUE!!

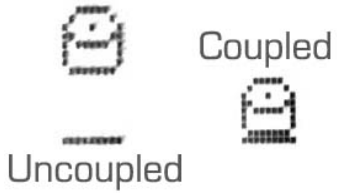
This key acts primarily as a shortcut key to the Scrolling B-Scan Mode from the main screen. In several menus the RIGHT ARROW acts to increase associated menu values.

LOG BUTTON (12)

Places you directly into the LOG menu where you can elect to start a NEW LOG (only choice of no other log exists), View an existing LOG, edit an existing LOG, ADD readings to an existing LOG or delete existing LOGs

COUPLANT ICON (13)

A Couplant Icon automatically changes states to help qualify the integrity of the accompanying thickness reading. It indicates satisfactory coupling, adequate material penetration, and proper probe/beam normalization (perpendiculanty to surface). Thickness readings must not be considered reliable if the Couplant Bar fails to concurrently appear, intermittently blinks, or flickers.



ZERO REFERENCE DISC (14)

Used with ZERO command button (6) to adjust for individual probe characteristics.

TRANSMITTER (15)

RECEIVER (16)

BATTERY ACCESS CAP (17)

Battery Replacement:
Loosen (counterclockwise) the large captive screw on the bottom of the gage with a small coin or screwdriver. Remove the discharged batteries and replace them with two new AA-size alkaline or NiMH rechargable batteries. Install them with proper polarity as indicated on the bottom of the battery chamber. Replace the endcap battery chamber cover into the gage and tighten the cover cap clockwise. When the batteries are completely discharged. removed, or replaced, re-establish the gage calibration setting.

OTHER FEATURES

AUTO-HOLD
When a coupled probe is lifted from the material surface, the Last thickness reading taken is conveniently retained on the display until either another thickness reading is taken, the two-minute non-usage lapse (Auto-Shutoff) occurs, or ON/VEL is depressed. This Auto-Hold feature does not affect readings as the coupled probe is scanned over a surface. The display updates approximately four times per second whenever the probe has valid coupling with the surface of a test object.

AUTO-SHUTOFF
The CB110 automatically turns itself off approximately three minutes after non-use, thereby eliminating the need to use the OFF switch. To reset the turnoff timer, take a thickness reading or press the ENTER key.
All TOUCH-COMMAND settings (calibration settings plus Touch Codes) are retained in memory (even when the gage turns its power off).

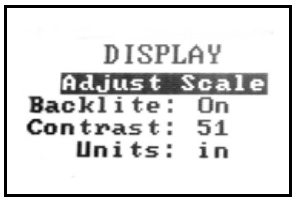
MAIN MENU & CONTROL FEATURES

Referring to the menu flow diagrams, or with thickness gage in hand, press the MENU key and review the list of items on this main menu.

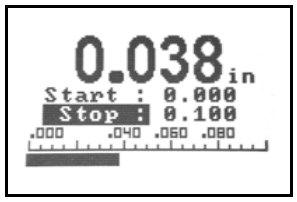
DISPLAY MENU

From the main menu place the cursor over the Display icon and press the ENTER key. Note: the display menu may also be reached by pressing the MODE button on the front panel. In the display menu please note the four functions available. They are; Adjust Scale, Backlight, Contrast & Units (measuring).

Scale



The Scale is a user adjustable parameter. It can start and end at any value within the CB110 specifications. Suggested scale values might be 10% over the maximum value of expected thickness to be measured. For instance, if the material under test is never expected to exceed 0.500" in thickness then a good starting point would be 0.550" or thereabouts. This will give the greatest amount of visual motion within the range of thickness. If on the other hand, the max thickness were still 0.500" and the scale were set to 5.00" then the range of motion would be a very small proportion of the total scale.



To adjust the Scan Bar, press the left arrow/mode (5) key and select “Adjust Scale” OR press the MENU (4) key and select “Adjust Scale” then press the ENTER (8) key. You will then be presented with the Adjust Scale Screen. From this point simply set the “Start” value to the appropriate minimum expected thickness using the LEFT and RIGHT ARROW keys. Then use the DOWN ARROW (9) key to select “Stop” and adjust this value to the maximum expected thickness value using the LEFT and RIGHT ARROW keys. Be sure to keep this value within expected thickness range for maximum effectiveness. NOTE: Use of this feature is optional. There is no need to use this feature if you do not choose to do so. It will not effect the

value or accuracy of readings regardless of the Scan Bar Scale range. If the Scan Bar Scale is set too low the bar will simply read Max Thickness value set on scale.

BACKLIGHT

The backlight has three settings:
AUTO (automatic). In this mode the backlight will turn on automatically when the transducer has sufficient coupling with the part under test. The backlight will turn off automatically after approximately 5 seconds if the transducer has not been contacted or coupled with the part since.
OFF: In this mode the backlight will stay off indefinitely. If the gage is being used in an area with high ambient light there is no need to use backlight. With the backlight turned off battery life will be increased significantly. As it becomes more difficult to see the display in darkened conditions you may turn the backlight on to the AUTO condition or the ON condition.
ON: In this mode the backlight will remain on continuously. This will also shorten battery life. Again there is no reason to run the backlight on while working in high ambient light conditions or outdoors.

CONTRAST

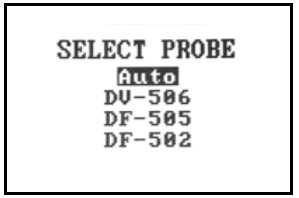
This control probably never be needed, unless the gage is being held at extreme visual angles from a user, or there are significant temperature extremes. In this case scrolling the contrast value down will darkened the display, and scrolling the contrast value up will lighten the display. Generally speaking this is a user specific control.

Units - in/mm

Scrolling down to the units mode allows the operator to select the units with which to measure inches or mm may be selected.

Pressing the MENU button one time from any item within this menu will return to the previous menu.

SELECT PROBE MENU

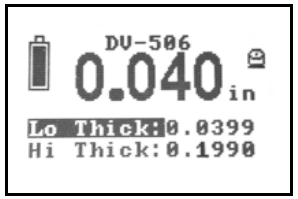


From the main menu, cursor down to the SELECT PROBE menu item and press the ENTER key. The normal mode of operation is the AUTO mode. In this mode you are able to take advantage of NDT Systems' Patented automatic probe recognition. In this mode the gage has been set

up for optimum performance with the available line of transducers specifically designed for the CB110. Please see the accessories page for other available transducers.

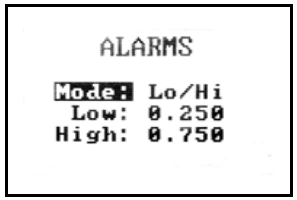
Also available in the SELECT PROBE menu is the library list of transducers. In time this list will be increased to support other transducers as well. These notifications will be available on the NDT Systems web site at www.NDTSystems.com.

TWO POINT CALIBRATION



Return to the main menu and press two point calibration. From this screen you can calibrate both the low thickness and high thickness values instead of using the Automatic Zero or single point method. Accuracies may be improved while using this mode, particularly on smaller diameter piping or elbows. You will however, need a sample representative of the geometry you wish to measure with at least two thickness points well-known. To use this mode the user places the transducer over the minimum thickness value to be measured and uses the right and left arrow keys to scroll the MIN THK number to the known minimum thickness value. Then place the transducer on the HIGH THK or upper thickness value and again use the right and left arrow keys to scroll to the appropriate value. This may have to be repeated a couple of times to further improve the accuracy.

ALARM MODES



The alarm modes allows the user to predefine a value which will notify the user if the thickness should fall below, above, or both. This indication is given by an LED indicator located near the menu button. Using the MODE function and the right and left arrow keys user can select from the following values. Off, low, high and Low/Hi. The alarm levels are set by moving the cursor to either the LOW or HIGH menu item and then using the right or left key to scroll to the appropriate cut off value. Once the values have been set turn on the mode of notification you would like in the alarm light will then notify you.

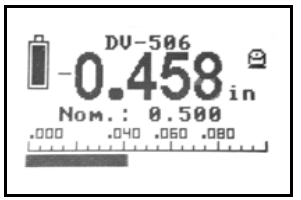
The alarm mode is also interactive with the minimum capture mode, as well as the data logger discussed below.

THICKNESS MODE

Return to the main menu and select THICKNESS MODE. In this mode you are offered three choices.

Normal thickness mode:
In this mode the main display screen will present only the current thickness value being measured. The Scan Bar will also relate to the same thickness.

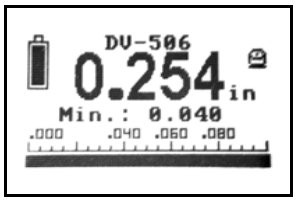
Differential Thickness Mode:



This mode displays the difference betweeen the measured thickness and a nominal value the user selects. The user selects two ways to input nominal value. For instance, if the nominal thickness value were 0.500 inches and the user would like to know the change from that value you would enter 0.500 inches and the primary thickness display would then indicate a value (+) or (-) from that value. Therefore if the measured value were actually 0.400 the primary thickness display would indicate a value (-0.100) rather than 0.400. You'll also note just below the primary thickness display in smaller text, the value of the nominal thickness you have selected. A quick way to set the nominal thickness value is to set the probe on a test block of that value and then press the ENTER key. This performs a sort of shortcut method to set the “nominal” value on-the-fly.

When you no longer wish to measure in the differential mode, you must return to the main menu, select thickness mode and return the cursor to the normal operating mode.

MIN HOLD



Pressing the ENTER key enters the MIN THICKNESS HOLD mode for the CB110. While in this mode the user can scan across the surface of a part and the gage will capture and display the minimum thickness during that

operation. To clear the value and start new simply press the ENTER key. While at the main screen this will set a blank value next to the MIN: text, just below the main thickness reading.

Additionally, if the low alarm is turned on and the MIN THK captures a value below the value set in the low alarm menu, the alarm LED will flash to indicate the minimum thickness value was below the value set in the low alarm menu somewhere in the area last scanned. This unique function notifies the user to go back and reinspect the scanned area to locate the low thickness value.

GAIN

This feature allows the user to set a gain value other than the default value. Though rarely used, this feature allows the user some flexibility when adjusting to various materials and surface conditions. When a gain level is set to the full value the gage will automatically be set to offer the optimum measurement capabilities. If using a transducer which incorporates the NDT Systems probe recognition routine, the standard gain value will be set to the default value once the gage is turned on again. This feature may require some experimentation should difficulties arise.

DATA LOGGER

The data logger in the all-new CB110 is one of the simplest loggers to navigate. It can present a log in a simple spreadsheet type view, or a simple linear list. The user has available of total of 50,000 data points which can be divided into an unlimited number of log files. Each log file can be named with up to 32 alphanumeric characters. This is an absolute first for any thickness gage in this price range!!

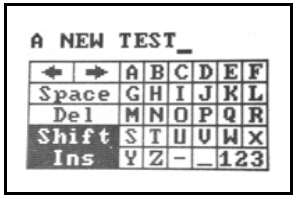
LOGGING DATA

Pressing the LOG button enters the data logger mode. If no files currently exist in the logger then the default screen value will simply read NEW. If there is at least one other log file, then this screen will read NEW, REVIEW or ERASE ALL.

NEW: (Create New Log)
Pressing NEW will present a menu with three choices; Log Type, Edit Name & Create.

Log Type: ENGINE, GRID or LINEAR
The Log Type is selected by using the right and left arrow keys. When selecting the grid mode a simple spreadsheet type of log will be created. This is a simple two dimensional log consisting of numbered rows & columns. The user will be prompted for the number of rows columns for the log.

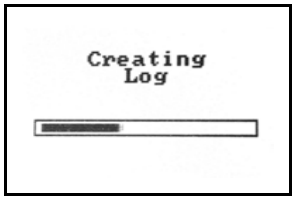
EDIT NAME:
When EDIT NAME is selected the user is presented with an alphanumeric screen and a flashing cursor. The log file is named by moving this cursor through the alphanumeric field and pressing ENTER to "build" the log file name. If no name is defined, the CB110 will assign the next numeric value available by default. When you are finished defining the log file name simply press the menu button to return to the New Log File menu.



CREATE:
Cursor down to CREATE. The user is then presented with either "Number

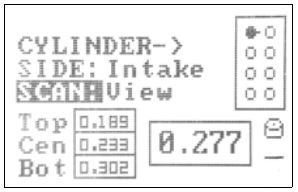
Of Points" if in the LINEAR mode or, the number of rows columns desired. Place the cursor over columns and adjust this value up or down from the default value, and then cursor to rows and adjust this value up or down to the desired value and then highlight CREATE.

When the CREATE menu item is selected and ENTER is pressed the user will notice the progress bar while the log is being built. If the log is small this bar will move across a screen very rapidly. If the log is very large this bar may take more time as the log file is built.



Once the log is built, the user is presented with either an ENGINE Icon View, Linear Row of four input boxes (cells), or a spreadsheet view of four Columns and three Rows which are visible. Above the boxes (cells) is an indication of the current row and column. A flashing cursor occupies the current cell. By default the cursor will start in row one and column one.

ENTERING DATA - ENGINE Log Mode



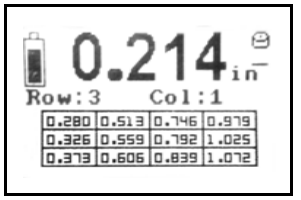
From the “Log Type” menu selection use the left & right. Study the Engine Icon itself. This is a box with 8 mini-circles in it. In the example to the right you will notice the upper left circle (cylinder) is filled in indicating it is the selected cylinder. You can define cylinder numbers as you please but the upper left one is #1, the next down is #2 and so forth. This will align with the printed tet report once downloaded via the optional CB110 Data Transfer Program.

Currently the SCAN item is selected in the example. In this case we would use the up arrow key to move the cursor over the CYLINDER selection. Then, you can use the left & right keyboard arrows to select the appropriate cylinder you are working in. Additionally, notice that there is a pointer on the filled in circle. This indicates the side of the bore you will be working on. Move the cursor to the SIDE menu selection and use the left and right keyboard arrows to select either the Front, Back, Intake or Exhaust position. This will be the side you will acquire and store thickness readings and scans for use in later reporting once the data is downloaded to the optional Data Transfer Software Package.

The next menu item down is the SCAN menu item. The 3 selections are NONE, RUN and VIEW. If the item says NONE and you want to run a scan in this location, use the left or right arrow keys to select RUN. Position the sensor (HAMMER Sensor Assembly recommended) at the top of the bore and when you are coupled and ready to run scan select the ENTER key. Start moving the Sensor to the bottom of the bore in a smooth even timed fashion. Ideally, you want one screen width of data to equal the top to bottom of cylinder. Some practice may be required. If you do make a mistake in the middle of the scan just wait for the screen to clear and start again. When you are satisfied with the scan press the MENU key to return to the Engine Log View. From here select the next location in the cylinder or the next cylinder to work within.

It is suggested that you at least name the log with the Serial # of the block under inspection. In some cases you may be supplied with multiple blocks from the same customer so just a customer name alone would not due. Again, you have up to 32 characters to name the log so you could indeed include the customer if you desired.

ENTERING DATA - GRID & LINEAR



To enter a value in the log, simply hold the transducer on the area of interest. Once a stable reading has been obtained simply press the ENTER key. You'll notice that the value held in the cell represents the value measured. To enter the next value simply use the right or left arrow keys to move to a new cell and repeat the same operation. The value in the current cell can be overwritten by pressing ENTER again if a mistake has been made.

The user has total flexibility to scroll throughout the spreadsheet. For instance, the user may elect to enter the first data point in row 6 column 7 while leaving the other cells blank or null. The log will be saved with as many or few points entered in the file whether or not the log is full.

Once finished entering data, pressing MENU will return the user to a screen which will allow the ability to view the current log, log more readings, edit the log file name, or erase the log. The current log name will be identified at the top of the screen.

Once finished with the logger function the user may press the MENU key to escape back to the main thickness measuring screen. If desired, the log key may be pressed again and should there be several logs available the log screen will display, the number of logs available, New, Review, Erase all.

NOTE: All readings stored & displayed in the log will be the actual thickness measured. You may choose to view the thickness in differential mode, however, the actual thickness will be logged when pressing enter

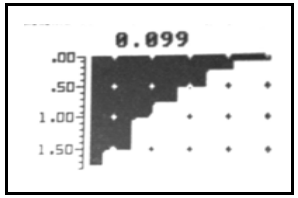
REVIEW
If review is selected the user will be presented with a sequential value of the logs and their associated 32 character name, if one had been defined. To select the desired log to review simply use the up arrow or down arrow key Press the ENTER key to either View Log, Log Readings (to add additional readings to the currently selected log), Edit Name to change the selected log's name or Erase.

ERASE**
If erase is selected the default value will be NO. If you choose to delete the file, use the down arrow to select YES and press ENTER.

CAUTION... Be very sure this is what you would like to do. There is no recovery of the deleted log file.

The files in the data logger may then be uploaded to a Windows-based PC via the TG110-DTP Data Transfer Program. Instructions for this program can be found in it's associated user's manual. Use of this program requires the purchase of the optional data transfer cable.

SCROLLING SECTION-SCAN



Perhaps the most innovative, intriguing and productive feature of the CB110 is the unique scrolling Section-SCAN feature. This feature is actually a time encoded Cross Section SCAN view. To activate the feature press the SCAN button or RIGHT ARROW key from the main measurement screen. The user will be presented with what appears to be a series of scrolling dots, moving right to left.

Along the left vertical axis you will note the scale value represents the thickness range value set for the SCAN BAR. Again, this can be reached by pressing the MENU button once to return to the main measurement screen, and then press either the MODE (left arrow) button and select scale or press the MENU button, select DISPLAY and then select SCALE. Adjust the scale start and stop to the desired values. Again the thickest value should be set to approximately 10 percent over the maximum expected thickness. This will allow the B-SCAN mode to present a graphic representation which expands vertically from the top to bottom of the display.

To return back to the SECTION-SCAN mode simply press the scan button from the main display screen. Again you'll be presented with a set of scrolling dots.

From this point, place the probe on the sample to be tested and in a smooth, even motion slide the probe across the surface of the part to be inspected. As you slide the probe across the surface you'll notice a cross-section view of the part being drawn as you inspect. The scrolling mode continues until you press ENTER. The screen will stop, and you can review the information acquired.

You may notice many blank sections in the Section-SCAN presentation. If this is the case be sure there is plenty of couplant or flow on the surface prior to entering the Section-SCAN mode. These blank spaces are generally an indication of poor couplant. In order to become more familiar with this new productive feature, a little practice on a known sample will help you learn the proper "technique".

While in the Section-SCAN mode pressing the up arrow key will eliminate the small thickness display just above the scrolling graphic area. The result is a scan mode which runs approximately 25 percent faster. This still allows you to correlate the thickness of the graphic representation using the scale on the left side of the display.

Additionally, if you press the down arrow key while in the scrolling mode the scaling dots will also disappear. This will improve the speed approximately another 10 percent although any horizontal reference will be removed.

Currently, the scrolling Cross Section-SCAN mode is for reference only.

One of the truly valuable features of the CB110 is the fact that it is a platform with which to grow. There is an ability to purchase additional software features in the future as the market requests. These features will be field upgradable with the purchase of the data transfer cable accessory.

CALIBRATION PROCEDURES

With prior functional review of all other sections of this manual, use the following procedure to calibrate the CB110:

1 Connect the probe and cable to the gage.
2 Momentarily depress ON/OFF to turn power on.
3 Confirm that the CB110 has passed it's internal tests & is at the main measurement screen.
4 Select the GAIN suitable for the intended application. Generally the default setting is appropriate so no further adjustment is needed.
5 Couple the probe to the metal Auto-Zero Reference Disc on the right side of the gage and depress ZERO. If you are using a radiused face Sensor be sure to rock the Sensor to obtain the lowest reading BEFORE selecting the ENTER accept function. Text will appear instructing you to press the ENTER key to confirm ZERO request.

6 Thickness Calibration
6.01 Calibration by Thickness Scrolling: Couple the probe to an accurately known thickness of the material (reference sample) to be gaged while scrolling UP or DOWN until the display precisely reads the reference thickness.

6.02 Calibration by Velocity Scrolling: If the ultrasonic velocity of the test material ***is known***, depress the UP or DOWN until the display precisely reads this velocity value. If the velocity is not known. it can be determined in accordance with the procedure specified in the Ultrasonic Velocity Section of this manual.

As a reminder the basic calibration procedure is outlined on the backside of the gage. As is recommended with any precision measurement tool, calibration accuracy should be checked periodically during use. More frequent checks are recommended if there are changes in the temperature of the test objects or in the ambient conditions.

ULTRASONIC VELOCITY MEASUREMENT

Since many factors can affect ultrasonic velocity, the following procedure should produce significantly more accurate results than using published data. If "approximate" gaging accuracy is acceptable, then use of published data, as shown in the Velocity Table located in the rear of this manual can be considered.

1. With a material reference sample of precisely known thickness, use thickness scrolling to calibrate the gage.
2. Remove the probe from the material reference sample, Momentarily depress either the UP or DOWN ARROW and read the displayed velocity for this particular material. This velocity value can now be used to calibrate the gage by velocity scrolling in the future.

Longitudinal Ultrasonic Velocity Table

Material	Inches/us	mm/us
Acrylic Resin	0.105*	2.67**
Aluminum	0.249	6.32
Brass, Navel	0.174*	4.43*
Bronze, Phosphor	0.139*	3.53*
Cast Iron - TYPICAL	0.181*	4.60*
Copper	0.183*	4.66*
Glass, Window	0.267*	6.79*
Inconel	0.225*	5.72*
Iron	0.232	5.9
Magnesium	0.248	6.31
Monel	0.237	6.02
Nickel	0.222	5.63
Steel, Mild	0.232	5.9
Steel, 4340	0.23	5.85
Steel, 303 CRES	0.233	5.66
Titanium	0.239	6.07
Zirconium	0.183	4.65

GAGING TIPS & TECHNIQUES

1. **Clean Surface**: Prior to gaging, always remove performance hindering foreign substances from the material surface (e.g. dirt, loose scale, corrosion, particles, and flaking paint).

2. **Excessive Surface Roughness**: Very rough surfaces can cause erratic, extremely low or no thickness readouts. In such cases, consider scraping, sanding, grinding or filing the surface smooth enough to obtain a proper response (provided such a procedure and the amount of metal removal are acceptable). High-viscosity couplants, the Special Power Mode or the Hi-Power Probe may also significantly improve the response.

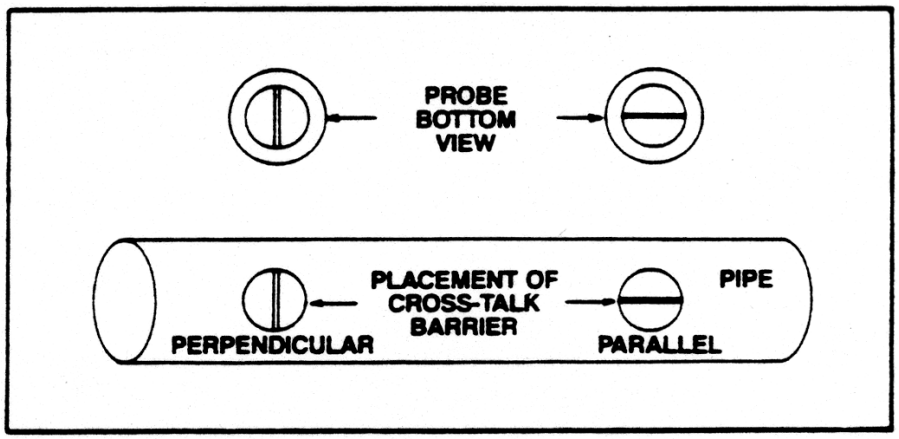
3. **Heavy Machine-Grooved Surfaces**: A uniformly-grooved surface, such as produced by a single point cutting tool, can cause the same undesirable effects as described in Paragraph 2. As a remedy, use a high-viscosity couplant and orient the probe's crosstalk barrier (located on the bottom of the probe) at right angles to the groove (patter) direction. If the above procedure fails, use the GAIN control located in the MAIN menu. Decrease the GAIN until the undesirable effect disappears, while assuring proper thickness can still be obtained within the desired expected MIN/MAX thickness range.

4. Try using a lower frequency probe if gaging thick materials or materials with large grain structures.

5. **Gaging Cylindrical Sections**: When gaging cylindrical shapes such as Engine cylinders or head ports etc., it is vital to establish probe normality (perpendicularity to surface) and select the proper orientation of the probe's cross-talk barrier. The cross-talk barrier is the thin material that splits the bottom of the probe into halves (its direction is marked on both sides of the probe housing).

6. To determine normality, rock the coupled probe back and forth along the curved direction on the material surface and watch the accompanying decrease/increase action of the thickness readout. Use the minimum thickness reading, as this represents probe normality.

Selection of probe cross-talk barrier orientation depends upon the material's surface diameter. See the following probe orientation figure. On large diameters, orient the probe so its barrier is perpendicular to the cylindrical axis of the material. On smaller diameters, initially orient the probe barrier both perpendicular to and parallel with the material's cylindrical axis (at the identical location) and then use the direction that gives the smaller thickness readout.



Probe Orientation On Cylinders

7. **Compound Contours**: For gaging elbows or cylinders, (also see Paragraph 5), rock the probe for a minimum reading in both the circumferential and longitudinal directions and then use the smaller of the two minimum readings. On spherical sections, rock the probe for a minimum reading in one direction and, again. or another minimum reading with the cross-talk barrier perpendicular to the first. Use the smaller of the two minimum readings. Compound contours are difficult to gage, so if successful results cannot be obtained, try using an ultrasonic flaw detector such as the Quantum TE or thickness gage with ‘A’ Trace capability such as NDT Systems' Eclipse TG-2.

8. **Non-Parallel Surfaces**: The surfaces on either side of a section must be relatively parallel or concentric in order to obtain a satisfactory ultrasonic echo for a thickness reading. Non-parallel or tapered surfaces will produce less accuracy or no reading at all. When porting heads it is advisable to have a rough idea of the overall internal

geometry of the head. If you have a few “DUDs” around it may be of value to section the head to better understand the back wall surface geometry. Also, there is a Video CD or Tape available to assist in the understanding of the Sonic inspection of heads. This is offered at no charge with the first purchase of a Port Probe.

9. **Material Temperature Effects**: Both the dimensions and the ultrasonic velocity of a material change with temperature, which, in turn affect calibration. This undesirable effect holds true for the material being gaged as well as for the probe. Although it is always good practice to re-calibrate when a noticeable change in ambient temperature occurs, the effect can normally be ignored for modest changes in ambient temperature.

   The situation becomes more complex when the material temperature is considerably different than ambient. One solution is to calibrate on a reference sample at the same temperature as the material. Another solution is to calibrate on a reference sample at ambient temperature and then add an experimentally derived correction factor for the temperature of the material.

   The gaging of hot steel products is an application where high temperatures will produce significant thickness readout errors (gage typically reads thicker than actual), unless some temperature correction or compensation technique is used.

10. **Excessively Attenuative Materials**: Some materials (fibrous, porous, large-grained, etc.) may absorb or scatter so much ultrasound that either a reading cannot be obtained or some abnormal reading (usually abnormally thin) occurs. In such cases, try the Special Power Mode or the Hi-Power Probe. If gaging is still unsuccessful, use an ultrasonic flaw detector such as NDT Systems' Eclipse TG-2 or Quantum TE.

11. **Grain Directionality Effects**: In many wrought and cast metals, the micro structural properties are directional. This means the ultrasonic velocity (and calibration) may differ, depending upon the beam direction with respect to the grain direction. For improved accuracy, always calibrate and subsequently gage in the same material grain direction..

GAGING PRECAUTIONS

Very Thin Sections: As with any ultrasonic thickness gage, when the sectional thickness falls below the minimum operating thickness for the specific probe in use, erroneous readings will result. It is virtually impossible to precisely specify the minimum thickness which can be gaged with a given probe/CB110 combination because the actual minimum thickness depends upon the particular application (material type, contour, surface conditions, temperature, etc.). Therefore, the minimum thickness limit should be closely approximated by experimentation on samples of the actual material/product.

One erroneous effect, called "doubling", sometimes occurs when gaging thicknesses fall below the minimum limit. Another effect, known as "pulse-envelope cycle-jumping," produces a reading somewhat larger than the actual thickness. It is advisable to double check critical thinner sections by using NDT Systems' NovaScope or an ultrasonic flaw detector such the Eclipse TG-2 or Quantum TE.

Pitting Corrosion: Pitted areas on the opposite metal surface can cause unexpected erratic changes in thickness readout or, in extreme cases, a lack of thickness readout. Very small (especially sharply pointed) pits may even go undetected (especially isolated single pits). When pitting is either detected or suspected, the area should be very carefully scanned while changing the orientation of the probe's cross-talk barrier to enhance delectability of the thinnest pitted spot (s). When positive results cannot be obtained, particularly on critical structures, use NDT Systems' NovaScope or an ultrasonic flaw detector such the Eclipse TG-2 or Quantum TE as a supplementary test method.

Material Misidentification: Always verify the type and anticipated thickness of material to be gaged. Erroneous thickness readouts will result if an instrument is calibrated to a material and thickness other than the test material.

Worn or Malfunctioning Probes: Immediately replace any probe that is malfunctioning or showing excessive or uneven wear.

Use of the ZERO Command: Zero the probe only on the metal Auto-Zero Reference Disc, located on the front of the gage. The instrument will lose calibration if ZERO is depressed while the probe is coupled to any other material.

Abnormal or Unusual Thickness Readings: The operator should always qualify abnormal/questionable thickness indications. While such indications may be caused by corrosion/erosion, the use of wrong material thickness. internal flaws, certain other materials, or gage factors (as discussed).

Material Stacks: It is not possible to gage the stack thickness of uncoupled material sheets piled upon one another because ultrasound reflects totally from the bottom surface of the outer sheet

ACCESSORIES

Standard Accessories: The standard CB110 Kit contains the gage (batteries installed), Standard Probe, Probe Cable, Plastic Couplant Bottle, Operating Manual.

Optional Accessories: Detachable Wriststrap, Flared Probe Holder, , and Accessory Carrying Case. Other accessories include Mini-Probes with top or side-mounted integral cables. Ultrahigh-Temperature Probe, Hi-Power Probe, Probe Cables, Spring-Loaded V-Groove Probe Housings and a Slip-On Protective Leather Case for the gage.

Probes Available

TG-505R "Standard"	**STANDARD PROBE** Dual-element, top-mounted microdot connectors, 0.040 to 20.00 inches thickness range, 5 MHz, 0.375 inch diameter element 0.60 inch diameter by 1.30 inch long case. "Requires LMD1 cable (not included).
HAMMER-01	HAMMER Cylinder Bore Inspection System. Bore size range 3.25" to 4.5". Incorporates pressurized sensor coupling vessel for smooth and even Section Scans
HAMMER-02	HAMMER Cylinder Bore Inspection System. Bore size range 2.5" to 3.5". Incorporates pressurized sensor coupling vessel for smooth and even Section Scans
PORT-01	Miniature Swivel Sensor Assembly used for the majority of cylinder head port work – Dual Element Range 0.040" to 2" Mild Curvature of face for flat to moderately curved inspection surfaces. , 5 MHz, 0.22 inch diameter element, 0.325 inch diameter contact face by 0.45 inch tall case. Sensor mounted at the end of a 6" long handle assembly. Includes Informative 25+ Min. CD Video on Port Inspection Tips & Tricks & Techniques. "Requires LMD1 cable (not included).
PORT-02	**Miniature Swivel Sensor Assembly** used for the majority of cylinder head port work – Dual Element Detachable Cable, 0.040 to 2 inches thickness range. Face radiused to fit within smaller radii down to 0.75". 5 MHz, 0.22 inch diameter element, 0.325 inch diameter contact face by 0.45 inch tall case. Sensor mounted at the end of a 6" long handle assembly. Includes Informative 25+ Min. CD Video on Port Inspection Tips & Tricks & Techniques. "Requires LMD1 cable (not included).
PORT-03	**Miniature Swivel Sensor Assembly** used for the majority of cylinder head port work – Dual Element Detachable Cable, 0.025 to 1 inches thickness range. Face radiused to fit within smaller radii down to 0.75". 7.5 MHz, 0.22 inch diameter element, 0.325 inch diameter contact face by 0.45 inch tall case. Sensor mounted at the end of a 6" long handle assembly. Includes Informative 25+ Min. CD Video on Port Inspection Tips & Tricks & Techniques. "Requires LMD1 cable (not included).
CB110DT	**DATA TRANSFER CABLE & WINDOWS BASED CB110-XFER Data Transfer Software** Connects CB110 to RS-232 port of PC for download of logged Engine and other data. Software prepares and prints Professional Cylinder Bore Reports for customer presentation. ANOTHER EXCLUSIVE!!
LMD1	**PORT Series PROBE CABLE** Dual coaxial cable, 6 feet long, Microdot and miniature Lemo connectors.
LC110	**LEATHER SLIP-ON INSTRUMENT CASE** Contoured leather case with cutouts for instrument display, push-button controls and probe connectors, a snap lock integral handhold or belt loop.
CC110	**EQUIPMENT CARRYING CASE** Pelican Style Carry Case, with custom cutout foam padding & plastic couplant squeeze bottle. (Case provided as part of all CB110 Packages, this is a replacement case should yours be misplaced).

CB110 Sidewinder - Users Manual

WARRANTY

NDT Systems, Inc. (hereinafter NDT Systems) warrants that reasonable care was used in the choice of materials and the manufacture of this instrument, and that the instrument conforms to the published ratings and characteristics applicable to the instrument at the time the instrument is shipped to the Buyer. This warranty shall extend for a period of one year from the date of shipment of the instrument (FOB Seller's plant) and shall in no event extend beyond such term. The Buyer shall notify NDT Systems by registered or certified mail, return receipt requested, of any claim of discovery of such defect. Failure to notify NDT Systems within the time and in the manner specified herein shall constitute a waiver of any such claim of defect or breach of warranty. The final determination of the existence of a defect or breach of this warranty shall be made by NDT Systems. This warranty shall extend to the Buyer only, and shall not be assignable or transferable to any other person.

DISCLAIMER OF WARRANTIES

THERE ARE NO WARRANTIES. EXPRESS OR IMPLIED. INCLUDING ANY IMPLIED WARRANTY OF MERCHANT ABILITY OR FITNESS FOR A PARTICULAR PURPOSE. OTHER THAN THOSE WARRANTIES SET FORTH IN THE PARAGRAPH ENTITLED "WARRANTY' ABOVE.

The above warranty shall not apply to digital panel meters and items with a limited life, such as batteries, probes or cables, nor to any instruments which have been subjected to misuse. improper installation or repair, alteration. or use beyond the published maximum ratings of the instrument.

BUYER'S REMEDIES

The Buyer's sole and exclusive remedy for breach of the above warranty shall be the repair or replacement (at the discretion of NDT Systems) of the instrument by NDT Systems free of charge. The Buyer shall return the instrument to NDT Systems. transportation prepaid. NDT Systems shall promptly repair or replace the instrument and return same to Buyer, FOB Seller's Plant, collect.

If. for any reason. NDT Systems is unable or unwilling to repair or replace the instrument or because of circumstances, the exclusive remedy provided herein fails of its essential purpose, or operates to deprive either party of the substantial value of its bargain then the Purchaser's exclusive remedy will be the return of the purchase price for the instrument. The liability of NDT Systems shall in no event be greater then the full amount of the purchase

price for the instrument.

Any attempt by NDT Systems to repair or replace any instrument sold hereunder shall not constitute an admission that the instrument, or any part thereof, is defective within the meaning of the above warranty, nor that NDT Systems has any legal responsibility to make such repair or effect such replacement.

Any such attempts, if unsuccessful, shall not create any liability on the part of NDT Systems and the purchaser is limited to the remedy set forth herein.

LIMITATIONS ON LIABILITY

NDT Systems shall not, under any circumstances, be liable for direct. incidental or consequential damages for any breach of contract, breach of warranty or misrepresentations. including the negligence of NDT Systems, including, but not limited to damages resulting directly or indirectly from the use, or loss of use. of the instrument sold hereunder, or the business of the Buyer or third persons wherein the instrument is utilized.

The above warranty and the obligations of NDT Systems hereunder, are expressly in lieu of, and the Buyer expressly waives, any other liability of NDT Systems based upon warranty, express of implied, contract, or the negligence of NDT Systems including but not limited to. negligence in the design of the instrument or in the choice of the materials therefor. or negligence in the repair or replacement of the instrument, whether such repair or replacement is required by the terms hereof or is voluntary, upon the part of NDT Systems.

Except as provided herein. no person is authorized to assume on behalf of NDT Systems any other or additional liability or responsibility in connection with the instrument. These terms and warranty are applicable to and complete acceptance of such a binding legal agreement.

NDT Systems, Inc.
17811 Georgetown Lane Huntington Beach, CA 92647
Jan 2004 (714)893-2438