REED

Model ST-156

Ultrasonic Thickness Gauge

Instruction Manual

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Features

- Dual technology provides automatic recognition for ferrous and non-ferrous metal substrates
- Magnetic induction for ferrous metal substrates
- Eddy current measurement for non-ferrous metal substrates
- One or two point calibration
- User-settable high/low alarms
- Easy Zero calibration
- Min, Max, and Average functions
- Memory stores up to 400 readings
- Easily delete single or group readings
- Auto-Power-off function Backlight
- Measurement Range: 0 to 1250 µm (0 to 49 mils)

Specifications

Working Temperature:	0°C - 40°C (32°F - 104°F)
Working relative humidity:	20% - 90%
Power Supply:	2 AA batteries
Dimensions:	110 x 50 x 23mm
Weight:	100g
Includes:	2 AAA batteries, plastic carrying case, steel and aluminum substrate, USB connecting cable, and a Program disc for Windows 98/2000/XP/Vista/7

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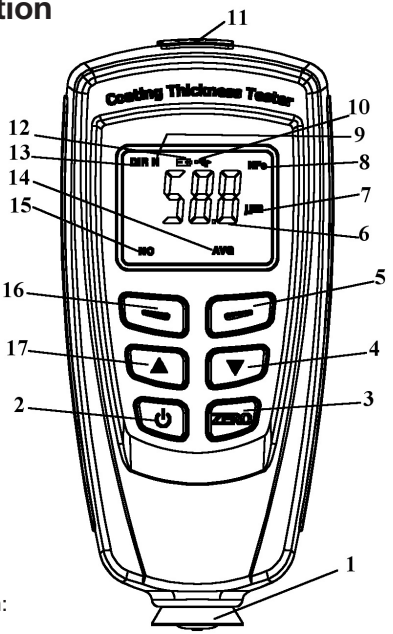
Sensor probe	F	N
Working Principle	Magnetic induction	Eddy current principle
Measuring Range	0-1250um, 0-9.21mils	0-1250um, 0-49.21mils
Guaranteed Tolerance of Reading	0-850um (+/-3%+1um), 850um-1250um(+/-5%), 0-33.46mils (+/-3%+0.039mils), 33.46mils-49.21mils (+/-5%)	0-850 um(+/-3%+1.5um), 850um-1250um(+/-5%), 0-33.46mils (+/3%+0.059mils), 33.46mils-49.21mils (+/-5%)
Precision	0-50um (0.1um), 50um-850um (1um), 850um-1250um (0.01mm), 0-1.968mils (0.001mils), 1.968mils-33.46mils (0.01mils), 33.46mils-49.21mils (0.1mils)	0-50um (0.1um), 50um-850um (1um), 850um-1250um (0.01mm), 0-1.968mils (0.001mils), 1.968mils-33.46mils (0.01mils), 33.46mils-49.21mils (0.1mils)
Minimum Curvature Radius	1.5mm	3mm
Diameter of Minimum Area	7mm	5mm
Basic Critical Thickness	0.5mm	0.3mm

For service on this or any other REED product or information on other REED products, contact REED Instruments at info@reedinstruments.com

Instrument Description



1. Probe
2. Power ON/OFF Button
3. Zero Calibration Button
4. Down/Right Button
5. Blue Bar Button
6. Main display
7. Measuring unit
8. NFe (non-ferrous)/ Fe (ferrous)
9. Indicates the probe working principle: AUTO, Magnetic induction, or Eddy current
10. Indicates that the meter is currently controlled via PC
11. USB connecting port
12. Low Battery Indicator
13. Working mode indication: DIRECT or GROUP
14. Statistic display: AVG, MAX, MIN, SDEV
15. The statistic number of measuring readings
16. Red Bar Button
17. Up/Left Button

Operating Instructions

System Menu Arrangement

Press the Power Button to turn the meter on; the gauge will default to measuring mode. Press the Red Bar Button to enter Menu. The following illustrates how the Menu system is arranged:

Menu
>Statistic view
  >>Average view
  >>Minimum view
  >>Maximum view
  >>Number view
  >>Sdev. view
>Options
  >>Measure mode
    >>>Single mode
    >>>Continuous mode
  >>Working mode
    >>>Direct
    >>>Group 1
    >>>Group 2
    >>>Group 3
    >>>Group 4
  >>Used probe
    >>>AUTO
    >>>Fe
    >>>No Fe
  >>Unit settings
    >>>um
    >>>mils
    >>>mm
  >>Backlight
    >>>ON
    >>>OFF

(Continued under Options)
  >>LCD Statistic
    >>>Average
    >>>Maximum
    >>>Minimum
    >>>Sdev.
  >>Auto power off
    >>>Enable
    >>>Disable
>Limit
  >>Limit settings
    >>>High limit
    >>>Low limit
  >>Delete limit
>Delete
  >>Current data
  >>All data
  >>Group data
>Measurement view
>Calibration
  >>Enable
  >>Disable
  >>Delete Zero N
  >>Delete Zero F

Basic Settings

Please refer to the Menu arrangement. Press the Red Bar Button to enter the Menu. Press the Up and Down Buttons to scroll through the Menu. Press the Red Bar Button for OK/Yes/Menu/Select functions, and the Blue Bar Button for Esc/No/Back functions.

Measuring Modes

Continuous Mode: In Continuous Mode, the probe is not lifted off the surface being measured. Readings are not accompanied by a beep. All readings taken in this mode are automatically entered into the statistics program as long as sufficient memory is available.

Single Mode: In Single Mode, the probe is lifted off the surface being measured and moved. Readings are accompanied by a beep. All readings taken in this mode are automatically entered into the statistics program as long as sufficient memory is available.

Probe Operating

The probe can work in three modes:

AUTO: The probe can automatically select the working mode. When placed on steel (magnetic substrates), it will work in magnetic induction principle. When placed on no-ferrous metals, it will work in eddy current principle.

Fe: The probe works in magnetic induction principle.

No-Fe: The probe works in eddy current principle.

Unit Settings

You can switch from Metric units (um, mm) to Imperial (mils) units. In “um” mode, the unit will switch to “mm” automatically when value of reading exceeds 850um. See the Specification section for more details.

Total-Reset

The Total-Reset function erases all data from memory. This includes all sets of readings of all work modes plus their associated statistics, calibration values and tolerance limits.

1) Switch off meter.
2) Press the Zero Calibration Button and the Power Button simultaneously.
3) The screen will display “SURE TO RESET”. Press the Red Bar Button for YES, or the Blue Bar Button for NO.
4) The meter will restart automatically.

Backlight

While in Measuring Mode, press the Blue Bar Button to switch the Backlight ON or OFF. You can change the Backlight default to ON or OFF in the Menu.

Statistic View

While in the Menu, choose “Statistic View” to toggle between Average, Maximum, Minimum and Standard Deviation functions. Press the Red Bar Button to select the current Statistic View and to return to measurement mode. A corresponding symbol of the Statistic View will be displayed on the lower right of the LCD. At the same time, the statistic number of the measured readings will display on the lower left of the LCD. Via the “Statistic View” in the Menu, you can look through all statistic values for a current group.

Measurement View

In the Menu, choose “Measurement View” to look through all measurement readings for current group.

Auto Power Off

The meter will power off automatically after 3 minutes of inactivity, or you can disable Auto-Power-Off via the Menu.

Direct and Group Mode

This meter offers two operating modes: Direct and Group Mode. In the Menu, choose “Options”, and select “Working mode” to select to work in either Direct Mode or to select a Group.

Direct Mode is intended for quick and occasional readings. In this mode, individual readings are logged to the memory provisionally. When the meter is turned off or switched to GROUP Mode, all readings will be deleted, but the statistic values won’t be changed until you take new measurements. The readings and statistical values can be shown on the LCD screen. The statistical analysis program can evaluate 80 readings. When the memory is full, new readings will replace old readings. In this mode, it has individual calibration values and limit values.

In Group Mode, there are four memory groupings that can store a maximum of 80 single readings, and 5 statistic values. Calibration values and limit values can individually be set and stored for every group. When the memory is full measuring will still continue, but will not be stored and statistic values won’t be changed. You can delete group data and statistic values, and reset the calibrate values and limit values. When measuring in GROUP Mode, the symbol “GROx” will appear on the LCD screen. Press the Power Button while holding the probe in the air, the meter will switch to DIRECT mode, and the last reading will be shown (if available).

Calibration Methods

There are four different methods available for calibration:
Basic calibration: Recommended for measurements on even surfaces and if the measuring object has the same material, size, and curvature as the zero plate attached in the casing.
Zero-point calibration: Recommended if measuring errors up to +-(3% of reading plus constant error of probe) are permitted (Example: Fe 1um; no-Fe 1.5um).
One-point calibration (calibrating using calibration foil): Recommended if expected readings are close to the calibration value and if the permitted error of probe is max. +-(1%...3% of reading plus constant probe error).

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Two-point calibration (using a set of two calibration foils):
a) Recommended for measurements on rough surfaces
b) Recommended for precise measurements on smooth surface if the thickness to be expected lies between that of the two calibration foils

Storing Calibration Values

If the meter is calibrated for a particular purpose, the calibration values will be stored in memory until changed.
The calibration procedure should be restarted from the beginning if:

- An incorrect reading has been taken
- An incorrect command has been entered
- The meter has been switched off

Calibration Example

Calibration is the required for accurate measurements. The more closely the calibration sample matches the product sample, the more accurate the calibration, and therefore the reading will be. If for instance, a product is to be measured on a steel cylinder, quality ST37 (mild steel), diameter 6mm, the calibration of the uncoated sample must take place on a steel cylinder of similar quality with the same diameter. The calibration sample must correspond to the product sample in the following ways:

- Curvature radius
- Substrate material properties
- Substrate thickness
- Size of measuring area
- The point at which the calibration is made on the calibration sample must always be identical with the point of measurement on the product itself, especially in the case of corners and edges of small parts

High-Accuracy Calibration

To achieve high-accuracy readings, it is advisable to log calibration values (both zero values and calibration foil values) several times in succession. In this way, the gauge will automatically establish a mean calibration value. For more details see Calibration Tips. The high-accuracy calibration is an obvious advantage when calibrating on uneven, e.g. shot-blasted, surfaces.

Cleaning the Measuring Point

Before calibration the probe tip must be free from grease, oil, scraps of metal, etc. The slightest impurity will affect measurement and distort readings.

Calibration Tips

Basic Calibration should only be used for measurements on even surfaces, i.e. on steel components made of conventional steel (mild steel) or on aluminum components. First select “Calibration Mode” via the Menu (Menu->Calibration->Enable). The LCD screen will display “Cal n (or 1 - 2) Zero n (or y)”. The “n” means “Not any point calibration and Zero calibration”, and “y” means “There is Zero calibration”. “Cal 1 - 2” means “There is One or Two point Calibration”. After finishing all Calibrating, we advise that you disable calibration via the Menu.

Preparing for Calibration

1) Switch the meter on, being sure the meter is at least 10cm (4”) away from any metals.
2) Substrate sample and necessary foils (calibration standard).
3) Set the Measuring Mode to Continuous or Single via the Menu.

Zero-point Calibration

1) Vertically place the probe on an uncoated sample (zero coating thickness).

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2) The LCD screen will display <x.x um>. Operating is different in Continuous Mode and Single Mode, see the “Measuring Mode” section for more details. Then, raise the probe at least 10cm (4”) away from the metal substrate.
3) Press and hold the Zero Calibration Button for about 1.5 seconds. When the LCD screen displays “0.0 um”, the calibration is finished.
4) Repeat this procedure several times. The calibration system always saves the mean value of the previous calibration point.

NOTE: You can delete the old Zero-point Calibration before making a new Zero-point Calibration via the Menu. The meter calculates the means of a max of 5 calibration readings. When full, the newest calibration value will replace the oldest calibration value. We suggest that you make a Zero Calibration when starting any measurement.

One-point Calibration

This method is recommended for high precision measurements, measurements on small parts, and on hardened and low-alloy steel.

1) Zero-point Calibrate according to the Zero-point Calibration instructions.
2) Lay the calibration foil on an uncoated sample, apply the probe and raise it if steady. Press Up or Down to adjust required foil thickness. The thickness of the foil should be roughly equivalent to the estimated coating thickness.
3) Repeat Step 2 about 5 times. It will get the mean value of previous calibration readings.
4) Now take readings by placing the probe on the coating and raise it if steady. It may be necessary to delete calibration, e.g. after entry of a faulty calibration value: MENU->delete->delete group data (**NOTE**: It will delete all data, limit data, one-point and two-point calibrations except for zero-point calibration). This will reactivate the default basic calibration for use on even surfaces.

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NOTE: The meter calculates the mean of a max of 5 calibration readings. When full, the newest calibration value will replace the oldest calibration value. Press Blue Bar Button to exit current calibration, or after 30 seconds the calibration will be become effective automatically. Press the Zero Calibration Button to make the current calibration effective. Even while a series of measurements is being taken, foil calibration can be carried out often as necessary. The old calibration will be overwritten; the Zero Calibration remains in memory.

Two-point Calibration

The meter needs to be in Single Mode (see "Working Mode" for instructions) for Two-point Calibration. This method requires the use of two different foils, a thin foil, and a thicker foil (about 1.5 times as thick as the thin one.) For best results, the thickness to be expected should be somewhere between the two calibration values. This method is suitable for taking measurements on rough shot-blasted surfaces or for high-precision readings. It is recommended to take 5 measurements as to reduce the effect of scattering, which occurs during calibration of upper and lower values. The calibration foils may be used in any order.

1) Zero-point Calibrate according to the instructions in "Zero-point Calibration" section.
2) One-point Calibrate according to the instructions in "One-point Calibration" section.
3) Repeat Step 2.
4) Take readings by placing the probe on the coating to be measured and raise it after the beep. The reading will show on the display.

NOTE: Apply the probe to the test sample several times. The thickness of the foil should be roughly equivalent to the estimated coating thickness. Even while a series of measurements is being taken, foil calibration can be carried as often as necessary. The old calibration will be overwritten; the Zero-point Calibration remains in memory until another is made.

Shot-blasted Surfaces

The physical nature of shot-blasted surfaces results in coating thickness readings that are too high. The mean thickness over the peaks can be determined as follows (not that the statistics program is of great benefit in this procedure).

Method A: The meter should be calibrated according to One or Two-point Calibration procedures. Use a smooth calibration sample with the same curvature radius and the same substrate as the later measuring sample. Now take approximately 10 readings on the uncoated, shot-blased sample to produce the mean value “Xo”. Then take approximately 10 readings on a coated, shot blasted test sample to produce the mean value “Xm”. The difference between the two mean values is the mean coating thickness “Xeff” over the peaks. The greater standard deviations of the two values “Xm” and “Xo” should also be taken into consideration: Xeff=(Xm-Xo)±S

Method B: Carry out a Zero-point Calibration of 10 readings on a shot-blased, uncoated sample. Then carry out a Foil Calibration on the uncoated substrate. The foil set should consist of a number of individual foils of max 50 microns thickness each, and should roughly correspond to the estimated coating thickness. The coating thickness can be read directly on the display and should be averaged from 5-10 single measurements. The Statistics Function is useful here.

Method C: This method also gives reliable results. Simply follow the Two-point Calibration method using two foils as described in the “Two-point Calibration” section. For a maximum approach to the respective nature of the surface, the foil value can be reached by using several foils, 50um each. The mean coating thickness should be calculated from 5-10 readings. The Statistics Function is very useful here.

NOTE: For coatings thicker than 300um, the influence of roughness generally is of no importance and it will not be necessary to apply above calibration methods.

General Remarks on Measurement

After the calibrations have been made, all subsequent measurements will lie within the guaranteed measuring tolerance. Strong magnetic fields near generators or live rails with strong currents can affect the reading. When using the Statistics Function for obtaining a mean value, it is advisable to place the probe several times at a typical measuring spot. Any false readings or outliers can be removed immediately via the Menu. The final reading derives from the statistical calculation and from the guaranteed tolerance levels of the gauge.

Coating Thickness D = X ± s ± u
Example:
Readings: 150um, 156um, 153um
Mean value: X = 153um
Standard deviation: s= ± 3um
Measuring uncertainty: u = ± (1% of reading + 1um)
D = 153 ± 3 ± (1.53um + 1um) = 153 ± 5.5um

Limit Function

Limits can be entered in Direct Mode and a selected Group memory at any time. Any reading, which falls outside the set tolerance limits, will be registered by a warning indication:

H: Reading above the HI limit
L: Reading below the LO limit

The limit values can be set by via the Menu. Press the Up or Down arrows to scroll between the High or Low limits. Select the limits with the Blue Bar Button, adjust the value with the Up and Down Buttons, and press the Blue Bar Button again to confirm the limit.

Using Statistics

The meter calculates statistics from a maximum of 80 readings (GRO1 - GRO4: a total maximum of 400 readings can be stored). In addition, readings can't be stored while in Direct Mode, but it can calculate statistics as GRO1 - GRO4. When the meter is turned off or the Work Mode setting has been changed, DIRECT statistics will be lost. The following Statistical Values are calculated:

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NO.: Number of readings in Work Mode
AVG: Average value
Sdev.: Standard deviation
MAX: Maximum reading
MIN: Minimum reading

Statistical Terms

Average Value

The sum of readings divided by the number of readings: $\overline{x} = \sum x/n$

Standard Deviation (Sdev.)

The sample standard deviation is a statistic that measures how "spread out" the sample is around the sample mean. The sample standard deviation increases with increasing spread out. The standard deviation of a set of numbers is the root mean square of the variance S2. The variance of a list is the square of the standard deviation of the list, that is, the average of the squares of the deviations of the numbers in the list from their mean divided by the (number of readings -1).

Variance S2= $\sqrt{S^2}$

Standard deviation S= $\sum (x - \overline{x})^2 /(n-1)$

NOTE: Deletion must take place immediately after an outlier or erratic reading has been taken. See the "Delete Functions" section for more information.

Storage Capacity Overflow

In Group Mode, if the storage capacity is exceeded, statistics will not be updated, although measurements can continue. If the memory is full, subsequent readings will omitted from the statistics. They will be marked with "FULL" on the LCD screen (when in single measuring mode). In Direct Mode, if the memory is full, the newest reading will replace the oldest reading, and statistics will be updated.

Delete Function

In the Menu, you can find following functions:

Delete Current Data: If you find the last measured reading is wrong, you can delete it via this function. At the same time, the statistics will be updated.

Delete All Data: You can delete all data and statistics of the Current Work Mode.

Delete Group Data: In addition, this function will delete High Alarm, Low Alarm, and One and Two-point Calibration Values

Meter Control via PC

All measured readings of all work modes can be downloaded to PC via USB port for data analysis. See software guide for more details.

Trouble Shooting

The following list of error messages explains how to identify and eliminate faults.

Err1, Err2, Err3: Connecting of probe fault; Deviant signal
Err1: Eddy current probe
Err2: Magnetic induction probe
Err3: Both probes
Err4, 5, 6: Reserved
Err7: Thickness fault

Battery Replacement

1) Place the meter upside down on a suitable surface
2) Remove the screws from the battery compartment with a cross tip screwdriver
3) Raise the lid of the Battery Compartment
4) Remove battery
5) Insert new battery
6) Close the lid and fasten with screw

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