English

Elcometer 456²

Coating Thickness Gauge

Top Models

Operating Instructions



These instructions apply to the following Elcometer 456[2] models:

- Ferrous (F)
- Non-Ferrous (NF)
- Dual Ferrous/Non-Ferrous (FNF)

Equipment described in these instructions is covered by the following Patents:

FNF UK Patent No: GB2306009B

FNF US Patent No: 5886522

F1 2 UK Patent No: 2367135B

F1 2 US Patent No. US 6,762,603

F1 2 German Patent Pending

This product meets the emc directive 89/336/EEC, amended 92/31/EEC and 93/68/EEC

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Thank you for your purchase of this Elcometer 456^2 Coating Thickness Gauge. Welcome to Elcometer.

Elcometer are world leaders in the design, manufacture and supply of coatings inspection equipment. Our products cover all aspects of coating inspection, from development through application to post application inspection.

The Elcometer 456^2 Coating Thickness Gauge is a world beating product. With the purchase of this gauge 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 Elcometer 456^2 Coating Thickness Gauge is a handheld gauge for fast and accurate measurement of the thickness of coatings on metal substrates.

The gauge is available in three versions; Basic, Standard and Top. This manual describes the operation of the **Elcometer 456^2 Top**.

All versions of the gauge feature an easy-to-use menu driven graphical interface which guides the user through tasks such as gauge configuration and calibration adjustment.

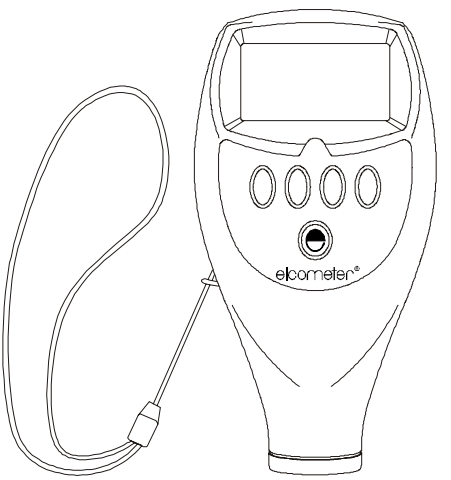


Figure 1. Elcometer 456^2 Coating Thickness Gauge

The gauge is available either with a built-in integral probe or as a separate probe version. A wide range of probes is available to suit requirements - see page 47. Separate probes may be standard, miniature or Plug in Integral Probes (PINIP™), and must be ordered separately.

1.1 Features

- A range of smooth and rough surface calibration adjustments.
- Menu driven backlit graphical user interface.
- Interchangeable probes (separate versions only).
- Statistics.
- Infrared interface.
- RS232 interface.
- High/low limits.
- Memory of up to 50 000 readings in up to 999 batches.
- Clock/alarm.
- Date and time stamping.

1.2 Standards

The Elcometer 456^2 can be used in accordance with the following National and International Standards:

Ferrous (F)	**Non-Ferrous (NF)**
BS 5411 (11)	BS 5411 (3)
BS 3900 (C5)	BS 3900 (C5)
ISO 2178	BS 5599
ISO 2808	ISO 2360
BS EN ISO 1461	ISO 2808
DIN 50981	DIN 50984
ASTM B 499	ASTM D 1400
ASTM D1186	ASTM B 244
ISO 19840	
SSPC-PA2 (2004)	

1.3 What this box contains

- Elcometer 456² Gauge with integral probe, or

  Elcometer 456² Gauge and separate probe (probe must be ordered separately)
- Calibration foils
- Gauge carrying pouch
- Wrist harness
- Batteries
- CD containing data collection software
- PC connection cable
- Operating instructions

1.4 Conventions in these instructions

The Elcometer 456² is controlled using a simple menu structure which helps you get the most from your gauge - see page 18.

As an example, the LANGUAGES option which is in SETUP from the MAIN MENU would be shown in these instructions as **MENU/SETUP/LANGUAGES**.

These instructions include images of Elcometer 456² screens with units set to microns (µm). Similar screens will be seen when the gauge is set to other units such as mils or inches.

1.5 Quick-start

To quickly configure the gauge and start taking readings:

1. Fit batteries: see page 6
2. Fit probe (separate versions only): see page 7
3. Switch on: see page 9
4. Select language: see page 11
5. Try taking a reading: see page 13
6. Adjust calibration: see page 25

The gauge is now configured and ready to use.

To maximise the benefits of your new Elcometer 456², please take some time to read these Operating Instructions. Do not hesitate to contact Elcometer or your Elcometer supplier if you have any questions.

2 GETTING STARTED

2.1 Fitting the batteries

1. Open battery compartment cover; press down in direction of arrow using thumb nail.
2. Insert 2 x LR03 (AAA), alkaline dry batteries taking care to ensure correct battery polarity (Figure 2).
3. Close battery compartment cover.

Rechargeable batteries can be used but they will only have 25% to 30% of the life of alkaline batteries.

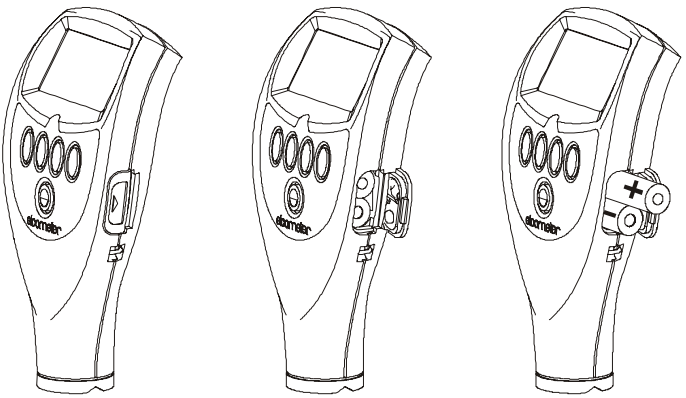


Figure 2. Fitting batteries - ensure correct battery polarity

2.2 Battery condition.

Symbol	Battery condition/action required
	100%
	66% to 100%
	33% to 66%, replacement recommended.
	16% to 33%, replacement required.
	<16%, gauge beeps every 10 seconds and symbol flashes - immediate replacement required.
	5 loud beeps, gauge switches off automatically.

2.3 Fitting probes (separate versions only)

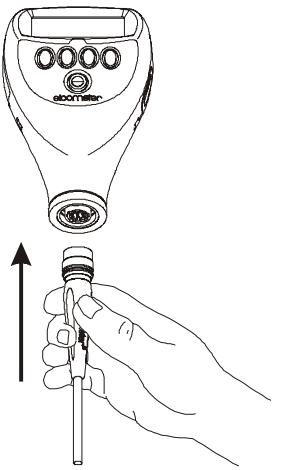
To ensure correct transfer of data from the probe and detection of the new probe, the gauge **must be switched off** when separate probes are fitted.

A probe must be calibrated once it has been fitted - see “Calibration adjustment” on page 25.

2.3.1 To fit the probe

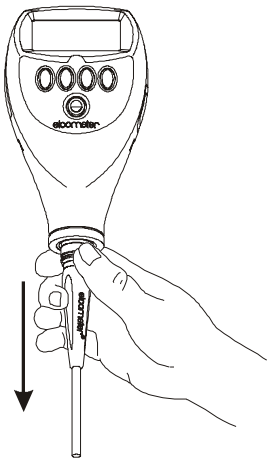
Align connector keyway and push in direction shown. The connector locks automatically.

Note: The design of the probe connector allows some movement between the probe and the gauge. This is intentional and does not affect measurement performance.



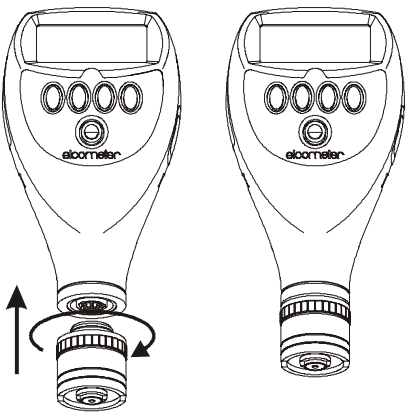
2.3.2 To release the probe

Grasp knurled section and pull gently away from the gauge. The connection will unlock and the probe will release.



2.3.3 To fit the PINIP™

Twist the PINIP™ until the connector locates. Taking care not to cross the threads, lock the probe by turning the locking ring 1½ times clockwise, or until tight.



2.4 The controls

The gauge is operated by 5 keys (Figure 3).

- On/Off key : Switches the gauge on or off.
- Softkeys: The function of these keys varies and is described by symbols and writing on the bottom line of the screen.
- LED: Red/green flashes when the gauge is switched on, green flashes when a reading is taken. Also indicates when a reading is inside or outside limits - see “Set limits” on page 43.

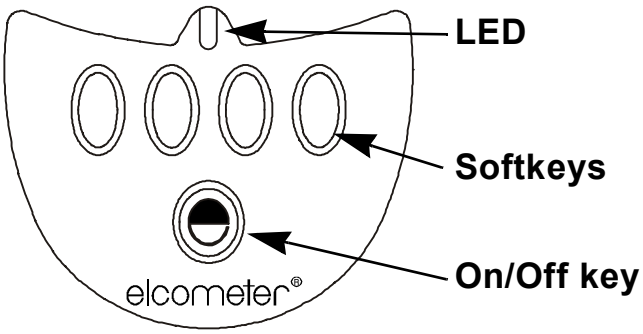
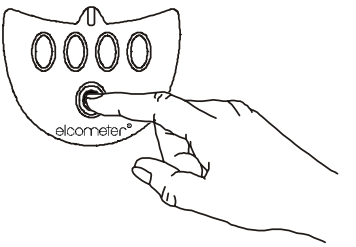


Figure 3. Elcometer 456² control keys

2.5 Switching the gauge on

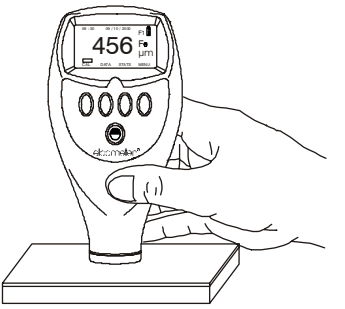
Gauges with separate and PINIP™ probes:

Press key to switch on gauge.



Gauges with integral probes:

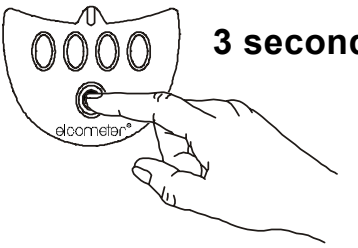
Press key to switch on gauge, or place the probe on a surface.



Note: Before switching the gauge on for the first time read “Selecting a language” on page 11.

2.6 Switching the gauge off

To switch off all gauge types, press and hold key for 3 seconds. The gauge will beep, two single tones followed by a double tone.



The Elcometer 456^2 switches itself off 60 seconds after the last operation unless the Auto Switch Off time is changed (**MENU/SETUP/AUTO SWITCH OFF**). The Auto Switch Off feature can be set to a maximum of 10 minutes or can be deactivated - see “AUTO SWITCH OFF:” on page 24.

2.7 The screen

Familiarise yourself with the Elcometer 456^2 screen. The screen displays:

- Welcome information
- Measurement information
- Menus to configure the gauge and control functions
- Help and miscellaneous information

When the gauge is switched on a welcome information screen may be displayed briefly (Figure 4).



Figure 4. Typical Elcometer 456^2 welcome screen

The screen where readings are displayed is called the Reading Screen (Figure 5). The reading screen can also include statistics if this option is selected.



Figure 5. Typical Elcometer 456^2 reading screen

2.8 Selecting a language

The Elcometer 456[2] has over 20 built-in languages. When the gauge is switched on for the first time after dispatch from the Elcometer factory the display will show the language selection screen (Figure 6).



Figure 6. Language selection screen

2.8.1 At first switch on

1. Press **Up/Down** softkeys to locate language required.
2. Press **SEL** softkey to activate the selected language.

   The screen displays an Elcometer 456[2] welcome screen (Figure 4) followed by the reading screen (Figure 5).

   The gauge operates in the new language until changed.

2.8.2 At any time

1. Switch gauge off.
2. Press and hold left hand softkey.
3. Press key to switch on gauge.

   The display will show language selection screen with current language highlighted by cursor.
4. Release left hand softkey.

   Follow the instructions given in 2.8.1.

Alternatively, select **MENU/SETUP/LANGUAGES** - see “Main MENU - Extended menu on” on page 18.

2.9 Interfaces

The gauge is fitted with an infrared interface (Figure 7) which allows information to be sent to a suitable printer.

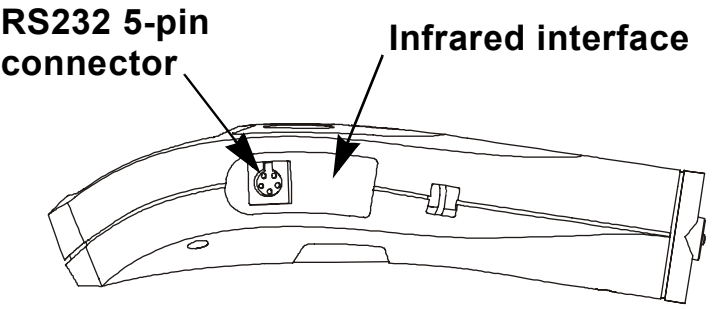


Figure 7. Infrared and RS232 interfaces

The RS232 5-pin connector next to the infrared interface is used with the PC connection cable to connect the gauge to a PC. This enables personalised screens to be downloaded to the gauge (see “Personalised welcome screen” on page 50) and measurement data to be transferred to a PC or printer.

For information on the range of Elcometer data collection software see “Transferring readings to a computer” on page 45.

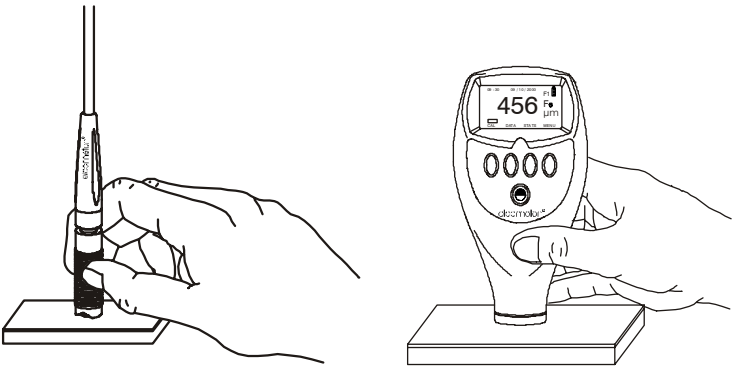
3 TAKING A READING

3.1 Before you start

- *Are you using the correct type of probe?*
  See “Probes” on page 47.
- *Is the probe calibrated?*
  See “Calibration adjustment” on page 25.
- *Do you require statistics?*
  See “Statistics” on page 34.
- *Do you want to save readings in memory?*
  See “Batching” on page 37.
- *What units of measurement do you want to use?*
  See “UNITS:” on page 23.

3.2 Procedure

1. Press  key to switch on gauge.
2. Place probe on surface to be measured. **The reading may be inaccurate if the probe is not held as shown in Figure 8**.



Separate probe **Integral probe**

Figure 8. Taking a reading

3. Reading is displayed on screen (Figure 9).

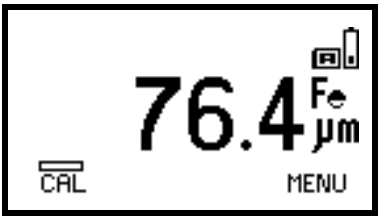


Figure 9. Typical reading

4 THE READING SCREEN AND MENUS

4.1 Reading screen

The content of the reading screen (Figure 10, Figure 11) depends upon the type of measurement being made and how the gauge is set up.

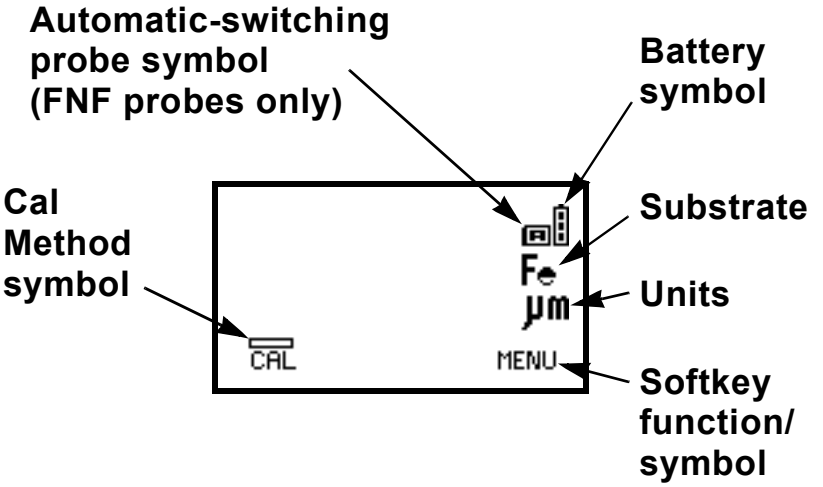


Figure 10. Example of reading screen with smooth surface calibration method selected

CAL. Operates selected calibration adjustment method.

MENU. This opens the main **MENU** of the gauge and provides access to user-selectable features - see page 18.

Note: If **CAL** softkey symbol is flashing the gauge should be recalibrated. This is due to the calibration adjustment method having been changed or a probe change - see “Calibration adjustment” on page 25. Batches cannot be created while the **CAL** softkey symbol is flashing.

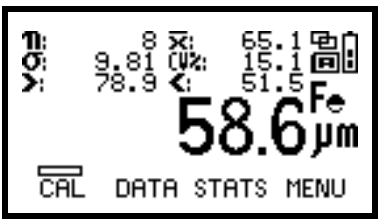


Figure 11. Reading screen in extended mode and showing full set of statistical values.

4.2 Main MENU

Gauge configuration and measurement functions are controlled using menus (Figure 12). The structure of the menus is shown on page 18.

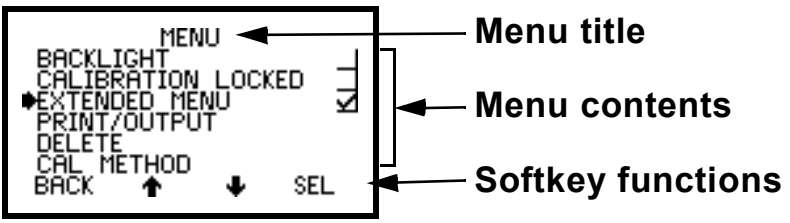


Figure 12. Typical Elcometer 456² menu

Some screens allow the status of a feature to be changed e.g. on to off or select or deselect, etc. A tick box ❑ indicates this type of feature. A tick against a menu item indicates the function is activated or selected.

SEL softkey selects the option displayed and in some cases toggles the status of a tick box off/on.

Up/Down softkeys ↑ ↓ move the cursor to the menu item required. The menus scroll up/down and a line across the screen indicates the start and end of the menu.

BACK softkey returns the gauge to a previous screen. Holding this softkey down will rapidly exit from any menu and return to the reading screen.

4.2.1 Simple and extended menus

The Elcometer 456² Top Gauge has two menu structures:

Extended menu off (simple menu mode): The gauge is shipped from the Elcometer factory with **EXTENDED MENU** turned off. In this simple menu mode the gauge can be calibrated and used to take measurements. This is the ideal setting for users who do not require access to advanced features of the gauge.

Extended menu on (extended menu mode): Additional items are automatically added to the **MENU** and the **STATS** softkey and **DATA** softkey are activated. These give access to more advanced functions such as statistics, batching, calibration method, print/output, setup, etc.

4.3 Main MENU - Extended menu off



Figure 13. Main menu - extended menu off

4.3.1 BACKLIGHT

Switches backlight on and off. Toggle tick box to activate/deactivate. With **BACKLIGHT** activated the display is illuminated for approximately 5 seconds when a reading is taken or a key pressed.

Note: The battery life is reduced by about one third when the backlight is activated.

4.3.2 CALIBATION LOCKED

Protects against inadvertent calibration adjustment. Toggle tick box to activate/deactivate. If **CAL** softkey is pressed while **CALIBRATION LOCKED** is activated the gauge displays **CALIBRATION LOCKED USE MENU TO UNLOCK**. The message disappears after 3 seconds.

4.3.3 Extended MENU

Provides access to additional features. Toggle tick box to activate/deactivate. See “Main MENU - Extended menu on” on page 18.

4.3.4 ABOUT

Provides information on Gauge, Probe, Contact information and Help (Figure 14):

GAUGE INFORMATION: Elcometer 456^2 model, software versions, etc.

PROBE INFORMATION: Probe type, range, etc.

CONTACT: Details of Elcometer offices worldwide and, if programmed, the contact details for the Supplier or Local Distributor.

HELP: Explains symbols used on Elcometer 456[2] display screens.

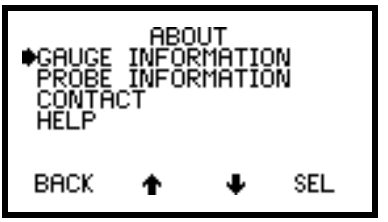


Figure 14. About menu

4.3.5 RESET

Selects Factory Calibration or Gauge resets. The **RESET** menu option (Figure 15) allows one of three gauge resets to be selected:

FACTORY CAL: Returns gauge to calibration settings created at time of manufacture of the probe.

Factory calibration will not necessarily restore precise calibration values. The calibration of the gauge should be adjusted before use, or at least checked to ensure that it has been previously adjusted correctly for the conditions of use.

INTL GAUGE[a]: Resets gauge to International default settings e.g. DD/MM/YY date format and metric units.

US GAUGE[b]: Resets gauge to USA default settings e.g. MM/DD/YY date format and imperial units.

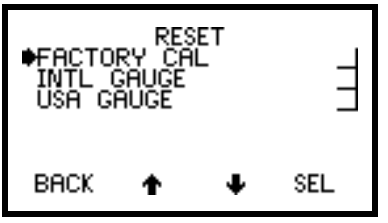


Figure 15. Reset menu

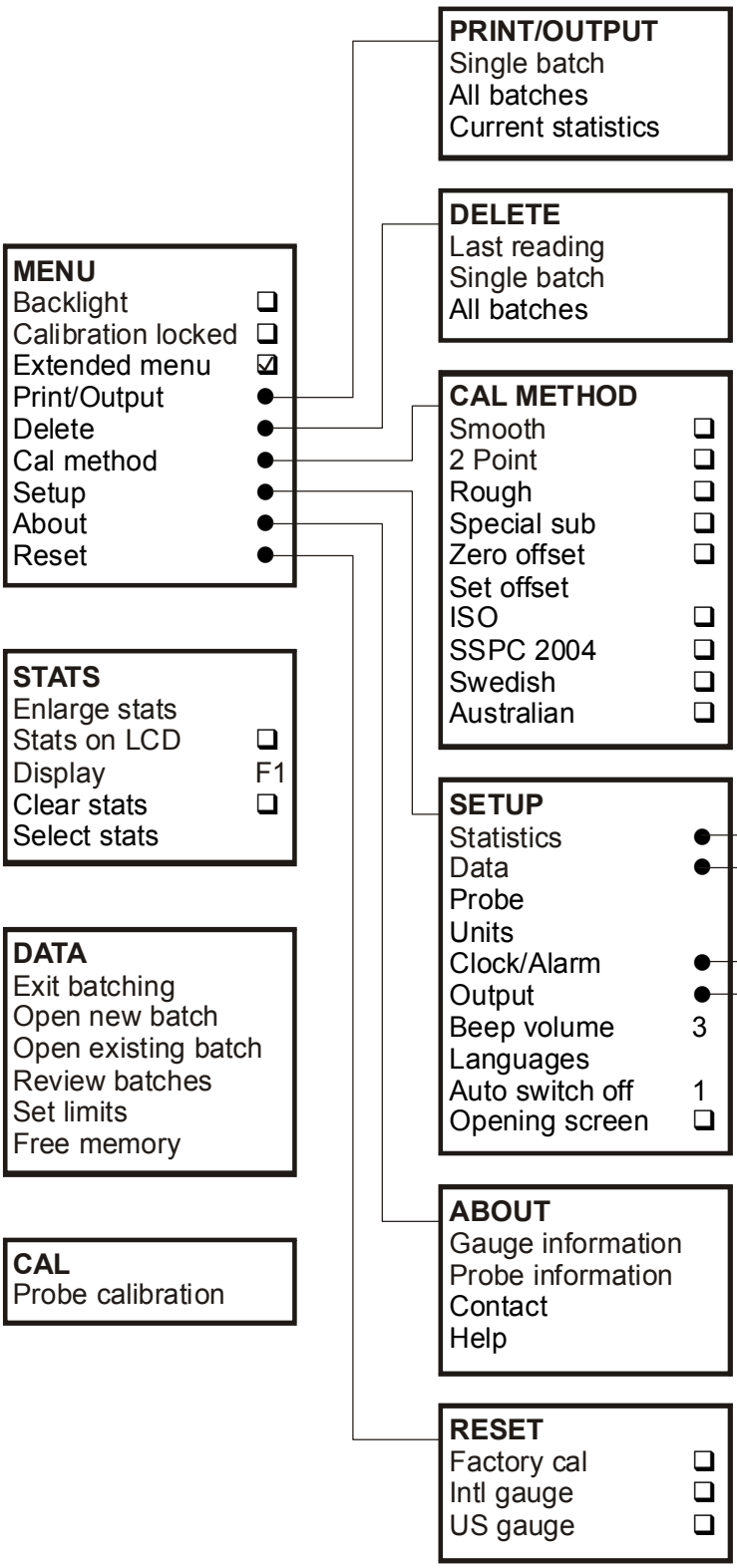
A confirmation screen will be displayed. Press **YES** to reset, **NO** to cancel.

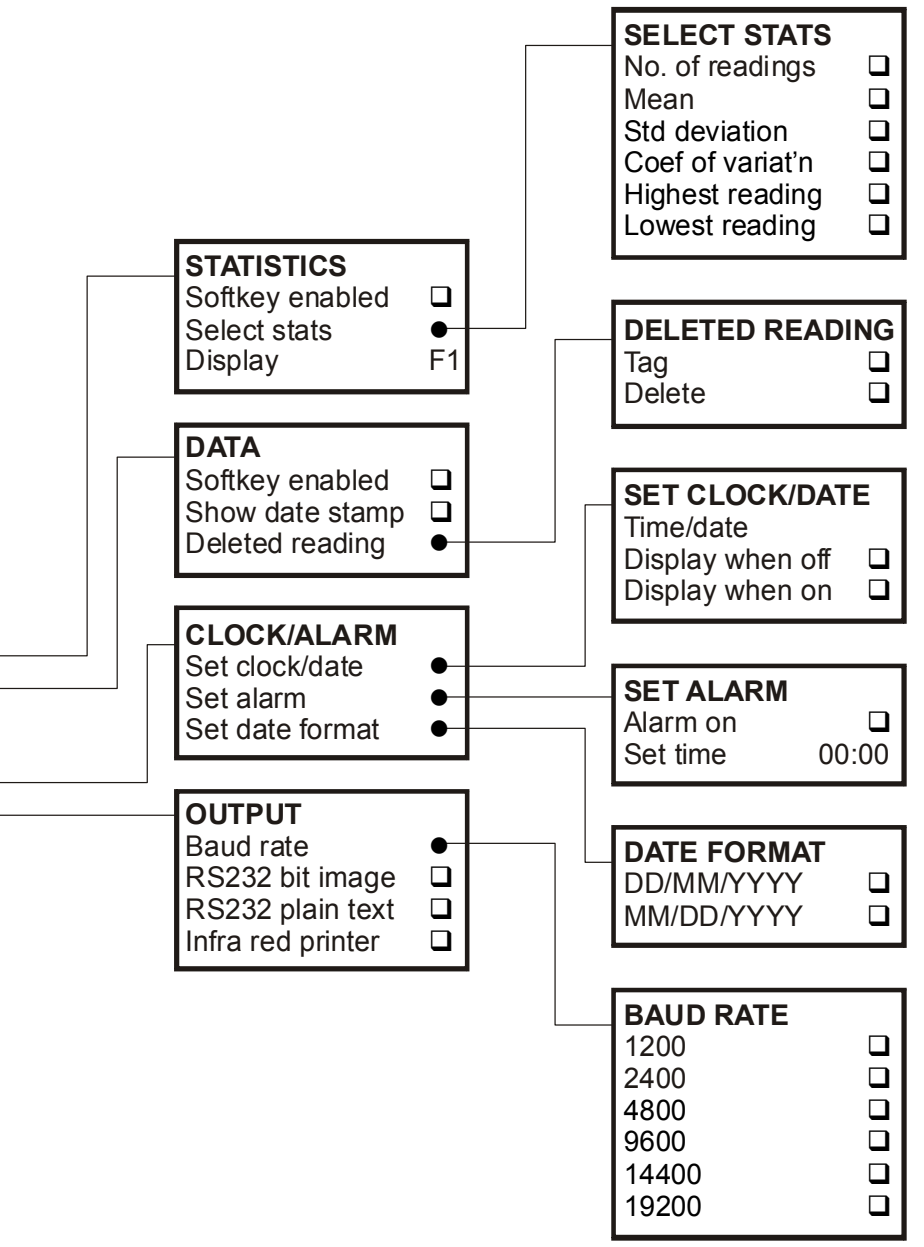
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a. International settings can also be activated at switch on. Press and hold softkey 3 and switch on gauge.
b. US settings can also be activated at switch on. Press and hold softkey 4 and switch on gauge.

4.4 Main MENU - Extended menu on

To toggle **EXTENDED MENU** on/off select **MENU/EXTENDED MENU/SEL**




SELECT STATS
No. of readings ❑
Mean ❑
Std deviation ❑
Coef of variat'n ❑
Highest reading ❑
Lowest reading ❑
STATISTICS
Softkey enabled ❑
Select stats ●
Display F1
DELETED READING
Tag ❑
Delete ❑
DATA
Softkey enabled ❑
Show date stamp ❑
Deleted reading ●
SET CLOCK/DATE
Time/date
Display when off ❑
Display when on ❑
CLOCK/ALARM
Set clock/date ●
Set alarm ●
Set date format ●
SET ALARM
Alarm on ❑
Set time 00:00
OUTPUT
Baud rate ●
RS232 bit image ❑
RS232 plain text ❑
Infra red printer ❑
DATE FORMAT
DD/MM/YYYY ❑
MM/DD/YYYY ❑
BAUD RATE
1200 ❑
2400 ❑
4800 ❑
9600 ❑
14400 ❑
19200 ❑

The following features are added to the **MENU** when **EXTENDED MENU** is active:

4.4.1 PRINT/OUTPUT

Outputs data to a printer or to a PC. A single batch of readings, all batches of readings, or the current statistical summary can be output via the infrared interface or the RS232 interface.

To use this function first setup using:

MENU/**SETUP**/**OUTPUT -** see “OUTPUT:” on page 23.

If no printers have been setup, **PRINT/OUTPUT** will display a **NOT AVAILABLE** message.

4.4.2 DELETE

Deletes last reading only, a single batch of readings or all batches of readings (Figure 16).



Figure 16. DELETE screen

LAST READING

Deletes last reading either in immediate mode or in batch mode.

Gauge displays **ARE YOU SURE?** (Figure 17).

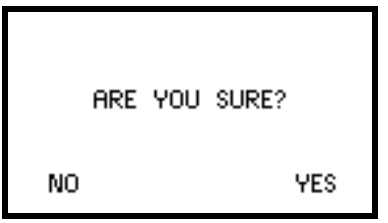


Figure 17. Delete last reading confirmation screen

Press **NO** softkey to include reading in statistical summary or **YES** softkey to delete reading.

If there is no reading to delete gauge displays **LAST READING NOT AVAILABLE** (Figure 18).



Figure 18. Delete last reading not available screen

SINGLE BATCH

Deletes the batch data.

The gauge displays the current batch or the last batch used (Figure 19).

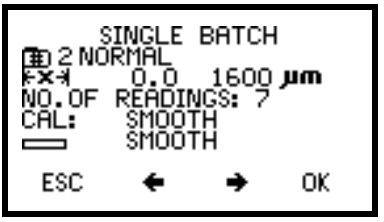


Figure 19. SINGLE BATCH screen

Use the **Right/Left** softkeys ← → to locate the batch to be deleted. At either end of the list of batches the gauge beeps. Press **OK** when the batch to be deleted is displayed. Gauge displays **ARE YOU SURE?** Press **NO** softkey to leave data unchanged or **YES** softkey to delete the batch. If there is no data stored in the memory the gauge displays **NOT AVAILABLE DATA MEMORY EMPTY** (Figure 20).



Figure 20. Memory empty screen

ALL BATCHES

Deletes all batches.

Gauge displays **ARE YOU SURE?** Press **NO** softkey to leave data unchanged or **YES** softkey to delete all the batches.

4.4.3 CAL METHOD

Allows selection of calibration method from list of options - see “Calibration method” on page 25 for more details.

4.4.4 SETUP

Used to select, change or activate gauge features:

STATISTICS: Activates statistics feature.

Stats softkey on/off.

Select stats - see “Select stats” on page 36.

Display - see “Display” on page 35.

DATA: Activates DATA softkey, SHOW DATE STAMP option and selects the DELETED READING menu (Figure 21).

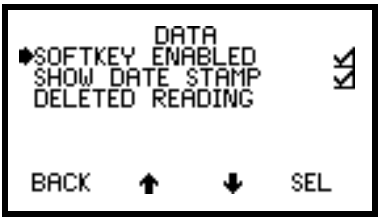


Figure 21. DATA menu screen

SOFTKEY ENABLED allows DATA softkey to be turned off when **EXTENDED MENU** is active.

SHOW DATE STAMP - toggles date stamp on or off in Review Batches - see “Review batches” on page 42.

DELETED READING screen (Figure 22) allows readings to be tagged or deleted.



Figure 22. DELETED READING screen

TAG - readings still appear in the batch (with a tag-deleted symbol ⃠), but they are not included in statistical calculations.

DELETE - readings are permanently deleted.

PROBE: Only for dual function probes (FNF and F1 2). Changes probe mode.

FNF probes - select from Automatic, F or N.

F1 2 probes - select from F1 or F2.

UNITS: Units are automatically set by the probe type, however the user can manually override the automatic setting. Select from µm, mm, mil, thou or inch.

CLOCK/ALARM: Allows setting of time, date and alarm functions and setting of the date format DD/MM/YY or MM/DD/YY (Figure 23).



Figure 23. CLOCK/ALARM screen

Time and date can be set to be displayed on the top line of the reading screen when the gauge is on.

Time and date can be set to be displayed in large digits when the gauge is switched off.

OUTPUT: Selects baud rate (Figure 24) and activates data output via the interfaces - see “Interfaces” on page 12.

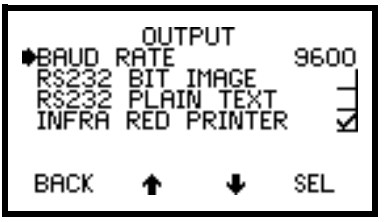


Figure 24. OUTPUT screen

BAUD RATE can be set at values from 1200 to 19200. The default value is 9600 baud.

RS232 BIT IMAGE. Toggle tick box to activate/deactivate. When activated, readings are sent to the RS232 interface as they are taken. All images and characters are output as bit-maps. This allows printing on the Elcometer Miniprinter (see “Miniprinter” on page 56).

RS232 PLAIN TEXT. Toggle tick box to activate/deactivate. When activated, readings are sent to the RS232 interface as they are taken. The gauge sends standard ASCII characters from the Courier New font set[c]. This allows printing on devices other than the Elcometer Miniprinter, e.g. RS 232 printers or PC via Elcometer software (page 45) or via HyperTerminal.

INFRA RED PRINTER. Toggle tick box to activate/deactivate. When activated, readings are sent to the infrared portable printer as they are taken. See "Infrared portable printer" on page 56 for sales part number of this optional accessory.

BEEP VOLUME: Changes volume.

- 0 = off
- 5 = loudest
- Default = 3

LANGUAGES: Allows selection of language.

AUTO SWITCH OFF: Changes delay before gauge switches off when displaying Reading Screen.

- Minimum = 1 minute
- Maximum = 10 minutes
- Default = 1 minute

Auto switch off may be disabled by selecting 'off' (In this case, switch off using On/Off key .)

OPENING SCREEN: Disables the opening (welcome) screens so that the gauge switches on to display the reading screen.

If a personalised welcome screen has been downloaded into the gauge (see page 50), Opening Screen must be activated to display this screen.

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c. When RS232 Plain Text is selected the following languages will be output as English: Chinese, Greek, Hebrew, Japanese, Korean, Russian, Lithuanian, Farsi.

5 CALIBRATION ADJUSTMENT

Calibration adjustment is the process of setting the gauge to known values of thickness to ensure accuracy on different substrate types, shapes and surface finishes.

Note: When using an FNF probe it must be calibrated in both the ferrous mode and in the non-ferrous mode to ensure accuracy of reading.

5.1 Calibration method

The calibration of the gauge can be adjusted (**MENU/CAL METHOD**) using several different methods described in National and International Standards.

The calibration adjustment method chosen is dependant on the condition of the substrate to be measured and is indicated on the screen by a symbol (Figure 25):

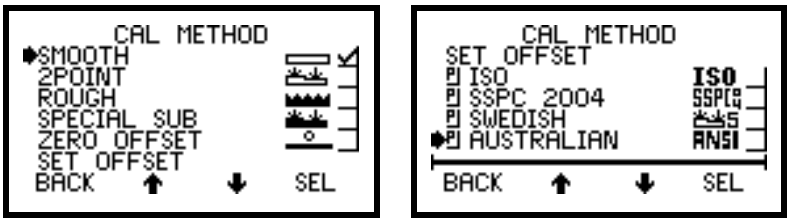


Figure 25. CAL METHOD screen

SMOOTH. Smooth surface calibration where the gauge is set to zero on the uncoated surface and a known thickness above the expected thickness of the coating.

2POINT. Calibration on a thin value and a thick value either side of the expected thickness. This enhances the accuracy of the gauge over the thickness range defined by the two values.

ROUGH. A calibration method similar to 2-Point. This enhances the accuracy of the gauge over the thickness range defined by the two values.

SPECIAL SUB. This method uses the 2-Point calibration for unusual substrate materials such as cast iron, certain types of stainless steel, high carbon steel, special aluminium alloys, etc.

ZERO OFFSET. This is the method described in ISO 19840 for coatings on steel surfaces roughened by

blast cleaning. The calibration uses the smooth surface technique, and a correction value (zero offset) is applied to each reading to account for the effect of the roughened surface; the value depends on the surface profile - see Table 1.

SET OFFSET. This screen sets and changes the offset for different surface roughness This value is used only with the Zero Offset calibration method.

Table 1: Correction values as detailed in ISO 19840

Profile according to ISO 8503-1	Correction Value (µm) (Zero Offset)
Fine	10
Medium	25
Coarse	40

5.2 Preset calibration methods

The gauge also contains four preset calibration methods which follow relevant standards. These set the calibration method and the data collection method (data collection method is only set when in batching mode).

ISO: (ISO 19840) This uses the Zero Offset calibration method with counted average data collection set to 5 readings.

SSPC: (SSPC-PA2 2004) This uses the 2-Point calibration method with counted average set to 3 readings.

SWEDISH: (SS 18 41 60) This uses the 2-Point calibration method with counted average set to 5 readings.

AUSTRALIAN: (AS 3894) This uses the Zero Offset calibration method with a correction value of 1/3 the surface profile peak-to-valley height and a counted average data collection set to 5 readings.

Note: When the calibration method is changed, e.g. from Smooth to Rough, the gauge will display a message (Figure 26).

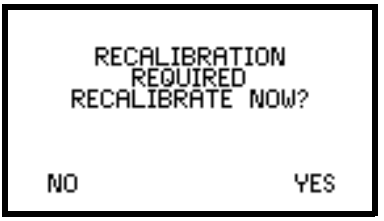


Figure 26. Recalibration required screen

If the **NO** softkey is pressed the **CAL** softkey symbol on the Readings Screen will flash to warn that calibration adjustment is still required. While the **CAL** softkey symbol is flashing new batches cannot be opened.

If the **YES** softkey is pressed the calibration adjustment procedure is activated - see “Calibration adjustment procedure” on page 28.

5.3 Calibration foils and standards

Calibration adjustment should be carried out with the appropriate probe on the same type of metal, the same curvature and similar finish to the item to be measured. It is best to use an uncoated sample of the items to be tested.

Calibration can be carried out using measured foils or coated standards.

Foils (shims). These are coating thickness standards which have been measured using techniques independent of the gauge. They are ideal for calibration because they provide a known value of thickness on the actual substrate to be measured. Calibration certificates for foils are available upon request.

When using foils care must be taken to keep the foils clean and free from dust and to avoid damage by creasing particularly the thinner foils. Always remove a foil from its storage wallet before use.

When calibrating a High Temperature PINIP™ Probe use the special thickness standards supplied with the probe - see “Calibrating High Temperature PINIP™ Probes” on page 33.

Note: To calibrate 5 mm (200 mils) and 13 mm (500 mils) range gauges it will be necessary to stack the foils (Figure 27). Care must be taken to avoid errors due to placing the foil labels between the foils.

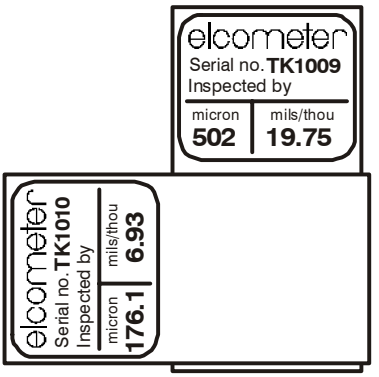


Figure 27. Stacking foils to increase thickness

Coated standards. Thickness standards using typical substrate materials coated with hardwearing materials and measured using techniques independent of the gauge.

Coated standards are most often used to confirm that the gauge meets its specifications if it is not possible to use foils (shims).

5.4 Calibration adjustment procedure

Calibration adjustment can be carried out at any time by pressing **CAL** softkey from the reading screen. To prevent inadvertent calibration adjustment the **CAL** softkey can be locked (**MENU/CALIBRATION LOCKED**).

The user is guided through the operation of the chosen calibration procedure by means of instructions and illustrations on the graphics screen. Audible warnings are also provided when action is required, e.g. when the probe must be placed down to get a reading.

If the routine is interrupted in any way the previous settings will be restored until after the full calibration routine has been completed or the reset has been completed.

The screen detail depends on the calibration method chosen, but the calibration is in two steps.

The following example is for a Smooth Calibration adjustment.

Step 1

1. Hold probe in air and press **CAL** softkey (Figure 28).

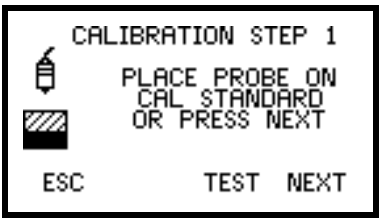


Figure 28. Step 1 - on thickness standard

ESC softkey returns the gauge to the Reading Screen from the Calibration Procedure without making any changes.

TEST softkey allows the user to take readings to verify the accuracy of the current calibration. These readings do not affect statistical calculations and are not added to batch memory.

2. Place probe on calibration standard. The gauge will display a reading.
3. Lift probe and then replace on calibration standard. Gauge displays the average ($\bar{x}$) of these readings and the last reading. Repeat this action until a stable reading is obtained.

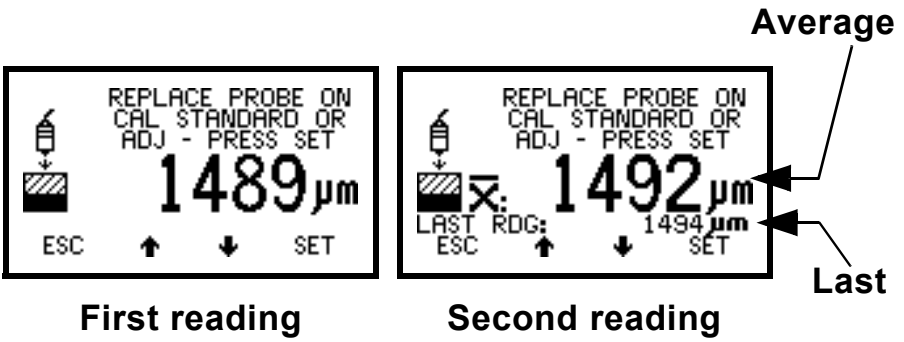


Figure 29. Step 1 - Calibration adjustment on thickness standard

To reject the displayed reading and start the calibration procedure again, press both the **Up** and **Down** softkeys at the same time.

To adjust the displayed reading until it is correct relative to the thickness standard use the **Up/Down** softkeys.

4. Press **SET** softkey to accept the value.

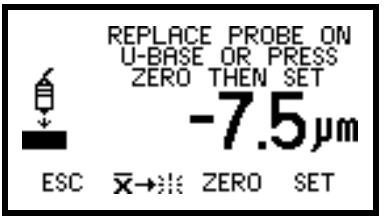
   Note: - - - indicates over-range (Figure 30). Taking a reading within range clears this screen.



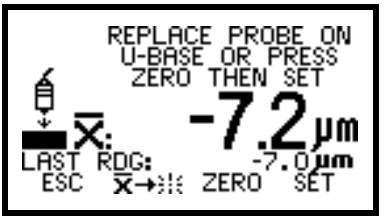
Figure 30. Over-range reading

Step 2

1. Place probe on uncoated standard or zero plate. The gauge will take and display a reading.
2. Lift probe and then replace on uncoated standard or zero plate. Gauge displays the average ($\bar{x}$) of these readings and the last reading. Repeat this action until a stable reading is obtained.



First reading



Second reading

Figure 31. Step 2 - Calibration adjustment on uncoated sample

To reject the displayed reading and start **Step 2** of the calibration procedure again, press the Reset softkey $\bar{x}\rightarrow$.

3. Press **ZERO** softkey to zero the display (Figure 32).

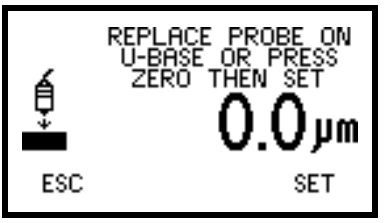


Figure 32. Zero the display

4. Press **SET** softkey to accept this value.

   The gauge will display the option to test the calibration of the gauge.

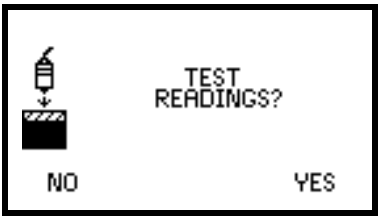


Figure 33. TEST READINGS screen

5. Either press **NO** softkey to complete the calibration adjustment procedure and return the gauge to the reading screen, or proceed to take test readings - see “Taking test readings” on page 31.

Taking test readings

Press **YES** softkey (see previous section) to take test readings. This allows the calibration of the gauge to be tested without adding readings to data memory or contributing to the statistical calculations.

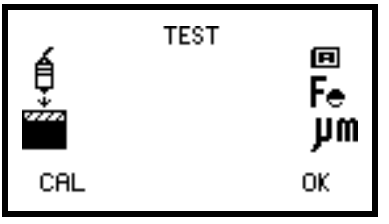


Figure 34. TEST READINGS screen

CAL softkey returns the gauge to **Step 1** of the calibration adjustment procedure.

OK softkey completes the calibration adjustment procedure and returns the gauge to the reading screen.

Other calibration methods

For the 2-POINT, ROUGH and SPECIAL SUBSTRATE calibration methods **Step 2** requires readings to be taken on a thin standard value instead of on an uncoated base.

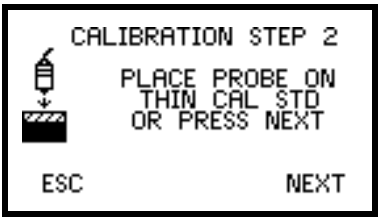
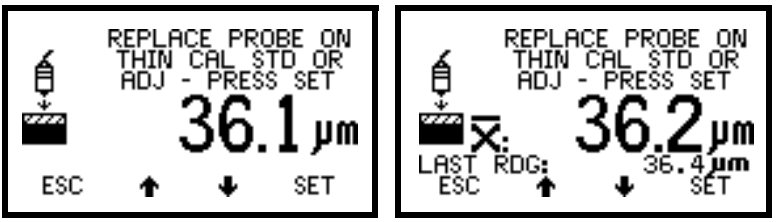


Figure 35. Step 2 - On thin standard

Repeating the reading will display the average. This is particularly useful for rough surfaces as it allows variations in the surface to be accounted for in the calibration adjustment, therefore improving the accuracy of the gauge.



First reading **Second reading**

Figure 36. Step 2 - Calibration adjustment on thin standard

Calibrating High Temperature PINIP™ Probes

Special thickness standards are supplied with F1 2 High Temperature PINIP™ Probes - see page 49. These thickness standards should be used in place of the calibration standard in **Step 1** of "Calibration adjustment procedure" on page 28.

1. Place appropriate thickness standard over end of PINIP™ probe.
2. Press **CAL** softkey.
3. Place probe on hot[d] surface and take a reading.
4. Lift probe and then replace on hot surface to take second reading.
5. Repeat as necessary until reading is stable.
6. Press **SET** to accept value.
7. Remove thickness standard from end of PINIP™ probe.
8. Proceed with **Step 2** - see page 30.

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d. The temperature of the surface used for calibration should be equal to the temperature of the substrate being measured.

6 STATISTICS

The Elcometer 456^2 Top has a Statistics feature (**STATS**) which calculates and displays a statistical analysis of readings as they are taken. The statistical calculations are also applied to the readings stored within a single batch in memory.

When **EXTENDED MENU** is active (**MENU/EXTENDED MENU/SEL**), press **STATS** softkey to access **STATS MENU** (Figure 37).

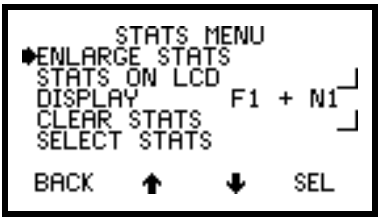


Figure 37. Stats menu

The statistical values available are:

- Number of Readings n:
- Mean $\bar{x}$:
- Standard Deviation σ:
- Coefficient of Variation CV%:
- Highest Reading >:
- Lowest Reading <:

See “Select stats” on page 36 and “Statistics terminology” on page 52.

6.1 ENLARGE STATS

Displays the chosen statistical values as double-height characters. The example screens (Figure 38) appear when all the statistical values are selected. The

Up/Down softkeys can be used to move through the list. **OK** softkey returns to the Reading Screen.

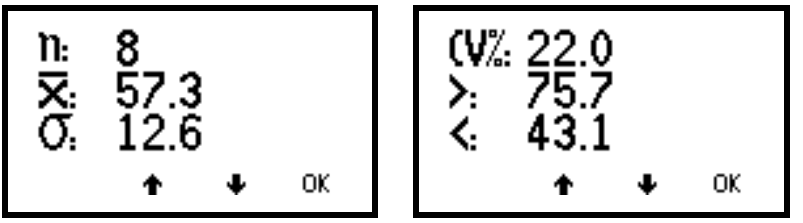


Figure 38. Enlarged statistics

6.2 STATS ON LCD

Activates the presentation of the chosen statistical values on the reading screen. If STATS ON LCD is activated while CLOCK ON LCD is active, the STATS are displayed and the CLOCK is not displayed.

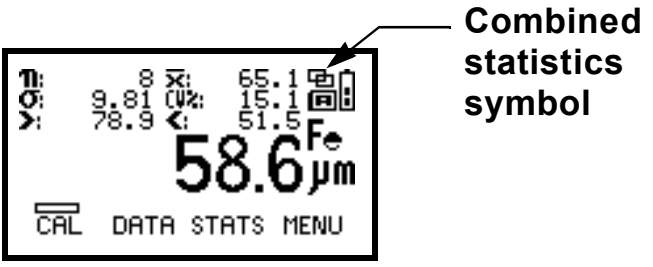


Figure 39. Reading screen with all statistics

6.3 DISPLAY

Only applies when using dual function probes. Allows selection of the types of readings used in the statistical calculation when a dual function probe is connected.

Probe	**Options**
FNF	F, N or F and N combined[e]
F1 2	F1, F2 or F1 and F2 combined[e]

6.4 CLEAR STATS

Resets to zero all statistical values selected in **STATS MENU/DISPLAY**.

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e. When readings are combined a symbol will be displayed on the Reading Screen (Figure 39).

6.5 SELECT STATS

Allows the user to chose which statistical values are displayed. The default condition is all values (Figure 40).

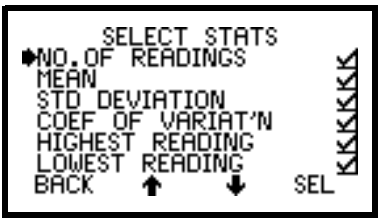


Figure 40. Select stats menu

Use **Up/Down** softkeys to move cursor and **SEL** softkey to select or deselect the statistical values.

7 BATCHING

The Elcometer 456^2 operates in one of two modes; immediate or batch.

Immediate mode. The gauge takes readings and calculates statistics but does not store any readings in memory (Figure 41).



Figure 41. Reading screen - Immediate mode

Batch mode. The gauge takes readings and calculates statistics and stores readings in memory (Figure 42). The gauge stores readings in one of up to 999 separate batches.

Batch mode (batching) allows reading data to be collected in groups to allow easier analysis of large structures or complex assemblies.

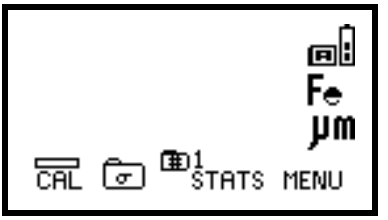


Figure 42. Reading screen - Batch mode

The Elcometer 456^2 Top has memory capacity for up to 50 000 readings in up to 999 batches.

Batching is configured using the **DATA MENU**.

To access the **DATA MENU** (Figure 43) press the **DATA** softkey (this softkey is only displayed with **EXTENDED MENU** on).



Figure 43. DATA MENU screen

7.1 EXIT BATCHING

This option returns the gauge to immediate mode and no further readings are stored in memory. The gauge returns to the Reading Screen.

7.2 OPEN NEW BATCH

This option opens (creates) a new batch using the next available batch number.

- To create a batch with new calibration settings use **OPEN NEW BATCH** in immediate mode - see 7.2.1.
- To create a batch with a copy of the calibration settings from another batch use **OPEN NEW BATCH** in batch mode - see 7.2.2. This is known as '**cloning'** a batch.

  Cloning is typically used when several products are being tested, each with different measurement and calibration settings. Cloning allows the settings for a product to be quickly and easily duplicated. To clone a batch, first open the batch to be cloned (see section 7.3) and then **OPEN NEW BATCH**.

Note: While the **CAL** softkey symbol is flashing, new batches cannot be opened. Calibrate the gauge before opening a new batch. FNF probes should be calibrated in F mode and in N mode.

7.2.1 Opening new batch in immediate mode

When a new batch is opened the following settings are copied into the batch from **immediate mode:**

- Calibration method
- Offset (if applied)
- Calibration adjustment

Note: Calibration method and offset must be set before opening the new batch. Calibration adjustment can be changed after the batch has been created - see "Calibration adjustment procedure" on page 28.

The initial **OPEN NEW BATCH** screen (Figure 44) stays on while the gauge sets up the batch, as indicated by the progress bar.



Figure 44. Initial OPEN NEW BATCH screen - Immediate mode

ESC takes the gauge back to **DATA MENU.**

The second **OPEN NEW BATCH** screen (Figure 45) shows the current batch settings.

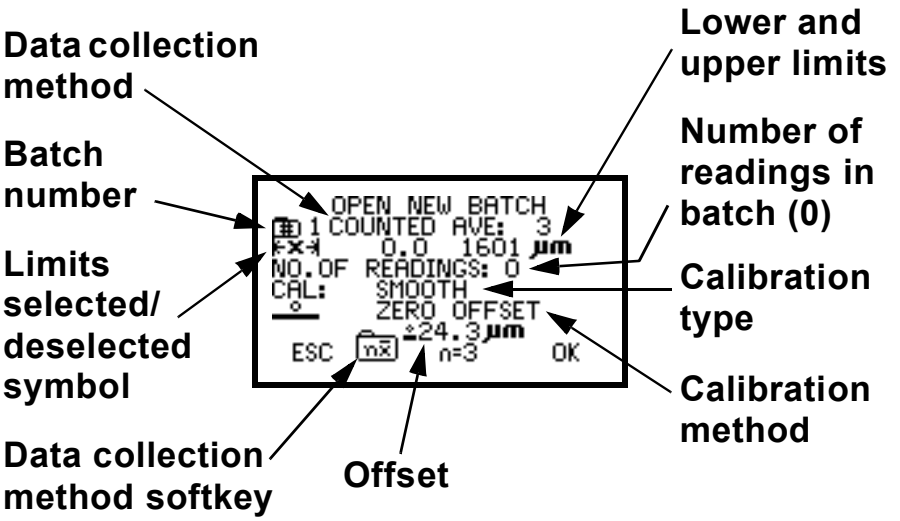


Figure 45. Second OPEN NEW BATCH screen - Immediate mode

Upper and lower **Limits** for the batch can be changed at any time once the batch has been created - see “Set limits” on page 43.

Data collection method must be set before **OK** softkey is pressed.

Data Collection Method

The Data Collection Method can be changed by pressing the **Data Collection Method** softkey or . The display toggles between two options, normal and counted average:

- **NORMAL** - Each reading is added to the number of readings and contributes to the statistical calculation.
- **COUNTED AVE: n** - Readings are taken in preset groups[f], the default being 5 readings, n=5 (Figure 46). At the end of each group the gauge beeps and calculates the average for the group and stores this average value, which is used for the statistical calculation. The individual readings in the group are not stored. The value for n can be changed[g] by pressing the **n=5**[h] softkey.

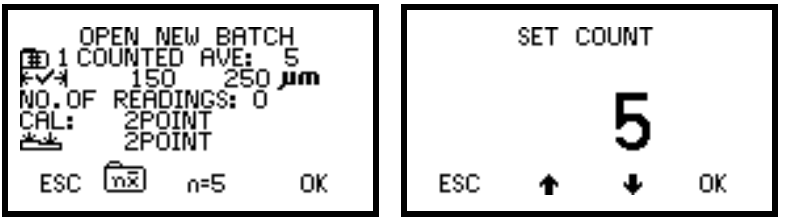


Figure 46. Setting data collection method Counted average n = 5

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f. When using an FNF probe in AUTO mode the first reading in each group will 'lock' the probe to that substrate for the whole of the group.
g. If a preset calibration method (see "Preset calibration methods" on page 26) is selected, the value for 'n' cannot be adjusted.
h. The value for 'n' shown on the softkey can be any number between 2 and 255.

7.2.2 Opening new batch in batch mode

Opening a new batch in batch mode duplicates (clones) an existing batch.

Cloning copies the following settings to the new batch:

- Limits
- Calibration method
- Data collection method
- Offset (if applied)
- Calibration adjustment

Note: Calibration method, data collection method and offset cannot be changed once the cloned batch has been created. Calibration adjustment and limits can be changed after the batch has been created - see “Calibration adjustment procedure” on page 28 and “Set limits” on page 43.

The initial **OPEN NEW BATCH** screen displays ‘**CURRENT BATCH**’.



Figure 47. Initial OPEN NEW BATCH screen - Batch mode

The second **OPEN NEW BATCH** screen (Figure 48) shows the new batch settings.

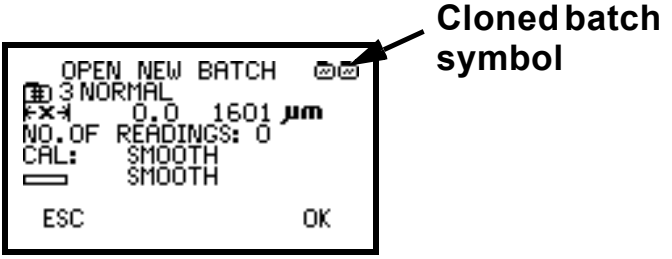


Figure 48. Second OPEN NEW BATCH screen - Batch mode

Press **OK** to create batch.

Batch numbering

The gauge automatically allocates the next batch number when a new batch is created. Up to 999 batches can be active at any time. Deleted batches are removed from the list so that batch numbers above 999 are valid. A deleted batch number cannot be reused until all the batches are deleted, when the batch number count starts again at 1.

7.3 OPEN EXISTING BATCH

This allows any batch to be opened to add readings. If the gauge is switched off with the batch open, the current batch will re-open when the gauge is switched back on.

Note: If the probe is changed to another probe of the same type the gauge will display a warning (Figure 49).

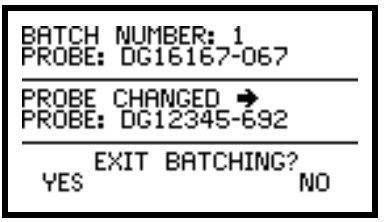


Figure 49. Changed probe warning screen

If **NO** is selected, the serial number and calibration data of the new probe are saved into the current batch as a data entry.

If **YES** is selected, the batch calibration details are retained and the user can locate and fit the original probe, if they wish.

7.4 REVIEW BATCHES

This allows the content of any batch to be displayed (Figure 50).

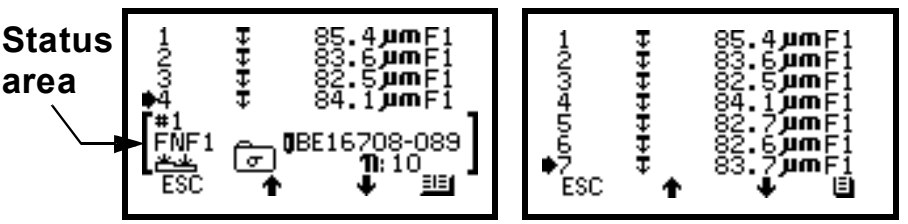


Figure 50. REVIEW BATCHES screen

The **Up/Down** softkeys move the cursor through the list of readings.

The **Status** softkey toggles the status area on/off.

The **Review Batches** screen can contain the following information:

- Readings (including symbols indicating whether they are above or below limits if LIMITS ON is activated).
- Date stamp (entered whenever the batch is opened).
- Probe change (includes date stamp and probe serial number).
- Recalibration (includes date stamp, recalibration stamp and, for dual function probes, the probe mode).

The status area in the bottom half of the screen displays the batch number and the type and serial number of the probe used when the batch was created.

7.5 SET LIMITS

Upper and lower values can be set by the user to monitor specification values.

To activate limits tick the **LIMITS ON** box (Figure 51).

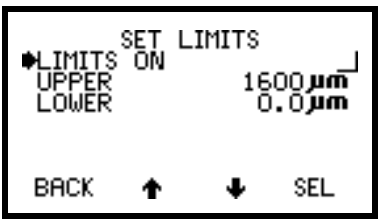


Figure 51. SET LIMITS screen

To set the **UPPER** and **LOWER** limit values move the cursor to the limit required and press **SEL**.

The gauge will display the current settings (Figure 52). Values shown are for illustration only.

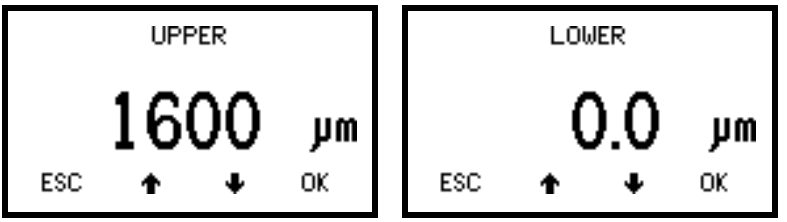


Figure 52. Setting upper and lower limits

Adjust the values with **Up/Down** softkeys. When the correct value is displayed, press **OK** to enter.

With **LIMITS ON** activated the out-of-limits reading will be indicated by a triple beep and a red light on the keypad LED. A reading within limits is indicated by a single beep and a green light. Out-of-limits symbols and will be stored in the batch and can be seen when the batch is reviewed.

7.6 FREE MEMORY

This option displays the amount of free memory available for storage of readings (Figure 53).

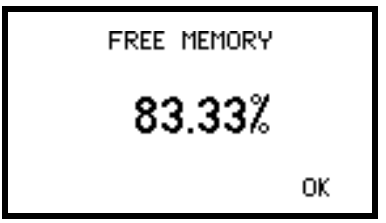


Figure 53. FREE MEMORY screen

8 TRANSFERRING READINGS TO A COMPUTER

Software is available which allows data to be transferred from an Elcometer 456^2 Top to a PC using the supplied PC connection cable. Elcometer supplies three types of data transfer software:

- Elcometer Data Transfer Software (EDTS$^+$ Excel Link)
- Elcometer Data Collection Software (EDCS)
- Elcometer Data Collection Software (EDCS$^+$)

The Elcometer 456^2 Top gauge is supplied with a CD containing EDTS$^+$ Excel Link, EDCS, and a demonstration version of EDCS$^+$. This software can also be downloaded from the Elcometer website www.elcometer.com.

8.1 EDTS$^+$ Excel Link

EDTS$^+$ Excel Link allows the user to transfer data from the memory of the gauge into Microsoft Excel. The data can then be processed in software such as Word or Excel.

8.2 EDCS and EDCS$^+$

EDCS$^+$ allows the user to transfer data from the memory of the gauge to a PC. It also includes all the charts that you may need together with a report designer to let you design the report the way you wish to see it. Data management and archiving is also included.

EDCS is a limited functionality version of EDCS$^+$.

EDCS$^+$ is available from your local Elcometer supplier or directly from Elcometer.

8.3 Software installation

EDTS$^+$ Excel Link, EDCS and EDCS$^+$ are compatible with computers operating on Windows™ 95 (service pack 1), 98, ME, NT, 2000 and XP. The installation conforms to the standard Windows method using ‘Setup.exe’.

8.4 Connecting the data transfer cable

1. Plug the 9-pin female D-type connector on one end of the data transfer cable into the COM port on the PC.
2. Plug the 5-pin connector on the other end of the data transfer cable into the RS232 connector on the side of the gauge - see “Interfaces” on page 12.
3. Switch on the gauge and ensure that the Reading Screen is displayed.

8.5 Setting-up the software

1. Start the communications software (EDTS^{+}, EDCS or EDCS^{+}).
2. Select gauge type 456.

8.6 Transferring data

Follow the on-screen instructions.

9 PROBES

An extensive range of probes is available for the Elcometer 456[2] Coating Thickness Gauge. Probes for ferrous (F), non-ferrous (N) and dual ferrous/non-ferrous (FNF) operation are available as either integral (built-in) or separate options.

Separate probes are fully interchangeable and are available in standard, PINIP™ and miniature formats.

PINIP™ format (Plug-In Integral Probe) is an integral style probe which plugs in to a separate gauge. This provides all the benefits of an integral gauge and the flexibility of a separate gauge in a single unit.

Miniature separate probes permit measurements where space is restricted.

9.1 Ferrous (F) probes

F probes measure the thickness of non-magnetic coatings on magnetic substrates. They can be used on paint, plastic, galvanising, enamel, powder paint, hard chrome and other coatings such as electro-less nickel applied to steel or iron.

9.2 Non-ferrous (N) probes[i]

N probes measure the thickness of non-magnetic coatings on non-magnetic metals. They can be used on anodising, paint, plastic coatings, powder paint, etc. applied to aluminium, brass, non-magnetic stainless steel, etc.

9.3 Dual ferrous/non-ferrous (FNF) probes

FNF probes are dual function, F and N in one probe. FNF gauges will automatically detect the type of substrate and set the mode accordingly. Alternatively the mode can be set manually - see “PROBE:” on page 23 and “Coatings on galvanised or metallised steel” on page 49.

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i. Using an N probe (or an FNF probe manually set to N1) on a ferrous substrate will give a reading, but the reading will be incorrect.

9.4 Probe interchangeability

The following table shows which probes can be used in the three types of Elcometer 456[2] Gauge.

Probe type		Gauge Type		
		F	N	FNF
FERROUS	F1 *	✓	×	✓
	F2 *	✓	×	✓
	F1 2 *	✓	×	✓
	F3 *	✓	×	✓
	F1 right angle	✓	×	✓
	F2 right angle	✓	×	✓
	F1 2 right angle	✓	×	✓
	F1 telescopic	✓	×	✓
	F2 telescopic	✓	×	✓
	F1 PINIP™	✓	×	✓
	F2 PINIP™	✓	×	✓
	F1 2 PINIP™ High Temp	✓	×	✓
	F3 PINIP™	✓	×	✓
	F3 miniature straight	✓	×	✓
	F3 miniature 45°	✓	×	✓
	F3 miniature 90°	✓	×	✓
NON-FERROUS	N1 *	×	✓	✓
	N2	×	✓	✓
	N1 right angle	×	✓	✓
	N1A anodiser's	×	✓	✓
	N1 PINIP™	×	✓	✓
	N3 miniature straight	×	✓	✓
	N3 miniature 45°	×	✓	✓
	N3 miniature 90°	×	✓	✓
DUAL	FNF1 *	×	×	✓
	FNF1 right angle	×	×	✓
	FNF PINIP™	×	×	✓

* indicates probes available for integral type gauges.

9.5 F1 2 probes

The F1 2 scale combines the F1 scale with the F2 scale in a single probe. The user selects the appropriate range for the work in hand. The resolution of the gauge is dependent on the scale selected on the gauge.

9.6 F1 2 High temperature PINIP™ probes



These probes are capable of measuring on surfaces up to 250°C (480°F). Wear appropriate protective clothing and take care to avoid bodily contact with the hot surface during measurement.

Do not exceed the maximum measurement speed when using these probes - see page 53.

Note: Refer to special calibration procedure - see “Calibrating High Temperature PINIP™ Probes” on page 33.

9.7 Coatings on galvanised or metallised steel

The FNF probe in fixed N1 mode may be used to measure paint coatings on galvanised, aluminium (Al) or zinc (Zn) sprayed steel substrates.

1. Set the gauge to the N1 mode (**MENU/SETUP/PROBE**).
2. Zero and calibrate the gauge on a sample of the coated steel - see “Calibration adjustment” on page 25.

   Care must be taken to ensure that the calibration conditions are not affected by changes in the zinc or aluminium coating thickness. This can be determined by checking the zero over an area of the galvanised or metal-coated steel. Metal coatings on steel above 50 µm (2 mil/thou) should be consistent enough to obtain a stable zero on the layer of metal.
3. Take readings.

10 PERSONALISED WELCOME SCREEN

A personalised welcome screen can be created and downloaded into the gauge.

Screen dimensions are 128 pixels x 64 pixels. The welcome screen is typically used to personalise the gauge with a logo, serial number, user name, etc. This is the first screen displayed when the gauge is switched on.

10.1 Creating the screen

1. Download Elcometer 'Welcome Screen Wizard' software. This software is available free of charge from the downloads section of the Elcometer website, www.elcometer.com.
2. Connect gauge to PC using 456 to PC connection cable.
3. Press  key to switch on gauge.
4. Ensure Reading Screen is displayed.
5. Run 'Welcome Screen Wizard' software and follow the on-screen instructions.

10.2 Deleting the screen

1. Run the 'Welcome Screen Wizard' software.
2. Click 'Next'.
3. Select 'Create a new screen setup'.
4. Click 'Next'.
5. Select 'Disabled'.
6. Click 'Next'.

Follow the remaining on-screen instructions to delete the welcome screen.

11 STORAGE AND TRANSIT



This gauge incorporates a Liquid Crystal Display (LCD). 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 carrying pouch when it is not being used.

Remove the batteries from the gauge and store them separately if the gauge 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.

12 MAINTENANCE

You own one of the finest hand-held coating thickness gauges in the world. If looked after, it will last a lifetime.

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 supplier or directly to Elcometer. Contact details are stored in the gauge - **MENU/ABOUT/CONTACT**.

Worldwide: sales@elcometer.com

Or USA/Canada: inc@elcometer.com

Note: **Probes will eventually wear. Probe life will depend on the number of measurements taken and how abrasive the coating is. Probe life can be prolonged by careful positioning of the probe on the surface.**

Replacement separate and PINIP™ probes can be fitted by the user without the need to return the gauge for service.

Gauges with an integral probe have to be returned for re-programming or replacement if the probe becomes worn or damaged.

13 STATISTICS TERMINOLOGY

Term	Meaning
COEF OF VARIAT'N (V%:	Coefficient of Variation. The standard deviation divided by the mean for a group of readings, expressed as a percentage.
HIGHEST READING >:	The value of the maximum thickness in a group of readings.
LOWEST READING <:	The value of the minimum thickness in a group of readings.
MEAN $\bar{x}$:	The average of a group of readings; the sum of the individual readings divided by the number of readings.
NO. OF READINGS n:	Number of Readings. The running value for the number of readings taken in a group. In the case of the averaging or counted average, the Number of Readings is the number of values recorded, not the total number of readings taken.
STD DEVIATION σ:	Standard Deviation. A statistical measure of the spread of values in a group of readings.

14 TECHNICAL DATA

14.1 Measurement speed

>60 readings per minute.

This rate is reduced to >40 readings per minute when Infrared printer output is active - see “OUTPUT:” on page 23.

When measuring high temperature materials measurement speed must be reduced to prevent overheating of the probe. The maximum measurement speed of the High Temperature PINIP™ probe at 250°C (480°F) is 4 readings per minute.

14.2 Minimum substrate thickness

Ferrous: 300 µm (12 mils)

Non-ferrous: 100 µm (4 mils)

Measurements can be taken on thinner substrates if 2-point calibration is carried out either side of the required substrate thickness, however gauges will have reduced range when adjusted for thin substrates.

14.3 Probe operating temperature

Separate ferrous probes:	150°C (300°F)
High temperature PINIP™ probes:	250°C (480°F)
Miniature probes without outer sleeve:	150°C (300°F)
All other probes:	80°C (176°F)

14.4 Physical

Weight (including batteries):	Separate Probe (FNF1), 190g (6.7oz) Separate Probe (PINIP™), 155g (5.5oz) Integral Probe, 130g (4.6oz)
Dimensions:	130 mm x 70 mm x 35 mm (5.12" x 2.76" x 1.38")
Gauge operating temperature:	0°C to 50°C (32°F to 120°F) Operation outside these limits depends upon climatic conditions.
Case:	High impact ABS

14.5 Power supply

Internal batteries, 2 x LR03 (AAA), alkaline[j] dry batteries or rechargeable[k] equivalents.

Battery life

30[l] hours to 40 hours continuous use with alkaline dry batteries. (15 000 to 20 000 readings at an average of 8 readings per minute.) Battery life is reduced by one third when using the backlight.

14.6 Packaging

The gauge is packed in cardboard and plastic packaging. Please ensure that this packaging is disposed of in an environmentally sensitive manner. Consult your Local Environmental Authority for further guidance.

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j. Alkaline batteries 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 batteries in fire.

k. Rechargeable batteries can be used if they are charged outside the gauge.

l. Battery life is reduced to approximately 25% of dry battery life when using rechargeable batteries. Follow the instructions provided by the battery manufacturer when charging and disposing of rechargeable batteries.

15 ACCESSORIES

The Elcometer 456^2 is complete with all the items required to get started and take measurements.

Many of the following accessories are optional. However, some are consumable items that may need to be replaced over the lifetime of the gauge.

All these accessories are available from Elcometer, or your local Elcometer supplier. At time of ordering please quote the sales part number which follows the description of each accessory.

15.1 Consumable items

Alkaline LR03 (AAA) Battery (2 required):	T9999329-

15.2 Probes

Full details of the extensive range of 456 probes can be obtained from Elcometer, your local Elcometer supplier or the Elcometer website, www.elcometer.com.

15.3 Foil sets

2.2 mm (85 mils) 8 pieces:	T9904199F
1.3 mm (51 mils) 3 pieces:	T9904199G
5.5 mm (220 mils) 4 pieces:	T9904199J
15 mm (595 mils) 4 pieces:	T9904199K

Individual foils in the range 12.5 µm to 20 mm (0.5 mil to 790 mils) and customised sets chosen from this range are also available. Consult your local Elcometer supplier.

15.4 Calibration certificates for foils

Certificates traceable to National Standards including UKAS and NIST are available on request.

15.5 Test certificates

A certificate with results of a standard test on known foil values over the full range of the probe. Order using sales part number TEST-456.

15.6 Coated thickness standards including certificate

Ferrous Standard (4 Values):	T995111261
Non-Ferrous Standard (4 Values):	T995111271
Ferrous Standard (2 Values):	T995166001
Non-Ferrous Standard (2 Values):	T995166011

15.7 Probe placement jig

To aid probe positioning on small components a probe placement jig is available and an adapter suitable for use with the full range of miniature probes is also available as an accessory.

Probe placement jig:	T95012880

15.8 Probe adapters

Jumbo Hand Grip (F and N probes):	T9997766-
Jumbo Hand Grip (FNF probes):	T99913225
V Adapter for pipes (F & N probes):	T9997381-
V Adapter for pipes (FNF probes):	T99913133

15.9 Infrared portable printer

Infrared Portable Printer:	X45613877
Thermal Printer Paper:	T99913878

15.10 Miniprinter

42 column, rechargeable battery powered Miniprinter complete with charger. Three charger options:

230V (UK Plug):	X4569964B
230V (European Plug):	X4569964C
110V (US Plug):	X4569964D

Miniprinter spares

456 to printer connection cable (25-pin):	T45616267
Ribbon Cassettes (Pack of 5):	T9769992-
Paper Rolls (Box of 20):	T9999993-

15.11 Bench Stands

Integral Probe Version:	T45616161
Integral/Separate Probe Version:	T45616162

15.12 PC Connection Cable

456 to PC Connection Cable (9-pin):	T45616217

Note: A 9-pin to 25-pin adapter may be required for certain PC RS232 ports.

16 RELATED EQUIPMENT

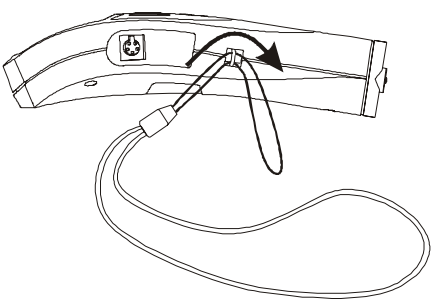
Elcometer produces a wide range of coating thickness gauges and associated paint inspection equipment. Users of the Elcometer 456^2 may also benefit from the following Elcometer products:

- Uncured powder thickness gauges
- Coatings analyser
- Inspection management software
- Mechanical coatings thickness gauges
- Appearance testers
- Adhesion testers

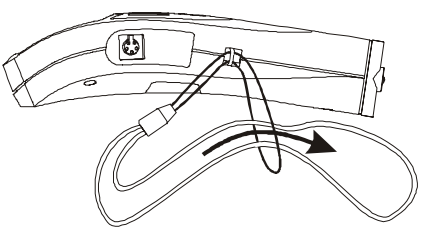
For further information contact Elcometer, your local Elcometer supplier or visit www.elcometer.com

17 FITTING THE WRIST HARNESS

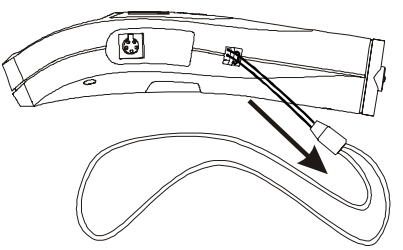
1. Pass harness round pin



2. Pass harness through loop



3. Pull tight



18 PROBE MEASUREMENT PERFORMANCE

Scale	Total range	Accuracy[a]	Resolution	in range
F1 F1 2 (F1 mode) FNF1 N1, N1A	0 µm to 1500 µm	±1% to ±3% or ±2.5 µm	0.1 µm 1.0 µm	0 µm to 99.9 µm 100 µm to 1500 µm
	0 mil to 60 mils	±1% to ±3% or ±0.1 mil	0.01 mil 0.1 mil	0 mil to 4.99 mils 5 mils to 60 mils
F2 F1 2 (F2 mode) N2	0 mm to 5.0 mm	±1% to ±3% or ±0.02 mm	1.0 µm 10 µm	0 mm to 0.99 mm 1.0 mm to 5.0 mm
	0 mil to 200 mils	±1% to ±3% or ±1 mil	0.1 mil 1 mil	0 mil to 49.9 mils 50 mils to 200 mils
F3	0 mm to 13 mm	±1% to ±3% or ±0.05 mm	1.0 µm 10 µm	0 mm to 1.99 mm 2 mm to 13 mm
	0 mil to 500 mils	±1% to ±3% or ±2.0 mils	0.1 mil 1 mil	0 mil to 99.9 mils 100 mils to 500 mils
FM3 NM3	0 µm to 500 µm	±1% to ±3% or ±2.5 µm	0.1 µm 1.0 µm	0 µm to 99.9 µm 100 µm to 500 µm
	0 mil to 10 mils	±1% to ±3% or ±1.0 mil	0.01 mil 0.1 mil	0 mil to 3.99 mils 4 mils to 10 mils

a. Whichever is the greater. Lower value achieved when calibrated close to the thickness to be measured.

19 PROBE CAPABILITIES

19.1 Integral probes

Probe type	Minimum convex surface diameter	Minimum concave surface radius	Headroom	Minimum sample diameter	Cal foil value[a]
F1 (or F1 2 set for F1 operation)	4 mm (0.16”)	25 mm (0.98”)	130 mm (5.1”)	4 mm (0.16”)	250 µm (10 mil)
F2 (or F1 2 set for F2 operation)	4 mm (0.16”)	25 mm (0.98”)	135 mm (5.3”)	8 mm (0.32”)	1 mm (40 mil)
F3	15 mm (0.59”)	40 mm (1.57”)	150 mm (5.9”)	14 mm (0.55”)	2.5 mm (100mil)
N1 (N)	35 mm (1.38”)	25 mm (0.98”)	130 mm (5.1”)	6 mm (0.24”)	250 µm (10 mil)
FNF1 (N)	38 mm (1.50”)	25 mm (0.98”)	135 mm (5.3”)	8 mm (0.32”)	250 µm (10 mil)
FNF1 (F)	4 mm (0.16”)	25 mm (0.98”)	135 mm (5.3”)	4 mm (0.16”)	250 µm (10 mil)

a. This is the recommended maximum calibration foil value to achieve the specified accuracy under these measurements conditions

19.2 Separate ferrous probes

Probe type	Minimum convex surface diameter	Minimum concave surface radius	Headroom	Minimum sample diameter	Cal foil value[a]
F1 (or F1 2 set to F1)	4 mm (0.16”)	25 mm (0.98”)	85 mm (3.35”)	4 mm (0.16”)	250 µm (10 mil)
F2 (or F1 2 set to F2)	4 mm (0.16”)	25 mm (0.98”)	89 mm (3.50”)	8 mm (0.32”)	1 mm (40 mil)
F1 Right Angle (or F1 2 set to F1)	4 mm (0.16”)	25 mm (0.98”)	28 mm (1.10”)	4 mm (0.16”)	250 µm (10 mil)
F2 Right Angle (or F1 2 set to F2)	4 mm (0.16”)	25 mm (0.98”)	32 mm (1.26”)	8 mm (0.32”)	1 mm (40 mil)
F1 Telescopic	4 mm (0.16”)	25 mm (0.98”)	32 mm (1.26”)	4 mm (0.16”)	250 µm (10 mil)
F2 Telescopic	4 mm (0.16”)	25 mm (0.98”)	36 mm (1.42”)	8 mm (0.32”)	1 mm (40 mil)
F3	15 mm (0.59”)	40 mm (1.57”)	102 mm (4.02”)	14 mm (0.55”)	2.5 mm (100 mil)

a. This is the recommended maximum calibration foil value to achieve the specified accuracy under these measurements conditions

19.3 Separate non-ferrous probes

Probe type	Minimum convex surface diameter	Minimum concave surface radius	Headroom	Minimum sample diameter	Cal foil value[a]
N1	35 mm (1.38”)	25 mm (0.98”)	85 mm (3.35”)	6 mm (0.24”)	250 µm (10 mil)
N1 Right Angle	35 mm (1.38”)	25 mm (0.98”)	28 mm (1.10”)	6 mm (0.24”)	250 µm (10 mil)
N1A Anodiser’s Probe	35 mm (1.38”)	25 mm (0.98”)	85 mm (3.35”)	6 mm (0.24”)	250 µm (10 mil)
N2	100 mm (3.97”)	150 mm (5.90”)	85 mm (3.35”)	14 mm (0.55”)	1 mm (40 mil)

a. This is the recommended maximum calibration foil value to achieve the specified accuracy under these measurements conditions

19.4 Separate dual FNF

Probe type	Minimum convex surface diameter	Minimum concave surface radius	Headroom	Minimum sample diameter	Cal foil value[a]
FNF1 (N)	38 mm (1.50”)	25 mm (0.98”)	88 mm (3.46”)	8 mm (0.32”)	250 µm (10 mil)
FNF1 (F)	4 mm (0.16”)	25 mm (0.98”)	88 mm (3.46”)	4 mm (0.16”)	250 µm (10 mil)
FNF1 Right Angle (N)	38 mm (1.50”)	25 mm (0.98”)	34 mm (1.34”)	8 mm (0.32”)	250 µm (10 mil)
FNF1 Right Angle (F)	4 mm (0.16”)	25 mm (0.98”)	34 mm (1.34”)	4 mm (0.16”)	250 µm (10 mil)

a. This is the recommended maximum calibration foil value to achieve the specified accuracy under these measurements conditions

19.5 PINIP™ probes

Probe type	Minimum convex surface diameter	Minimum concave surface radius	Headroom	Minimum sample diameter	Cal foil value[a]
F1 (or F1 2 set to F1)	4 mm (0.16”)	60 mm (2.36”)	155 mm (6.10”)	4 mm (0.16”)	250 µm (10 mil)
F2 (or F1 2 set to F2)	4 mm (0.16”)	60 mm (2.36”)	159 mm (6.25”)	8 mm (0.32”)	1 mm (40 mil)
F3	15 mm (0.59”)	45 mm (1.77”)	169 mm (6.65”)	14 mm (0.55”)	2.5 mm (100mil)
N1	35 mm (1.38”)	50 mm (1.97”)	155 mm (6.09”)	6 mm (0.24”)	250 µm (10 mil)
FNF1 (N)	38 mm (1.50”)	55 mm (2.17”)	156 mm (6.15”)	8 mm (0.32”)	250 µm (10 mil)
FNF1 (F)	4 mm (0.16”)	55 mm (2.17”)	156 mm (6.14”)	4 mm (0.16”)	250 µm (10 mil)

a. This is the recommended maximum calibration foil value to achieve the specified accuracy under these measurements conditions

19.6 Separate miniature ferrous probes

Probe Type	Minimum convex surface diameter	Minimum concave surface radius	Minimum sample diameter	Minimum access height	Minimum access width	Overall length (headroom)
F, Straight, 45 mm (1.77”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	6 mm (0.24”)		150 mm (5.91”)
F, Straight, 150 mm (5.9”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	6 mm (0.24”)		260 mm (10.24”)
F, 45°, 45 mm (1.77”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	18 mm (0.71”)	7 mm (0.28”)	145 mm (5.71”)
F, 45°, 150 mm (5.9”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	18 mm (0.71”)	7 mm (0.28”)	250 mm (9.84”)
F, 90°, 45 mm (1.77”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	16 mm (0.63”)	7 mm (0.28”)	140 mm (5.51”)
F, 90°, 150 mm (5.9”)	1.5 mm (0.06”)	6.5 mm (0.26”)	3 mm (0.12”)	16 mm (0.63”)	7 mm (0.28”)	245 mm (9.64”)

19.7 Separate miniature non-ferrous probes

Probe Type	Minimum convex diameter	Minimum concave radius	Minimum sample diameter	Minimum access height	Minimum access width	Overall length (headroom)
NF, Straight, 45 mm (1.77”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	6 mm (0.24”)		150 mm (5.91”)
NF, Straight, 150 mm (5.9”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	6mm (0.24”)		260 mm (10.24”)
NF, 45°, 45 mm (1.77”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	18 mm (0.71”)	7 mm (0.28”)	145 mm (5.71”)
NF, 45°, 150 mm (5.9”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	18 mm (0.71”)	7 mm (0.28”)	250 mm (9.84”)
NF, 90°, 45 mm (1.77”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	16 mm (0.63”)	7 mm (0.28”)	140 mm (5.51”)
NF, 90°, 150 mm (5.9”)	3 mm (0.12”)	25 mm (0.98”)	4 mm (0.16”)	16 mm (0.63”)	7 mm (0.28”)	245 mm (9.64”)

20 ERROR MESSAGES

Under certain conditions the gauge will display error messages (Figure 54). These messages are normally cleared by pressing any one of the softkeys. The cause of the error will be indicated by the message and should be corrected before proceeding.

Error message	Causes	Action to take
#1 - PROBE	Probe-to-gauge communication failure.	Integral gauge - return to Elcometer*. Separate gauge - remove probe and refit. If error persists, return to Elcometer*.
#2 - PROBE	Corrupt data output from probe.	Integral gauge - return to Elcometer*. Separate gauge - try new probe. If error persists, return to Elcometer*.
#3 - PROBE	Internal error.	Return to Elcometer*.
PROBE UNSUPPORTED	a) Probe is dual FNF, but gauge is ferrous only, or non-ferrous only. See page 47. b) Old gauge software does not support new probe.	a) Gauge model F and gauge model N cannot be used with a dual FNF probe. b) Return to Elcometer* for software upgrade.
PROBE CHANGED	Probe has been changed.	Calibration adjustment required.

Error message	Causes	Action to take
UNSTABLE READING	a) External electro-magnetic interference. b) Gauge faulty.	a) Isolate from electro-magnetic interference. b) Return to Elcometer*.
VALUE TOO LARGE	Numerical error.	Switch gauge off then on again. If error persists contact Elcometer.
CALIBRATION	Incorrect calibration calculation.	Re-calibrate. If error persists, return to Elcometer*.
LANGUAGE MEMORY	Software error.	Return to Elcometer*.

* Contact Elcometer or your local Elcometer Supplier to arrange return.

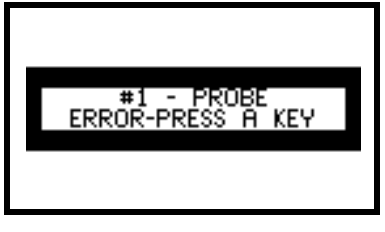


Figure 54. Example error message - no probe is connected to gauge

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