

Elcometer 456³

Coating Thickness Gauge

Basic Models

Operating Instructions



These instructions apply to the following Elcometer 456³ models:
Ferrous (F), Non-Ferrous (NF) and 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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A copy of this Instruction Manual is available for download on our Website via www.elcometer.com/downloads.

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The Elcometer 456³ 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 456³ 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 456³ Basic**.

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.

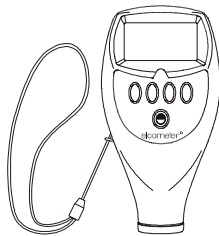


Figure 1.
Elcometer 456³
Coating Thickness
Gauge

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 33. 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).
- Simple statistics.
- Monitoring of readings to NDFT in accordance with 90/10 rule.
- RS232 interface.

1.2 STANDARDS

The Elcometer 456³ 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 456³ Gauge with integral probe, or Elcometer 456³ Gauge and separate probe (probe must be ordered separately)
- Calibration foils
- Gauge carrying pouch
- Wrist harness
- Batteries
- Operating instructions

1.4 CONVENTIONS IN THESE INSTRUCTIONS

The Elcometer 456³ 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 456³ 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 7 |
| 2. Fit probe ^a : | see page 8 |
| 3. Switch on: | see page 9 |
| 4. Select language: | see page 11 |
| 5. Try taking a reading: | see page 12 |
| 6. Adjust calibration: | see page 22 |

The gauge is now configured and ready to use.

To maximise the benefits of your new Elcometer 456³, please take some time to read these Operating Instructions. Do not hesitate to contact Elcometer or your Elcometer supplier if you have any questions.

a. Gauges with separate probes only

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.

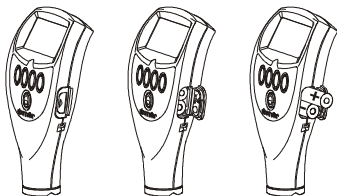


Figure 2. Fitting batteries - ensure correct battery polarity

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)



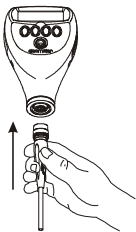
To ensure correct transfer of data from the probe and detection of the new probe, the gauge **must be switched off** when separate probes are fitted.

A probe must be calibrated once it has been fitted - see “Calibration adjustment” on page 22.

To fit the probe

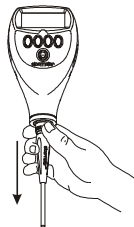
Align connector keyway and push in direction shown. The connector locks automatically.

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.



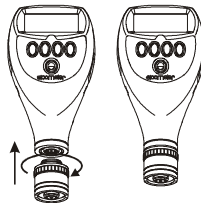
To release the probe

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




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. Indicates when readings pass or fail the 90/10 rule (see page 31).

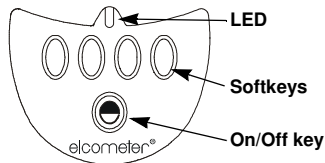
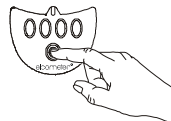


Figure 3. Elcometer 456³ control keys


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.

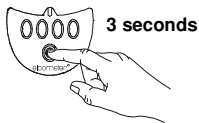


Note: Before switching the gauge on for the first time read “Selecting a language” on page 11.

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 456³ 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 20.

2.7 THE SCREEN

Familiarise yourself with the Elcometer 456³ 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 456³ welcome screen

The screen where measurement values and statistics are displayed is called the Reading Screen. The character size of the measurement value decreases as additional information is shown on the display (Figure 5). To maximise character size, switch off statistics (see Stats on LCD, page 30) and unlock the softkeys (see SOFTKEYS LOCKED:, page 21).

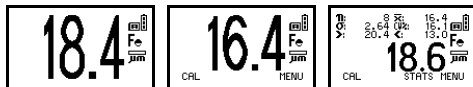


Figure 5. Typical Elcometer 456³ reading screens

2.8 SELECTING A LANGUAGE

The Elcometer 456³ 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


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 456³ welcome screen (Figure 4) followed by the reading screen (Figure 5).

The gauge operates in the new language until changed.

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 above to select the language.

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

2.9 INTERFACES

An RS232 5-pin connector is located on the side of your gauge. Use this connector and the optional PC connection cable to connect your gauge to a PC to enable you to create personalised 'welcome' screens (see "Personalised welcome screen" on page 35) or transfer individual readings and a statistical summary.

RS232 5-pin connector

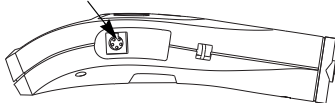



Figure 7. RS232 interface

3 TAKING A READING

3.1 BEFORE YOU START

- *Are you using the correct type of probe?*
See "Probes" on page 33.
- *Is the probe calibrated?*
See "Calibration adjustment" on page 22.
- *Do you require statistics?*
See "Statistics" on page 29.
- *What units of measurement do you want to use?*
See "UNITS:" on page 20.

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.**

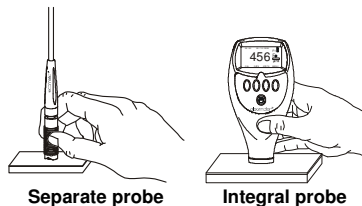


Figure 8. Taking a reading

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

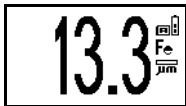


Figure 9. Typical reading

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.

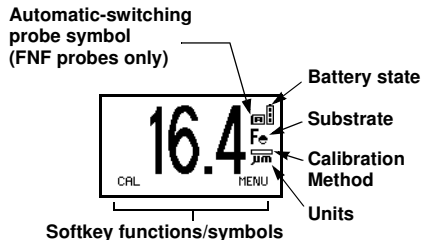


Figure 10. Example of reading screen with smooth surface calibration method selected

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 22.

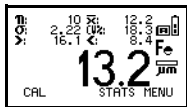


Figure 11. Reading screen in extended mode and showing full set of statistical values.

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.

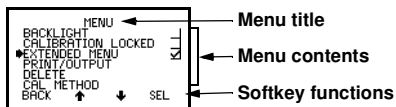


Figure 12. Typical Elcometer 456³ menu

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.

SIMPLE AND EXTENDED MENUS

The Elcometer 456³ Basic 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 is activated. These give access to more advanced functions such as statistics, calibration method, print/output, setup, etc.

4.3 MAIN MENU - EXTENDED MENU OFF



Figure 13. Main menu - extended menu off

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.

CALIBRATION 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.

EXTENDED MENU

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

ABOUT

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

GAUGE INFORMATION: Elcometer 456³ 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 456³ display screens.

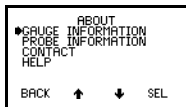


Figure 14. About menu

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^b: Resets gauge to International default settings e.g. DD/MM/YY date format and metric units.

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

USA GAUGE^c: Resets gauge to USA default settings e.g. MM/DD/YY date format and imperial units.

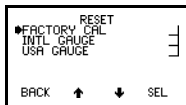


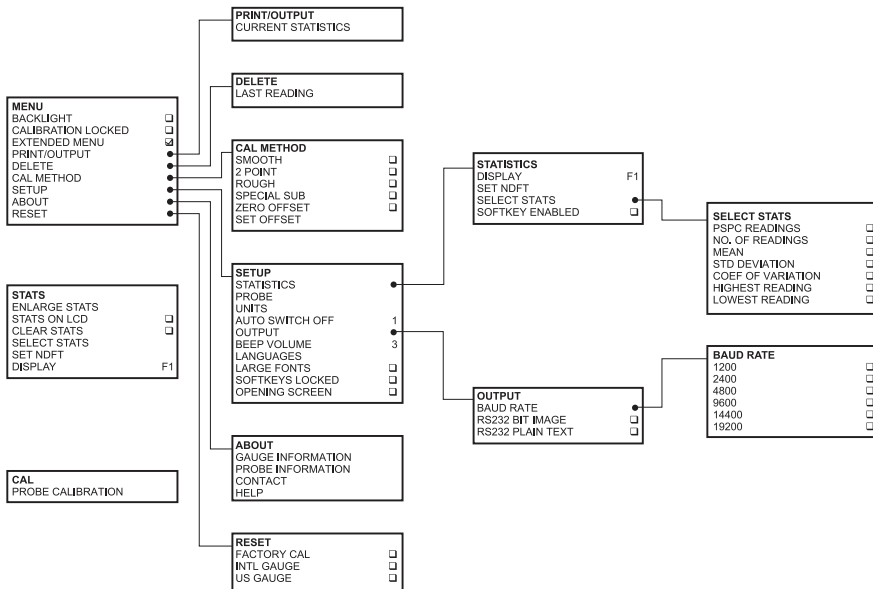
Figure 15. Reset menu

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

-
- c. USA 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**



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

PRINT/OUTPUT

Outputs individual readings or a statistical summary via the RS232 interface.

To use this function, first setup using:

MENU/SETUP/OUTPUT - see “OUTPUT:” on page 20.

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

DELETE

Deletes last reading only. Gauge displays **ARE YOU SURE?** (Figure 16).

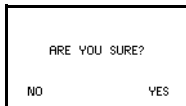


Figure 16. Delete last reading confirmation screen

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

If there is no reading to delete, the gauge displays:



Figure 17. Delete last reading not available screen

Press **OK** to return to Delete menu.

CAL METHOD

Allows selection of calibration method from list of options - see “Calibration method” on page 22 for more details.

SETUP

Used to select, change or activate gauge features:

STATISTICS: Activates simple statistics feature.

Display - see “Display” on page 32.

Set NDFT - see “Set NDFT” on page 31

Select stats - see “Select stats” on page 31.

Softkey enabled - switches STATS softkey on/off.

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 μ m, mm, mil, thou or inch.

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 .)

OUTPUT: Activates data output. Toggle tick box to activate/deactivate. When activated, readings are sent to the mini portable printer as they are taken. See "Miniprinter" on page 42 for sales part number of this optional accessory.

OUTPUT: Selects baud rate (Figure 18) and activates data output via the RS232 interface - see "Interfaces" on page 12.

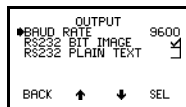


Figure 18. OUTPUT screen

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 42).

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^d. This allows printing on devices other than the Elcometer Miniprinter, e.g.

RS 232 printers or PC via Elcometer software or via HyperTerminal.

BEEP VOLUME: Changes volume.

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

LANGUAGES: Allows selection of language.

LARGE FONTS: When ticked, displays all menus and screens using double height, single width fonts (for improved legibility, if needed).



Figure 19. Large fonts enabled

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

SOFTKEYS LOCKED: When ticked, the softkey functions will always be displayed.

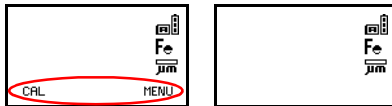


Figure 20. Softkeys locked/unlocked

When un-ticked, the softkey functions disappear from the reading screen 5 seconds after the reading screen has been displayed, or 5 seconds after pressing any key. To view the functions again, press any one of the four softkeys.

Softkey functions are *always* visible in menus.

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 35), Opening Screen must be activated to display this screen.

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 21):

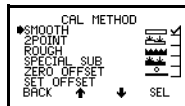


Figure 21. CAL METHOD screen

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 from ISO 19840

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

Note: When the calibration method is changed, e.g. from Smooth to Rough, the gauge will display a message (Figure 22).

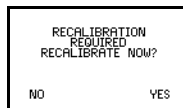


Figure 22. Recalibration required screen

If the **NO** softkey is pressed the **CAL** softkey symbol on the Readings Screen will flash to warn that calibration adjustment is still required.

If the **YES** softkey is pressed the calibration adjustment procedure is activated - see "Calibration adjustment procedure" on page 24.

5.2 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 29.

Note: To calibrate 5 mm (200 mils) and 13 mm (500 mils) range gauges it will be necessary to stack the foils (Figure 23). Care must be taken to

avoid errors due to placing the foil labels between the foils.

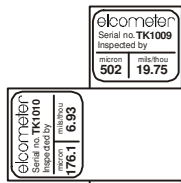


Figure 23. Stacking foils to increase thickness

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).

5.3 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 24).

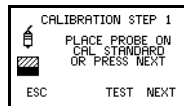


Figure 24. Step 1 - on thickness standard

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.

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.

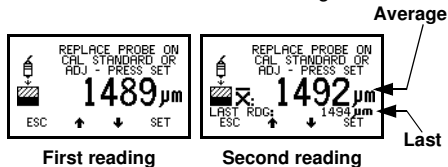


Figure 25. Step 1 - Calibration adjustment on thickness standard

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 26). Taking a reading within range clears this screen.

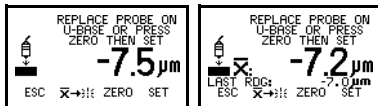


Figure 26. Over-range reading

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 27. 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 $\bar{x} \rightarrow \rightarrow \rightarrow$.

- Press **ZERO** softkey to zero the display (Figure 28).

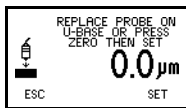


Figure 28. Zero the display

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

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

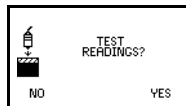


Figure 29. TEST READINGS screen

- 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 below.

Taking test readings

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

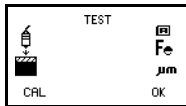


Figure 30. TEST READINGS screen

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

OK softkey exits 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.

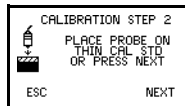
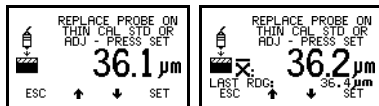


Figure 31. Step 2 - On thin standard

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 32. 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 35. These thickness standards should be used in place of the calibration standard in **Step 1** of “Calibration adjustment procedure” on page 24.

1. Place appropriate thickness standard over end of PINIP™ probe.
2. Press **CAL** softkey.
3. Place probe on hot^e 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 26.

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

6 STATISTICS

The Elcometer 456³ Basic has a Simple Statistics feature (**STATS**) which calculates and displays a statistical analysis of readings as they are taken.

When **EXTENDED MENU** is active, press **STATS** softkey to access **STATS MENU** (Figure 33).



Figure 33. Stats menu

The statistics available are:

- Number of Readings **T**;
- Mean **x̄**;
- Standard Deviation **σ**;
- Coefficient of Variation **[V%]**;
- Highest Reading **➤**;
- Lowest Reading **◀**;
- % greater to or equal to NDFT **≥ND**;
- % between 90% and 100% of NDFT **90%..100%**;
- 90/10 pass or fail **90:10**;

For more information see:

- “Select stats” on page 31.
- “Statistics terminology” on page 38.

If you require statistics in batches, or memory for readings, Elcometer 456³ models Standard and Top provide this facility. Contact Elcometer or your local Elcometer supplier for more details.

6.1 ENLARGE STATS

Displays the chosen statistical values as double-height characters. The example screens (Figure 34) 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.

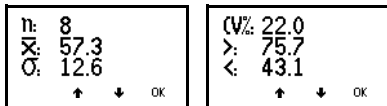


Figure 34. Enlarged statistics

6.2 STATS ON LCD

Activates the presentation of the chosen statistical values on the reading screen.

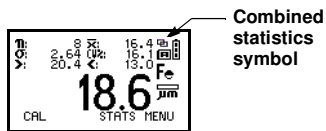


Figure 35. Reading screen with all statistics

6.3 CLEAR STATS

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

6.4 SELECT STATS

Allows the user to choose which statistical values are displayed. The default condition is all values except PSPC readings (Figure 36).

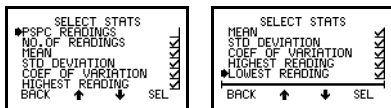


Figure 36. Select stats menu

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

Note: When *PSPC readings* is selected, no other values can be selected and the *SET NDFT* screen will be displayed automatically.

See “Set NDFT” on page 31 for further information about *PSPC* and *NDFT*.

6.5 SET NDFT

The factory default value^f for *NDFT*^g is 320 μm (12.6 mils).

If you need to adjust this value, select ‘SET NDFT’, use the **Up/Down** softkeys \uparrow \downarrow to adjust the value and then press **OK**. If any readings have been taken in immediate mode, a screen will be displayed warning that the statistics will be cleared. Press **YES** to continue (to change the *NDFT* value) or **NO** to escape (and leave the value unchanged).

ABOUT PSPC^h READINGS

Your gauge is capable of displaying *PSPC* readings according to the 90/10 rule as defined in the *IMO*ⁱ requirements.

To pass the 90/10 rule (Figure 37):

- At least 90% of all thickness measurements shall be greater than or equal to *NDFT*, and

-
- f. Default value from *PSPC* for Ballast Water Tanks
 - g. Nominal Dry Film Thickness
 - h. Performance Standard for Protective Coatings
 - i. International Maritime Organisation

- none of the remaining measurements shall be below $0.9 \times \text{NDFT}$.

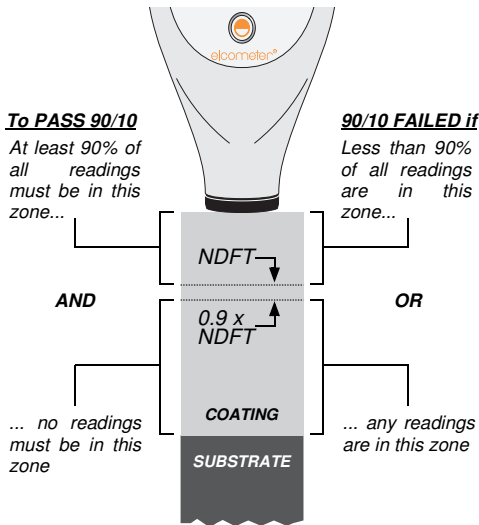


Figure 37. Pass/Fail criteria for 90/10 rule

When PSPC statistics are selected the standard statistics displayed on the screen are replaced by those for PSPC (Figure 38):

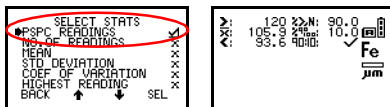


Figure 38. PSPC statistics - selected and displayed on reading screen

While you are taking readings with PSPC statistics selected, your gauge will beep and flash the LED:

Pass	✓	: 1 beep	Green flash
Fail (90%)	✗!	: 3 beeps	Green flash
Fail (<0.9xNDFT)	✗	: 3 beeps	Red flash

6.6 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 ^d
F1 2	F1, F2 or F1 and F2 combined ^d

7 PROBES

An extensive range of probes is available for the Elcometer 456³ 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.

7.1 FERROUS (F) PROBES

F probes measure the thickness of non-magnetic coatings on magnetic substrates. They can be used

- j. When readings are combined a  symbol will be displayed on the Reading Screen (Figure 35).

on paint, plastic, galvanising, enamel, powder paint, hard chrome and other coatings such as electroless nickel applied to steel or iron.

7.2 NON-FERROUS (N) PROBES^K

N probes measure the thickness of non-metallic 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.

7.3 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 20 and “Coatings on galvanised or metallised steel” on page 35.

- k. 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.

7.4 PROBE INTERCHANGEABILITY

The following table shows which probes can be used in the three types of Elcometer 456³ 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™	✓	✗	✓
	FM3 miniature straight	✓	✗	✓
	FM3 miniature 45°	✓	✗	✓
	FM3 miniature 90°	✓	✗	✓

Probe type		Gauge Type		
		F	N	FNF
NON-FERROUS	N1 *	✗	✓	✓
	N2	✗	✓	✓
	N1 right angle	✗	✓	✓
	N1A anodiser's	✗	✓	✓
	N1 PINIP™	✗	✓	✓
	NM3 miniature straight	✗	✓	✓
	NM3 miniature 45°	✗	✓	✓
DUAL	NM3 miniature 90°	✗	✓	✓
	FNF1 *	✗	✗	✓
	FNF1 right angle	✗	✗	✓
	FNF PINIP™	✗	✗	✓

* indicates probes available for integral type gauges.

7.5 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.

7.6 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 39.

Note: Refer to special calibration procedure - see “Calibrating High Temperature PINIP™ Probes” on page 29.

7.7 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 22.

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.

8 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.

8.1 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 optional 456 to PC connection cable - see "PC Connection Cable" on page 42.
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.

8.2 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.

9 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.

10 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.

11 STATISTICS TERMINOLOGY

Term		Meaning
COEF OF VARIAT'N	$\frac{S}{\bar{X}}$	Coefficient of Variation. The standard deviation divided by the mean for a group of readings, expressed as a percentage.
HIGHEST READING	\rightarrow	The value of the maximum thickness in a group of readings.
LOWEST READING	\leftarrow	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 mode, 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.
PERCENT GREATER OR EQUAL TO NDFT	$\geq N$	The percentage (%) of readings greater than or equal to the value of NDFT (see "Set NDFT" on page 31)
PERCENT BETWEEN 90% AND 100% NDFT	$\geq 90\%$	The percentage (%) of readings less than the value of NDFT but greater than 90% of the value of NDFT.
90:10 PASS / FAIL	$90:10$	90/10 test results: \checkmark = pass, $\times!$ = failed on 90% test, \times = fail due to a reading below 0.9xNDFT (if a number between 1 and 10 is displayed, insufficient measurements have been taken to be statistically valid - take more measurements)

12 TECHNICAL DATA

12.1 MEASUREMENT SPEED

>60 readings per minute.

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.

12.2 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.

12.3 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)

12.4 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

12.5 POWER SUPPLY

Internal batteries, 2 x LR03 (AAA), alkaline^l dry batteries or rechargeable^m equivalents.

Battery life

30ⁿ 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.

12.6 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.

-
- i. 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.
 - m. Rechargeable batteries can be used if they are charged outside the gauge.
 - n. 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.

13 ACCESSORIES

The Elcometer 456³ 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.

13.1 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.

13.2 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.

13.3 CALIBRATION CERTIFICATES FOR FOILS

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

13.4 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.

13.5 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

13.6 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
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13.7 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
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13.8 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-

13.9 BENCH STANDS

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

13.10 PC CONNECTION CABLE

456 to PC Connection Cable (9-pin):	T99916217
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Note: A 9-pin to 25-pin adapter may be required for certain PC RS232 ports.

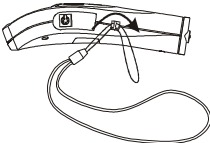
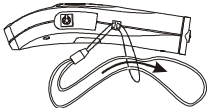
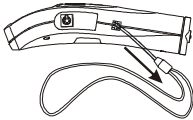
14 RELATED EQUIPMENT

Elcometer produces a wide range of coating thickness gauges and associated paint inspection equipment. Users of the Elcometer 456³ 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

15 FITTING THE WRIST HARNESS

1. Pass harness round pin	
2. Pass harness through loop	
3. Pull tight	

16 PROBE MEASUREMENT PERFORMANCE

Scale	Total range	Accuracy ^a	Resolution	in range
F1 F1 2 (F1 mode) FNF1 N1, N1A	0 μ m to 1500 μ m	$\pm 1\%$ to $\pm 3\%$ or ± 2.5 μ m	0.1 μ m 1.0 μ m	0 μ m to 99.9 μ m 100 μ m to 1500 μ m
	0 mil to 60 mils	$\pm 1\%$ to $\pm 3\%$ or ± 0.1 mil	0.01 mil 0.1 mil	0 mil to 4.99 mils 5 mils to 60 mils
F1 2 (F2 mode) N2	0 mm to 5.0 mm	$\pm 1\%$ to $\pm 3\%$ or ± 0.02 mm	1.0 μ m 10 μ m	0 mm to 0.99 mm 1.0 mm to 5.0 mm
	0 mil to 200 mils	$\pm 1\%$ to $\pm 3\%$ 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	$\pm 1\%$ to $\pm 3\%$ or ± 0.05 mm	1.0 μ m 10 μ m	0 mm to 1.99 mm 2 mm to 13 mm
	0 mil to 500 mils	$\pm 1\%$ to $\pm 3\%$ or ± 2.0 mils	0.1 mil 1 mil	0 mil to 99.9 mils 100 mils to 500 mils
FM3 NM3	0 μ m to 500 μ m	$\pm 1\%$ to $\pm 3\%$ or ± 2.5 μ m	0.1 μ m 1.0 μ m	0 μ m to 99.9 μ m 100 μ m to 500 μ m
	0 mil to 10 mils	$\pm 1\%$ to $\pm 3\%$ or ± 1.0 mil	0.01 mil 0.1 mil	0 mil to 3.99 mils 4 mils to 10 mils
F6	0 mm to 25 mm	$\pm 1\%$ to $\pm 3\%$ or ± 0.1 mm	10 μ m 100 μ m	0 mm to 1.99 mm 2 mm to 25 mm
	0 mil to 980 mils	$\pm 1\%$ to $\pm 3\%$ or ± 2.0 mils	1 mil 10 mil	0 mil to 99.9 mils 100 mils to 980 mils
N6	0 mm to 30 mm	$\pm 1\%$ to $\pm 3\%$ or ± 0.05 mm	10 μ m 100 μ m	0 mm to 1.99 mm 2 mm to 30 mm
	0 mil to 1200 mils	$\pm 1\%$ to $\pm 3\%$ or ± 2.0 mils	1 mil 10 mil	0 mil to 99.9 mils 100 mils to 1200 mils

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

17 PROBE CAPABILITIES

17.1 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)
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 measurement conditions

17.2 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)
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)
F1 2 Right Angle (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)
F1 2 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)
F6	35 mm	170 mm	150 mm	51 x 51 mm (2" x 2")	5 mm (200 mil)

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

17.3 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)
N6	Flat surface	400 mm	160 mm	58 mm	Any

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

17.4 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 measurement conditions

17.5 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)
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 measurement conditions

17.6 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")

17.7 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")

18 ERROR MESSAGES

Under certain conditions the gauge will display error messages (Figure 39). 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 33. 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.
UNSTABLE READING	a) External electro-magnetic interference. b) Gauge faulty.	a) Isolate from electro-magnetic interference. b) Return to Elcometer*.

Error message	Causes	Action to take
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 39. Example error message - no probe is connected to gauge

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