MiniTest 650

Operating Instructions

Advancing with Technology ElektroPhysik

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1. General Information

1.1 Applications

The compact and handy pocket gauges have been designed for non-destructive, fast and precise coating thickness measurement.. According to model and probe type, the gauges work either on the magnetic induction priniciple or on the eddy currents principle. The FN models work on both prinicples. All models conform to the following industrial standards:

DIN 50981, 50982, 50984, DIN EN ISO 2178, 2360, ASTM B499, B244, BS 5411. In 1995, DIN 50981 and 50984 have been replaced by DIN EN ISO 2178 and DIN EN ISO 2360.

The principal applications lie in the field of corrosion protection. The gauges are ideal for manufacturers and their customers, for offices and specialist advisers, for paint shops and electroplaters, for the chemical, automotive, shipbuilding and aircraft industries and for light and heavy engineering.

The range of application results from the gauge model:

- MiniTest 650 F works on the magnetic induction principle and should be used for measuring non-magnetic coatings such as aluminium, chrome, copper, zinc, paint and varnish, enamel, rubber etc., on iron or steel substrates. It is also suitable for alloyed and hardened magnetic steel.
- MiniTest 650 N works on the eddy-current principle and should be used for insulating coatings on all non-ferrous metals and on austenitic stainless steels, e.g. paint, anodising coatings, ceramics, etc. applied on aluminium, copper, zinc die-casting, brass, etc.
- MiniTest 650 FN works on both priniciples, magnetic induction and the eddy-current principle. The FN probe can measure on both susbrates, ferrous and non-ferrous metals. When switched to automatic mode, this probe identifies the type of substrate and automatically switches to the suitable measuring principle.

1.2 Description of the gauge

The battery powered gauge is equipped with a 1m probe cable and a large, easy-to-reasd dispaly to show readings and user information. A display back light ensure easy reading of screen data in poor lit conditions. Easy-to operate, the gauge allows automatic storage of up to 9,999 readings in a data memory as well as statistical evaluation.

Note:

MiniTest 650 FN offers two different modes: manual and auotmatic mode.

- The manual mode serves to activate either the magnetic induction principle (F) or the eddy-current principle (N) by means of the arrow keys.
- In automatic mode, due to a special evaluation algorithm the gauge always shows the correct thickness readings according to the current application (Ferrous or Non-ferrous). This requires that the gauge has been calibrated previously for both substrates.

The statistical values (n, x, s, max, min) are stored in separate memories for ferrous and non-ferrous substrates.

All MiniTest models are also suitable for special applicatons such as measuring on special geometries. After the gauge has been calibrated to the specific parameters, these are automatically taken into consideration.

1.3 Supply schedule

- Gauge with probe and 3 batteries
- Control standar(s)
- Calibration foils
- Operating instructions
- Soft pouch

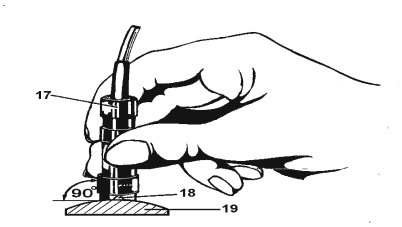
1.3.1 Accessories

- Precision stand for measuring smallparts.
- Msoft7000 basic editiondata tranfer program
- rechargeable batteries incl. charger
- USB connecting cable

1.4 Probe design

All probe systems are spring-mounted in the probe sleeve. This ensures safe and stable positioning of the probe and constant contact pressure. A V-groove in the sleeve of the probes facilitates reliable readings also on small cylindrical parts.

The probe should be held by the spring-mounted sleeve.The hemispherical tip is made of hard and durable material.



17 Spring-mounted sleeve for holding the probe

18 V-groove for safe positioning on curved surfaces

19 Measuring object

2. Preparing MiniTest 650

2.1 Checking power supply

1. 3 x 1.5 Volts Alkaline battery or
   3 x 1.2 Volts rechargeable battery

2. Check battery condition by pressing ON .

- **No LC display at all:** No batteries inserted or insufficient battery charge, unable to illuminate display

- **If BAT symbol does not appear:** Batteries are sufficiently charged

- **If BAT symbol flashes and gauge switches off after about 1 sec:** Batteries must be replaced immediately!

If the BAT symbol flashes during measurement, batteries are running low and should be replaced before the gauge is switched on again. If you do not replace batteries, the BAT symbol appears permanently and the gauge switches off.

Note:

Erratic readings readings due to low battery voltage do not occur.

2.2 Replacing batteries

1. Place the gauge upside down on a table.
2. Unscrew the lid of the battery compartment and raise from housing.
3. Remove batteries.
4. Insert new batteries.
5. Put the lid back on the housing and tighten the screws.

Caution:

Respect polarities when replacing batteries and make sure to change batteries within 10 seconds in order to prevent data loss in memory (readings, calibration values, basic settings, etc. may be lost !)

2.3 Start-up functions

The MiniTest 650 gauges include a number of functions that can only be called up or activated at switch-on.

Gauge function	Keys to press
Total-Reset	ZERO + CLEAR + ON
LCDDisplay Test	⇧ key + ON
Basic Settings	ZERO + ON

2.3.1 Total reset

A total reset is intended to delete all statistical and calibration values and the gauge will resume the basic Mode setting (ZERO - : / 0, see section 2.4).

1. Switch off gauge.
2. Press ZERO + CLEAR + ON simultaneously.

Please note: Total reset is confirmed by a long bleep.

2.3.2 LCD display test

The LCD display test enables you to see all display segments. Please proceed as follows:

1. Switch the gauge off.

2. Press ⇧ and ON keys and hold down. As long as the arrow key is depressed, all sections of the LC display will be shown.

2.4 Basic settings

1. Switch the gauge off, hold down ZERO key and press ON.

2. Keep both keys pressed until you hear the signal. The gauge will now display a pair of numbers: 1:0 or 1:1.

Note:

If you are using the MiniTest 650 FN model, use the arrow keys to activate eiher the (F) section (⇧) or the N section (⇩) as requested or wait 3 seconds to activate the automatic swiching mode.

3. Press ZERO to move through each of the table's function from 1 to 4:

1	Switch-off mode
2	Keylock
3	Display backlight
4	Measuring unit

Use the arrow keys (⇧ or ⇩) to set your requested option (0) or (1).

4. Press ZERO again to return to measuring mode.

Important note:

Please make sure to switch the gauge OFF and ON again each time you have changed any of the above mode settings (switch-off mode, keylock, display backlight or measuring unit).

Table of basic settings

Zero-key / Function	Arrow key/ setting	Mode	Setting
1	0	Automatic Switch off	Enabled
	1		Disabled
2	0	Keylock- for ZERO, CAL	Disabled
	1		Enabled
3	0	Display backlight	Disabled
	1		Enabled
4	0	Measuring unit	metric / µm
	1		imperial / mils

2.4.1 Automatic switch off

The gauge is programd to switch itself off after about 90 seconds of inactivity. This can hinder operations in certain circumstances. In this case, please disable the automatic switch off mode in order to operate in the continuous mode.

Please refer to the table of basic settings in section 2.4 to adjust to the requested mode by means of the ZERO- and arrow keys as described.

2.4.2 KEYLOCK for ZERO- and CAL-keys

An unintended change of calibration can be prevented by using the KEYLOCK function. This function locks the calibration keys.

To activate the KEYLOCK function please refer to the table of gauge settings in section 2.4. Select option with the ZERO and arrow keys as described.

2.4.3 Display backlight

All MiniTest 650 models are equipped with a display backlight which can be disabled in order to save battery life. If the backlight function is enabled, it lights the display for about 2 seconds after a reading has been taken.

To activate the display light please refer to the table of gauge settings in section 2.4. Select option with the ZERO and arrow keys as described.

2.4.4 Select a measuring unit

Readings can be taken and displayed in metric and in imperial units. To switch from metric units (µm, mm, cm) to imperials (mils, inch) or vice versa.

Please refer to the table of gauge settings in section 2.4. Select option with the ZERO and arrow keys as described.

3. Calibration and measurement

3.1 General remarks on calibration

3.1.1 Calibration methods

Three different calibration methods are available for the MiniTest 650 gauges:

- Standard calibration

  recommended for even surfaces and for approximate measurements, i.e. those that do not require the degree of accuracy of one-point calibration.

- One-point calibration: set zero without using foil

  recommended when measuring errors up to 4 % of reading are permitted. The given error range of the probe of ± 2 µm should also be taken into account.

- Two-point calibration: set zero and cali-brate using one foil

  recommended when measuring errors of between 2 % of reading are permitted. The given error range of the probe of ± 2 µm should also be taken into account.

3.1.2 Saving calibration values

Once a calibration has been saved, it will stay in memory until changed. (See also section 3.1.8, ‘Stability of calibration values’).

To change calibration, simply carry out a new calibration. This automatically deletes the previous calibration values and the new ones will be valid.

Note:

Calibration procedure must be restarted from the beginning if during calibration

- an incorrect reading has been taken
- incorrect command has been entered
- the gauge has switched off for any reason

3.1.3 Calibration example

Calibration is the most important requirement for accurate measurement. The more a calibration sample matches to the measuring sample, the more accurate will be calibration and measurement.

The calibration sample should correspond to the measuring sample in the following characteristics:

- radius of surface curvature
- substrate characteristics
- substrate thickness
- size of measuring area

For more detailed information please refer to the technical details in chapter 12.

The point at which the calibration is made on the calibration sample must always be identical with the point of measurement on the product itself, especially if measurement should be made at edges of small components.

For such applications, the use of the precision stand is recommended.

3.1.4 Influence of substrate thickness

In the case of steel samples, the substrate thickness has no negative influence on the meauring accuracy as long as the steel base is thicker than the measuring range of probe.

In the case of non-ferrous metals, 50 µm (2 mils) substrate thickness is sufficient. In addition, the substrate must be strong enough not to give way under the pressure of the probe tip. Thin Aluminican be measured, if stuck on a hard base.

The zero referene plate supplied with the gauge (according to model made of steel or aluminium) is intended for checking mesuring accuracy. It is not intended for calibration!

Exceptions:

The zero reference plate made of steel may be used for calibration if the measuring object has a smooth and even surface (e.g. it must not be shot-blasted) and if the steel substrate is thicker than 1mm (40 mils).

The zero reference plate made of Aluminium may be used for calibration, if the measuring object is smooth and even and if the Aluminium substrate is thickner than 50µm (2 mils).

3.1.5 High-accuracy calibration

To achieve high-accuracy readings, it is advisable to log calibration values (both zero values and calibration foil values) several times in succession. In this way the gauge will automatically establish a mean calibration value. For more details see sections 3.2.2 - 3.2.4 on calibration.

This method is especially recommended for measuring uneven, e.g. shot-blasted surfaces.

3.1.6 Cleaning the measuring point

Before calibrating, make sure the measuring point and the probe tip are free from grease, oil, metal chips etc. The slightest impurity will affect measurement and distort readings.

3.1.7 Acoustic signal

Whether the probe is being used for calibration or for measurement, it must be held in place and not lifted until the bleep sounds.

3.1.8 Stability of calibration values

The gauge automatically compensates for changes in temperature or other drift influences. For that reason, once a calibration has been stored, it is not necessary to recalibrate.

3.2 Calbration hints

When calibrating according to sections 3.2.2 to 3.2.3, the basic procedure is always as follows:

1. Start calibration by pressing the appropriate calibration key (ZERO or CAL).
2. Put the probe on the calibration foil several times.
3. In case of CAL-calibration method, adjust the calibration value to the calibration foil thickness by means of arrow keys.
4. Confirm calibration by pressing the calibration key again (ZERO or CAL).

3.2.1 Activate standard calibration

The probe must be at a distance of at least 50 mm (2") from metal components.

1. Press ZERO and CLEAR.
2. Take readings.

The standard calibration stored in the gauge should only be used for measurements on even surfaces, i.e.

a) on steel components made of conventional construction steel (mild steel)

b) on aluminium components and other non-ferrous metals e.g. copper, zinc, brass etc.

Note:

It is important that on an uncoated sample, zero is shown within the permitted tolerances, otherwise you have to proceed on one-point or two-point calibration.

3.2.2 One-point calibration without foil (zero only)

1. Press ZERO to initialise ZERO calibration. Display shows ZERO (flashing) and MEAN (steady). MEAN indicates that the value shown is a mean value calculated from the readings you have taken.

2. Place the probe on the uncoated sample (zero coating thickness) and raise it after the bleep.

   Place the probe on the uncoated sample several times. The display always shows the mean value calculated from the previous readings.

   To discontinue ZERO calibration, press CLEAR.

3. Press ZERO to confirm zero calibration. ZERO will appear on display (steady).

4. Now take readings by placing the probe on the coating to be measured and raise it after the bleep. The thickness value is shown on display.

   It may be necessary to delete the ZERO calibration, e.g. if an erratic zero value has been entered. In this case, please proceed as follows:

   Press ZERO followed by CLEAR. ZERO calibration and any existing CAL calibration will be deleted.

Note:

Above action will reactivate the default standard calibration for use on even surfaces.

4. Now take readings by placing the probe on the coating to be measured and raise it after the bleep. The thickness value is shown on display.

   It may be necessary to delete the ZERO calibration, e.g. if an erratic zero value has been entered. In this case, please proceed as follows:

   Press ZERO followed by CLEAR. ZERO calibration and any existing CAL calibration will be deleted.

Note:

Above action will reactivate the default standard calibration for use on even surfaces.

3.2.3 Two-point calibration: ZERO and one calibration foil

This method is recommended for high precision measurement and for measurement on small components or on hardened or ow-alloy steel.

1. Press ZERO to initialise ZERO calibration.
   Display shows ZERO (flashing) and MEAN (steady). MEAN indicates that the value shown is a mean value.

2. Place the probe on the uncoated sample (coating thickness: 0) several times and raise it after the bleep.
   The display always shows the mean value of the readings you have taken.

   To discontinue ZERO calibration, press CLEAR.

3. Press ZERO to confirm ZERO calibration. ZERO (steady) will be shown on display.

4. Press CAL to initialise foil calibration.

   The display will show CAL (flashing) and MEAN (steady). MEAN indicates that the value shown is a mean value.

5. Put the calibration foil on an uncoated sample, put the probe on it and raise it after the bleep. Repeat several times. The display shows the mean value calculated from the readings you have taken.

   The thickness of the foil should be roughly equivalent to the coating thickness to be expected. The smallest adjustable calibration value is 20 µm. However, it is recommend to use a minium foil thickness of 50µm for calibration.

Note:

You can abort calibration procedure by pressing CLEAR. The gauge returns to measuring mode and the previously stored calibration is valid.

6. Use arrow keys to adjust to the required foils thickness.

7. Press CAL to confirm CAL calibration. CAL will appear on display (steady).

8. Now take readings by placing the probe on the measuring object. Raise probe after the bleep.

It may be necessary to delete the CAL calibration if, for example, an incorrect calibration value has been entered. In this case please proceed as follows:

a) Press CAL followed by CLEAR. This deletes CAL calibration and any existing ZERO calibration.

Note:

Above action reactivates the default standard calibration for use on even surfaces.

Foil calibration can be repeated as often as required even if a series of measurements is being taken. This action deletes the previous foil calibration and the new one will be valid. ZERO-calibration , however will stay unchanged. will be overwritten; the ZERO calibration remains in memory.

3.2.4 Calibration and measurement with MiniTest 650 FN

The dual probe of MiniTest 650 FN uses both, the magnetic induction (measuring range: 0 ... 2 mm (0 ... 0.08") and the eddy-current principle (measuring range: 0 ... 2 mm (0 ... 0.08")).

To select the required measuring method, press ON. „FERR“ (ferrous) will flash on screen.

- Press (⇧) to select the magnetic-induction principle („Ferrous“).

- Press (⇩) to select the eddy-currents priniciple („Non-ferrous“) .

If none of the keys is pressed, the gauge will automatically switch to automatic mode after about 3 seconds.

The automaic mode is recommended if the type of substrate (steel or non-ferrous metal) is not known.

For calibration in automatic mode, it is necessary first to take a measurement on the uncoated substrate. According to substrate, display will show FERR or NON-FERR. After this, calibration and measurement can be performed as discribed under 3.2.2, 3.2.3 and 3.2.5.

If you wish to measure on both, steel and non-ferrous substrates, calibration must be performed for both substrates, i.e. on the uncoated samples of both, the ferrous and non-ferrous substrate. After this, you can proceed on measurement and change between the two substrates as required.

3.2.5 Calibration and measurement on shot blasted surfaces

When measuring on shot-blasted surfaces, readings tend to be higher than the actual coating thickness. This is du to the physical nature of shot-blasted surfaces. In this case, it is recommended to use the statistics program and to calculate the mean thickness over the peaks as follows:

Method A (Rz > 20µm)

This method should be used for surfaces with a roughness grade of min. 20 µm (0.8 mils).

1. The gauge should be calibrated according to the method described in 3.2.2 or 3.2.3. For calibration, firs tse un uncoated sample which is not shot-blasted. Its surface should be smooth and it should have the same curvature radius and be of the same substrate type as the later measuring object.

2. Now take an uncoated but shot-blasted sample (also with the same curvature radius and subsrate as the later measuring object) and take about 10 readings to obtain the mean $\overline{X}o$.

3. After this, take approx. 10 further readings on a coated shot blasted sample of the same quality to produce the mean value $\overline{X}m$.

4. The difference $(\overline{X}m - \overline{X}o) \pm s$ gives you the mean value of coating thickness ($\overline{x}_{eff}$)over the peaks with „s“ being the higher standard deviation of the two values $\overline{X}m$ and $\overline{X}o$.

   $\overline{x}_{eff} = (\overline{X}m - \overline{X}o) \pm s$

Method B (Rz < 20µm)

This method should be used for surfaces with a roughness grade of max. < 20 µm (0.8 mils).

1. Carry out zero calibration by taking as set of 10 readings on a shot-blasted, uncoated sample. Then carry out foil calibration on the uncoated sample. You can lay a set of individual foils of max. 50 µm (2 mils) thickness each upon another. The total thickness should roughly correspond to the actual coating thickness to be expected.

   The coating thickness can be read directly from display and should be averaged from 5... 10 single readings. The statistics function is useful here.

Note:

In case of coatings of more than 300 µm thickness, the influence of roughness can be neglected and it will not be necessary to calibrate according to methods A or B as discribed above.

3.2.6 Changing primary calibration

Under certain circumstances it may become necessary to chang the primary calibration of the gauge, e.g.

- if the probe tip is worn
- for measuring special applications.

On request, the primary calibration can be changed according to your special application. Please contact ElektroPhysik for more details.

3.3 General remarks on measurement

Once calibration has been made according to the instruction, the readings will be within the guaranteed measuring tolerance (see technical data). However, strong magnetic fields near generators or live rails with strong currents may affect measurement.

When using the statistic program it is recommended to obtain a mean value by placing the probe several times on a typical measuring spot. Any false or freak readings can be cleared immediately by pressing CLEAR.

The final thickness reading results from the statistical calculation and the guaranteed measurng tolerance.

Coating thickness = $\overline{X} \pm s \pm u$

4. Statistics program

The MiniTest 650 calculates statistics from a maximum of 9,999 readings. The statistics print-out includes statistical readings such as n, x, s, max, min but not the single readings (see 4.5). The single readings can be printed out when measurement is being taken.

The statistics program automatically stores and evaluates the readings of a series of measure-ments. The analysis of any one series is displayed and printed-out as follows:

n-values:	number of single values
mean ($\overline{x}$):	mean of single values
st.d. (s):	standard deviation
max:	highest single value
min:	lowest single value

At least 2 single values are required to obtain a statistical analysis which consists of the 5 values listed above.

4.1 Statistical terms

Mean $\overline{x}$

The sum of single readings divided by the total number of readings.

$$\overline{x} = \frac{\Sigma x}{n}$$

Standard deviation s (STD. DEV.):

The sample standard deviation is a statistic that measures how „spread out" the sample is around the sample mean. The sample standard deviation increases with increasing spread out. The standard deviation of a set of numbers is the root mean square of the variance **s².**

The variance of a list is the square of the standard deviation of the list, that is, the average of the squares of the deviations of the numbers in the list from their mean divided by the (number of readings minus 1).

Variance $s^2 = \frac{\Sigma(x - \overline{x})^2}{n - 1}$

Standard deviation $s = \sqrt{s^2}$

4.2 Taking a series of measurements for statistical analysis

1. The statistics program automaticaly stores all readings for statistical evaluation.
2. Check whether the gauge must be calibrated and/or if any redundand statistical values need to be erased.
3. To recalibrate the gauge, simply overwrite the currently valid calibration.
4. Any remaining statistical values can be erased by pressing STATS and CLEAR.

4.3 Storage capacity overflow

If storage capacity (max. 9,999 values) has been exceeded, you can continue to take readings. These readings, however, will not be taken into account for statistics calculation, i.e. the statistics will not be updated any more. Any subsequent reading that will not go into the statistics, will be marked with an error message (E1 will be shown for a second).

4.4 Display and print-out statistics

Each time STATS is pressed, the statistical values will appear in the following order: N (values), MEAN, ST.D., MAX, MIN.

- If a PC is connected, the statiscal values are transferred via the USB interface.

Note: The statistical values can be viewed at any time, even while taking a series of measurements .

5. 'Delete' functions

5.1 Delete the last reading

Press CLEAR once immediately after a reading has been taken. A short bleep confirms deletion of the reading.

5.2 Delete statistics

Press STATS and CLEAR. A short bleep confirms deletion.

With the model MiniTest 650 FN, statistics are deleted separately for the F- and N-part respectively. Fore deleting statistics, please proceed as follows:

- In automatic mode, activate the required probe part (F or N) by taking a reading on the required substrate (on steel for F and e.g. Aluminium for N). Press STATS and CLEAR. A short bleep confirms statistics deletion of the currently selected part (F or N respectively).
- You can also switch the gauge off and on again and activate the F- or N-part by means of the arrow keys. Then press STATS and CLEAR. A short bleep confirms statistics deletion of the currently selected part (F or N respectively).

6. Interface description

Via the USB interface, the MiniTest 650 can connect to a computer for on-line measurements or display of statistics. This requires an USB connecting cable which can be supplied as an optional accessory.

7. Accessories

- Precision stand for high-precision readings and measurements on small components
- Data transfer program Msoft 7000 basic edition
- NiMH rechargeable batteries and charger 230V AC or 110V AC
- USB connecting cable

8. Care and Maintenance

The MiniTest needs an occasional battery change but is otherwise maintenance-free. Used batteries must be removed from the gauge without delay.

Battery disposal: Do not discard used batteries in your regular trash. Please observe your local instructions for battery disposal.

9. Customer service

Please send a damaged or defective gauge directly to ElektroPhysik or to your local dealer. Please enclose a brief error description.

10. Troubleshooting

The following list of error messages explains how to identify and eliminate faults. "E" (E = error).

Faults which cause the gauge to switch off:

E 3: Defective probe. This message only appears immediately after switch on. Please send gauge and probe for checking/repair.

E 4: Probe is giving unstable readings (e.g. as a result of strong fluctuations in the magnetic field or readings taken on soft coatings).

E 5: Probe was held too close to metal at witch on: Keep away from metal parts, hold probe in the air, switch off and on again.

E 6: Low battery. Replace battery.

Error messages displayed for about 1.5 sec:

E 11: Full memory: Delete statistics memory.

Errors without errors message:

- Gauge does not switch off automatically
- Gauge unable to take readings
- malfunction of keyboard
- illogical readings

The quickest remedy is a Total Reset!

Please note: After Total Reset, deletion of the last reading, of all calibration values and statistics is confirmed by a long bleep.

11. Operating example

For checking gauge operatability, please use the zero reference plate supplied with the gauge (made of steel or Aluminium according to model).

For calibration, please use un uncoated sample and calibration foils.

1. Press ON.

- According gauge model, display shows FERROUS or NON-FERROUS along with „µm“ or“mils“, respectively.

  For MiniTest 650 FN applies the following:

a. FERROUS flashes on the display.

b. Press arrow keys within the next 3 sec. to choose the required substrate:

   Press (⇧) for measurement on steel (“Ferr”).

   Press (⇩) for measurement on non-ferrous metals (“Non-Ferr”).

   (If necessary switch off and start again.)

   If no choice is done, the gauge automatically switches to automatic mode, three seconds after switch on, i.e. the gauge automatically identifies the type of substrate.

2. Press ZERO.

- ZERO flashes on the display

3. Place the probe several times on the zero reference plate (Fe or Al, respectively)

4. Press ZERO.

- ZERO appears on display (steady)

5. The one-point calibration (zero calibration) is valid now and you can start measurement.

- At initial use: take a calibration foil, lay it on the zero reference plate, place the probe on it several times and read value from display.

  The gauge will now display the calibration foil thickness, taking into account gauge tolerances.

- For taking readings: Place probe on the coated measuring object and read thickness value from display.

For increasing measuring accuracy, you can perform another calibration using one of the foils.:

6. Press CAL. CAL flashes on the display.

7. Place one of the calibration foils on the zero plate and apply the probe several times.

8. Usa arrow keys to adjust the thickness of the foil.

9. Press CAL.

   - The display will show ZERO and CAL and „µm“ or „mils“, respectively.

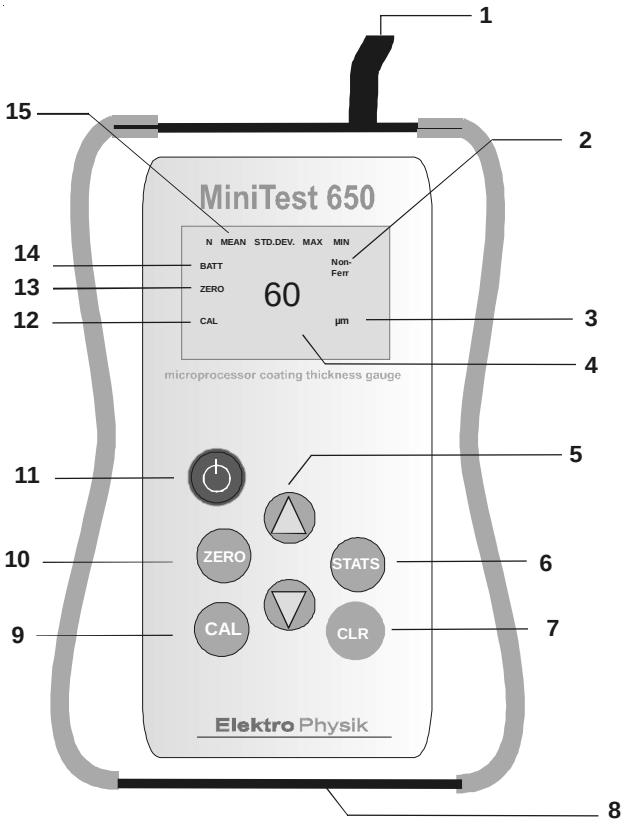
10. Now you can start to take readings.

12. Technical data

Model	650 F	650 FN	650 N
Substrate	steel	steel and non-ferrous metals	non-ferrous metals
Meausring principle	magnetic induction	magnetic induction / eddy currents	eddy currents
Measuring range	0 ... 3000 µm/ 120 mils	FN: 0... 2000 µm/ 80 mils	0 ... 2000 µm/ 80 mils
Low range sensitivity	1µm		
Tolerance	± (2 % of reading + 2 µm) / ± (2 % of reading + 0.08 mils) /		
Smallest curvature radius	5 mm / 0.2" convex		
	25 mm / 1" concave		

Model	650 F	650 FN	650 N
Min. measuring surface	Ø 20 mm/ 0.8"	Ø 20 mm/ 0.8"	Ø 20 mm/ 0.8"
Min. substrate thickness	0,5 mm/ 20 mils	0,5 mm (F)/ 20 mils 50 µm (N)/ 2 mils	50 µm / 2 mils
Dimensions	Gauge: 70 mm x 122 mm x 32 mm 2.7" x 4.8" x 1.26" Probe: Ø 15 mm x 62 mm 0.60" x 2.44"		
Weight	225 grams / 7.93 ozs		
Power supply	3 Micro-AAA batteries for more than 10,000 readings		
Norms and standards	The measuring principles conform to DIN, ISO, BS, ASTM		
Ambient temperature	Gauge: 0°C...50 °C/ 32° to 122 ° F Probe: -10°C...70°C/ 14° to 158 °F		
Interface	USB		

13. Schematic display



1 Probe

2 Non-Ferr, indicates measuring principles for ferrous (Ferr) or non-ferrous (Non-Ferr) substrates.

3 Measuring unit. Switches automatically according to reading between µm/mm.

4 4-digit LC display with floating point (with mm)

5 Arrow keys for ajusting to requested parameters (e. g. calibration values)

6 Key for calling the statistics

7 Clear-key

8 Battery compartment on the back of gauge

9 Key for calibrating by means of standards

10 Key for zeroing the gauge without calibration standards

11 ON/OFF-key

12 Indicates the calibration method with calibration foils

13 Indicates zeroing

14 BATT: Indicates low battery of accu state

15 Indicates that the value shown on display is a statistical value

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