

# eXacto

english

Technical Reference and Operating Manual

Advancing with Technology

**ElektroPhysik**

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# Attention!

## 1. Safety notes

Please read the safety notes in chapter 12 prior to operating the gauge.

## 2. Foil set

The foil set which is used for calibrating the gauge can be found in the **compartment on the bottom of the gauge**:

- Place the gauge upside down on a suitable surface.
- Open the compartment by pulling the clip back.
- The foil set is situated above the battery compartment.
- Close the compartment after having removed the foil set.

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The eXacto coating thickness gauges work either on the magnetic induction principle or on the eddy current principle, depending on the type of gauge used. The gauges conform the following industrial standards:

DIN EN ISO 2178

DIN EN ISO 2360

DIN EN ISO 2808

DIN 50982

ASTM B244

ASTM B499

## 1. General Information

### 1.1 Application

This compact, handy pocket gauge is designed for non-destructive, fast and precise coating thickness measurement. The principal applications are in the field of corrosion protection. It is ideal for manufacturers and their customers, for offices and specialist advisers, for paint shops and electroplaters, for the chemical, automobile, shipbuilding and aircraft industries and for light and heavy engineering.

When connected to the MiniPrint 4100 portable printer, you can print-out the last 90 single readings and the statistics of all readings, either immediately or at a later date.

The range of applications is indicated by the gauge type:

- The eXacto F gauge works on the magnetic induction principle and should be used for non-magnetic coatings such as aluminum, chrome, copper, zinc, paint and varnish, enamel, rubber etc., on an iron or steel substrate; it is also suitable for alloyed and hardened magnetic steel.
- The eXacto N gauge 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, anodizing coatings, ceramics, etc. applied on aluminum, copper, zinc die-casting, brass, etc.
- The eXacto FN combines the two principles in one gauge. The dual probe can measure both, on ferrous and on non-ferrous metal substrates.

### 1.2 Description of the gauge

Measured values and user information are shown on a large, easy-to-read LC display. A display back light (optional) ensures easy reading of screen data in poorly-lit conditions.

The user-friendly measuring mode of eXacto allows automatic storage and statistical evaluation of readings.

#### Note:

With the FN model, selection of the measuring principle is performed after switch-on by pressing arrow keys. Three options are available: AUTO F/N, Ferrous and Non-ferrous. Confirm your selection by pressing ENTER key.

- When selecting **Ferrous**, the magnetic-induction principle is activated, when selecting **Non-ferrous**, the Eddy currents principle is activated. To switch from Ferrous to Non-ferrous, the gauge must be switched off before making your new selection.

- When selecting the **AUTO F/N option**, the gauge automatically identifies the substrate metall (ferrous or non-ferrous).

The statistical values measured on steel or on non-ferrous metal ( $n$ ,  $\bar{x}$ ,  $s$ ,  $\max$ ,  $\min$ ) are stored in one common memory.

All eXacto gauges are suitable for particular fields of application, e. g. for measurement on special geometries. After storage of the corresponding parameters the gauge automatically takes them into consideration.

The portable data printer MiniPrint 4100 allows immediate or subsequent printing of the last 90 single readings and of all statistics (5 statistical values). The data transfer between the MiniPrint and the gauge takes place via infrared interfaces.

### 1.3 Function keys

Five function keys are available to operate the eXacto gauge:

Key	Meaning
ON	Turning the gauge on and off
ENTER	Confirming the selection/option
Arrow	Selecting an option, adjusting a value
CLR	Deleting the selected data
ESC	Aborting the actual function

### 1.4 Supply schedule

The eXacto supply schedule includes the following items:

- eXacto gauge either with integrated or external probe
- 2 alkaline batteries
- zero standard(s)

- calibration foils
- multilingual operating instructions
- wrist cord

### 1.5 Probe design

All three models eXacto F, eXacto N and eXacto FN are available in two different versions:

- eXacto with integrated probe:

The probe system is spring-mounted in the front of the gauge.

- eXacto with external probe:

The probe is firmly connected to the gauge by means of a cable.

The design of both models ensures safe and stable positioning of the probe and even contact pressure. A V-groove in the bottom of the gauge facilitates reliable readings on small cylindrical parts.

The hemispherical tip is made of hard and durable material.

## 2. Preparing the gauge

### 2.1 Power supply

The eXacto gauge needs alkaline or accumulator batteries of the following size:

2 x 1,2 - 1,5 V AAA, Micro, LR03 or AM4

The battery charge is constantly checked. This prevents faulty measurements caused by empty batteries.

After switching the gauge on, the following indicators for the battery charge may be displayed:

- No LC display:  
No batteries in the gauge or battery charge to low for any operation.
- No bAtt display:  
Batteries are sufficiently charged.
- After switching on the gauge, bAtt is displayed and the battery symbol flashes.  
The gauge switches itself off after about 1 second. Replace batteries immediately.

- The battery symbol flashes during measurements:  
The batteries are running low and should be replaced before the gauge is switched on again.

### 2.2 Replacing the batteries

1. Place the gauge upside down on a suitable surface.
2. Open the compartment by pulling the clip back.
3. Remove the old batteries.
4. Insert the new batteries.
5. Close the compartment.

#### **Note:**

Take care for polarity when inserting batteries. Wrong polarity will cause data loss. The plus pole must be directed to the probe system, the minus-pole should be positioned in the opposite direction.

An interval of more than 30 seconds between removing the old batteries and inserting the new ones will also result in the loss of data (readings, calibration values, set-up values).

## 2.3 Start-up functions

Some functions are only accessible through start-up of the gauge.

Table of start-up functions:

Function	Key combination
Total-Reset	ESC + CLR + ON
LCD-Test	↑-Key + ON
Power saving mode	↓-Key + CLR + ON
Optical indicator	↑-Key + CLR + ON

### 2.3.1 Total reset

A total reset erases all statistical, calibration and limit data and the gauge will resume the basic settings.

1. Switch off gauge.
2. Hold down the ESC-key and the CLR-key, then press ON.

Total reset is confirmed by a long beep.

### 2.3.2 LCD segment test

The LCD segment test enables all sections of the LC display to be inspected and checked.

1. Switch off the gauge.
2. Hold down the ARROW (↑) - key, press ON and keep both keys depressed. As long as the arrow key is depressed, all sections of the LC display will be shown.

The device id will be send via the infrared interface, e. g.:

ElektroPhysik

eXacto

FN2

Ser. Nr. 312 865

Software V2.12

### 2.3.3 Power saving mode

The power saving mode switches the gauge off approximately 1.5 min after a measurement has been

## Preparing the gauge

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taken if no further measurement or input follows. If the energy saving mode is not activated, the gauge stays on-line until it is turned off manually. This considerably shortens the life of the battery.

1. Switch the gauge on.
2. In order to switch the energy saving modus on or off, hold down the ARROW (⇩) and CLR key, then press ON shortly.

### 2.3.4 Additional optical indicator

The additional indicator flashes shortly after each measurement and helps to recognize that a measurement has been completed. The additional indicator, however, shortens the life of the battery.

1. Switch the gauge off.
2. Press ARROW (⇩), CLR and ON key simultaneously to switch the additional indicator on and off.

## 2.4 Basic gauge settings

1. The eXacto gauge is in the measuring mode (a black arrow points to the item "MENU").

2. Activate the MENU mode by pressing the ENTER key.
3. Select the OPTION mode by pressing the ARROW key (⇩) once and activate it by pressing the ENTER key.

### 2.4.1 Selecting a measuring unit

Select the measuring unit ( $\mu\text{m}$  or mils) by pointing the black arrow to the measuring unit with the ARROW keys. Activate the selection by pressing the ENTER key.

### 2.4.2 Activating the LC display light

Select the menu entry "LIGHT" by pointing the black arrow to the "LIGHT" entry. Activate the selection by pressing the ENTER key.

The display shows the status of the light setting. You can change the status by pressing the ARROW keys and activate this selection by pressing the ENTER key.

### 2.4.3 Activating the block mode

Select the menu entry "BLOCK" by pointing the black arrow to the "BLOCK" entry. Activate the selection by pressing the ENTER key.

The display shows the status of the block statistics automatic. You can change the status by pressing the ARROW keys and activate this selection by pressing the ENTER key.

If the block mode is switched on, the display shows the number of readings per block. This counter can be adjusted to a value between 5 and 30 with the ARROW keys and can be activated by pressing the ENTER key.

### 3. Calibration and measurement

#### 3.1 General remarks on calibration

Calibration is the most important requirement for accurate measurement. The more closely the calibration sample matches the product sample, the more accurate the calibration, and therefore the reading, will be.

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

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

The calibration sample should correspond to the product sample in the following ways:

- in the radius of curvature of the surface
- in the characteristics of the substrate
- in the thickness of the substrate
- in the size of the area to be measured

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

#### 3.1.1 Methods of calibration

Three different calibration methods are available for the eXacto gauges:

- Standard calibration (factory setting):  
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):

## Calibration and measurement

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recommended when measuring errors up to 4 % of the measured value are permitted.

- Two-point calibration (set zero and calibrate with one foil):

recommended when measuring errors up to 3 % of the measured value are permitted.

### 3.1.2 Saving calibration values

The calibration values are stored in memory even after the gauge has been turned off.

If a calibration is to be altered, simply carry out a new calibration. This automatically deletes the previous calibration values and saves the new ones for immediate use.

#### Note:

Calibration cannot be continued if during the calibration procedure

- an incorrect reading has been taken;
- an incorrect command has been entered;

- the gauge has switched off for any reason.

In such cases, calibration procedure must be repeated from the beginning.

### 3.1.3 Influence of substrate thickness

When measuring on steel substrates, the substrate thickness is of no consequence as long as it is thicker than 1 mm (40 mils).

In the case of non-ferrous metals, a substrate thickness of 50 µm (2 mils) is sufficient. However, the substrate must be strong enough not to give way under the pressure of the probe tip. A thin coating on an aluminum foil, for instance, can be measured, if the Aluminium foil is stuck on a hard base.

The enclosed steel and aluminum zero plates are for test purposes only and not for calibration.

#### Exceptions:

The zero plates may be used for calibration if the product sample has a smooth, even surface (not shot-blasted) and

- if steel parts are thicker than 1 mm (40 mils).
- if aluminum parts are thicker than 50  $\mu\text{m}$  (2mils). In this case the enclosed aluminum zero plate may be used for calibration.

### 3.1.4 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 an obvious advantage when calibrating on uneven, e.g. shot-blasted surfaces.

### 3.1.5 Stabilization of calibration values

No recalibration is necessary in changeable external conditions, e. g. variations in ambient temperature, as the gauge automatically takes these into account.

## 3.2 Calibration

### 3.2.1 Activate standard calibration (factory setting)

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

1. Activate MENU by pressing the ENTER key.
2. Select the ZERO function with the ARROW keys and activate it with the ENTER key.
3. Press the CLR key and subsequently the ENTER key.

The standard default calibration should only be used for measurements on even surfaces, i. e.

- a) on steel components made of conventional construction steel (mild steel);
- b) on aluminum components and other non-ferrous metals e.g. copper, zinc, brass etc..

### Note:

It is important to record a sufficient number of exact zero readings on an uncoated sample. Otherwise, one-point or two-point calibration should be used.

### 3.2.2 One-point / Zero calibration

1. Activate menu mode by pressing the ENTER key.
2. Select the ZERO function with the ARROW keys and activate it with the ENTER key. The zero calibration will be initialized and the LC display shows flashing "ZERO" and steady "Mean". "Means" indicates that the mean value of the readings will be shown on the display.
3. Place the probe on uncoated sample (coating thickness 0) and raise it after the beep. Repeat this procedure several (3 ... 10) times. The display shows the mean value of the readings.
4. Activate the zero calibration by pressing the ENTER key. The LC display will show steady "ZERO". The zero calibration can be aborted by pressing the ESC key.

It may be necessary to delete a zero calibration if, e. g., an incorrect zero value is entered. Refer to 3.2.1.

### 3.2.3 Two-point calibration

This method is recommended for high precision measurement and for measurement on small components, hardened and low-alloy steels.

1. Carry out one-point calibration.
2. Activate menu mode by pressing the ENTER key.
3. Select the CAL function with the ARROW keys and activate it with the ENTER key. The CAL calibration will be initialized and the LC display shows flashing "CAL" and steady "MEAN". "MEAN" indicates that the mean value of the readings will be shown on the display.
4. Place the calibration foil on the uncoated sample, apply the probe and raise it after the beep. The thickness of the foil should be roughly equivalent to the estimated coating thickness.
5. Repeat this procedure several (3 ... 10) times. The display always shows the mean value of the previous readings.
6. Adjust to the thickness of the foil with the ARROW keys.

7. Activate the CAL calibration by pressing the ENTER key. Repeat this procedure several (3... 10) times. The display always shows the mean value of the previous readings. The LC display will show steady "CAL". The CAL calibration can be aborted by pressing the ESC key.

It may be necessary to delete a CAL calibration if, e. g., an incorrect zero value is entered. Refer to 3.2.1.

### Note:

Even while a series of measurements is being taken, foil calibration can be carried out as often as necessary. The previous calibration will be overwritten; the ZERO calibration remains in memory.

### 3.2.4 Calibration and Measurement with eXacto FN

The gauge eXacto FN uses both the magnetic induction and the eddy current principle.

Selection of the measuring method is made after switching the gauge on. The LC display shows the following options:

- **AUTO F/N**

This mode can be used, if the substrate type (ferrous or non-ferrous metal substrate) is not known.

- **Ferrous**

The magnetic induction method is used for measurements on ferromagnetic substrates.

- **Non-Ferrous**

The eddy current method is used for measurements on non-ferrous metal substrates.

The flashing arrow points to the last selected mode.

Select the required measuring method with the ARROW keys and activate it by pressing the ENTER key. If neither key is pressed, the gauge will automatically switch to the previously selected mode after about 3 seconds.

Calibration for the automatic mode requires a previous measurement on the uncoated substrate. The display will then show FERR or NON-FERR.

For calibration and measurement, proceed as normal according to either 3.2.2 or 3.2.3.

For alternating measurements on steel and non-ferrous substrates, calibration must be performed on uncoated

## Calibration and measurement

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samples of both substrates. Measurements can then be carried out immediately.

### 3.2.5 Calibration and measurement on shot blasted surfaces.

The physical nature of shot-blasted surfaces results in coating thickness readings which are higher than the actual thickness. The mean thickness over the peaks can be determined as follows (note that the statistics program is of great benefit in this procedure):

Method A (for roughness grade of min. 20  $\mu\text{m}$ /0.8 mils):

1. The gauge should be calibrated according to the method described in 3.2.2 or 3.2.3. Use a smooth surface with the same curvature radius and the same substrate.
2. Take approx. 10 readings on the uncoated, shot-blasted surface to produce the mean value  $\bar{x}_0$ .
3. Take approx. 10 readings on the coated and similarly shot blasted test sample to produce the mean value  $\bar{x}_m$ .

4. The difference  $(\bar{x}_m - \bar{x}_0) \pm s$  is the mean coating thickness over the peaks  $\bar{x}$  eff, s is the greater of the two standard deviations of the values  $\bar{x}_m$  and  $\bar{x}_0$ .

#### Method B (for roughness grade of max. 20 $\mu\text{m}$ /0.8 mils)

1. Carry out a zero calibration of 10 readings on a shot-blasted, uncoated substrate. Then calibrate with a foil on the uncoated substrate. The foil set should consist of a number of individual foils of max. 50  $\mu\text{m}$  (2 mils) thickness each and should roughly correspond to the estimated coating thickness.
2. The coating thickness can be read directly and should be averaged from 5 ... 10 single measurements. The statistics function is useful here.

#### Note:

For coating thickness over 300 microns/12 mils, the influence of surface roughness can be neglected and it is not necessary to apply above methods.

### 3.3 General remarks on measurement

After careful calibration has been made all subsequent measurements will lie within the guaranteed measuring tolerance (see technical data).

In order to obtain mean values, several measurements have to be taken at the same spot. The gauge automatically calculates the statistics from the single values. Any false or erratic reading can be cleared immediately by pressing CLR.

The final reading derives from:

1. the statistical calculations;
2. the guaranteed uncertainty of measurement of the gauge.

## 4. Measurement using statistics

The eXacto gauge can calculate statistics from an unlimited series of measurements. The statistical values can be printed out without a list of corresponding single values (see 4.4). Single values can only be printed out directly during measurement.

This program automatically stores and evaluates the readings of a series. The analysis of any one series appears on the display and on the print-out as follows:

N : number of single values

Mean ( $\bar{x}$ ) : mean of single values

Std.Dev (s) : standard deviation

Max : highest single value

Min : lowest single value

At least 2 single values are required to produce a statistical analysis, which will consist of the 5 parameters as listed above.

### 4.1 Statistical terms

· Mean  $\bar{x}$

$$\bar{x} = \frac{\sum x}{n}$$

The mean is the sum of the single values divided by the number of readings.

## Measurement using statistics

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- Standard deviation s (Std. Dev)

The standard deviation is a measure of the variance of readings. The greater the variance, the greater the standard deviation.

S is calculated from the positive square root of the variance  $s^2$ .

Variance is defined as the sum of the deviations from the arithmetical mean squared, then divided by the number of measured values minus 1.

Variance: 
$$s^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

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

### 4.2 Measuring for statistical analysis

1. The gauge can be used for measurements immediately after it has been switched on. All readings will automatically be logged to the statistics program.
2. Remember to check whether calibration is required and/or if any redundant statistical values need to be erased.
3. To recalibrate, simply overwrite the old calibration.

### 4.3 Storage capacity overflow

If the storage capacity (more than 90 single or 45 block values) is exceeded, the 5 statistical values will be updated, but the single readings or block groups will not be stored any more though measurement can continue.

### 4.4 Display, transfer and print-out statistics

The statistical values can be displayed and printed out as follows:

1. Display statistics (without printer)

Press the ENTER key 7 times. The statistical values will appear in the order N (values), Mean, Std.Dev., Max, Min.

2. Printing single statistical values

Provided the data transfer the data transfer from the gauge to the printer via the infrared connection is ensured, the statistical values can be printed out or transferred via the ElektroPhysik infrared adaptor to a PC.

Each time STATS is pressed the statistical values will be printed/transferred in the order N (values), Mean, Std.Dev., Max, Min.

The statistical values can be viewed at any time, even while a series of measurements is being taken.

### 5. Delete functions

#### 5.1 Deleting the last reading

Press the CLR key once immediately after a reading has been taken. A short beep confirms that the reading has been deleted.

#### 5.2 Deleting statistics

1. Press the ENTER key twice to enter the statistics menu.
2. Press the CLR key to clear the statistics.
3. Press the ENTER key to confirm the deletion or abort the deletion by pressing the ESC key.
4. The display shows a zero to indicate that the number of stored readings is zero. Confirm this with the ENTER key.

### 6. Optional accessories

- MiniPrint 4100, portable data printer
- infrared adaptor for eXacto / PC
- . MSave data transmission software

### 7. Printing

1. Switch on gauge and printer (see separate instruction manual MiniPrint 4100).
2. Position gauge and printer at a maximum distance of 1m making sure an error free communication.
3. The viewing angle between both instruments must not exceed 30°.

### 8. Data transfer

The data transfer between the eXacto gauge and an RS232C PC interface (COM1:, COM2:) takes place via the ElektroPhysik infrared adaptor.

For data transfer, the data transmission software MSave release 2.20 (Art. Nr. 80-901-1501) is required.

### 9. Maintenance

The eXacto gauge needs an occasional battery change but is otherwise maintenance-free. Used batteries must be removed from the gauge without delay. It is extremely robust, but, as with any measuring gauge, it is to be handled with care.

### 10. After sales service

State-of-the-art methods using high-quality components as well as a quality management system certified to DIN EN ISO 9001 ensure an optimum quality of the gauge.

Should you nevertheless detect an error or malfunction on your gauge, please inform the ElektroPhysik Service responsible for your products, giving the details including a description of the error or malfunction.

If there is anything specific you would like to know about the use, handling, operation or specifications of the gauges, please contact your nearest ElektroPhysik representative, or the following addresses direct:

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## 11. Troubleshooting

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

Display	Meaning	Action
Prob	Probe defective	Factory repair
Stab	Infinite values not stable	Remove the gauge from strong magnetic or electrical fields
Air	Gauge not in the air	The gauge must have a distance of 10 cm/4 " to any metal
bAtt	Battery empty	Replace the battery

## 12. Safety notes

Strong magnetic fields near generators or live rails with strong currents can affect the reading. Measurements can also be influenced by high-frequency magnetic fields which are, among others, caused by mobile phones, computer keyboards, TV screens and computer monitors.

## 13. Technical data

### 13.1 Technical data (metric system)

Gauge type	eXacto F	eXacto FN	eXacto N
Measuring principle	magnetic induction	magnetic induction eddy current	eddy current
Measuring range	0 ...3000µm	0 ...2000µm	
Low range resolution	0,1 µm		
Uncertainty of measurement	± (2µm + 3% of the reading)		
Min. curvature radius of measuring object	convex 5 mm, concave external probe: 25 mm concave integrated probe: 35 mm at the edges, 60 mm in the middle of measuring object		
Min. target area	Ø 20 mm		
Min. substrate thickness	F = 0,5 mm, N = 50 µm		
Case dimensions	165 mm(L) x 44 mm(B) x 38 mm(H)		
Weight	approx. 200g		
Ambient temperature	0 ... 50°C		
Power supply	2 batteries AAA, Micro, LR03, AM4		

### 13.2 Technical data (imperial system)

Gauge type	eXacto F	eXacto FN	eXacto N
Measuring principle	magnetic induction	magnetic induction	eddy current
		eddy current	
Measuring range	0 ... 120mils	0 ... 80 mils	
Low range resolution	0.01 mils		
Uncertainty of measurement	± (0.08 mils + 3% of the reading)		
Min. curvature-radius of measuring object	convex: 0.2", concave external probe: 1.0" concave internal probe: 1.4" at the edges, 2.4" in the middle of object		
Min. target area	Ø 0.8"		
Min. substrate thickness	F = 20 mils, N = 2 mils		
Case dimensions	6.6" (L) x 1.8" (W) x 1.5" (D)		
Weight	approx. 7 ounces		
Ambient temperature	0 ... 50°C		
Power supply	2 batteries AAA, Micro, LR03, AM4		

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