

ZAPPITEC

Eddy Current Electrical Conductivity Meter for nonmagnetic metals Mod. 12Z



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1. Introduction

The Portable Eddy Current Conductivity Meter ZAPPITEC mod. 12Z takes advantage of the latest technological advances to provide an equipment that does not require special training, allowing non-destructive, quick and precise measurements of electrical conductivity in non-ferromagnetic metals.

Conductivity measurements are an invaluable tool to check in a non destructive way the purity of metals. It is also used to sort different alloys according to its conductivity or heat treatment and to monitor heat treatment and heat damage in aerospace aluminium alloys among many other applications. It can also be used to evaluate thermal conductivity in metals and alloys.

1.1 Electrical Conductivity units

The Electrical Conductivity is a property of solids which describes its ability to allow the flow of electrical currents. The higher the conductivity, the lower are the energy losses in a current-carrying conductor

The SI unit for conductivity is the S/m (**S**iemens per **m**eter). Since metals are very good conductors their conductivity is usually given in MS/m (**M**ega**S**iemens per **m**eter).

The conductivity of metals changes significantly with temperature. To allow easy comparison between different metals, conductivity values are normally standardized at a temperature of 20°C (293K or 68°F).

Measurements are usually made in **%IACS** units, an acronym that means:

“percent of International Annealed Copper Standard”

In this unit the standard annealed copper is by definition 100 %IACS at 20°C, while very pure copper can reach up to 102.7 %IACS at 20°C.

Conductivity units can be converted using the following formula:

$$0.58 \times \sigma_{\%IACS} = \sigma_{MS/m}$$

Where:

$\sigma_{\%IACS}$ = Conductivity in %IACS

$\sigma_{MS/m}$ = Conductivity in MS/m

1.2 Conductivity values of some pure metals

<i>metal</i>	<i>Conductivity in %IACS</i>
(Ag) - Silver 99.99+%	108.6
(Cu) - Copper 99.99+%	102.7
(Au) - Gold 99.99+%	77.9
(Al) - Aluminium 99.95+%	65.1
(Zn) - Zinc	29.2

Conductivity of selected pure metals

2. Principle of operation

A high-frequency magnetic field (60kHz) is generated by the 12Z sensor which induces eddy currents in the bulk of the sample to be tested. There is no need for physical contact between the sensor and the sample, allowing true non-contact measurement. This allows precise measurements through non conductive coatings such as paints or surface oxides.

A simulation of the relative intensity of the magnetic field generated by the sensor is shown below. This field is restricted to a circular area 10mm in diameter.

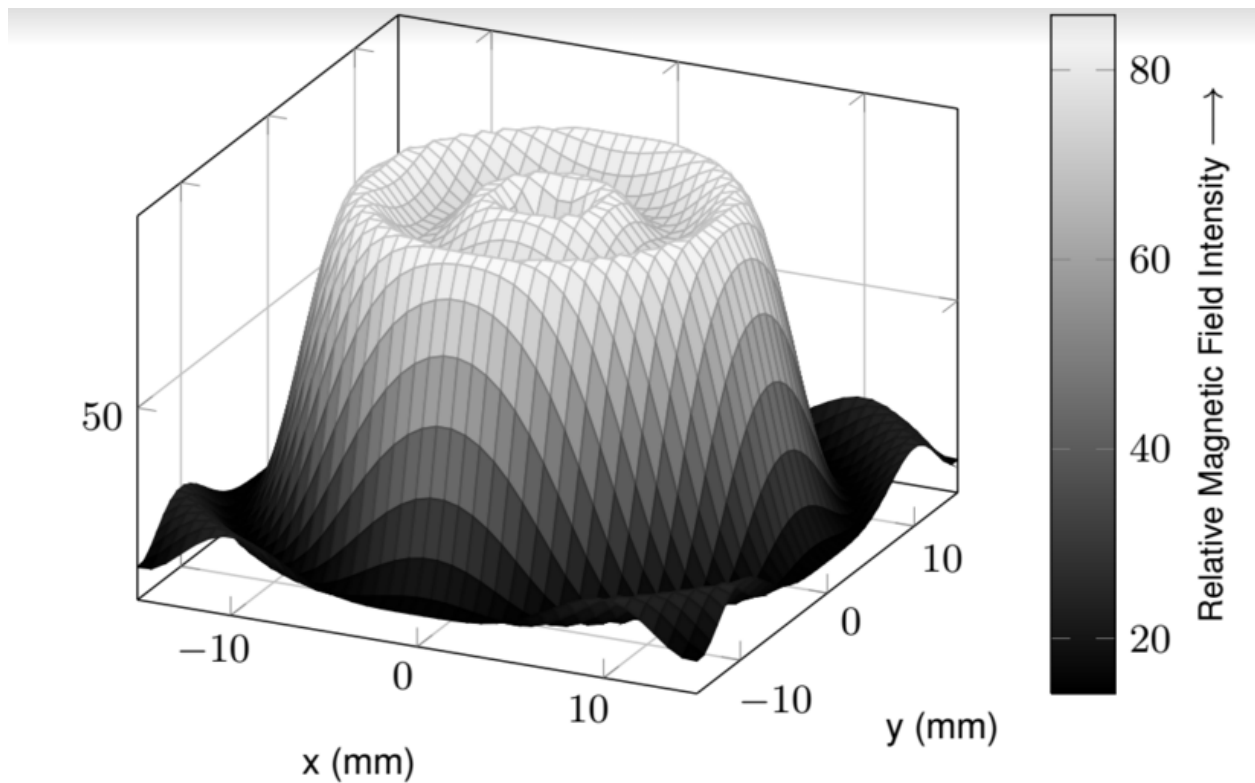


Fig. 1: Magnetic field generated by the ZAPPITEC model 12Z sensor

The minimum sample thickness for proper measurement depends on the conductivity of the material and it can be determined from the graph below:

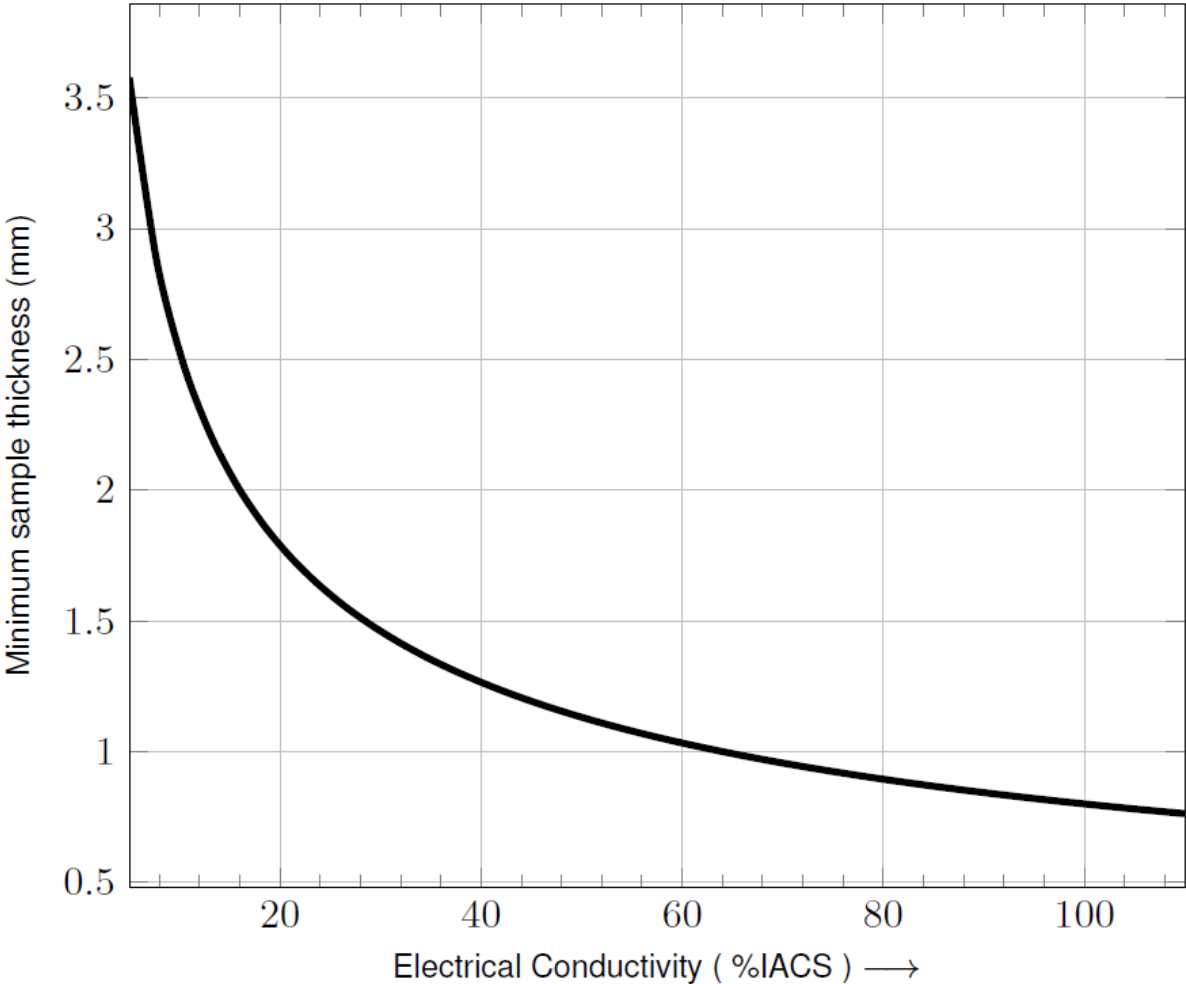
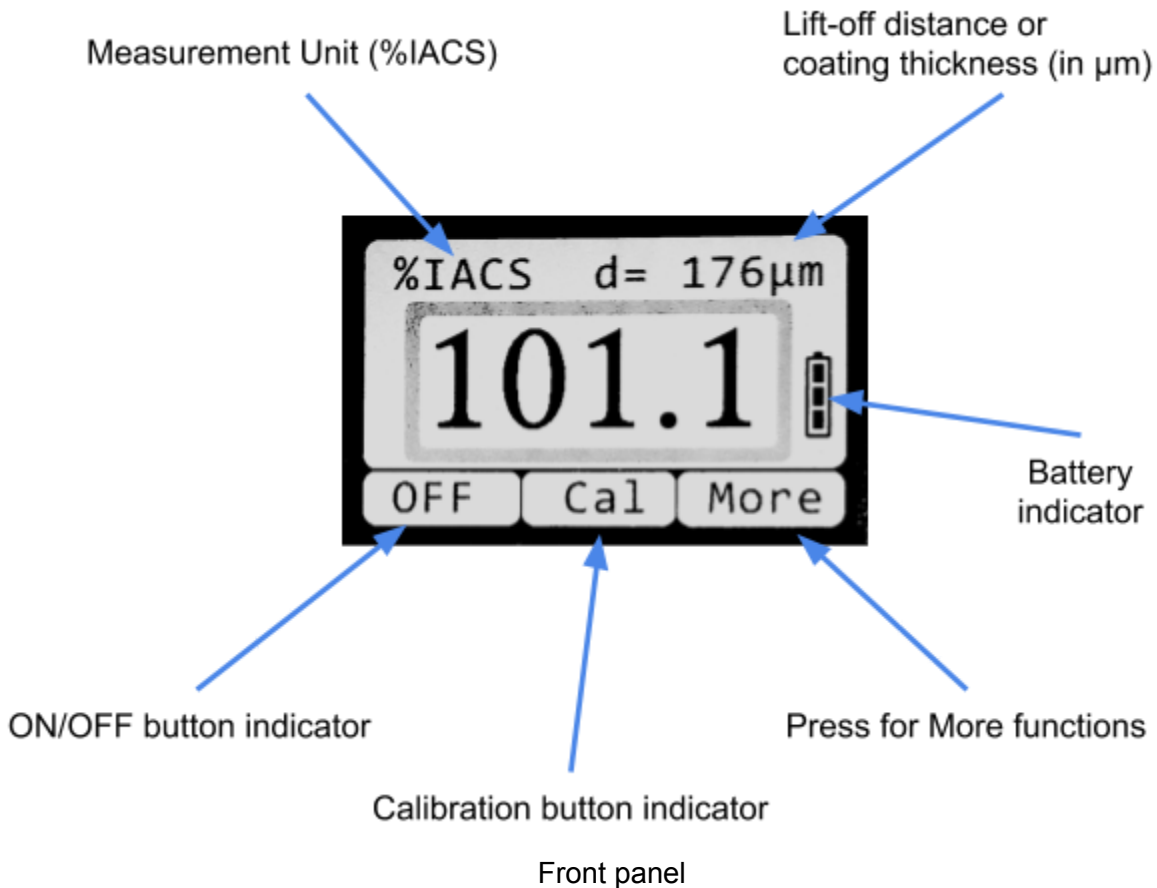


Fig. 2: Minimum sample thickness vs Electrical Conductivity

3. Operating instructions

3.1 General description



The Conductivity Meter model 12Z has three context-sensitive buttons and a high resolution LCD display. The function of each button is shown in the lower part of the display. When not measuring conductivity the display shows the temperature of the probe in $^{\circ}\text{C}$.

The leftmost button turns the instrument on and off, the central button performs Calibration (**Cal**) and the rightmost button allows access to more functions.

The model 12Z has the following special features:

→ **Automatic 1 point Calibration**

The conductivity values of standards shipped with the instrument are recorded in its non-volatile memory. To calibrate, just place the sensor against the standard and press "Cal". The 12Z will now be calibrated around that conductivity value. The instrument can only be calibrated with the standards supplied with the unit.

→ **Lift-off compensation and measurement**

The 12Z provides the user with lift-off measurements which can be used to evaluate coating thickness or surface condition. It allows to accurately measure conductivity even in rough "as-cast" surfaces.

→ **Low power operation**

The unit is powered by four "AA" alkaline batteries which provide around 100 hours of continuous measurement. The auto-shut-off system extends battery life by turning off the unit if it is not being used. Replace all four batteries immediately when the battery indicator shows an empty battery.

3.2 Measurement procedure

For maximum accuracy the following procedure is recommended:

1. The surfaces to be measured must be flat and larger than 10mm in diameter. The thickness of the sample should be above the minimum recommended in Fig. 2.
2. The equipment must be calibrated with a supplied standard which conductivity is closest to the conductivity of the sample to be measured.
3. The standards and the sample to be measured must be at the same temperature. If that's not the case, place the standard over the sample and wait some minutes to allow the temperatures to equalize before measurements. Temperature differences between standard and sample are likely to cause significant errors in the measurements.
4. Use only the properly identified standards shipped with your model 12Z.

Once the above conditions have been satisfied, proceed to measurement:

1. Turn the instrument on and wait a few seconds for stabilization
2. Calibrate: place the sensor on the appropriate standard shipped with the equipment. Press "Cal". The value will be adjusted to the value engraved on the standard used.
3. Measure: place the sensor firmly on the sample to be measured. The value on screen is the conductivity of the sample already corrected to the value at 20 °C, even if the ambient temperature is different.

The DC-11M will turn off automatically after 8 minutes of inactivity to save battery. It is possible to turn off the equipment at any moment pressing the “OFF” button for one second.

Additional remarks

Take special care of the standards shipped with the mod. 12Z. These are necessary for correct calibration. Calibration will use only one standard at a time, preferably the standard which has the conductivity closest to the sample to be measured.

Example: To measure copper, use the copper standard shipped with the 12Z. For measurements in aluminium, the aluminium standard is generally the most adequate.

Use only the standards supplied with the equipment.

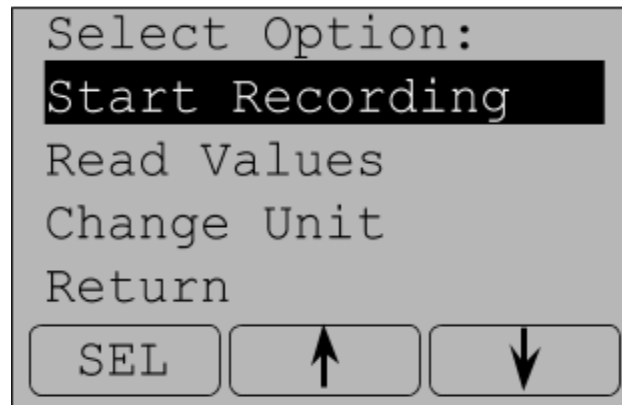
Do not use on surfaces that are either hot, wet or dirty to avoid damage to the probe.

It's recommended to certify your mod. 12Z and its standards periodically. ZAPPITEC can supply this service.

3.3 Logging and Change Unit

Starting from firmware version 1.3 the mod 12Z Eddy current conductivity meter offers logging capability.

Pressing "More" gives access to the following menu:



To navigate through the items in the menu use the up and down arrows. To select one item, press SEL.

The menu functions are described below:

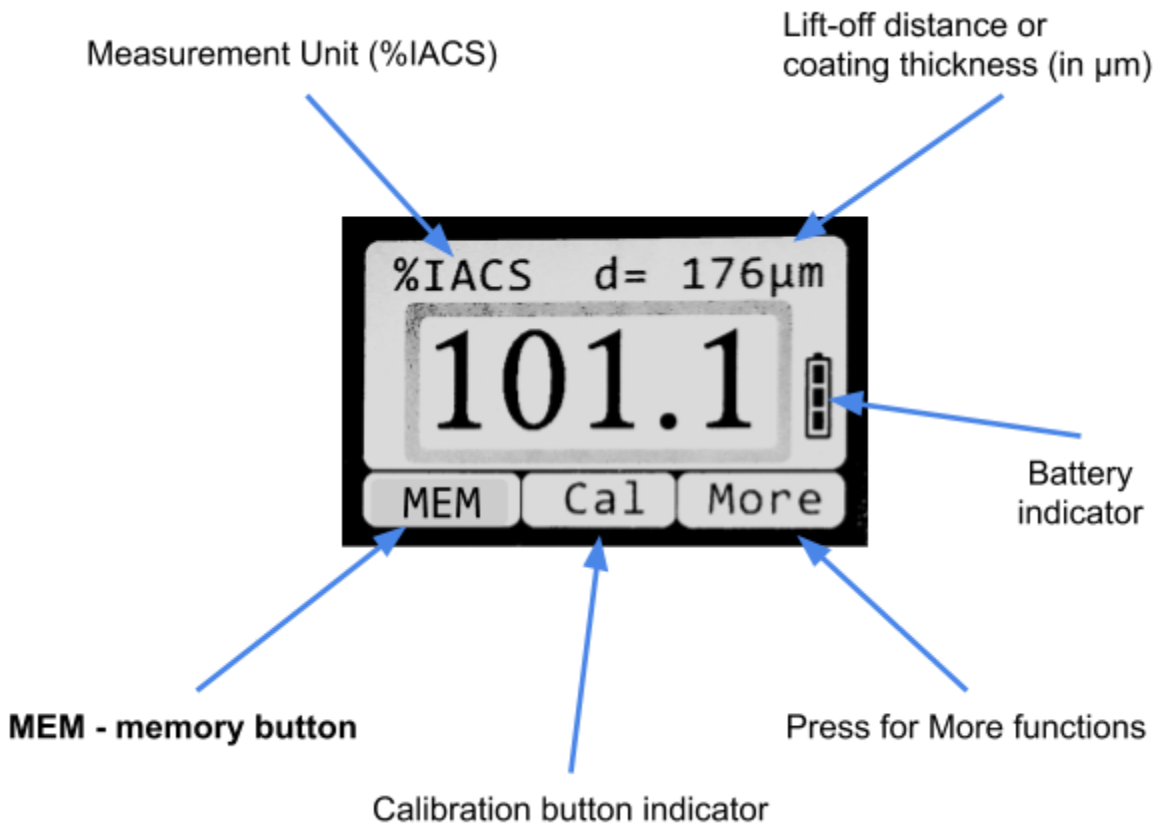
- **Start Recording:** allows the user to access the logging function
- **Read Values:** access or delete the recorded values
- **Change unit:** changes the unit from %IACS to MS/m and vice versa
- **Return:** goes back to the main screen

Start recording

To start recording just press SEL and the following message will appear in the display:



The instrument will then go back to the main screen, with the "OFF" button replaced by "MEM":



To record a measurement just press "MEM". A message will flash briefly at the top of the display confirming that the value was recorded and reporting the memory position where it was stored:

| STORED Memory n. 03 |

If the display shows 0.0, no value will be recorded and a message will flash briefly:

| No Value to Store |

Once more than 60 values are recorded the display will flash the following message:

| MEMORY FULL |

In that case delete all values (see "Read Values" menu entry below) to start over.

To turn the instrument off Press "More", then "Stop Recording". The display will go back to the main screen where "OFF" will replace the "MEM" button.

Read Values

This entry allows reading and deleting of all values in memory. Each page shows up to 12 values. To see more values press "NEXT". To delete all values press "DEL" and confirm delete by pressing "YES". The values are kept even if the instrument is powered off.

Change Unit

This option allows changing the displayed unit from %IACS to MS/m. The instrument will go back to its default setting when powered off.

Return

By selecting this option, the instrument will return to the main screen.

4. Specifications

Measurement Range:	1 - 110 %IACS
Resolution:	0.1% IACS (65-110 %IACS) 0.05 %IACS (30-65 %IACS) 0.02%IACS (10-30 %IACS) 0.01%IACS (1-10 %IACS)
Measuring distance:	Up to 0.3 mm
Precision	Better than 1% around supplied standards
Operating Frequency	60kHz
Power	4× Alkaline batteries size AA for ~100 hours continuous use ¹
Logging (v 1.3 and above)	Logging memory for up to 60 measurements

¹ Always use good quality alkaline cells preferably with leakage guarantee. Do not mix old with new batteries. When replacing the batteries use four new batteries from the same package. Do not keep spent batteries in the battery compartment. When replacing batteries, please pull first the negative side of the battery first. When inserting new batteries, start with the positive and then push the negative side in place.