



REAL TIME CORROSION MONITORING
(71.04 VERSION)

Clean air solutions

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1. Introduction

ISA-CHECK II is an autonomous data logger that allows air quality to be judged by measuring the rate of atmospheric corrosion of metal sensors.

The monitoring system is comprised of two main parts: corrosion sensor and electronic logger.

The corrosion sensors consist of a metal track deposited on a non-conductive substrate. The thickness of the metal track defines the sensitivity and service life of the sensor depending on the environment. The service life is defined as the time to consume one-half of the thickness of the track. The two standard sensors used with the ISA-Check II product are a 500 nm thick copper and a 500 nm thick silver sensor.

For a given sensor, the reference track is protected against corrosion by protective tape.

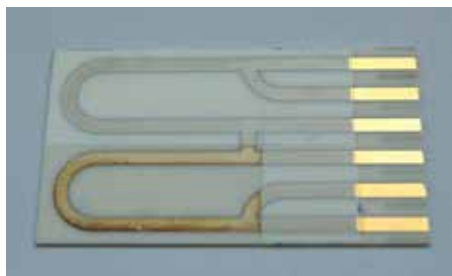


Fig. 1.1: Corroded 500 nm silver sensor.

1.1. Loggers, sensors, data pencils

The ISA-CHECK II is designed to work with two sensors. In addition, it measures relative humidity (RH), temperature and atmospheric pressure. It is equipped with a LCD display that can be activated by pressing the button on the right side and a control lamp (3 color LED) on the left side.











Fig. 1.2: ISA-CHECK II logger with two sensors. Red circle: push button activating the LCD screen, Yellow circle: control lamp (3 color LED).

By pushing the button repeatedly, information on about the environment (relative humidity, temperature and pressure), the corrosion thickness during the last 24h, the corrosivity during the last 24h, according to the standard ISA 71.04.2013, the sensor consumption (%) and the logger's status, can be displayed. The detailed information displayed are given in the Fig 1.3.

The control lamp (3 color LED) flashes red when one sensor wear reaches 100 %. In this case, the used sensor has to be replaced by a new sensor or a calibration/replacement track (see Table 1.2). The ISA-Check II device requires two sensors and/or two replacement tracks to work properly.

The control lamp (3 color LED) is lighted when pressing button, during the displaying of the sensor information, as function as the measured corrosivity during the last 24h hours: green (G1), orange (G2) and red (G3 and GX).

The corrosion thickness during the last 24 h (nm/day) and the corrosivity (G1, G2, G3, GX), according to the ISA 71.04.2013 standard, are not calculated during the 5 first days of exposure. During this five first days the screen displays “?.??”.

PB	Screen	Details
1		RH: Relative Humidity (%) T: Temperature (°C)
2		P: Pressure (hPa)
3		#Sensor 1 is the sensor positioned on the left side, usually : Cu 500 nm sensor
4		Corrosion during the last 24 h (nm/day) <i>Not available during the first five days of exposure</i>
5		Corrosivity (G1, G2, G3, GX), during the last 24h, according to the ISA 71.04.2013 <i>Not available during the first five days of exposure</i>
6		Sensor consumption in (%)
7		#Sensor 2 is the sensor positioned on the right side, usually : Ag 500 nm sensor
8		Corrosion during the last 24 h (nm/day) <i>Not available during the first five days of exposure</i>




9		Corrosivity (G1, G2, G3, GX), during the last 24h, according to the ISA 71.04.2013 <i>Not available during the first five days of exposure</i>
10		Sensor consumption in (%)
11		Logger status : Stopped / Recording

Fig. 1.3: Information shown on the ISA-CHECK II display.





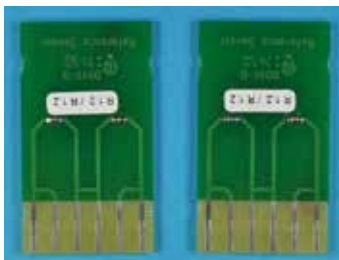

A non-contact inductive data pencil (Table 1.2) is used to start the logger and read the data. It must be connected to a computer with the software ISA-Check II installed.

The software ISA-Check II is provided on a USB flash drive with the data pencil.

In addition, two calibration and replacement tracks are provided with each logger. These tracks can be used to replace a used sensor and/or to control the working of the logger.

See below for a list of all components of the monitoring system.

1.2 Table of components

Component	Photography	
logger	 ISA-CHECK II	
sensor	 Copper (Cu) 500 nm sensor	 Silver (Ag) 500 nm sensor
data pencil	 USB data pencil	
calibration and replacement tracks		
manual		
USB Drive	Memory stick/flash drive with manual and USB drivers	

2. Getting started

Caution: The apparatus is sensitive to electrostatic discharges. The operator should discharge any electrostatic charge prior to handling an ISA-Check II logger by touching a grounded metal object.

2.1 Installing the USB driver for the data pencil

The USB data pencil can be connected directly to the computer's USB port. On most MS-Windows versions, the driver installation is done automatically through internet. If you do not have access to internet, the drivers are present on the USB flash drive with the software (for 32 and 64 bits MS-Windows: XP, Vista, 7 and 8). Open the ISA-CHECK II USB flash drive. Find the driver for your Windows version in the correct folder within the "USB drivers" folder. The USB driver installation guide can also be found in the folder.

2.2 ISA-Check II software installation

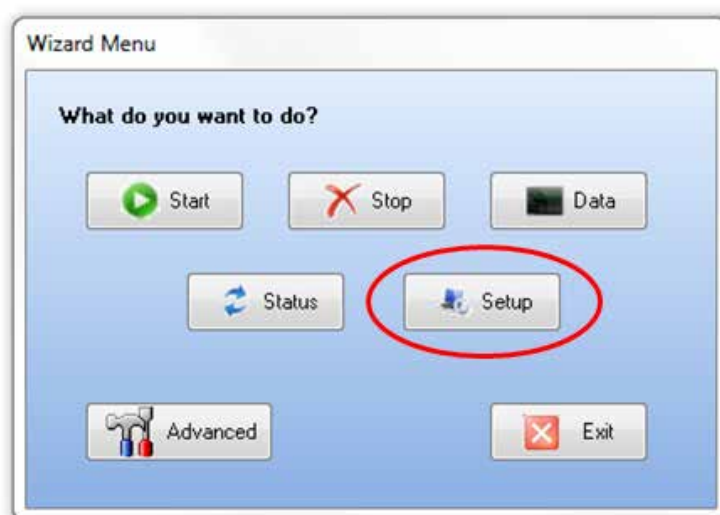
Next, install the ISA-CHECK II software. The set-up .exe file can be found in the root folder of the ISA-CHECK II USB flash drive. The installation wizard will guide you through the installation.

2.3 Data pencil detection

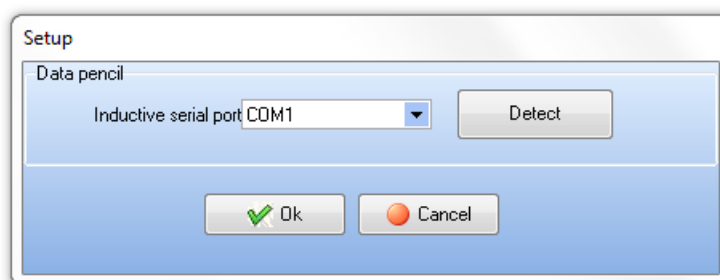
After installing the software, the data pencil must be set up within the ISA-CHECK II program. The setup procedure should only need to be done once for a specific computer. We recommend that the same USB port be used each time to ensure that the data pencil will be found by the computer.

Remember that a driver must be installed if the data pencil will be used with a USB port (see section 2.1 above).

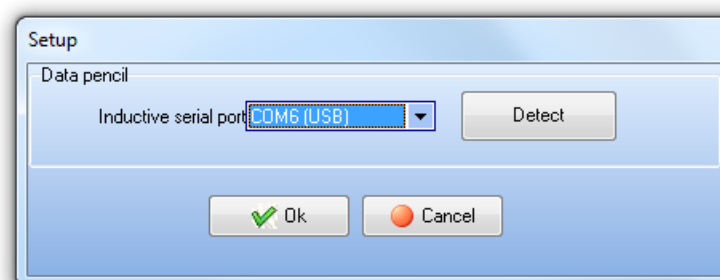
In the ISA-CHECK II Wizard Menu, select Setup.



After attaching the data pencil to the computer, push the Detect button to detect the port automatically.



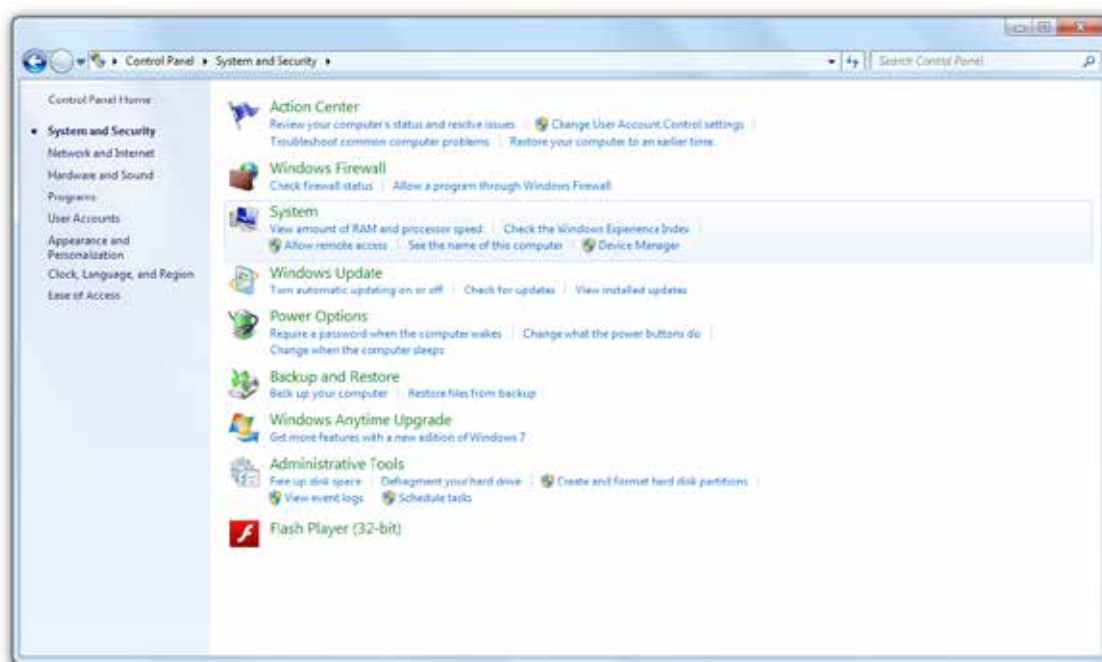
Note: The auto-detect may not work, especially if the computer is used with other analytical equipment. The port name should be followed by “(USB)”. If USB is not noted, pull down the Inductive serial port list to find the port with “(USB)” next to it and select this port.



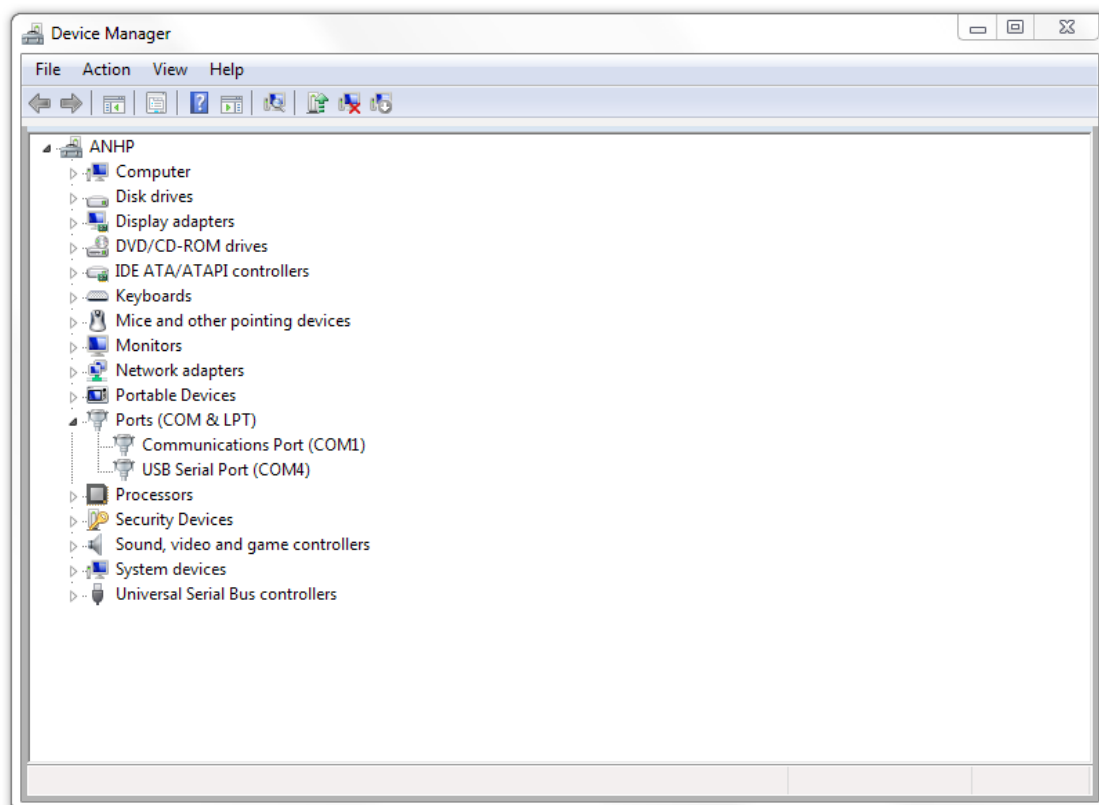
The data pencil should now be ready to use.

If the auto-detect does not work, please follow the steps below to look for the data pencil’s location in the Device Manager.

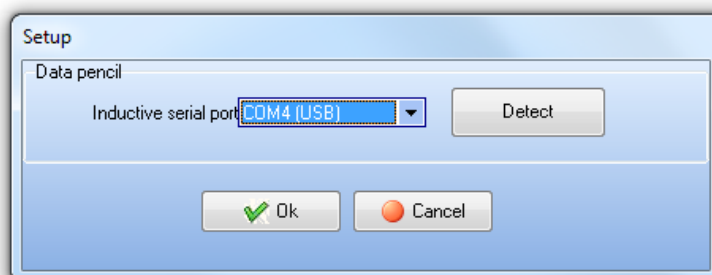
After attaching the data pencil to the computer and installing the drivers, open the Windows Control Panel and choose System and open the Device Manager.



Open the Ports (COM & LPT) information and find the USB Serial Port. (In this example, the data pencil is in COM4.)



Start ISA-CHECK II and open the Setup dialog box. Choose the correct port from the Inductive serial port list.



The data pencil should now be ready to use. Remember to use the same USB port every time.

2.4 Preparing the sensor

If you do not have pre-mounted sensors or if you want to switch sensors, follow the instructions below. Please be very careful not to touch the sensor track on the front side or the contacts.

If you wear gloves, please note that cotton gloves are not suitable at all and that latex gloves could affect silver sensors. The sensor 1, on the left has to be copper (500 nm thick) and the sensor 2, on the right, silver (500 nm thick), as described below.



Using the photos below as a guide, insert the sensor into the connector until it fits securely. Being careful not to touch the metal track or the contacts, insert the sensor into the opening of the connector.



Without touching the front of the sensor, push the sensor into the connector as far as it will go.



Wrong sensor installation



Good sensor installation

2.5 Optimal logger positioning



Fig. 2.1: Recommended positioning for the ISA-CHECK II logger

To protect the sensor surfaces, it is recommended to position the ISA-CHECK II vertically e.g. on a wall (see Fig. 2.1). Please consider very carefully the points below regarding where to put the ISA-Check II since this will affect your resulting measurements and what they represent.

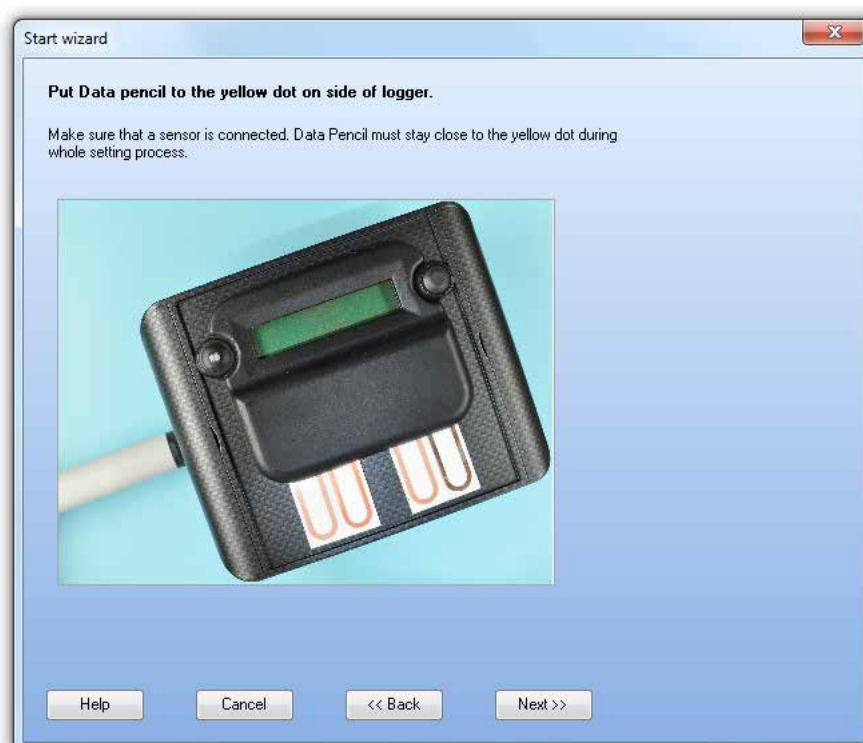
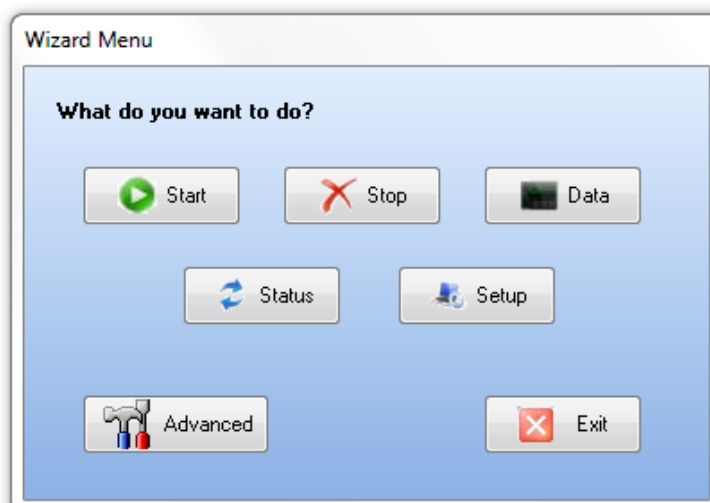
- The corrosivity may vary substantially inside a room since RH and temperature varies depending on heat sources and ventilation.
- A forced ventilation outlet from an equipment will be warmer and less moist than the average and may contain local sources e.g. nitrogen oxides from sparks or electrical relays
- If there is an air inlet equipped with molecular filtration one can assume that the air very close to the inlet will be very clean
- A position far away of an air intake will be more affected by possible internal sources from equipment and leakages through walls, windows and electrical conduits.
- Select a position close to the object to protect if this is the sought information
- Select a position in the middle of a room over 1m from the floor and away for all types of local disturbances to get a best average value
- Select a position close to an air inlet if the main pollution sources are outside and the inlet concentration should be monitored

3. Corrosion monitoring using the software wizard

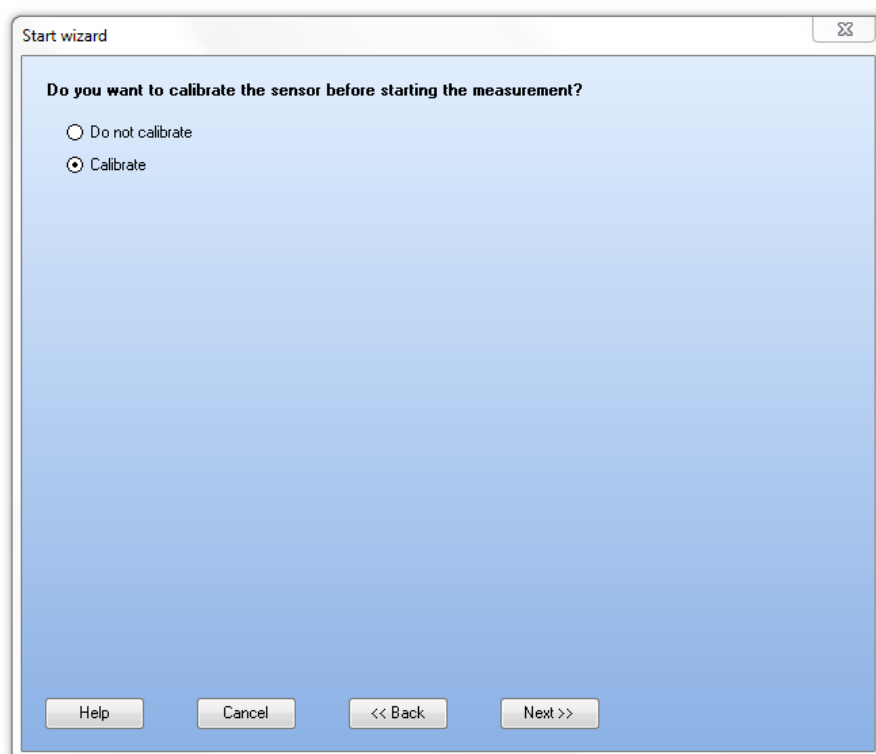
3.1 Starting data acquisition

Place the data pencil close to the yellow symbol on the left side of ISA-Check II.

Start the software, click on Start.

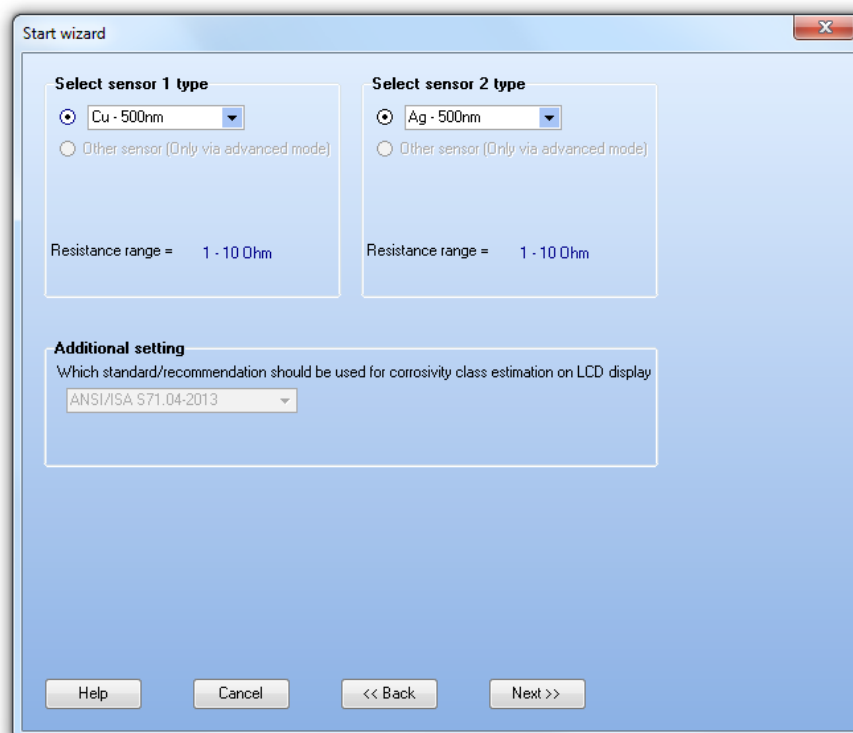


Press next.



If you start a new measurement with a new sensor, you have to calibrate the logger. So, click on Calibrate and then on Next.

Warning: Before calibrating, please wait at least 30 minutes after sensor insertion for the temperature in the sensor to stabilize. Otherwise, the subsequent corrosion depth measurement can be shifted.

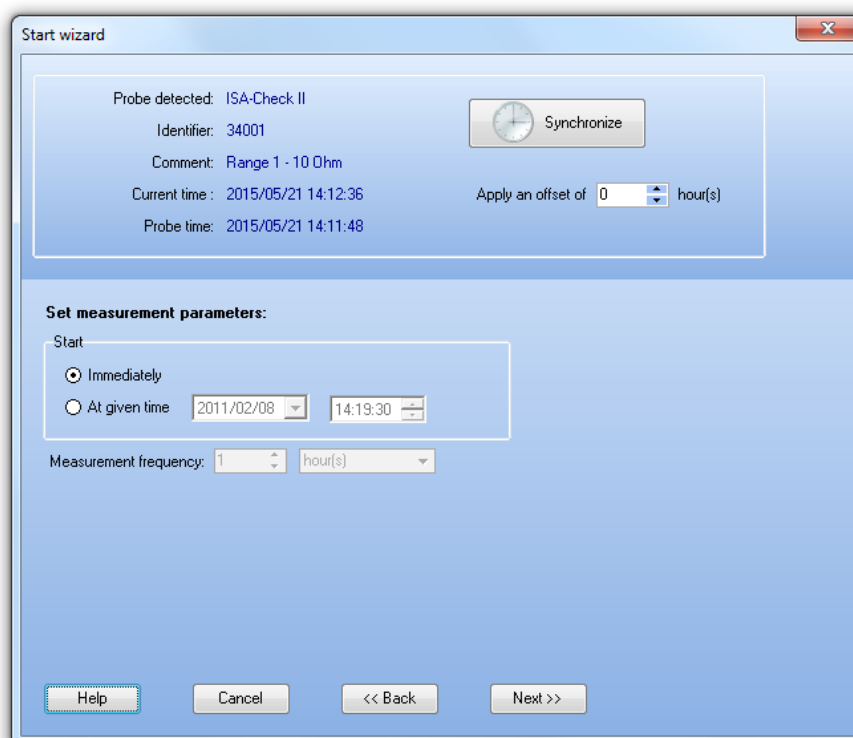


The sensor 1, on the left should be copper (500 nm thick) and the sensor 2, on the right, should be silver (500 nm thick), as described below.

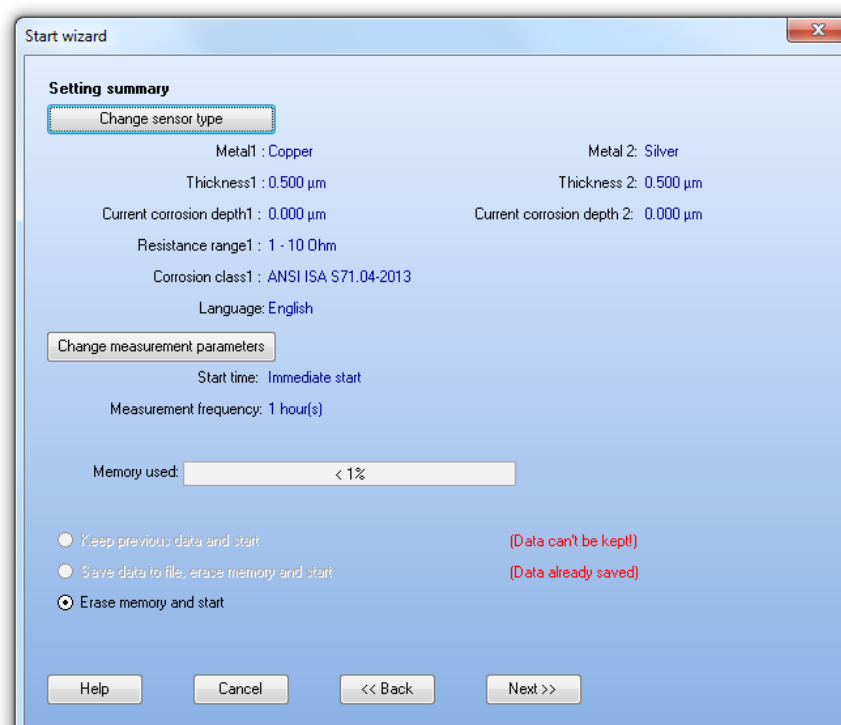
If you have made a previous measurement with the logger before, you will be asked to erase the data in the logger's internal memory. It is recommended that you save the data to a file, which you can use later with the software (.mes). If you do not have data, you can skip that step and continue without saving.



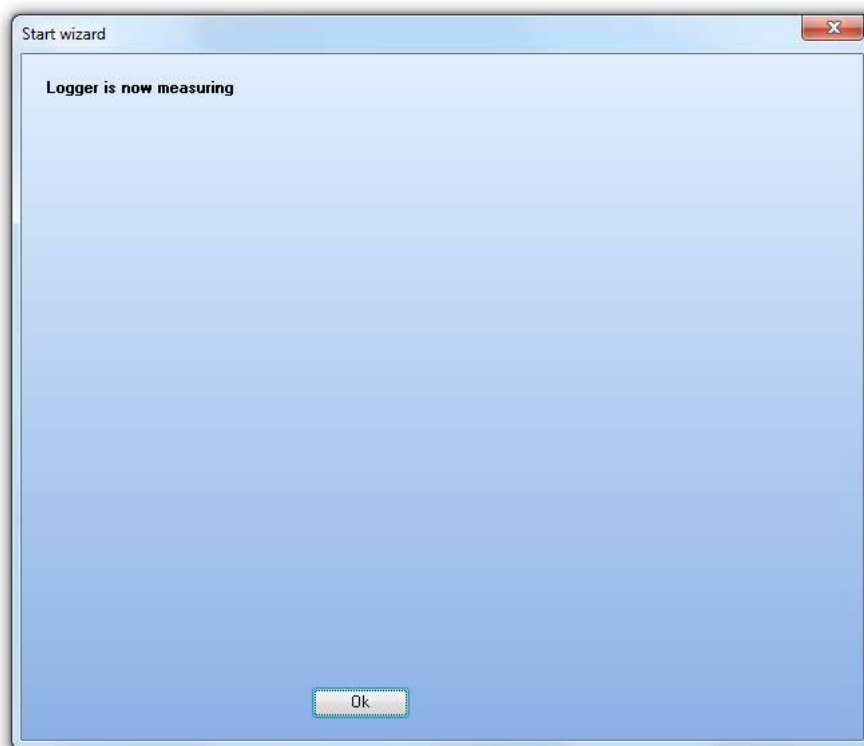
The logger is now calibrated. You can start the logger immediately or at a given time (for example, if you calibrate the logger in your office, but want to measure in a place with a different temperature you can delay the start appropriately). Please ensure that the name and identifier on the back of the logger and the text on the screen is identical and that the time reading on the computer and probe is the same. If there is a difference this can be corrected by pressing synchronize.



Please check the setting summary before starting the probe.

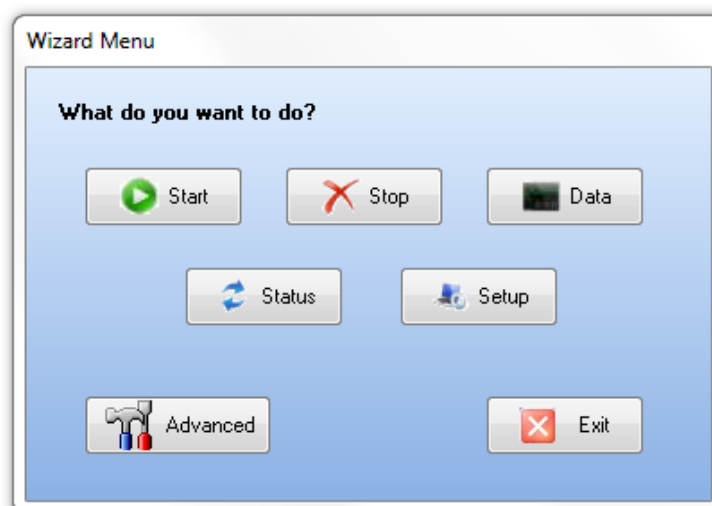


When the probe is started the following windows appears

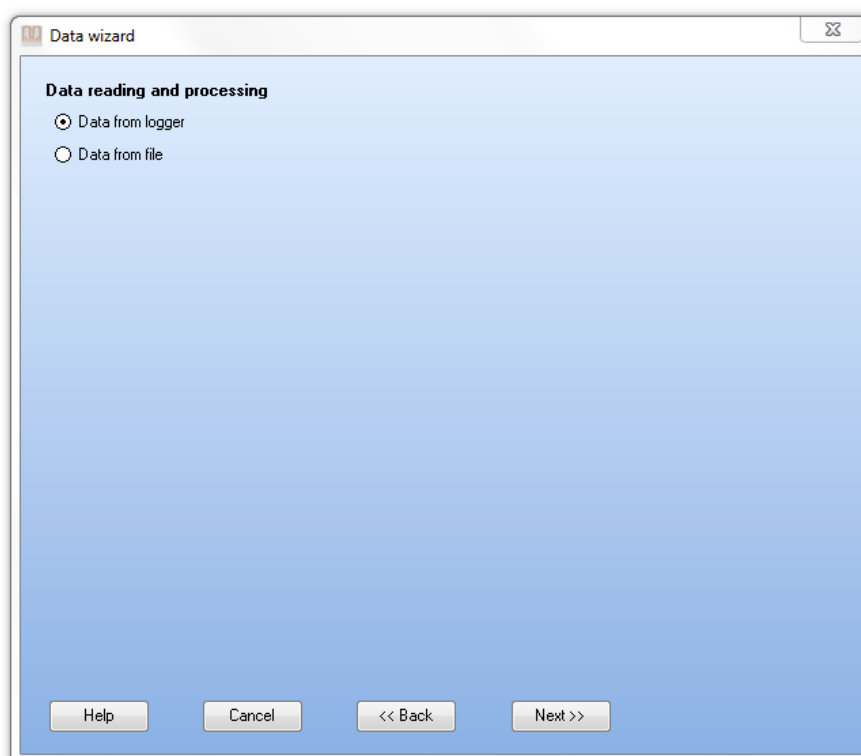


3.2 Reading and understanding data (data treatment, data export)

Start the software and click on Data.



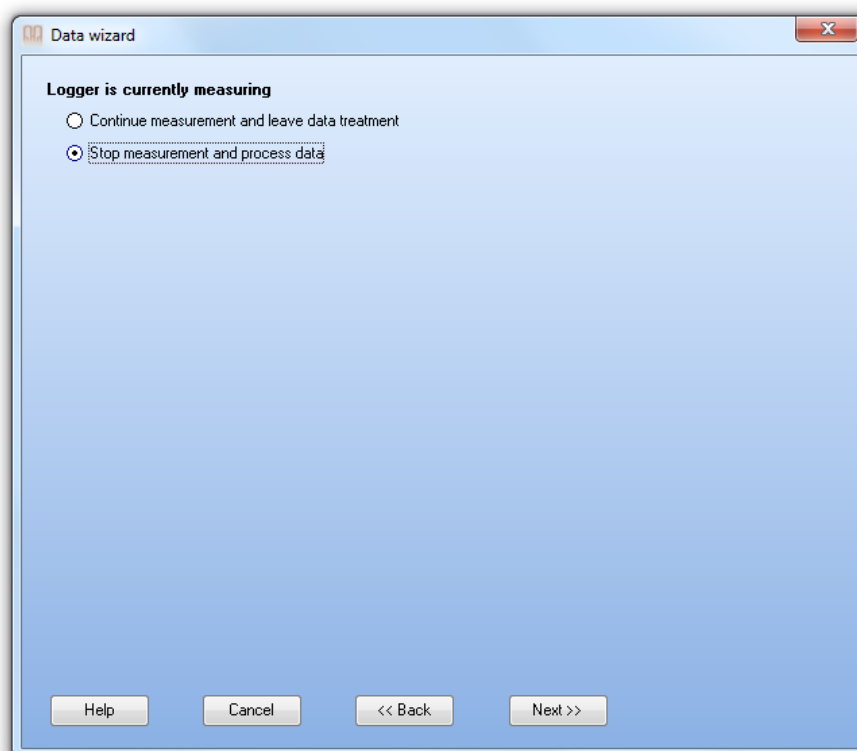
Select Data from ISA-Check II logger (or from file if you want to look at saved data) and click on Next.



Put the data pencil to the yellow dot on ISA-Check II logger.



The logger must be stopped to read the data, so choose "Stop measurement and process Data".



A graph will be displayed.

By default, filtered data will be shown. Five filters have been designed to improve the measurement presentation by removing noise due to small temperature variations. Under certain conditions, it may be better to switch off one or more filters. Examples of non-filtered and filtered measurements are shown below (Fig. 3.1).

You can choose which curves to show by clicking on the checkmarks above the graph. The corrosion rate for a specific portion of the data can be calculated by moving the red lines so that they bracket the area of interest.

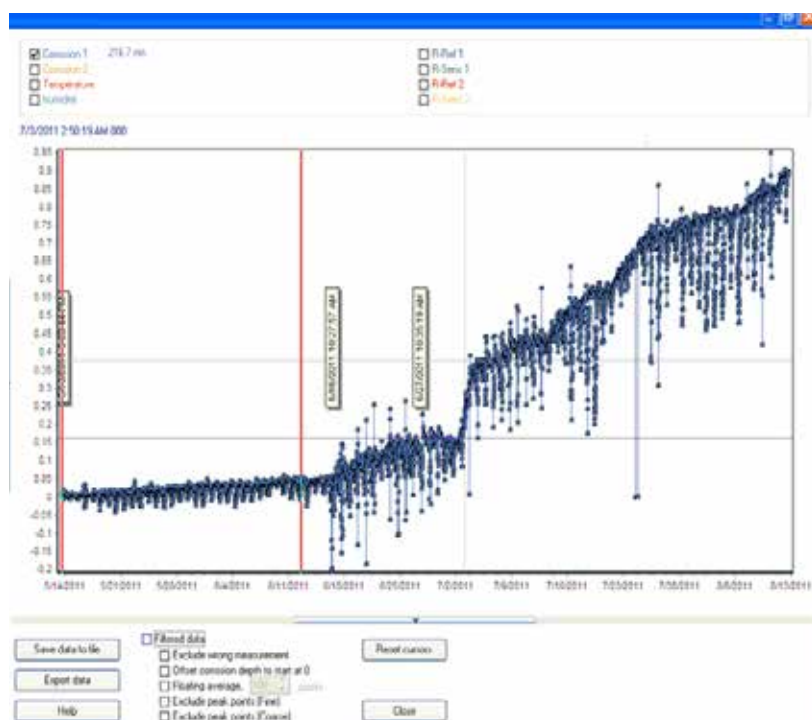


Fig. 3.1(a): Measured corrosion depth data, shown non-filtered.



Fig. 3.1(b): Measured corrosion depth data, shown filtered.

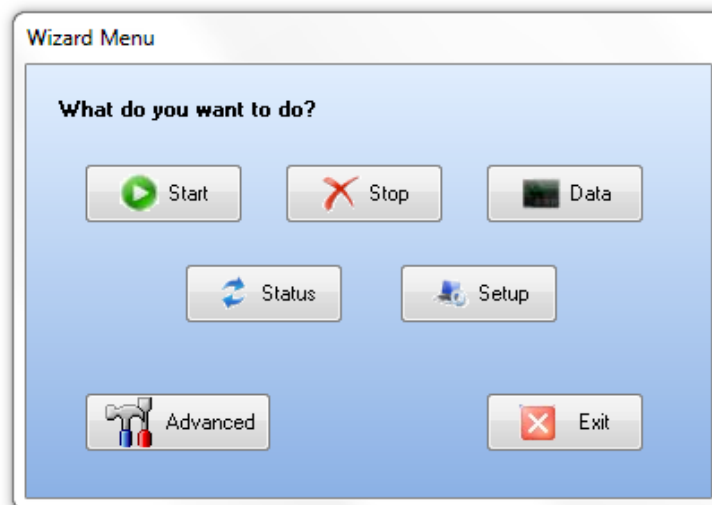
Please note: The corrosion class given is only an estimation. For details, see Appendix section A.2.

“Save data to file” allows the data to be saved as an .mes file, which can later be processed by the software. Remember to save the data before erasing the logger’s internal memory!

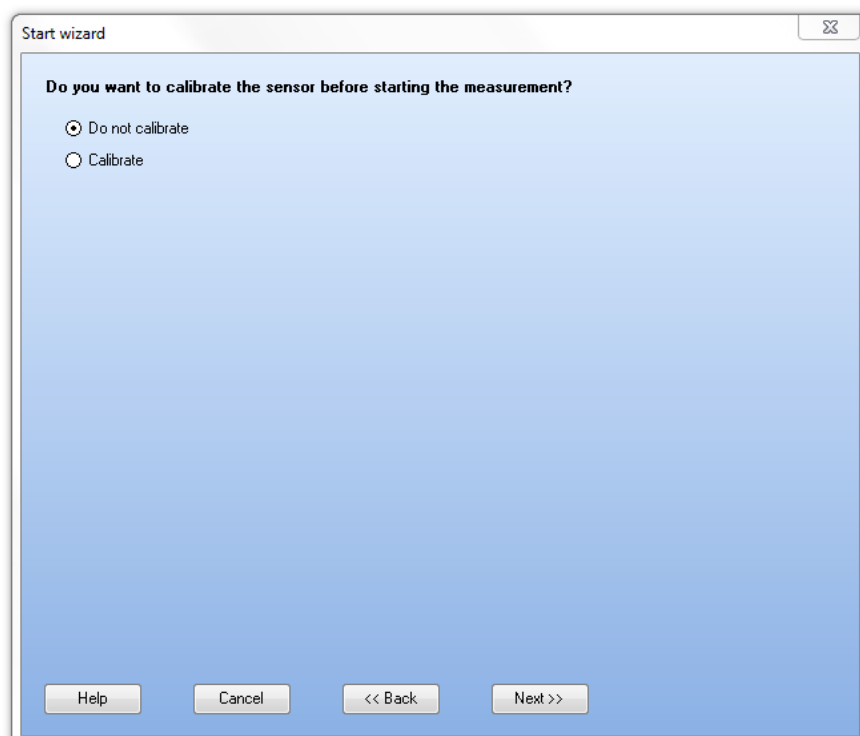
Additionally, you can “Export” the visible data to a .txt file, which can be opened in other softwares e.g. MS Excel.

3.3 Restarting the logger without / with changing the sensor

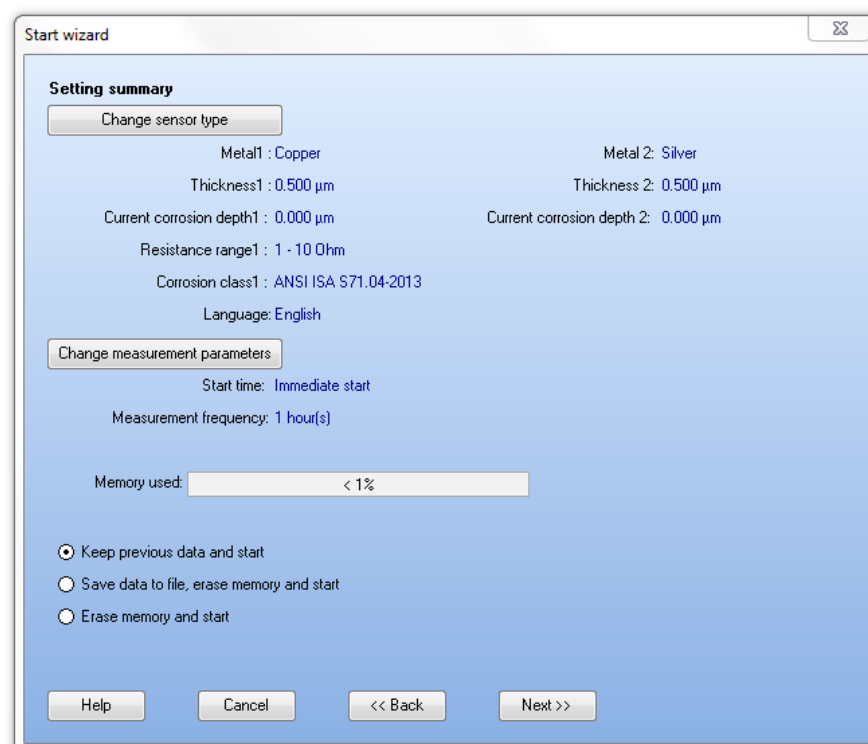
If you want to continue the measurement after looking at the data, close the graphing window and click on Start. If you are starting with a **new sensor**, follow the steps in section 3.1 again.



When you restart the logger to **continue the measurement**, choose **Do not calibrate** and follow the steps to restart the logger.

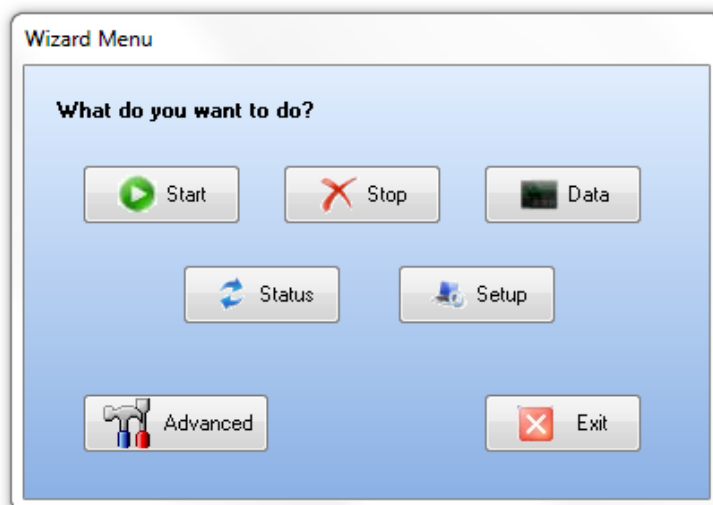


In the last step, you will have three alternatives about what to do with the data stored in the logger's internal memory: "Keep previous data and start", "Save data to file, erase memory and start" and "Erase memory and start". If you are monitoring with the same sensor in the same location, it is recommended that you choose the first alternative. All data collected so far will remain in the logger's internal memory. If you have changed the logger location, you may want to choose the second alternative. The third alternative is only recommended if you have already saved the data to a file (.mes).

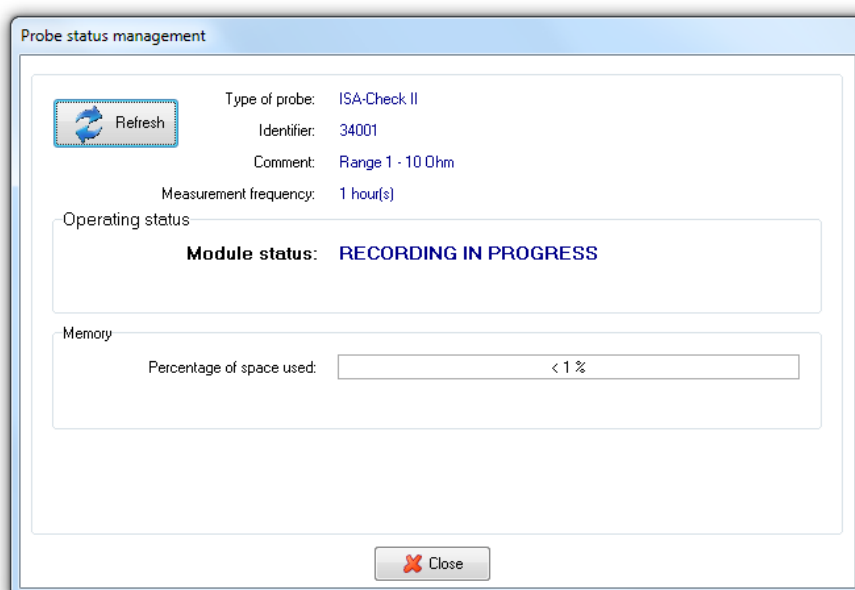


3.4 Checking the status of the logger

The status of the logger can be checked by clicking on the Status button.



Information about whether the logger is recording, stopped or ready to start at a certain time will be shown in the status window. The type of logger, logger serial number, range, and measurement frequency are also shown.



Appendix A

A.1 Corrosion measurement principle

The ISA-CHECK II monitoring system assesses the air corrosivity using the electrical resistance (ER) technique. The electronic unit measures and registers the change over time of the electrical resistance of a thin metal track applied on an insulating substrate. If the metal corrodes, the cross-sectional area of the track decreases and the electrical resistance increases. Part of the metal track is protected by an organic coating or tape and, thus, serves as a reference to compensate for resistivity changes due to variations in temperature.

Assuming that the electrical conductivity of the track is proportional to the remaining metal track thickness and assuming that corrosion products do not contribute to the conductivity, the corrosion depth of the metallic sensor, Δh , can be calculated according to equation

$$\Delta h = h_{ref,init} \left(\frac{R_{ref,init}}{R_{sens,init}} - \frac{R_{ref}}{R_{sens}} \right)$$

where $h_{ref,init}$ is the initial thickness of the reference metallic track, which is considered to be equal to the sensing track at the beginning of exposure, R_{sens} and R_{ref} are the resistances of the sensor and reference tracks at the time of measurement, and $R_{sens,init}$ and $R_{ref,init}$ are the initial resistances of the sensor and reference tracks. The calculation is based on the electrical resistances measured as a potential difference along the track through which defined currents pass (see Fig. A.1). Using resistance values from both the sensing and reference (protected) parts of the metal track allows the impact of temperature fluctuations to be eliminated.

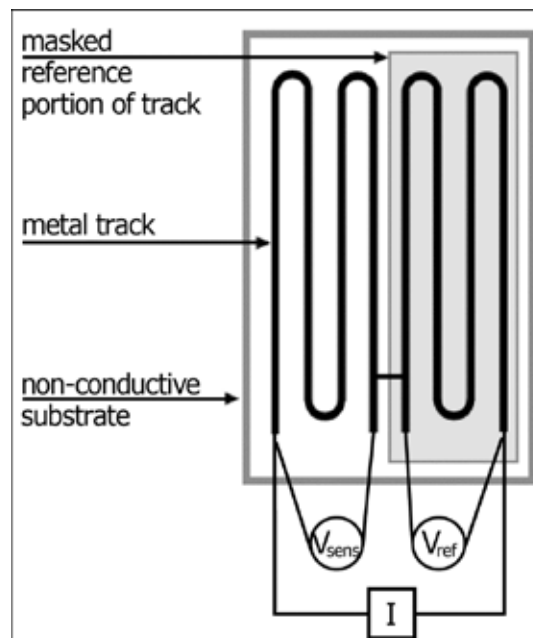


Fig. A.1: Schematic of the sensor designed to use the electrical resistance method

The width of the measuring track is from 1 to 2 mm, depending on sensor type, and the length is over 100 mm. This geometry ensures high sensitivity to changes in the electrical resistance due to metal corrosion. However, the sensitivity and service life of the sensors depend mainly on the thickness of the metallic track: the lower the thickness, the higher the sensitivity and the shorter the service life. The service life can be

assessed as the time to consume one-half of the thickness of the track. Therefore, sensors with different track thicknesses are available for different environments.

The corrosion rate can be calculated by the ISA-CHECK II program. It is given in nm/year, nm/30 days or $\mu\text{m}/\text{year}$.

A.2 Corrosivity classification

The corrosivity classification for silver and copper in indoor environments is widely used as a general measure of the air quality.

The classification according to ISA 71.04-2013 [1] is based on the thickness of the layer of corrosion products formed on metal coupons within 30 days of exposure, see Table A.1. It is calculated from the charge needed for electrochemical reduction of the corrosion products

To calculate the thickness of the corroded metal based on the thickness of the corrosion products formed, three pieces of information are needed: (1) the density of the metal, (2) the density of the corrosion products, (3) the ratio between the mass of the corrosion products and the mass of corroded metal. The last two values are not known and must be estimated. The density of the corrosion products is assumed to be about 6.0 and 7.3 for cuprous oxide, Cu_2O and silver sulphide, Ag_2S , respectively [2]. The ratio between the mass of formed corrosion products and the mass of corroded metal was obtained from the ISO 11844-1 standard [3]. It is 1.50 and 1.15 for copper and silver, respectively. Thus, the following equation can be used to estimate the corrosion buildup b from corrosion depth Δh :

$$b = \frac{\rho_M \cdot c \cdot \Delta h}{\rho_e}$$

where ρ_M is the density of the metal, ρ_{CP} is the density of the corrosion products and c is the ratio between the mass of the formed corrosion products and the mass of the corroded metal.

A.3 Limitations of the corrosivity classification

The corrosion depth measured by ISA-CHECK II loggers and given in nm or μ corresponds to the maximum reduction in the metal track cross-section. It tends thus to be somewhat higher than mean corrosion depth estimated from, e.g., mass loss.

The standards usually prescribe the minimum size of the coupons to be exposed. These are generally larger than the area of the measuring track of ISA-CHECK II sensors.

The standards define the exposure period as 30 days or 1 year. If the exposure period is shorter or longer than specified in a standard, the resulting air corrosivity classification is only indicative. This is due to the fact that corrosion processes for most metals in most environments are non-linear and any inter/extrapolation can be misleading.

In addition, several simplifying assumptions are applied for the estimation of the corrosivity classification according to ISA 71.04-2013, so the given levels (G1, G2, G3, GX), during a 24h period should be considered as an indication.

A.4 Corrosivity classification tables

Table A.1: Corrosivity classification of indoor atmospheres according to ANSI/ISA S71.04-2013 for copper and silver; in nm/30 days of corrosion build-up (thickness of corrosion products)

Material	Class	G1	G2	G3	GX
	Level	Mild	Moderate	Harsh	Severe
Copper	Corrosion	< 30	< 100	< 200	> 200
Silver	Corrosion	< 20	< 100	< 200	> 200

A.5 References

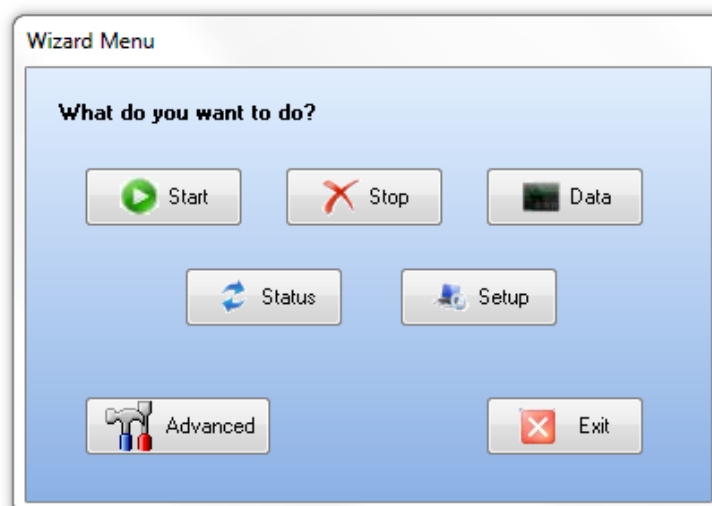
1. ANSI/ISA-71.04-2013, Environmental conditions for process measurement and control systems: Airborne contaminants, ANSI/ISA-The Instrumentation, System and Automation Society (2013).
2. W. E. Campbell and U. B. Thomas: Tarnish studies. The Electrolytic Reduction Method for the Analysis of Films on Metal Surfaces, Trans. Electrochem. Soc. 76, 303 (1939), DOI:10.1149/1.3500286.
3. ISO 11844-1, Corrosion of metals and alloys – classification of low corrosivity of indoor atmospheres – Part 1: determination and estimation of indoor corrosivity, International Organization of Standardization, Genève, Suisse (2006).

Appendix B

B.1 Corrosion monitoring using the Advanced software mode

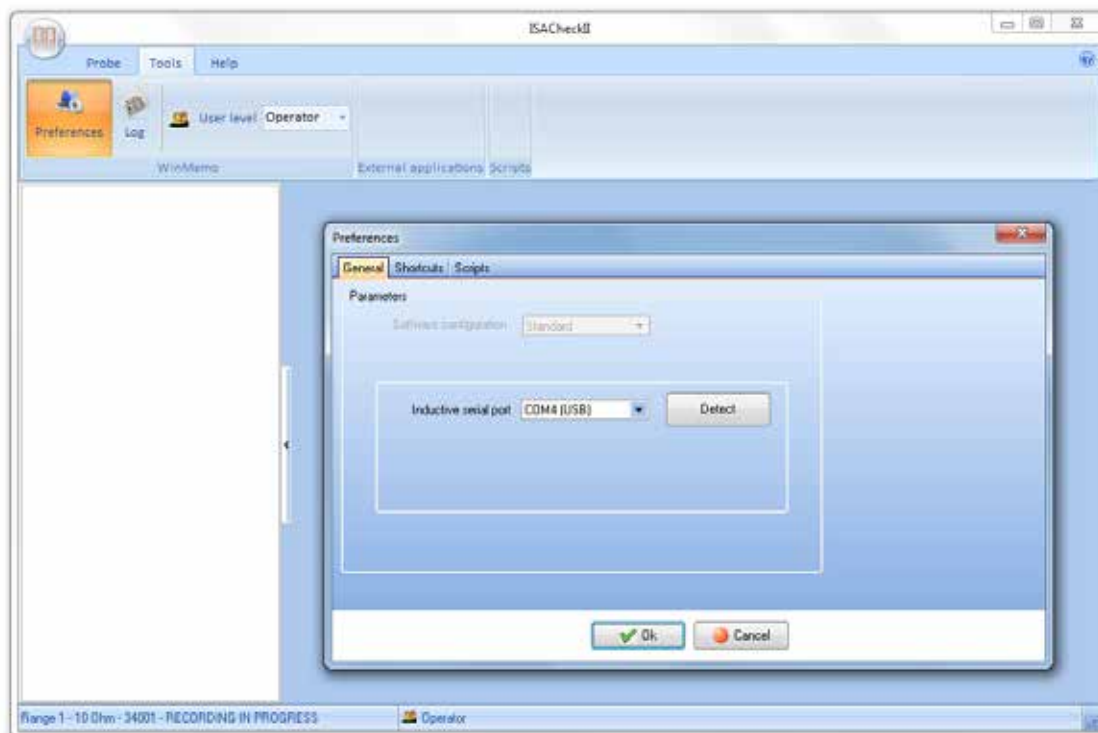
In special applications where more advanced measurements should be made or other metals than copper or silver are used this appendix have instructions on how to access the advanced mode. Please do not go into this mode without previous training. Please contact your Camfil office for further instruction if you may want to use this mode .

To use ISA-CHECK II in the Advanced mode, click on Advanced in the ISA-CHECK II Wizard Menu.



B.2 Installing and finding the data pencil

Follow the steps in Chapter 2 to detect the data pencil. You can also search for the data pencil in Tools>Preferences in the advanced mode. You will only need to do this once if you always use the same USB port for the data pencil.



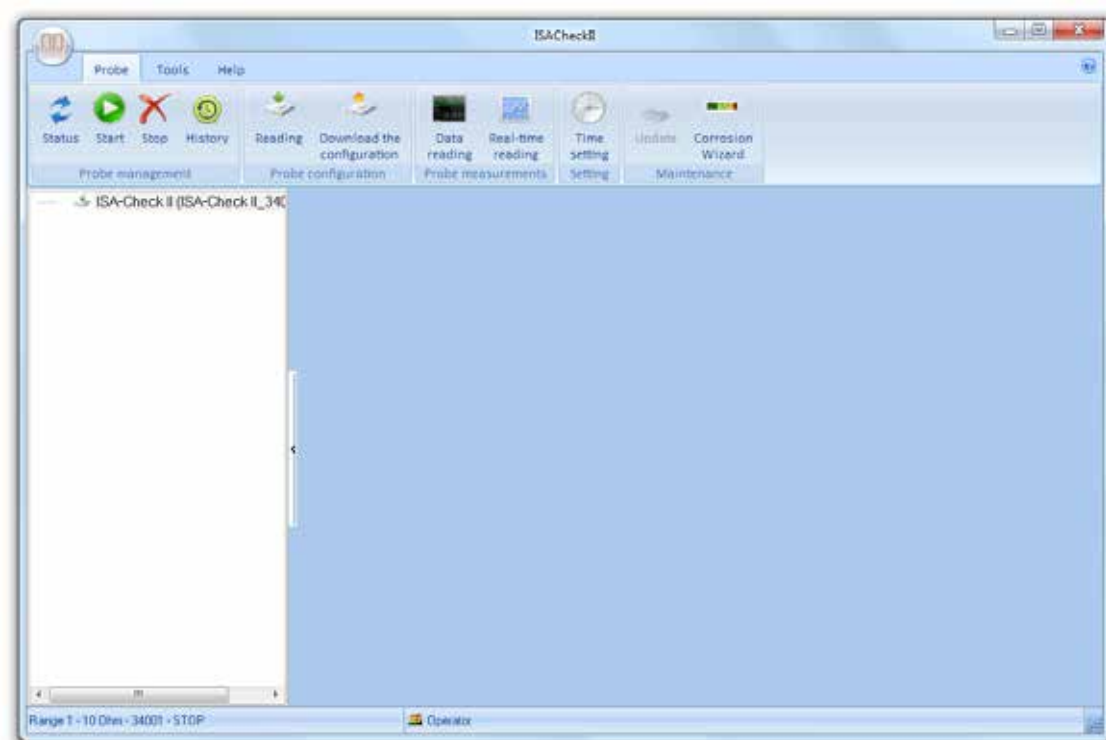
B.3 Synchronizing date and time

If you did not follow the instructions in section 2.4, place the data pencil close to the yellow circle of the logger. In Probe tab, click on Time setting button. If the date and time of the logger and the computer are different, click on synchronize. After the software has communicated with the logger, the Time setting section should show logger information, and date and time (the logger and computer might be off by a second).

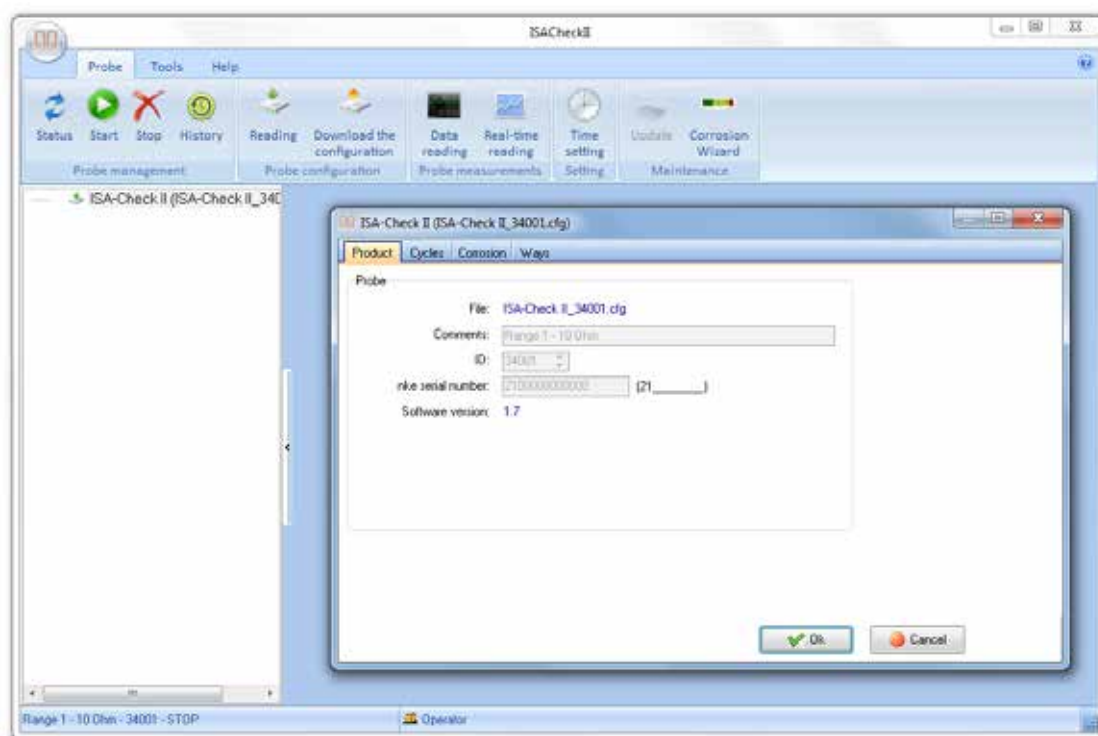


B.4 Choosing the measurement frequency

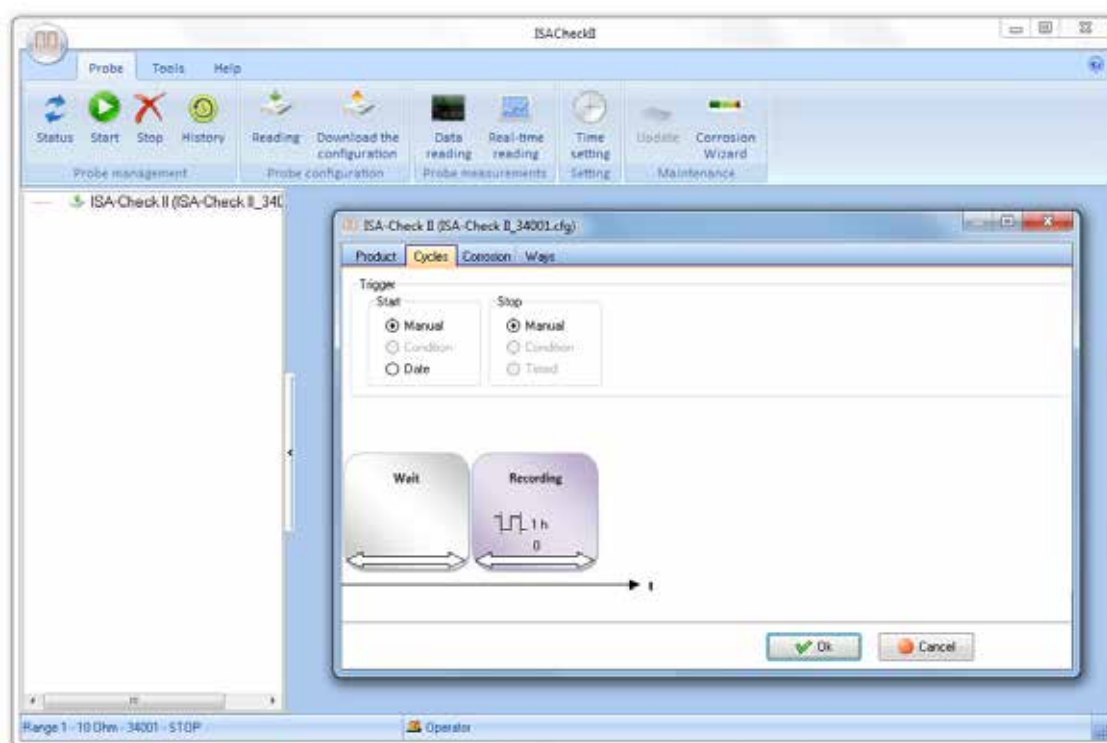
If the logger is measuring, you will have to stop the measurement. You can do this by clicking on Stop or by checking the Status and stopping the logger there. Then click on Reading. The software reads the settings from the logger:



Double-click on the ISA-CHECK II file on the left side of the window. The settings will open:



Click on Cycles in order to choose the measurement frequency.

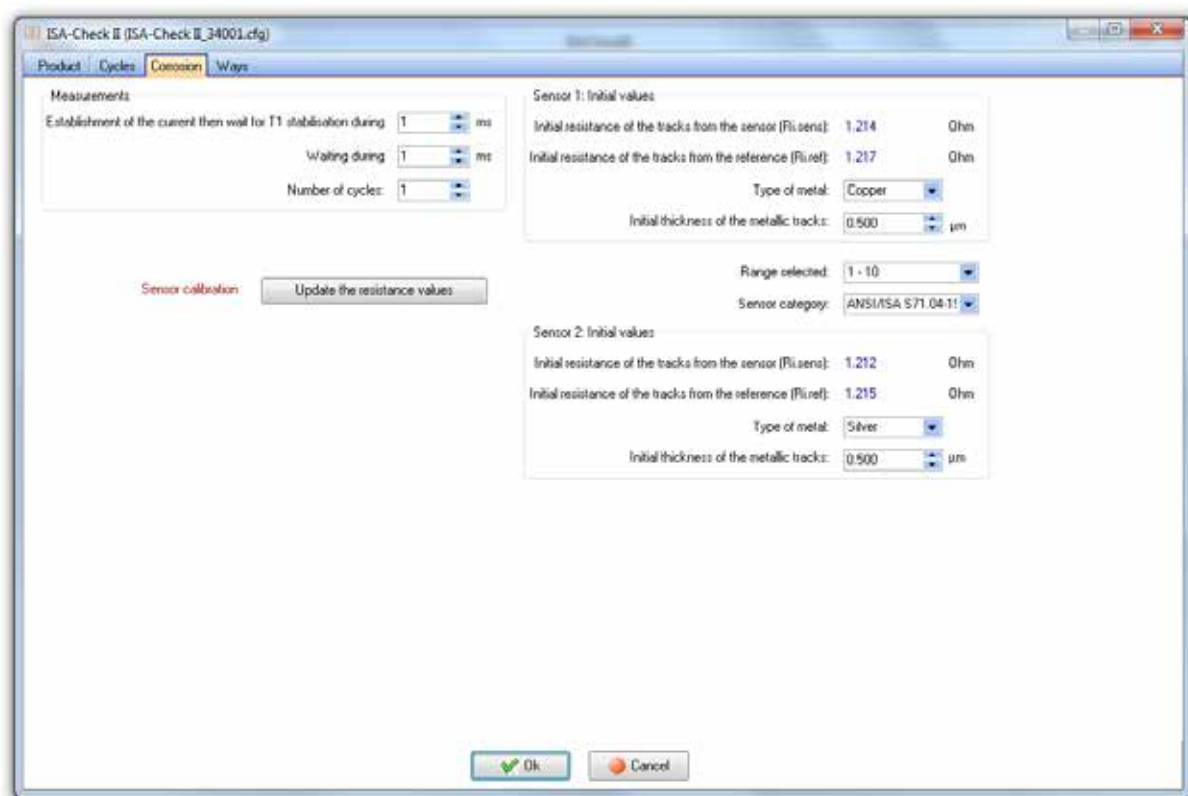


By clicking on Recording you can change the measurement frequency. Please note that the smaller the frequency is the more data will accumulate. **In addition, the information displayed on the LCD screen (corrosion thickness and corrosivity) will be affected by a changing of frequency. This information has been designed to work at 1 hour frequency only.** Choose an appropriate frequency for your application. For most applications, there is no reason to measure more often than every 15 or 30 minutes.

You can start the logger immediately (Manual start) or at a given time (Date start). You might want to start at a specific time if you calibrate the logger in your office and want to have time to place the logger in the measurement location.

B.5 Choosing the correct measurement range

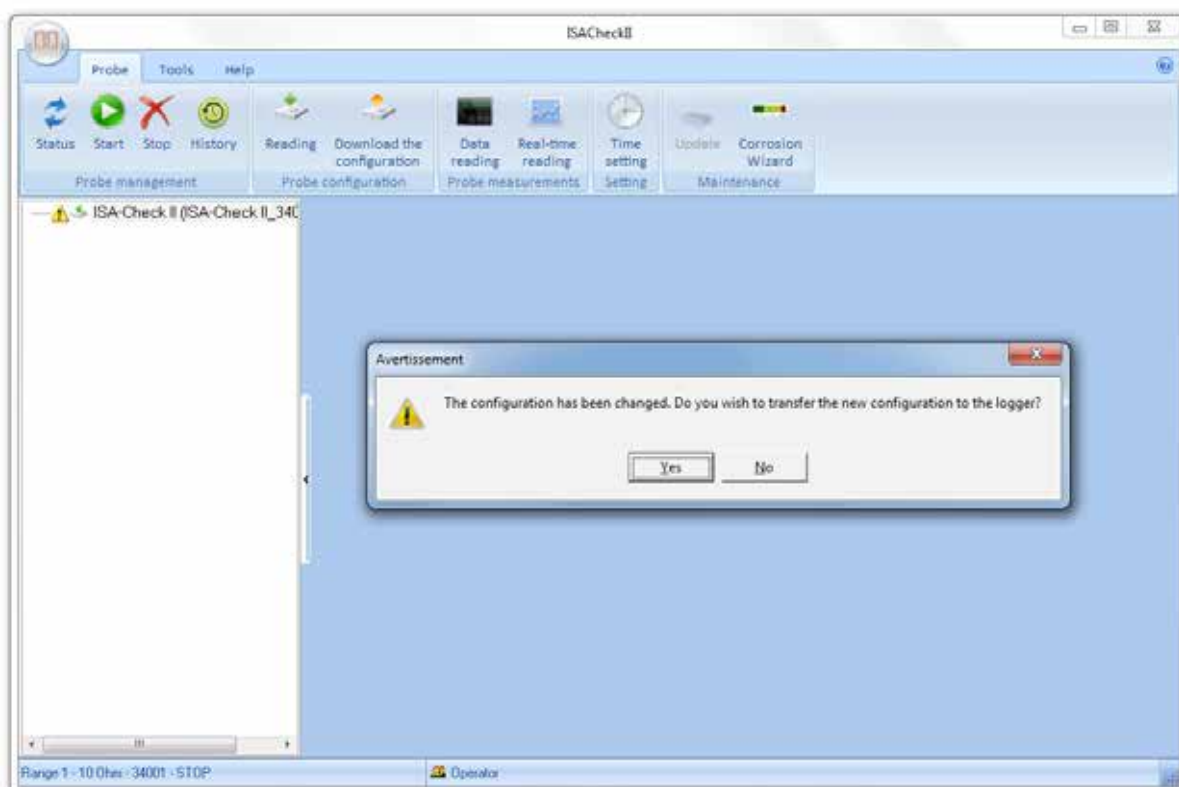
By clicking on the “Name of logger” tab, you can change the sensor and the measurement range.



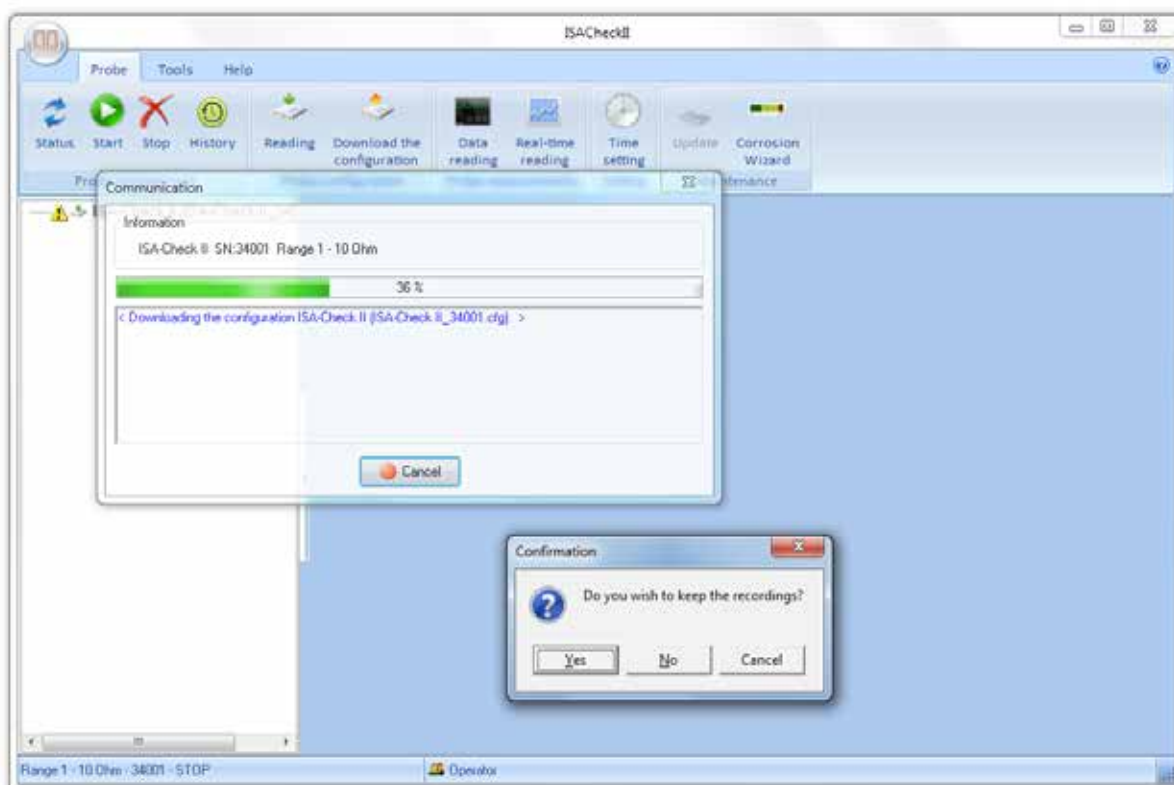
Choose the sensor metals, thicknesses, and measurement range from the pull-down menus (check the documentation that came with the sensors). In “Sensor category,” you can choose the appropriate standard for the corrosion class estimation. Then you have to calibrate the logger by updating the resistance values. Click on “Updating the resistance values” and then on OK.

Warning: Before calibrating, please wait at least 30 minutes after sensor insertion for the temperature in the sensor to stabilize. Otherwise, the subsequent corrosion depth measurement can be shifted.

Wait until the message “Calibrating sensor” changes to “Sensor calibration” again. The new values appear on the upper right corner of the window. Close the window by clicking on Ok. Answer the next question with Yes.



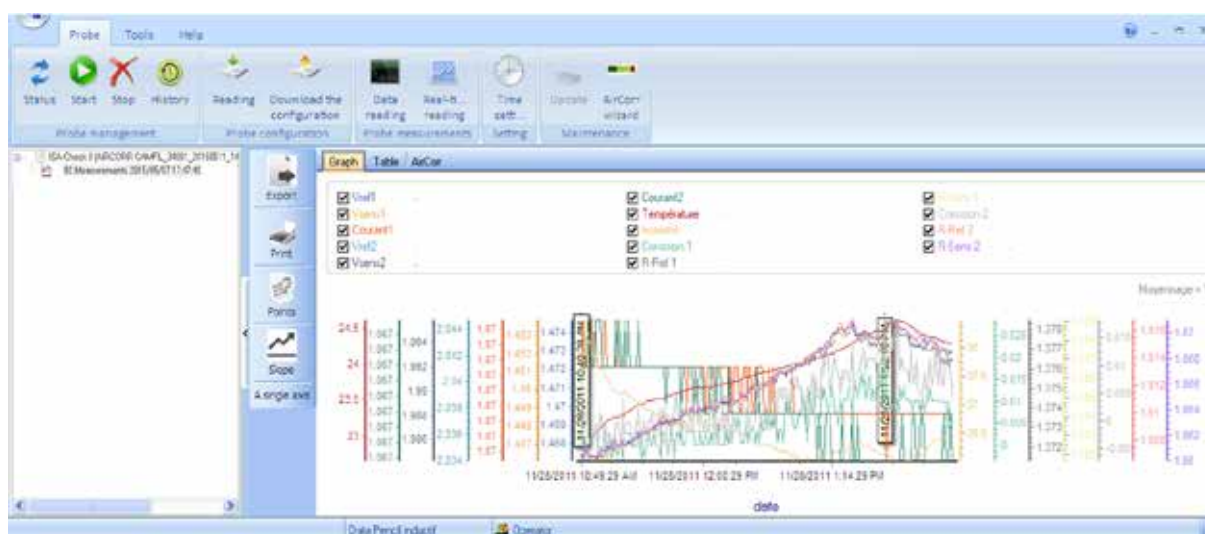
In this window, you have to choose “no” when you want to upload the new configuration. Then you are ready to start the logger by clicking on Start.



The logger is measuring now. You can test this by clicking on Status.

B.6 Reading and understanding data (data treatment, data export)

To read out the logger's data, you have to stop the recording by clicking on Stop. Then click on Data reading. Click on "x measures" in the left part of the window. The measurement graphs appear in the right window.



You can choose which curves to show by clicking on the checkmarks above the graph. A table and a diagram including the corrosion class estimation are available under "Table" and "NAME OF LOGGER," respectively.

By default, filtered data will be displayed. Five filters have been designed to improve the measurement presentation because some noise due to small temperature variations is inherently present in the corrosion depth record. Under certain conditions, it may be better to switch off one or more filters. Examples of non-filtered and filtered measurements are shown below (Fig. 4.1).

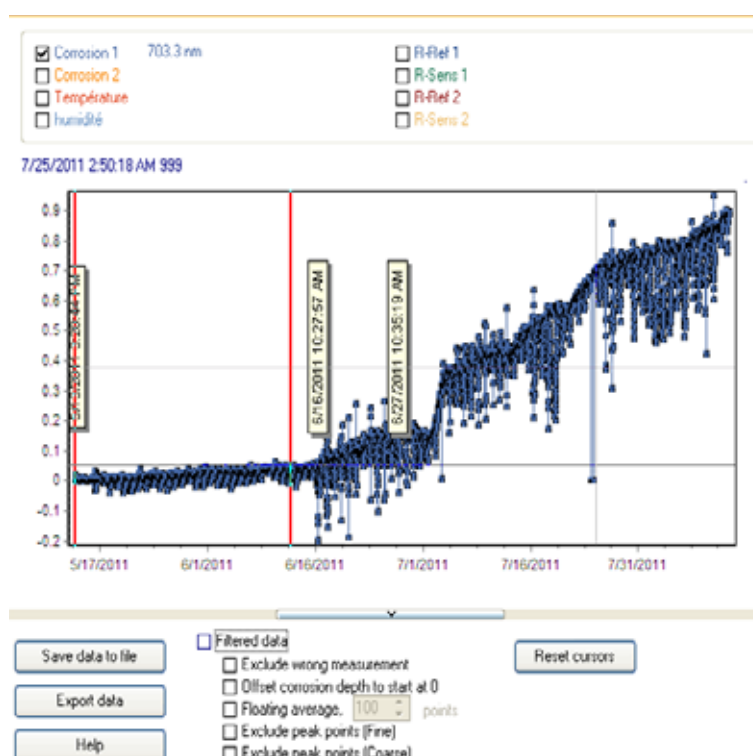


Fig. 4.1(a): Measured corrosion depth data, shown non-filtered.

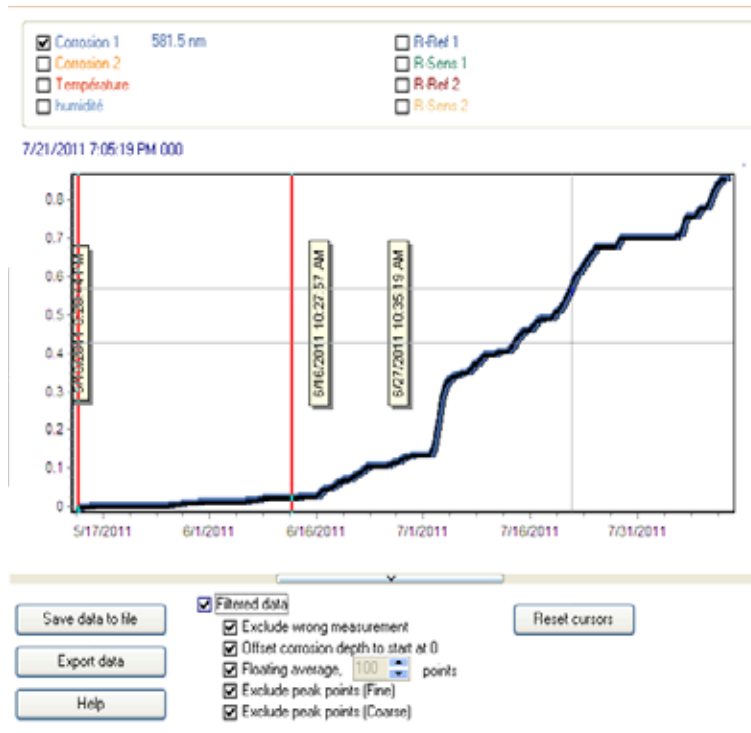


Fig. 4.1(b): Measured corrosion depth data, shown filtered.

Please note: The corrosion class given is only an estimation. For details, see Appendix section A.2.

“Save data to file” allows the data to be saved as an .mes file, which can be processed by the software. Remember to save the data before erasing the logger’s internal memory!

Additionally, you can “Export” the visible data to a .txt file, which can be opened in Excel.

If you close the software without saving it will ask you a) to save the configuration file and b) to save the .mes file.

B.7 Restarting the logger without / with changing the sensor

After you have changed the sensor, you will have to go through steps 4.3 and 4.4 again. If you just want to continue with the measurement, click on Start. You will be asked if you want to save the recordings.

If you choose Yes, the new data will be added to the old ones. It is recommended that you choose Yes unless you are starting a new experiment. By choosing No, the logger’s internal memory will be erased. Be sure to have saved the data to a measurement file in this case.

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