

AIR-X

ON-LINE OIL AERATION MEASUREMENT

USER'S MANUAL

Table of contents

Table of contents	2
CAUTION	3
Characteristics	4
1. Presentation	5
1.1. Introduction	5
1.2. Measurement principle	5
1.3. Description of Air-X equipment	7
2. Air-X installation	11
3. Air-X use and software	14
3.1. Aeration measurement (→ File).....	14
3.2. Graphical functions (→ Display).....	17
3.3. MCA Calibration and spectrum adjustment (→ Calibration).....	20
3.4. Calibrations: 100% Air and temperature calibrations (→ Calibration)	22
3.5. Calibrations of the inputs and outputs (→ Calibration).....	26
3.6. Options menu (→ Option).....	27
4. Troubleshooting - Solutions	27

CAUTION



The Air-X measurement unit contains a radioactive source which is installed on the measurement chamber. It is designed to avoid exposure to radiations.

THE DISMANTLE OF ANY SEALED COMPONENT FROM THE MEASUREMENT CHAMBER IS STRICTLY FORBIDDEN.

THE REPLACEMENT OF THE RADIOACTIVE SOURCES IS RECOMMENDED EVERY TWO YEARS AND MUST BE PERFORMED BY DSI.



The Air-X electronic box is supplied with 110 or 220 VAC and the radiation detector is powered with high voltage (+/- 1000V).

The equipment must be switched off before any manipulation on the electronic components and any manipulation must be performed by qualified electricians.



Hot oil circulates in the Air-X measurement chamber. Every manipulation on the hydraulic loops must be performed when the oil is cold (temperature to be checked with the temperature sensors)

For commercial or technical support, please contact:



DSi SPRL
3 Rue du Mont d'Orcq
B-7503 Froyennes
Belgique
☎ 0032 (0) 69 64 06 04
📠 0032 (0) 69 78 00 79
Mail : infos@deltabeam.net
Web : www.deltabeam.net

Characteristics

General

Dimensions (L x W x H):	350 x 300 x 150 mm
Weight:	10 kg
Temperature range:	10 °C to 50°C
Power supply:	110 - 220 VAC / 50Hz – 60 Hz (power 500W)

Hydraulic

Fluids:	All types of lubricants
Viscosity range:	3.8 to 3500 mm ² /s
Temperature range:	10 to 150°C
Pressure range:	Measurement : around atmospheric pressure (up to 0.2 bars abs for dissolved air measurement) Capacity of the chamber : 0.2 to 5 bars abs
Oil flow:	up to 80 l/ min (1 Inch BSP)
Hydraulic connectors:	BSP 1 Inch – adapters on request
Oil sample volume:	0.3 liter for the measurement chamber

Measurement

Measurement range:	0 to 100% aeration rate in oil
Accuracy for a new source:	0.5 % at 10s acquisition time 0.3 % at 30s acquisition time 0.2 % at 60s acquisition time
Oil sample volume:	< 0.3 liter

Data

Analog inputs:	BNC 0 – 10 V
Analog outputs:	BNC 0 – 4 V

Laptop

Standard PC (Windows 7 or 8) with Air-X Software

Cables

USB cable length:	5 m + extender if necessary
Air-X unit cables length:	10 m standard
Power supply:	110 - 220 VAC cable

1. Presentation

1.1. Introduction

The Air-X is an on-line lubricant aeration measurement device, using density measurement through X-rays transmission. The exempted X-rays sources are not in direct contact with the lubricant (no contamination of the oil).

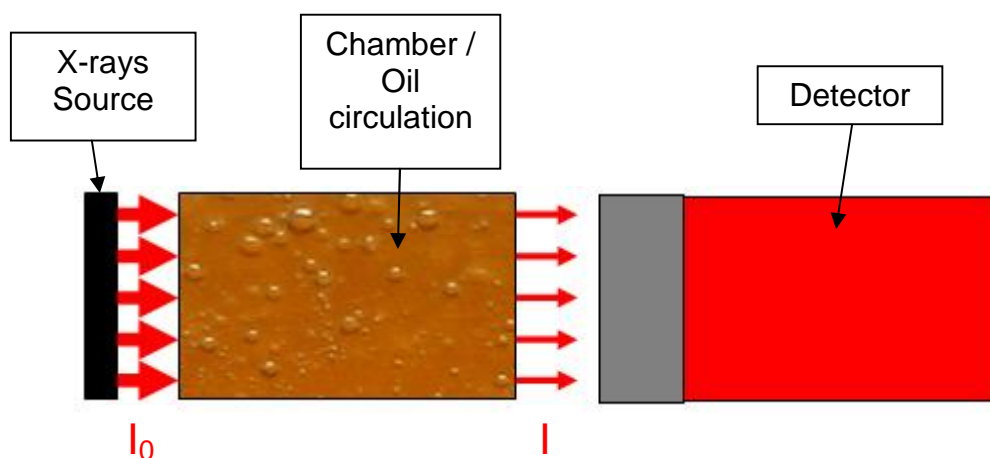
Aeration or gases in the lubricant can lead to bad consequences in a running engine: loss of lubrication, loss of power, engine overheating, increase of engine noise...

It can be present in 3 different forms: bubbles, foam or dissolved gases.

Aeration rate (foam and bubbles) can be measured everywhere in the lubrication circuit of any hydraulic system, at atmospheric pressure or in a pressurized place.

1.2. Measurement principle

The operating principle is based on an accurate density measurement using X-rays transmission. Oil coming from the mechanical system circulates into a compact measuring chamber where a density measurement is continuously performed. The X-rays source is on one side of the chamber, and the detector in front of the source on the other side of the chamber.



The detector gets a maximum count rate of the X-rays when the chamber is empty (100% air) whereas this intensity decreases with oil in the chamber. A calibration 100% air (empty chamber) and a temperature calibration 100% oil (in non-aerating conditions with variation of the temperature) must be performed before any measurement in order to convert the count rate into an aeration rate.

During a measurement, aeration (in terms of volume) is computed by the Air-X software and graphically displayed. Measurement data's are temperature corrected (because of the variation of the density with the temperature).

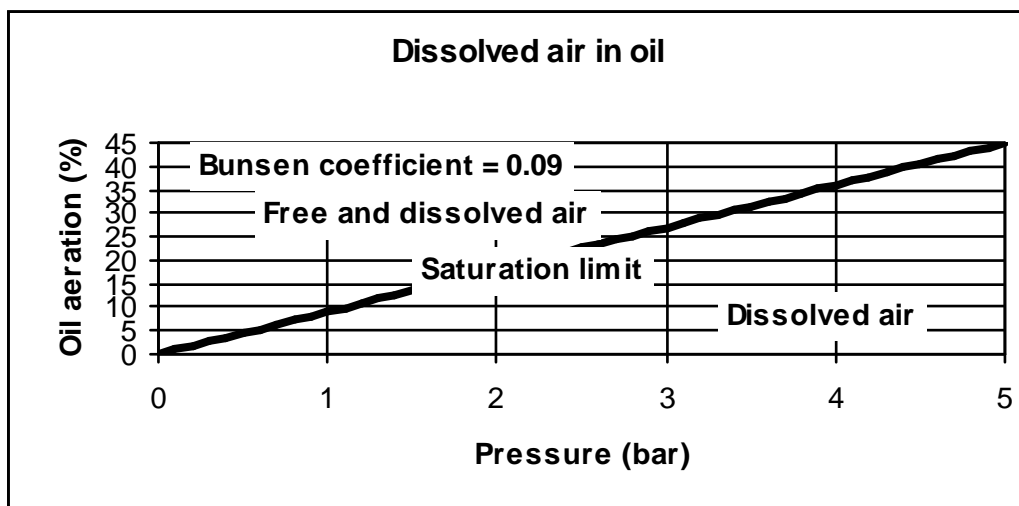
The pressure also has a significant impact on the aeration measurement: overpressure reduces the volume of the oil bubbles, what decreases the measured values of aeration, and depressure increases the volume of the oil bubbles, what increases the measured values of aeration.

A function in the Air-X software takes this parameter into account and corrects the results in function of the pressure in the chamber to calculate a nominal value at atmospheric pressure of aeration named "Corrected aeration".

$$\begin{aligned} \text{Corrected Aeration} &= \text{Aeration} * \text{pressure in the Air-X chamber} \\ &= \text{Aeration at atmospheric pressure (1 atm = 1 bar absolute)} \end{aligned}$$

In this way, the Corrected Aeration results can be compared to each other independently of the pressure in the Air-X chamber.

Dissolved air also has an impact on the aeration measurement. Regarding Henry's law, it is admitted that about 9% of air are dissolved in the oil for 1 bar absolute of pressure. Dissolved air is invisible (molecular form, not bubbles form) and not directly measurable by the Air-X.



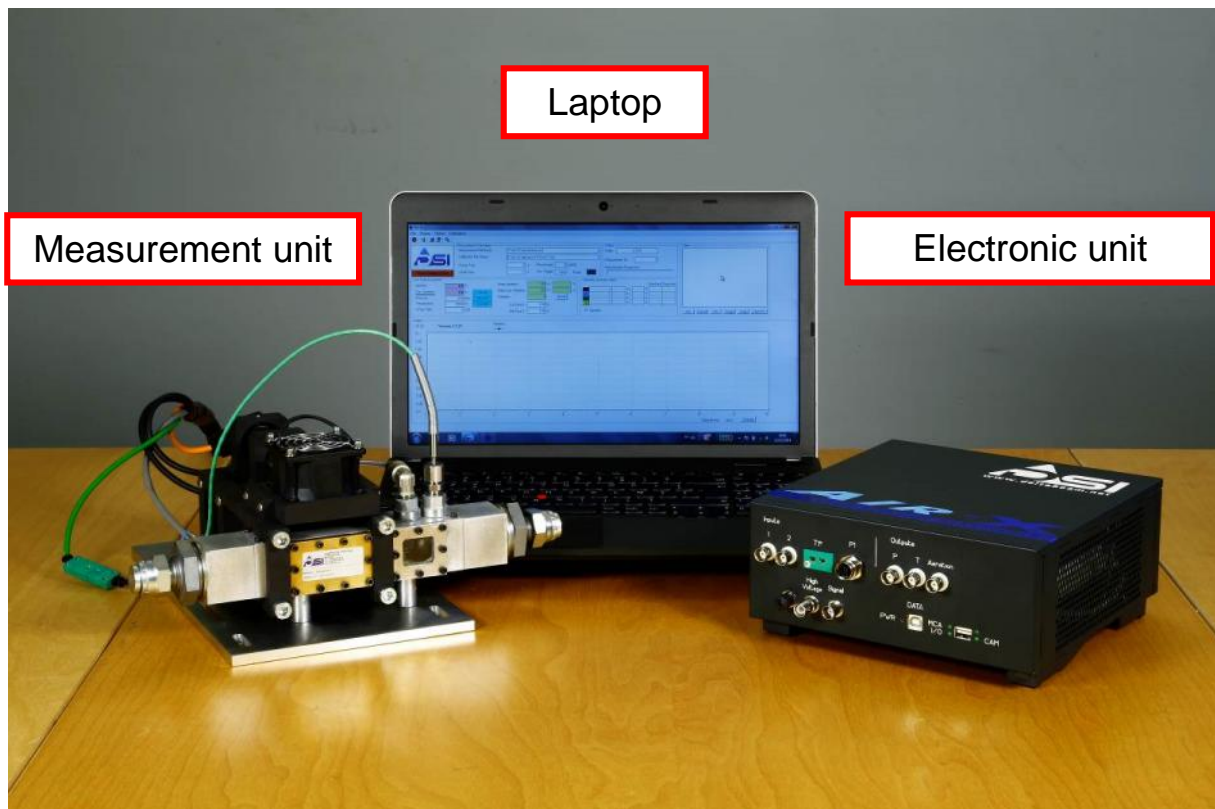
By taking the pressure in the Air-X chamber into account, the amount of dissolved air can be calculated and added to the Air-X results, following that law.

1.3. Description of Air-X equipment

The Air-X measurement equipment includes a measurement unit, an electronic box and a laptop equipped with the Air-X software (described in section 3).

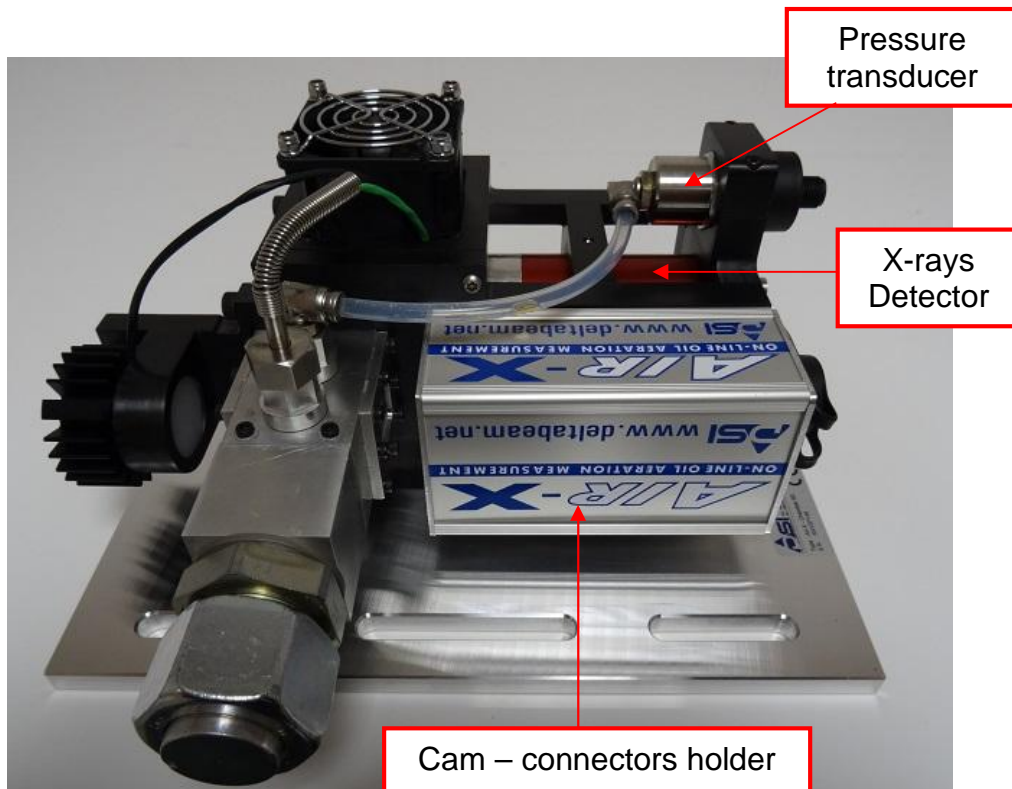
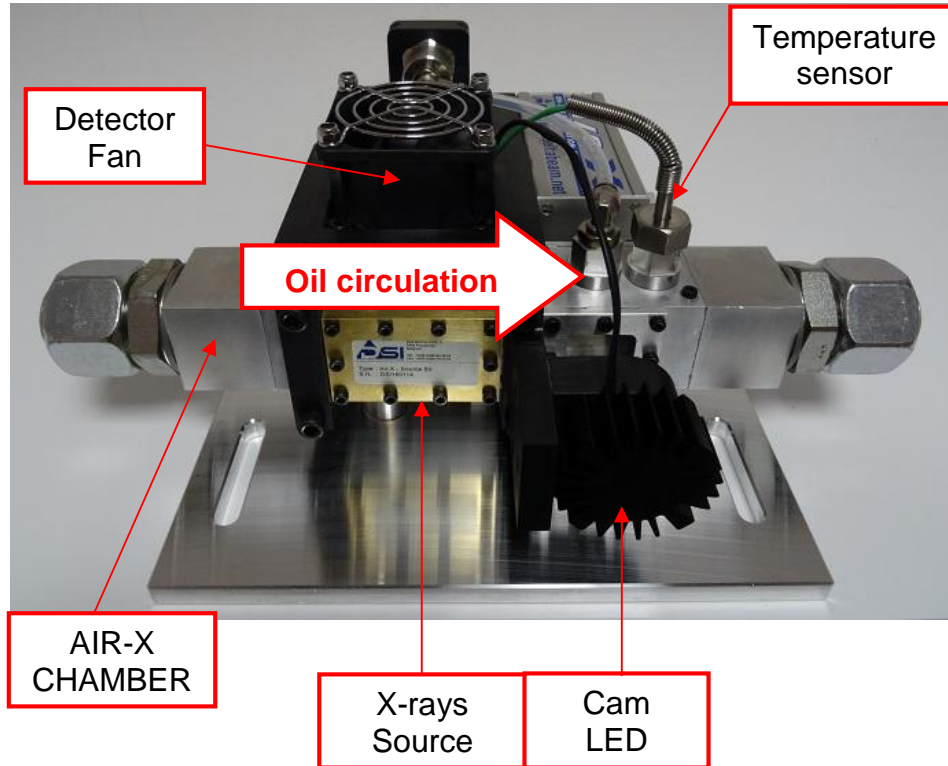
The measurement unit is made of a measurement chamber on which are installed several components: X-rays source, X-rays detector, temperature and pressure sensors, and a cam.

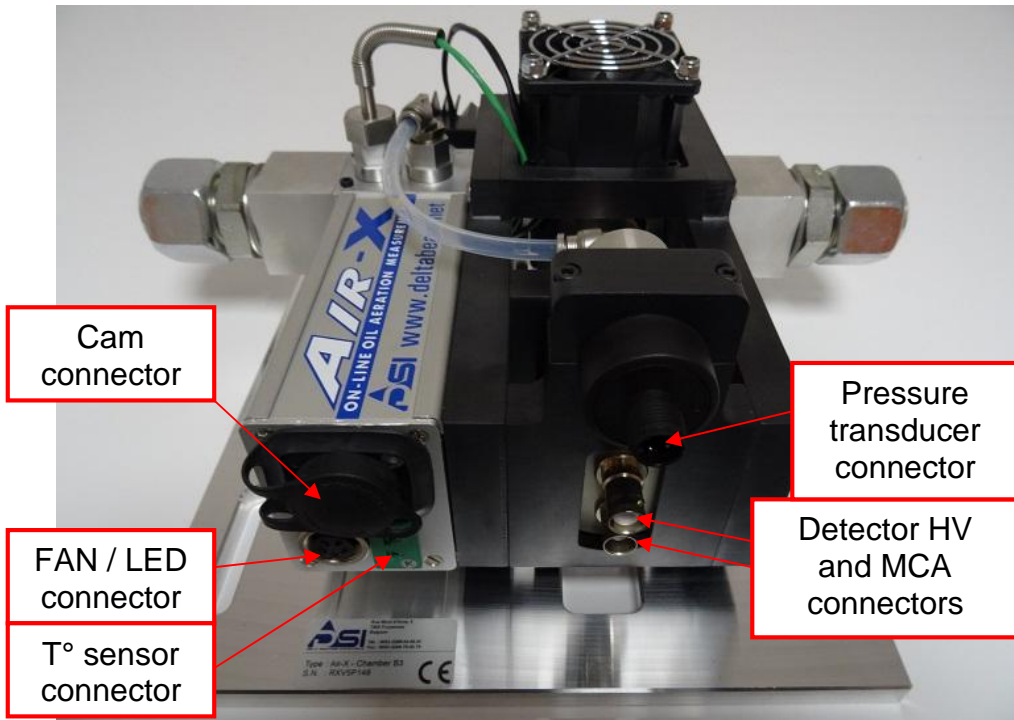
The measurement unit is connected to the electronic box with specific cables. This electronic box contains MCA (Multi-channel analysis) systems and I/O board for exchange of data's (pressure, temperature, external signals) between the measurement unit and the laptop.



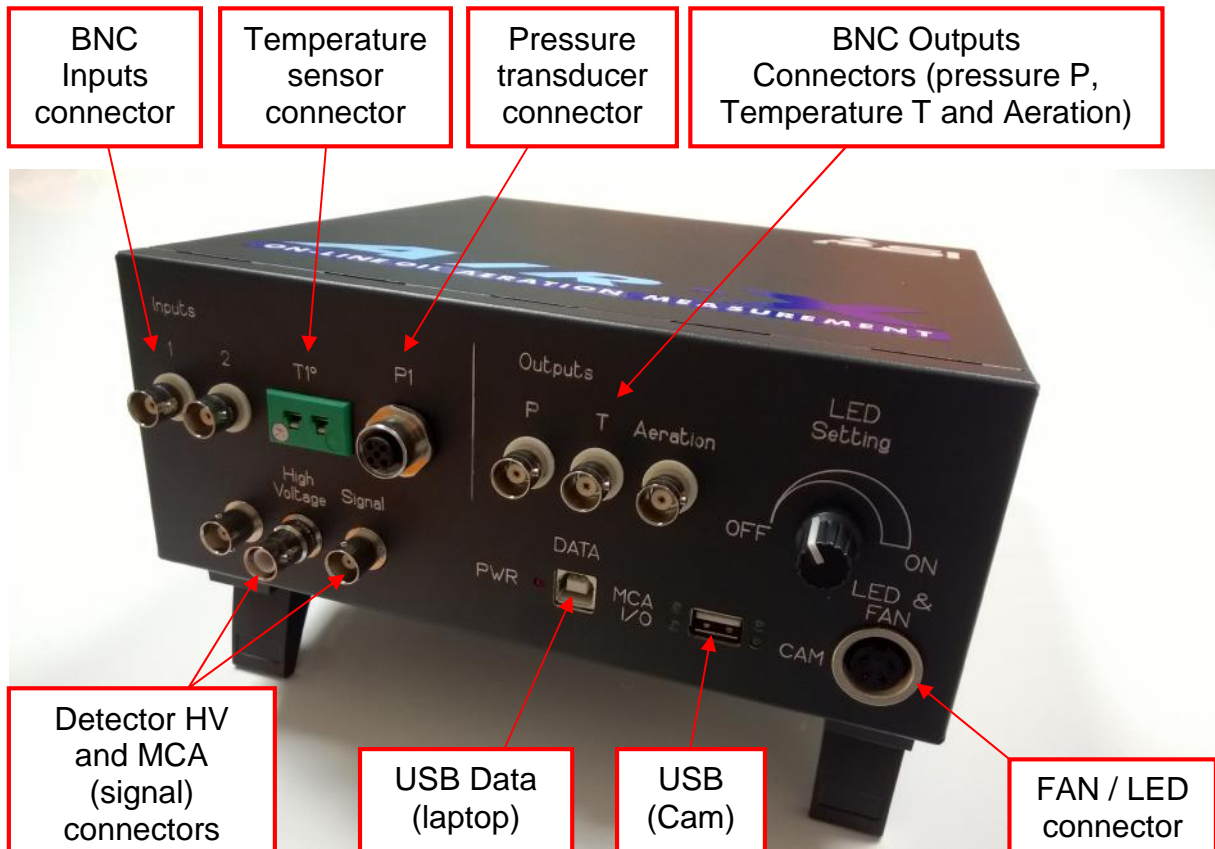
The electronic unit is connected to the laptop with USB.

View of an Air-X measurement unit:

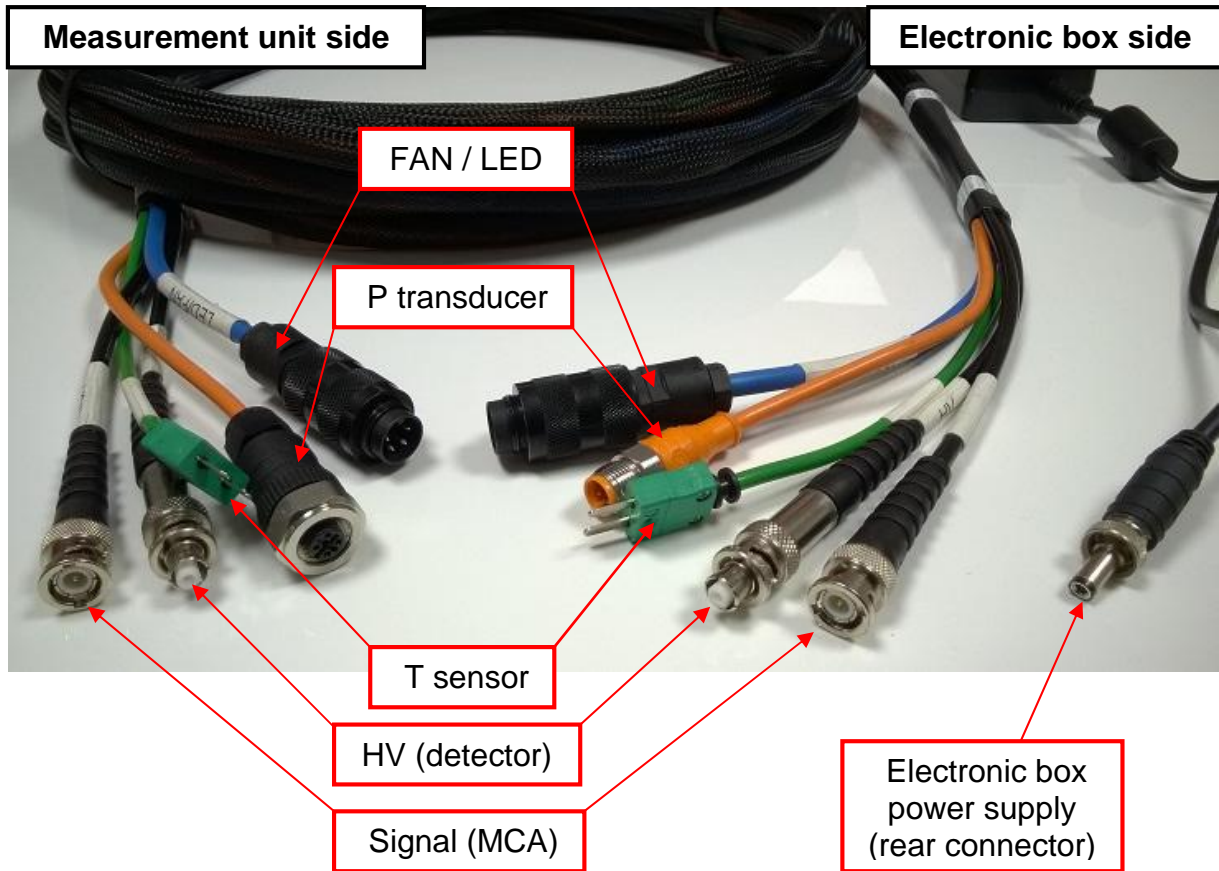




View of the electronic unit:



View of a set of cables:



The cams can also be connected with USB cables.

2. Air-X installation

1. Install the measurement unit close to the hydraulic system on which aeration has to be measured. The chamber must be installed as vertically as possible - with a minimum angle of 15° relative to the horizontal and in accordance with the oil circulation direction from bottom to top. Please avoid vibrations and heating sources (exhaust line for instance). The measurement unit can be fixed on any type of holder by using screws through the holes of the basis of the unit.
2. Connect the measurement unit and the hydraulic system with the hoses. Aeration rate can be measured everywhere in the lubrication circuit, at atmospheric pressure or in a pressurized place. In any situation:
 - The oil temperature in the measurement chamber must be quite close to the sampling place oil temperature in the hydraulic system (maximum temperature gap: 15°C) and the oil temperature must be stabilized during the measurement (maximum temperature variation: 2°C / minute).
 - The oil flow in the measurement chamber must be at least 2 liters / min.
 - The pressure in the measurement chamber must be quite close to the atmospheric pressure (+/- 0.3 bar, so between 0.7 and 1.3 bar absolute) in order to get reliable results, because of the reduced impact of the dissolved air.

If the measurement is performed in a pressurized place (for example, the oil gallery of an engine), a needle valve should be installed in the inlet line to the Air-X measurement unit in order to get the required temperature, flow and pressure into the Air-X chamber.

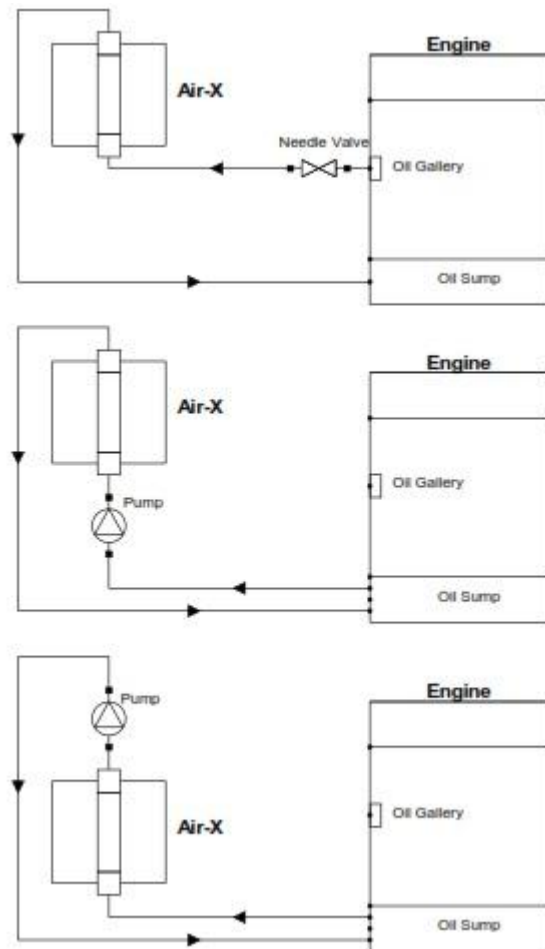


Needle valve for gallery measurement

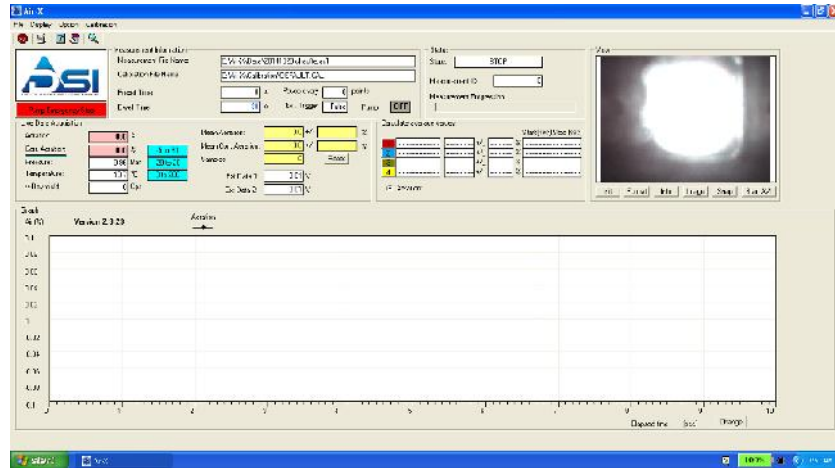
The length of the hoses between the hydraulic system and the Air-X measurement unit must be as low as possible in order to reduce the pressure and temperature drops, and the chosen diameters must be in accordance with the flow rates. However, between the needle valve (if installed) and the Air-X measurement chamber, we recommend a length of hose of 1 to 1.5 meter with 1/2 Inch diameter (minimum 1/4 Inch).

Examples of installations:

Pressurized oil (gallery) or oil at atmospheric pressure (sump)



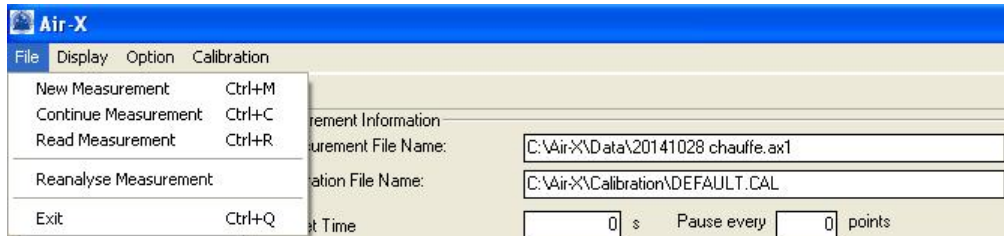
- Connect all the cables (according to the description and the cable references) between the electronic box and the measurement unit, the electronic box to the laptop (USB DATA connector), power supplies, and switch on the electronic box (rear power supply and switches) and the laptop.
It is advised to let the electronic warm up for 1 hour before starting any measurement (including calibrations). In this purpose, the electronic box can remain switched on during the nights.
- Start Air-X software (icon on the desktop):



3. Air-X use and software

The Air-X unit is fully controlled by the software and all the operations (except hoses connections) can be done from the test bench control room.

3.1. Aeration measurement (→ File)

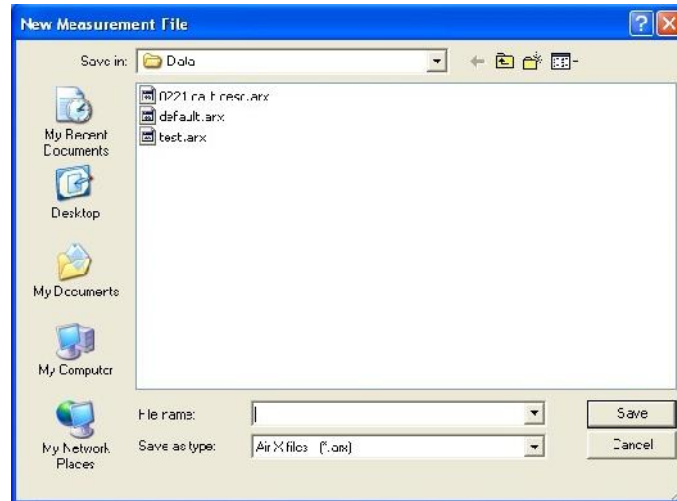


As already explained, the Air-X uses the X-rays transmission measurement principle: X-rays emitted from the source cross the measurement chamber and are caught by the detector. While crossing the lubricant, the X-rays flux is attenuated proportionally to the density of the lubricant. The presence of gases in the lubricant reduces its density and, via the calibrations, the volume of gas can be determined by measuring the X-rays flux.

X-rays emission is a statistical phenomenon implying that the precision of the measurement will depend on the number of events detected (i.e. X-rays); this means that longer the measurement acquisition is, higher the precision will be.

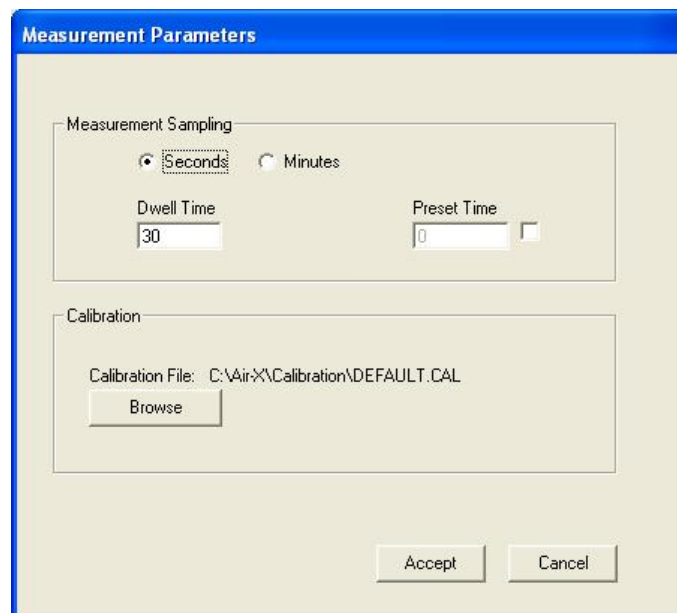
a) New measurement

To start a new measurement, click on “File” and select “New measurement”. A window will ask you a file name to save the data’s (the extension is .ax1) in “C:\Air-X\Data”




When done, a window will appear, asking for the measurement parameters:

- Dwell Time: It corresponds to the acquisition time for one measurement point, which cannot be less than 1 second. Typically, select 30 seconds.
- Preset Time: If selected, this sets the duration of the measurement for an automatic measurement stop after defined time. If not selected, the measurement can be stopped by clicking on “Stop” [●].
- The calibration file: It corresponds to the temperature calibration file of the tested lubricant (see in “Temperature calibration”).



By clicking on “Accept”, a window will ask you to check the parameters of the temperature calibration file and to check that your experiment is ready. By clicking on “Start”, the measurement will start. Make sure that the oil is well circulating.

The measurement can be stopped at any time by clicking on “Stop” [].

b) Continue a measurement

Every previously stopped measurement can be resumed by selecting “Continue measurement”. A window will ask which .ax1 file to resume. After having selected it, the operations are the same as for a new measurement.

c) Read a measurement

A previous measurement can be displayed again with this function, by selecting the corresponding .ax1 file.

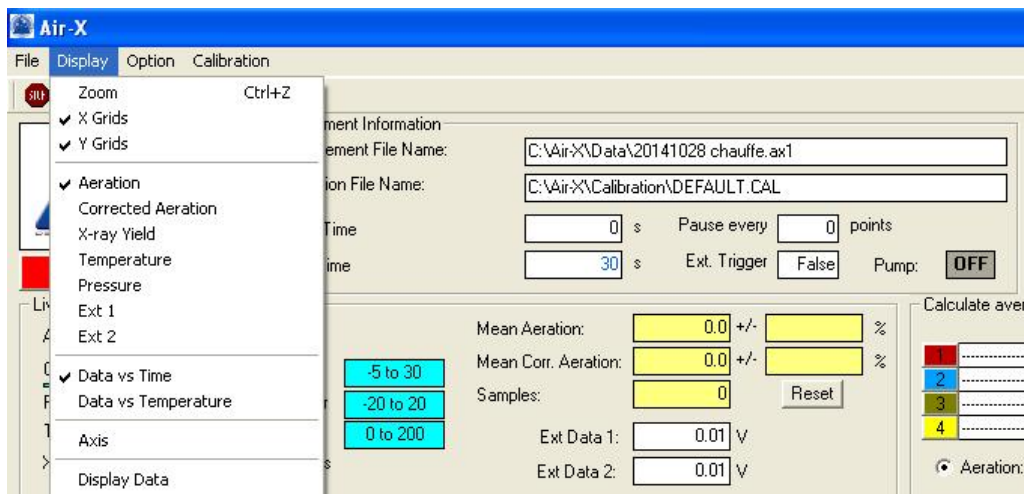
d) Reanalyze a measurement

This function allows to reanalyze a previous measurement with another temperature calibration file. Select the proper .ax1 file and the proper calibration .cal file. Then the software will automatically ask a new file name for the reanalyzed file and display it.

e) Exit

This function closes the software window.

3.2. Graphical functions (→ Display)



The Air-X software provides a graphical display of the parameters during and after a measurement.

Parameters display selection:

Five parameters can be displayed on the graph:

- Aeration
- corrected aeration (taking the pressure into account for “atmospheric” result)
- X-ray yield
- Temperature in the chamber
- Pressure in the chamber

And two user’s external analogic inputs:

- External Data 1 (IN 1 BNC connector)
- External Data 2 (IN 2 BNC connector)


The display of X-rays yield is not compatible with aeration (as it is only used for the temperature calibration).


X axis selection:

“Data vs time” or “Data vs temperature” can be selected.

“X-ray yield vs temperature” is only useful for the temperature calibration but has to be displayed to enable the temperature calibration function.

Zoom:

Click on the  icon or go in “Display” menu and select “Zoom” to be in zoom mode. To zoom in, left click on upper left corner of the area you want to zoom in and slide down to the lower right corner (a rectangle will be drawn). Once the area is selected, release the right click and the zoom of the area will be drawn.

To zoom out, click on the  icon or deselect “Zoom” in the “Display” menu.

Axis:

An auto-scale automatically adjusts the graphical window and the axis of the graph. However, by selecting “Axis” in the “Display” menu, you can access to manual settings of all the axes (aeration, yield, temperature, pressure)

Scaling	X axis	Aeration / RX Yield	Temperature	Pressure	Ext 1	Ext 2
Automatic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Manual	seconds					
Min	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Max	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

X axis legend

Elapsed Time
 Clock Time
 Measurement ID

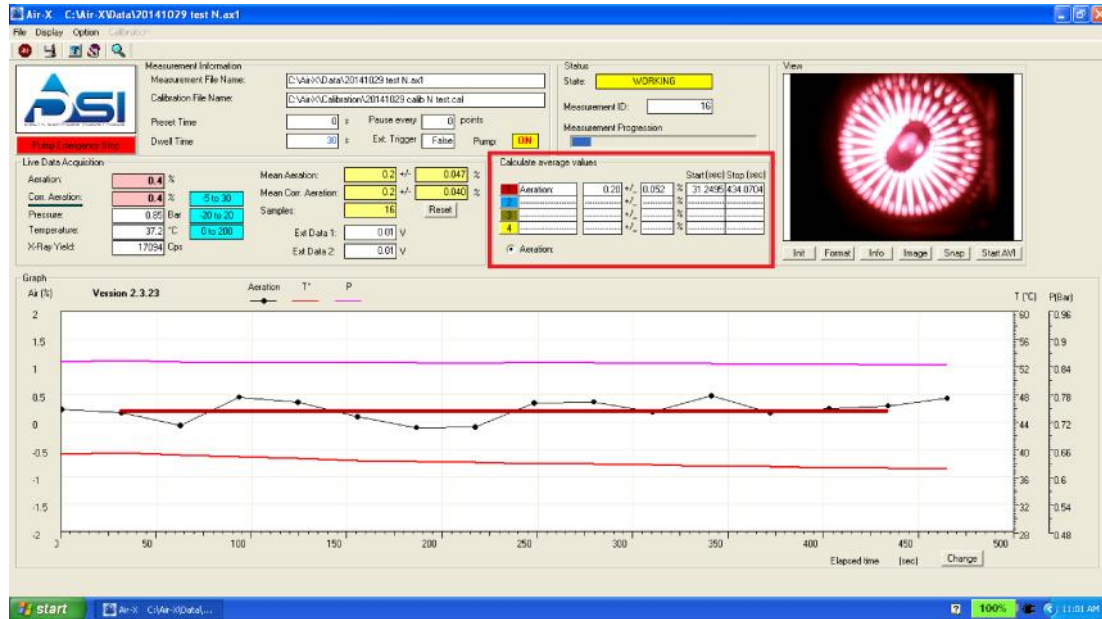
Accept Cancel

“Elapsed Time”, “Clock Time” or “Measurement ID” (measurement point numbers) can be selected for the X-axis.

Display Data:

This function displays a table in which all the measurement data's are gathered. This table can be exported with “Generate txt file” or “Generate csv file” (see in “Option”).

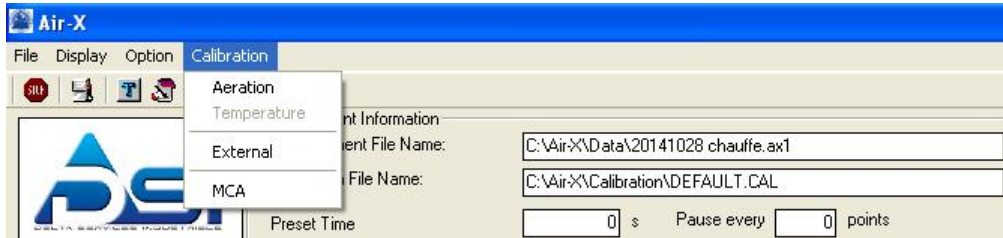
Calculation of the average results:



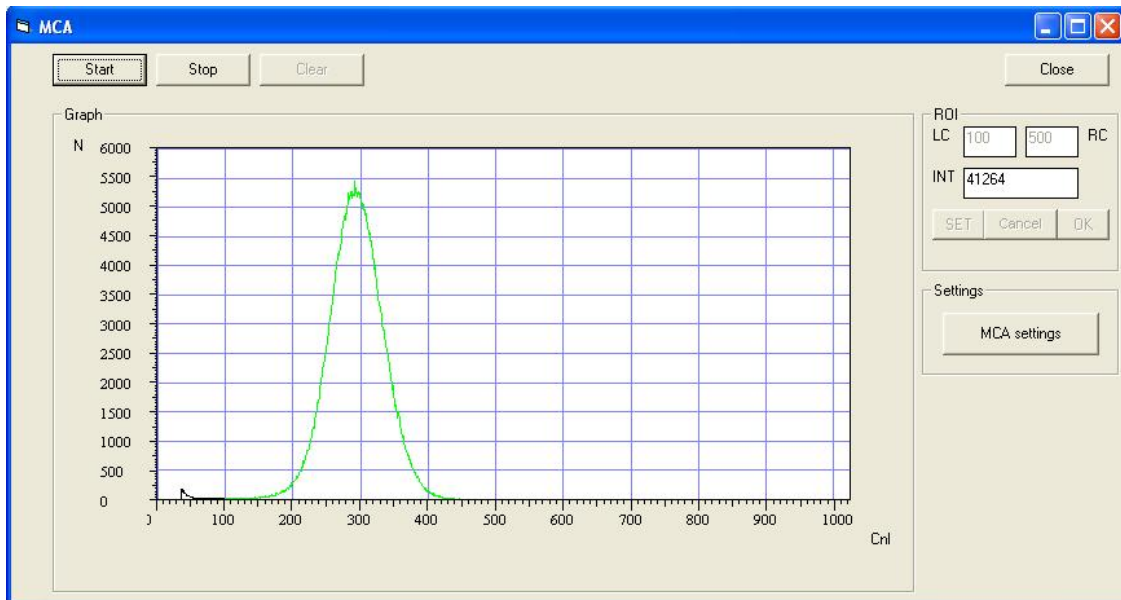
This function allows to calculate the average aeration (or corrected aeration) rate on a graphical area. Select a numbered colored square in “Calculate average values” (“ACTIVATED” will be displayed) and select then the desired area on the graphic by clicking on the extremities of the area. The calculated value and a straight line will be displayed. Click again on the numbered colored square to remove them.

3.3. MCA Calibration and spectrum adjustment (→ Calibration)

The source installed in the Air-X emits low energy X-rays and the spectrum can be graphically displayed. **The correct settings of the spectrum acquisition are necessary for the reliability of any measurement.**



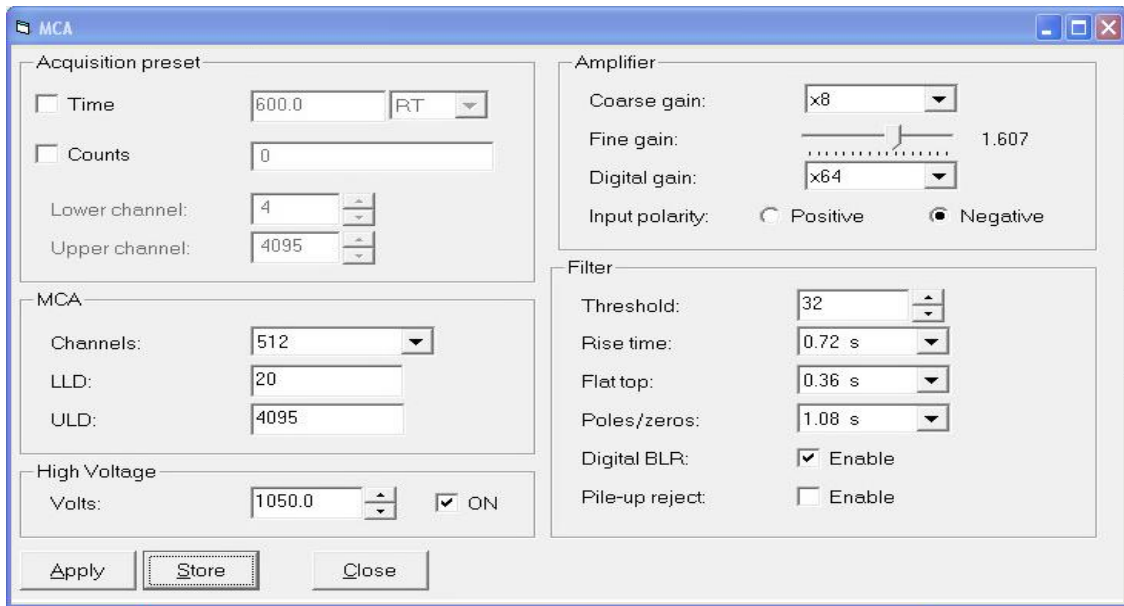
By clicking on “MCA” in the “Calibration” menu, a graphical window is showing the spectrum on-line. **The spectrum must be periodically checked and especially each time the Air-X has been moved from site to site.**



If an old spectrum is displayed in the window, click on “Clear” and then click on “Start” to start the acquisition and display a new current spectrum. The green area is the region of interest (ROI) where the yield of X-rays is counted. This ROI must surround the peak which is centered on channel 300. The left channel LC is typically set at 100 and the right channel RC at 500. If the peak is correctly positioned, as on the picture, click on “Stop” and then on “Close”.

The ROI LC and RC parameters can be changed once the acquisition is stopped by modifying the values and clicking on “SET” and on “OK” to save the changes.

By clicking on “MCA Settings”, a window appears with all the settings of the X-rays MCA and the amplifier.



Those settings are factory settings and should normally not be changed by the user.

A 0% and 100% aeration calibration have to be redone after this operation.

3.4. Calibrations: 100% Air and temperature calibrations (→ Calibration)

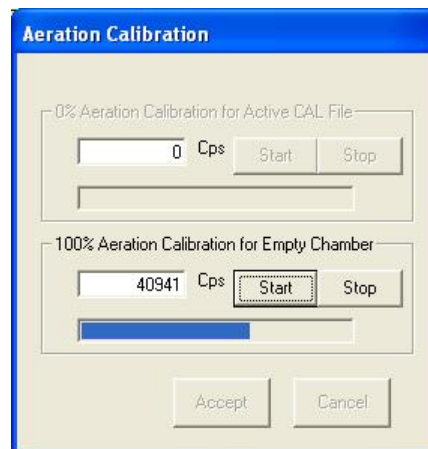
Two aerated states of lubricant must be known - 0% and 100% - in order to define the relationship between the intensity of the signal (count rate) and the aeration rate.

100% air calibration procedure:

To perform a 100% aeration measurement:

- Empty the Air-X chamber. The presence of oil in the chamber can be checked through the cam window.
- Click on “Calibration” menu and select “Aeration”.
- Click on “Start” in the “100% aeration calibration for empty chamber” frame and let the software perform the count rate acquisition.
- Once the measurement is completed, click on “Accept” to save the calibration.

We recommend to perform this calibration every six months (the program takes the decay of the source into account). The calibration must be redone in case of modification of the geometry of the detection system (modification of the position of the detector for instance).



The 100% calibration value can easily be checked when the chamber is empty, by starting a measurement and checking the aeration value: 100% +/- 1%. If this is not the case, a new 100% calibration must be performed.

Temperature calibration:

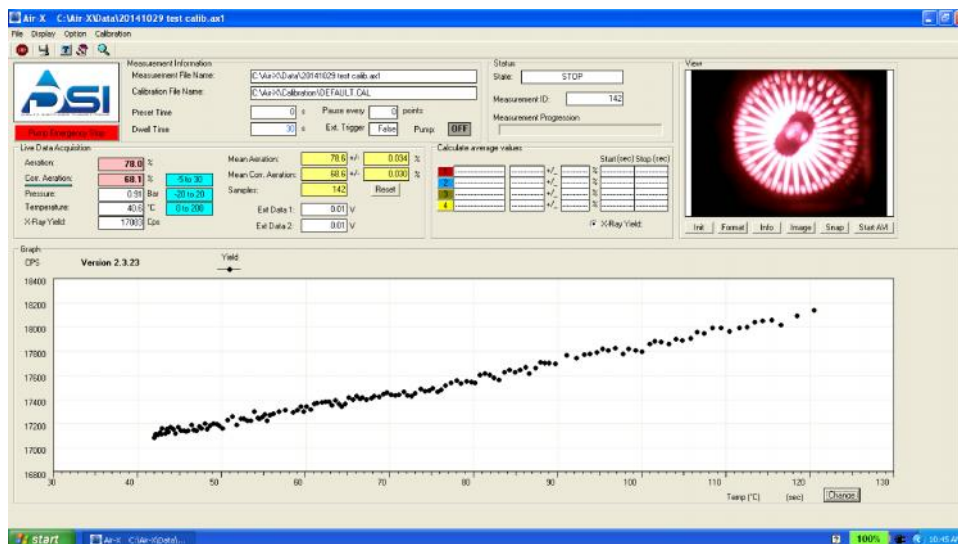
The purpose of the temperature calibration is to **define the 0% Air on the complete range of oil temperature expected for the measurement.**

It must be performed with oil in circulation and in non-aerated conditions.

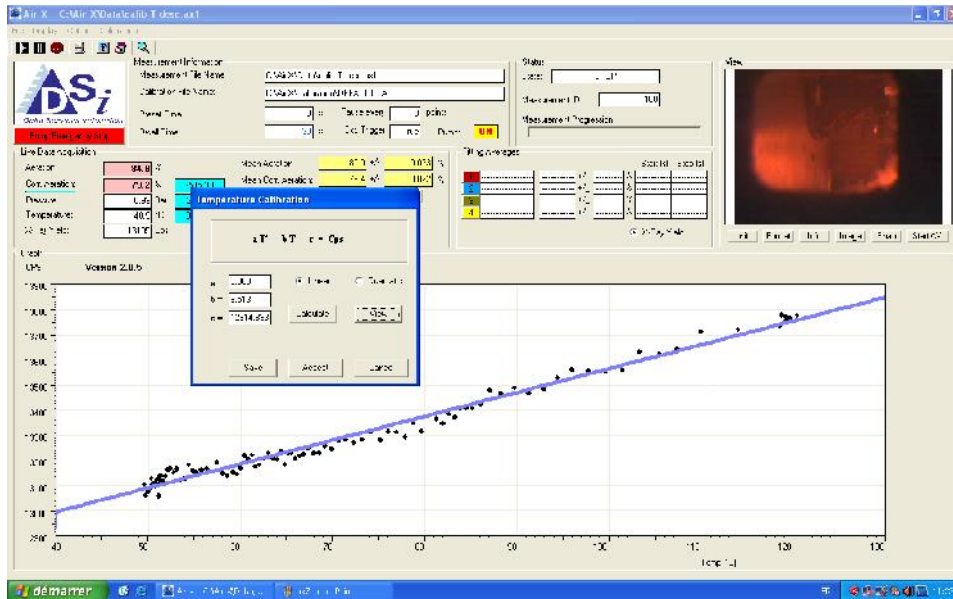
A calibration has to be performed only once for each type of lubricant and can be reused afterwards for this same lubricant.

Temperature calibration has to be performed once for a type of lubricant:

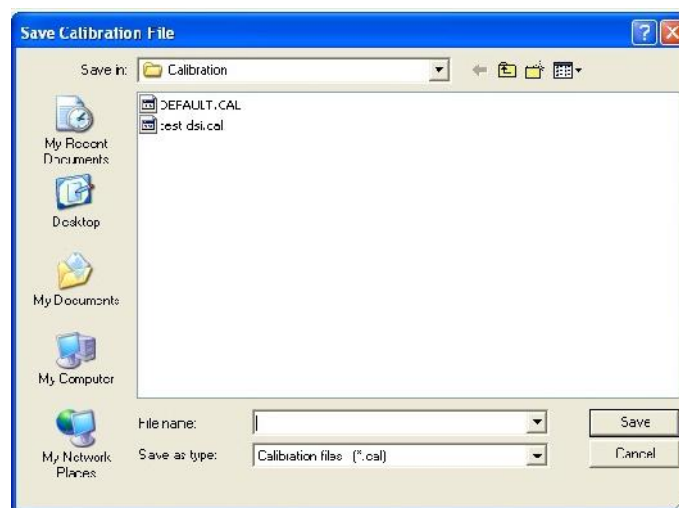
- Use an external heater (tank - minimum five liters of capacity) and a pump in order to make circulate the oil in the Air-X chamber.
- Run the pump at a flow rate of 1 lit/min minimum and make sure that the oil circulates well in the chamber (without aeration)
- Heat the oil in the heater up to the maximum test temperature (150°C max).
- Start a new measurement with dwell time 30 seconds and – after 2 minutes - stop the heater to let the oil cool down by itself during the measurement.
- Once the oil temperature has reached 50 to 40°C, stop the measurement.
- In the “Display” menu, **select “X-ray Yield” and “Data vs Temperature”**, the X-ray yield vs temperature will display an increasing straight line.



- In the “Calibration” menu, select “Temperature”. A window will appear, describing briefly the procedure, click “Ok”. Then, on the calibration window, you can see the temperature vs yield equation (1st degree linear law) and the value of the current coefficients in the text boxes.



- Click on “Calculate” to calculate the new coefficients (you can click on “View” to see the behavior of the straight line on the graph). Then, click on “Save”, a new window will ask to save the calibration file in “C: \Air-X\Calibration”.



- Click “Save” when done and “Accept” if you want to use this calibration for your next measurement.

After this operation, the temperature calibration is done for the current lubricant.

0% air calibration procedure:

The 0% calibration is automatically performed during the temperature calibration. However, if an offset appears at 0% oil aeration – because of oil aging for instance – it is possible to recalibrate the zero.

The procedure is the same as the 100% air calibration but using “0% aeration calibration”.

The oil circulating in the chamber must not be aerated and its temperature must be stabilized during the calibration.

Be careful: this action will modify the values of the current temperature calibration file (.cal). It is recommended to make a copy of the calibration file before any recalibration.



3.5. Calibrations of the inputs and outputs (→ Calibration)

By selecting “External” in the “Calibration” menu, the configuration window appears:

External inputs

Two external analog signals from the user (0 to 10V) – which must be connected to the proper Analogue BNC Input - can be on-line displayed on the graph (speed and load for instance). The unit (rpm or Nm for instance) must be written in “Units” - the ratio Units / Volt in “Slope” and a offset (if necessary) in “Intercept”.

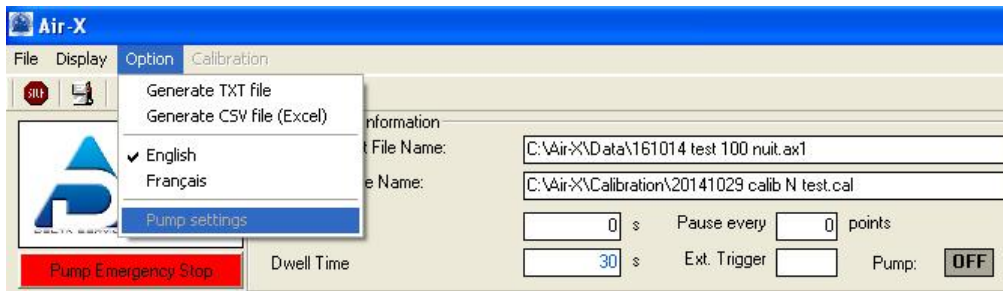
External outputs

The values of Aeration (or Corrected Aeration), temperature and pressure can be sent to another user’s external computer as an output voltage (Analogue BNC Output). The minimum and the maximum expected values must first be defined and, when done, the output can be tested by selecting four different values so that the acquisition on the external computer can be calibrated.

Some other safety settings are also available.

Click on “Confirm” and “Ok” when done.

3.6. Options menu (→ Option)



Generate TXT or CSV files:

Those options generate the current displayed measurement file (.ax1) in .txt [📄] format or in .csv [📊] format. This file is stored in “C:\Air-X\Data” and can be copied on an USB key.

Language:

The “English” or “Français” allows the user to select the language.

Pump Settings:

No pump installed on this version

4. Troubleshooting - Solutions

Troubleshooting	Solutions
Error message “MCA board not found, only off-line functions will be available”	Check the unit power supply and the USB connection, then exit and restart the software
Error message “I/O board not found”	Check I/O board parameters by running InstaCal (Measurement computing). Select “Refresh board”, right click on the board and select “configure”, then select “8 single ended”

The Air-X software installation procedure is available on the laptop