

FireSting[®]-GO₂

Pocket Oxygen Meter

USER MANUAL

O₂



FireSting®-GO2

Pocket Oxygen Meter

Document Version 1.26

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1 INTRODUCTION

The **FireSting®-GO2** is a hand-held fiber-optic oxygen meter based on the established **FireSting®** technology featuring:

- broad oxygen sensor portfolio (micro- and minisensors, robust probes, sensor spots, flow-through cells, respiration vials)
- sensors for the full and the trace oxygen range
- measurements in water as well as in the gas phase
- automatic temperature and pressure compensation
- proven **REDFLASH** technology

with **New Features**

- integrated high contrast LCD display
- integrated rechargeable battery and memory
- extremely low power consumption for long-term logging

and **Operation Modes**

- stand-alone via intuitive LCD user interface
- with Windows PC via USB



The new pocket meter **FireSting®-GO2** completes the portfolio of different fiber-optic oxygen meters from **PyroScience**, comprising PC-operated 1-, 2- or 4-channel **FireSting®-O2** meters with a broad oxygen sensor portfolio and the 1-channel **Pico-O2** meter for advanced applications of contactless sensors, e.g. in microfluidics. The **FireSting®-GO2** has integrated memory and battery and combines the established **FireSting®-GO2** technology with stand-alone operation and the ability of long-term logging for >1 year. With this flexibility, oxygen measurements can be performed independent of a PC at different locations using the broad range of fiber-optic oxygen sensors from **PyroScience**.

The **FireSting®-GO2** impresses by its compactness, functionality and extremely low power consumption allowing for long-term logging without the need of recharging. The handling of the **FireSting®-GO2** is intuitive and all information concerning the connected and internal sensors, measurement and logging parameters are displayed on a high contrast LCD display.

More information concerning our product portfolio can be found on our website at <https://www.pyroscience.com/> or contact us under info@pyroscience.com.

Your **PyroScience** Team



2 SAFETY GUIDELINES

The **FireSting®-GO2** is a laboratory instrument to be used with fiber-optic oxygen sensors (optodes) from **PyroScience**. In order to guarantee an optimal performance of the **FireSting®-GO2**, please follow these operation instructions and safety guidelines.

If any problems or damage evolve, please turn the instrument off and disconnect it immediately. Mark this **FireSting®-GO2** to prevent any further use and consult **PyroScience** for repair or maintenance service. The **FireSting®-GO2** should not be manipulated or opened by unauthorized persons, only by **PyroScience** or persons advised directly from **PyroScience**.

Please note that opening the housing will void the warranty. There are no serviceable parts inside the device.

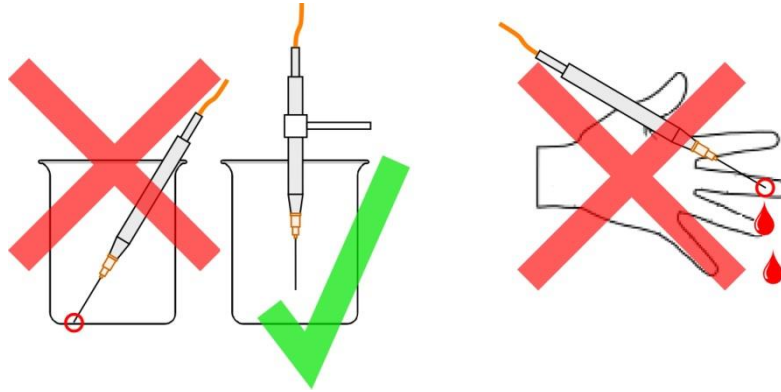
The **FireSting®-GO2** meter and the sensors should be kept and stored outside the reach of children in a secure place under dry and clean conditions at room temperature, avoiding moisture, dust, corrosive conditions and heating of the instrument. This device and the sensors are not intended for medical, military or other safety relevant areas. They must not be used for applications in humans; not for in vivo examination on humans, not for human-diagnostic or therapeutic purposes. The sensors must not be brought in direct contact with foods intended for consumption by humans.

The **FireSting®-GO2** has an integrated lithium-ion battery, so please follow the general safety instructions for their use. The **FireSting®-GO2** is not water-proof and should be used by qualified personal only, following the operation instructions and safety guidelines of this manual. Please follow the appropriate laws and guidelines for safety like EEC directives for protective labor legislation, national protective labor legislation, safety regulations for accident prevention and safety data-sheets from manufacturers of chemicals used during measurements.

Calibration and application of the sensors, data acquisition, data processing and data publication is on the user's authority.

When used in the field, the environmental conditions (like high humidity, dust, exposure to direct solar radiation) may cause damage or interference of the **FireSting®-GO2**, which is on the user's authority.

Before using the oxygen meter **FireSting®-GO2** and its sensors, read carefully the available instructions and user manuals.



In case of problems or damage, turn the instrument off, disconnect and mark it to prevent any further use! Consult **PyroScience** for advice! There are no serviceable parts inside the device. Opening the housing will void the warranty!

The **FireSting®-GO2** is not water-proof, is sensitive to corrosive conditions and to changes in temperature causing condensation. Avoid any condition (e.g. direct sun light) causing a heating of the device above 50°C (122°F) or below 0°C (32°F). Avoid elevated humidity causing condensing conditions. Please follow the safety instructions for integrated lithium-ion batteries.

Handle the sensors with care especially after removal of the protective cap! Prevent mechanical stress to the fragile sensing tip and injuries with needle-type sensors! Avoid strong bending of the fiber cable!

Calibration and application of the sensors, data acquisition, treatment and publication is on the user's authority!

The sensors and the oxygen meter **FireSting®-GO2** are not intended for medical, diagnostic, therapeutic, or military purposes or any other safety-critical applications. The sensors must not be used for applications in humans and must not be brought in direct contact with foods intended for consumption by humans.

The **FireSting®-GO2** and sensors should be used in the laboratory by qualified personnel only, following the user instructions and the safety guidelines of the manual, as well as the appropriate laws and guidelines for safety in the laboratory!

Keep the sensors and the oxygen meter **FireSting®-GO2** out of reach of children!

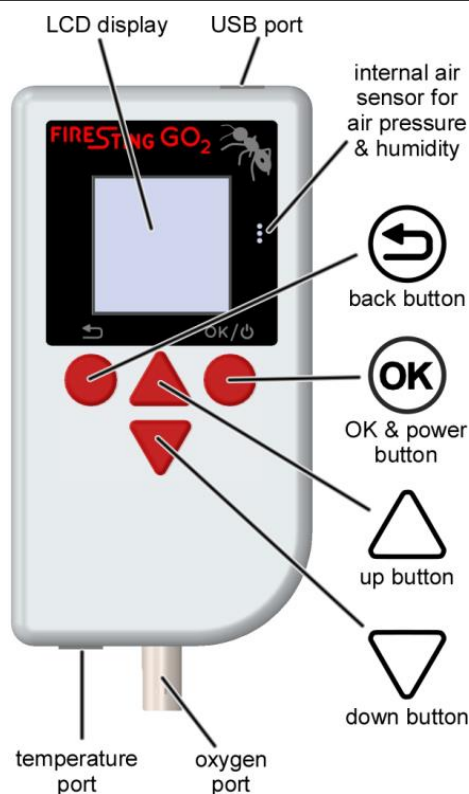
3 OVERVIEW FIRESTING®-GO2

This chapter provides an overview about the principle components and general operation procedures of the pocket oxygen meter **FireSting®-GO2**.

3.1 Ports and Integrated Sensors

The **FireSting®-GO2** has three ports and one integrated sensor:

- **micro-USB port** for charging and communication
- **oxygen port** for connecting a fiber-optic oxygen sensor
- **temperature port** for connecting a temperature sensor
- **internal air sensor** for pressure and relative humidity



3.1.1 Micro-USB Port

The micro-USB port is used for recharging the integrated battery of the **FireSting®-GO2** (see below), as well as for data communication with a PC in combination with the software "**FireSting®-GO2 Manager**". This software is especially needed for downloading and inspecting logged data files from the **FireSting®-GO2** device.

3.1.2 Oxygen Port

Fiber-optic oxygen sensors from **PyroScience** with ST-connectors are connected to the oxygen port. Please refer to the website of **PyroScience** concerning the broad range of available oxygen sensor types. Remove the protective caps from the oxygen port as well as from the ST-connector of the oxygen sensor. Then, insert the ST-connector into the oxygen port and turn the bayonet coupling gently clockwise until the plug is locked firmly.

3.1.3 Temperature Port

Temperature sensors (4-wire Pt100-sensors with LEMO connectors) are connected to the temperature port by simply pushing the connector into the port. Please refer to the website of **PyroScience** concerning available temperature sensors.

The temperature sensor can be used for automatic temperature compensation of the oxygen measurement.

3.1.4 Internal Air Sensor

The internal air sensor measures the pressure and the relative humidity of the ambient air. It is located behind the three little air inlets located next to the right side of the display. These sensors are needed for a precise determination of the actual oxygen level, if the oxygen sensor is calibrated in ambient air. The pressure sensor is additionally used for automatic pressure compensation of the oxygen measurement.

Keep the three little air inlets of the air sensor clean and dry in order to assure a proper operation of this sensor. Do not cover these air holes during the measurements.

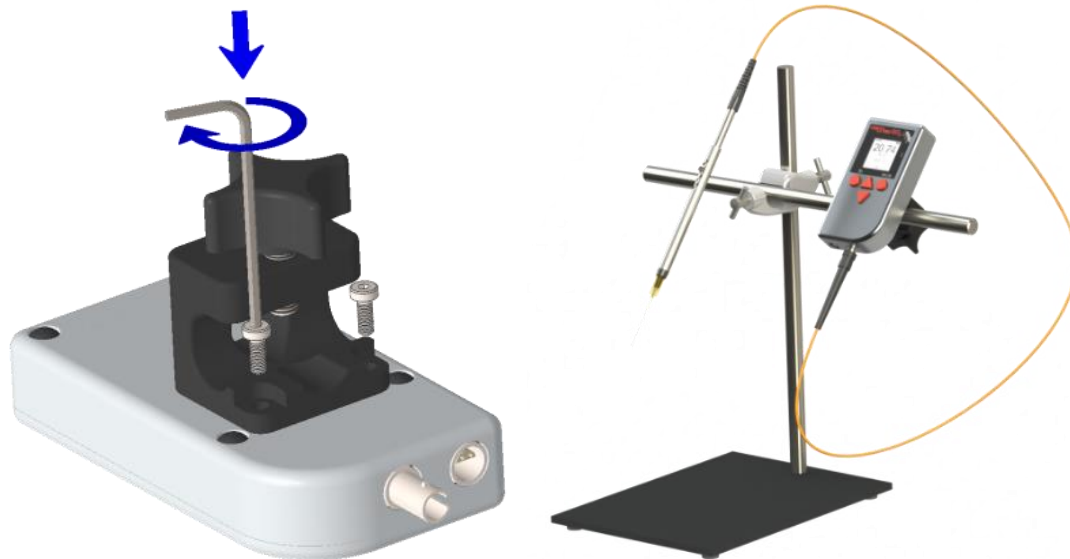
3.1.5 Connector X1 (Power, Digital Interface, Analog In)

The **FireSting®-GO2** is switched on and off by pressing the right button for ca. 1 second (OK button). Note, that the device cannot be switched off, while the device is logging data or while it is in the PC mode (see below).

If the device does not switch on by pressing the OK button, the integrated battery needs to be recharged. For this, connect the USB port of the **FireSting®-GO2** to any standard micro-USB charger or to any available computer USB port (with the included USB cable). Typically, the battery is fully recharged within ca. 2 hours.

3.2 Stand clamp

The **FireSting®-GO2** can be optionally mounted on common lab stands with the included stand clamp. For this, remove the red silicone shell from the device and mount the stand clamp as shown in the image.



3.3 User Interface

The user interface of the **FireSting®-GO2** consists of the display and four buttons. The high-contrast display features ultra-low power consumption. Therefore, it is permanently activated without significantly reducing the run-time of the rechargeable battery. The four buttons allow for an intuitive stand-alone operation of the **FireSting®-GO2**.

- Ⓞ **OK Button:** If pressed for 1 second, the device is switched on or off. If pressed shortly, then this button is generally used for selecting an item or for confirming a setting. Alternatively, the lower right corner of the display might show a context specific function, e.g., MENU, START, NEXT, or SAMPLE.
- ↶ **Back Button:** This button is generally used for "going back" e.g., in menus, or for cancelling an operation. Alternatively, the lower left corner of the display might show a context specific function, e.g., CANCEL, BACK, or STOP. If pressed for 10 seconds, a hardware reset of the device can be performed.
- ▲
▼ **Up and Down Buttons:** The context specific functionality of these buttons is always indicated by small black triangles (▲ or ▼) in the display. They are generally used for

selecting items from menus or dialog screens, but also for adjusting numerical values e.g. when adjusting the **Sensor Code** or a temperature value in the settings.

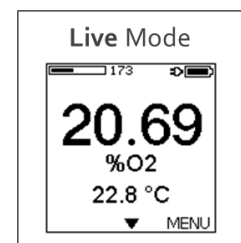
Depending on the operation mode, there might be several „sub-screens” available, which is indicated by small black triangles (▲ or ▼) appearing in the upper or lower line of the display. By pressing the up or down buttons, the screen content will scroll up or down, revealing the other sub-screens.

3.4 Operation Modes

The user interface of the **FireSting®-GO2** meter comprises five different operation modes: Live Mode, Menu Mode, Logging Mode, Standby Mode, and PC Mode.

3.4.1 Live Mode

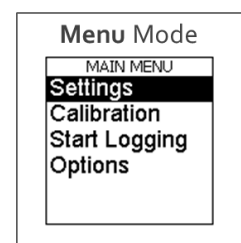
After switching on the **FireSting®-GO2**, the device starts in the Live Mode. Here the device performs a measurement every 2 seconds and shows the results in altogether four sub-screens. The data are not logged in this mode. For more details on the Live mode refer to chapter 3.4.1.



3.4.2 Menu Mode

The Menu Mode can be opened in the Live Mode by pressing the OK button. The menu is used for:

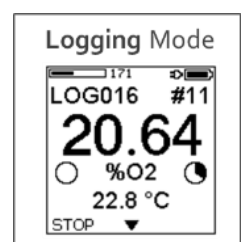
- adjusting the settings
- performing sensor calibration
- starting data logging
- accessing diverse options



After exiting the menu mode with the BACK button, the device reverts to the Live Mode. For details on the menu mode refer to chapter 3.4.2.

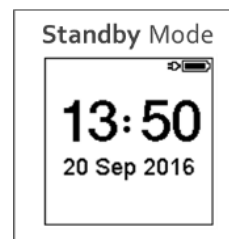
3.4.3 Logging Mode

The Logging Mode is started by selecting "Start Logging" in the main menu and pressing the OK button. In the logging mode the measured data points (sensor readings) are saved in a log file within the internal data memory of the device. Altogether six sub-screens provide the user with detailed information about the progress of the data logging. If the Logging Mode is terminated, the device will revert to the Live Mode. For more details on the logging mode refer to chapter 3.4.3.



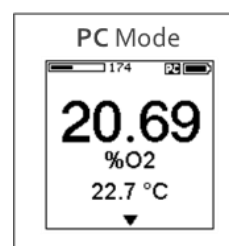
3.4.4 Standby Mode

The device automatically enters the Standby Mode, if the user did not press any button within 5 minutes in the Live Mode. Here the measurements are stopped to prolong the lifetime of the connected oxygen sensor. For details on the Standby Mode refer to chapter 3.4.4.



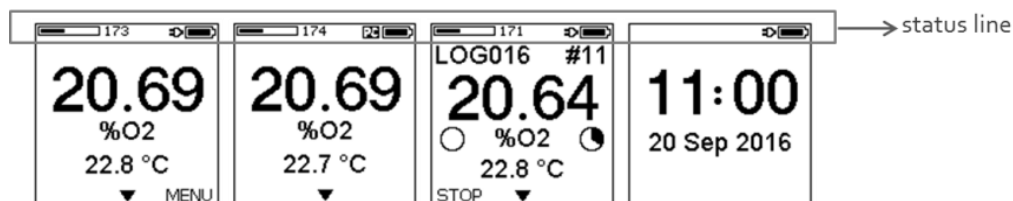
3.4.5 PC Mode

If the device is connected to a PC with the included USB cable and the software **FireSting®-GO2** Manager is started, the device enters the PC Mode. This is indicated by the "PC" symbol in the upper right corner of the display. Here the Menu Mode is not accessible, only the sub-screens are accessible with the UP and DOWN buttons. For more details on the PC mode refer to chapter 3.4.5.



3.5 Status Line

In all modes except for the Menu Mode, the status line is shown in the upper line of the display.



The battery symbol indicates the actual charge level of the internal battery. The plug symbol indicates that an external power supply is connected to the USB port. An arrow symbol between the plug and the battery symbol indicates that charging is in progress. And the PC symbol indicates that the device is in the PC Mode after the **FireSting®-GO2** Manager software has been started on an external computer (connected via the USB port).

In the Live, PC or Logging Mode, an additional bar graph and a numerical value show the so-called "signal intensity". It provides important information on the actual condition and remaining lifetime of the connected oxygen sensor.

Potential warnings (**Low Signal, No Signal, Too High, Bad Ref**) regarding problems with the oxygen sensor signal are displayed at the position of the bar graph. For more details about trouble shooting these warnings refer to chapter 11.

Do not continue with measurements if a warning is shown!

4 QUICK START

4.1 Getting Started

Connect the oxygen sensor and optionally the temperature sensor to the corresponding ports of the **FireSting®-GO2** (chapter 3.1). Start the **FireSting®-GO2** meter by pressing the OK button for about 1 sec. Check the battery charge level of the device in the status line and recharge the battery if necessary. Select MENU with the OK button and first **Adjust** the local **Time and Date** in the **Options Menu** (chapter 6.4.1)

4.2 Settings and Options Adjustments

For details refer to chapter 6.2.

Open the **Settings Menu**, enter the **Sensor Code** of the connected oxygen sensor, select the sample **Medium** and choose your preferred **Oxygen Units**. Adjust the sample **Temperature** used for the temperature compensation of the oxygen measurements (**Sensor or Fixed**). If applicable, adjust the sample **Salinity**.

4.3 Sensor Calibration

For details refer to chapter 6.3.

Open the **Calibration Menu** in the main menu and review if the correct **Sensor Code** was adjusted. Prepare appropriate air and 0% calibration standards. Open **Calibrate Air** and select the type of temperature compensation used during the calibration: **Sensor** for automatic temperature compensation with the connected temperature sensor or **Fixed** with a defined and constant calibration temperature (needs to be measured and controlled). Then select the appropriate calibration medium equivalent to the sample under investigation: **Ambient Air** for gas measurements and **Air Saturated Water** for measurements in aqueous samples. Insert the oxygen and temperature sensor into the air calibration standard, wait for steady state and press SET AIR.

After a successful air calibration, open **Calibrate 0%**, select the type of temperature compensation used during the calibration (**Sensor or Fixed**, see above), insert the oxygen and temperature sensor into the 0% calibration standard, wait for steady state and press SET 0%.

4.4 Live Measurements

Exit the menu by pressing the BACK button. Measurements are performed now in the Live Mode every 2 seconds. Access the different sub-screens with the UP and DOWN buttons, showing the measurement results. Note, that the data are NOT logged in the Live Mode.

4.5 Data logging

For details refer to chapter 7.

Open **Start Logging** in the Main Menu. Choose the appropriate mode: **Manual** for manual logging, i.e. data points are logged each time the OK button (SAMPLE) is pressed; **Continuous** for automatized logging with adjustable **Logging Interval** and **Logging Duration**. The logged data are displayed numerically and graphically on several sub-screens. If the data logging is finished, EXIT the Logging Mode with the BACK button.

4.6 Data management and inspection

For details refer to chapter 10.4.

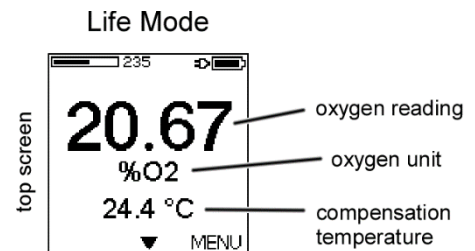
Download and install the **FireSting®-GO2** Manager software from the **PyroScience** website to a Windows PC. Connect the **FireSting®-GO2** device with the included USB cable, and start the software. Go to the **File** tab, select a log file and click on **Download & Inspect**. This will download the log file from the device to the PC, and show the logged data in the **Log Inspector** window.

5 LIVE MODE

After power-up or after activation from standby the **FireSting®-GO2** is in the Live Mode. Measurements are performed every 2 seconds. The different sub-screens can be accessed with the UP and DOWN buttons. Note, that the data are NOT logged in the Live Mode.

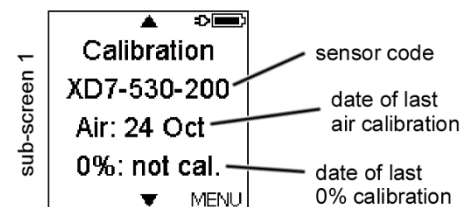
5.1 Top Screen

Here, the current reading of the connected oxygen sensor and the selected oxygen unit (see chapter 6.2.3) is shown, as well as the compensation temperature (sensor or fixed, see chapter 6.2.4).



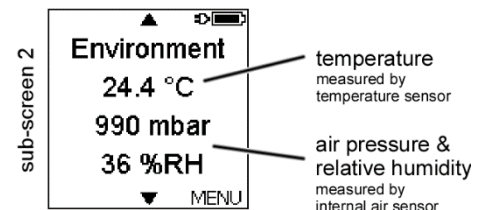
5.2 Sub-screen 1

Here the **Sensor Code** and the dates of the last **Calibrations** are shown (see chapter 6.3).



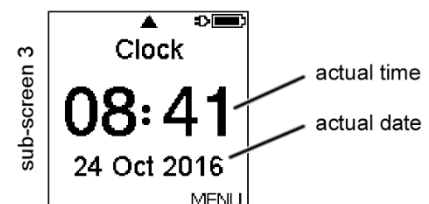
5.3 Sub-screen 2

This sub-screen shows details on the **Environment**, including the readings of the temperature sensor (if connected) and of the internal air sensor, including the air pressure (mbar) and relative humidity (%RH) (see chapter Fehler! Verweisquelle k onnte nicht gefunden werden.).



5.4 Sub-screen 3

This sub-screen shows the Clock with the actual time and date. Refer to chapter 6.4.1 how to set the clock.



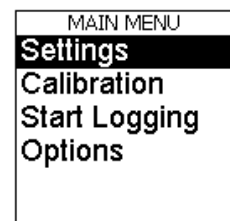
6 MENU MODE

6.1 Main Menu

The menu is entered by pressing the OK button in the Live Mode, opening the main menu.

The main menu has four entries:

- **Settings:** opens the Settings Menu (chapter 6.2)
- **Calibration:** opens the Calibration Menu (chapter 6.3)
- **Start Logging:** starts data logging (chapter Fehler! Verweisquelle konnte nicht gefunden werden.)
- **Options:** opens the Options Menu (chapter 6.4)

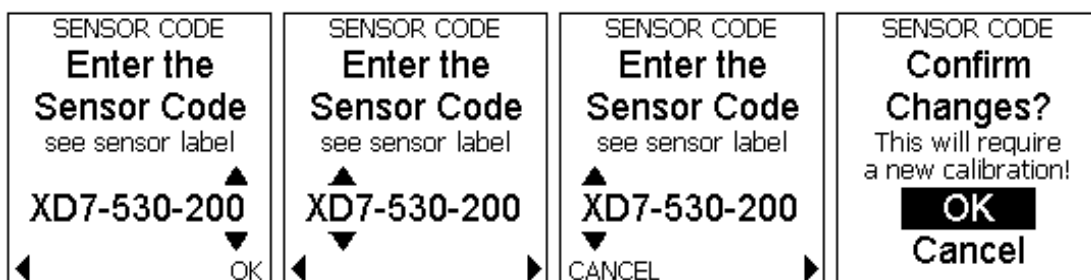
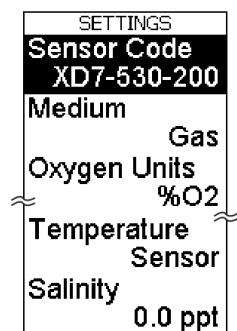


6.2 Settings Menu

The following settings have to be adjusted in the Settings Menu.

6.2.1 Sensor Code

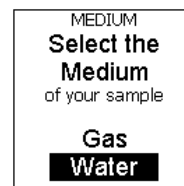
The **Sensor Code** written on the label attached to the sensor or on the stickers/bags of contactless sensors must be entered every time a new oxygen sensor is connected. Enter this **Sensor Code** by moving the cursor with the BACK and OK buttons, and by adjusting each letter/number with the UP and DOWN buttons. Press OK after the last number of the **Sensor Code** has been adjusted. Confirm the changes by pressing OK once more.



Changing the **Sensor Code** will discard the last calibration!

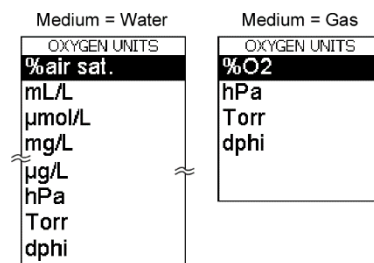
6.2.2 Medium

Adjust here the medium **Gas or Water** of your sample.



6.2.3 Oxygen Units

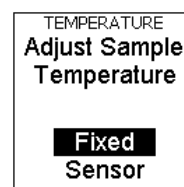
Select here your preferred oxygen unit. Note, that the available oxygen units depend on the chosen medium.



6.2.4 Temperature

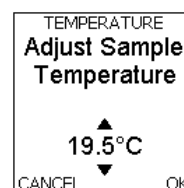
Here the temperature of the sample has to be adjusted. This is important in order to assure a correct temperature compensation of the oxygen measurement.

Select **Sensor** for enabling automatic temperature compensation based on temperature measurements of the connected Pt100 temperature sensor (chapter 4.2).



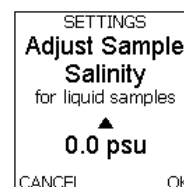
In order to ensure proper automatic temperature compensation, position the temperature sensor in the sample, so that it measures the same temperature as given around the oxygen sensor tip.

If your sample is kept at a constant temperature, then the automatic temperature compensation can be deactivated by selecting **Fixed**. Now you must enter the fixed temperature of your sample used for the temperature compensation of the oxygen measurement.



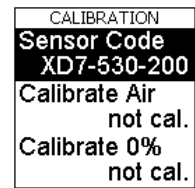
6.2.5 Salinity

The salinity of the sample only has to be adjusted for measurements in saline samples (e.g., seawater) using an oxygen concentration unit, like µmol/L or mg/L.



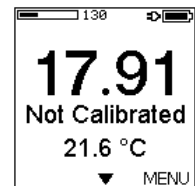
6.3 Calibration Menu

After adjusting the sensor **Settings** (see chapter 6.2) and the local date and time in the **Options** menu (see **Adjust Time** and **Date** in chapter 6.4.1), the connected oxygen sensor needs to be calibrated before the measurements. Note, that the top screen of the Live Mode shows the warning **Not Calibrated** after a new **Sensor Code** has been entered. The calibration is performed in the **Calibration** menu.



The oxygen sensor can be calibrated at two calibration points:

- (1) at ambient air or in air saturated water (**Calibrate Air**), and
- (2) at 0%O₂, i.e. anoxic conditions (**Calibrate 0%**). For highest precision it is recommended to calibrate both calibration points. However, if the expected measuring range is close to one of the calibration points, then a 1-point calibration might be sufficient. For example, if the expected measuring range in a liquid sample is 90-100% air sat., then a 1-point calibration at air saturated water is for many applications sufficient. In this case the 0% calibration is taken from the factory calibration encoded in the **Sensor Code**.



It is recommended to perform the calibration at conditions close to the environmental conditions during the measurements, especially regarding the temperature.

6.3.1 Sensor Code

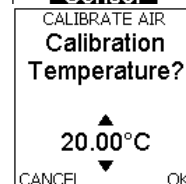
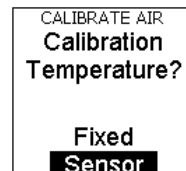
For security the **Calibration menu** repeats the **Sensor Code** entry, which is in fact identical to the **Sensor Code** entry given in the **Settings** menu (chapter 6.2.1).

Before starting the calibration, double check that the correct **Sensor Code** has been entered, as written on the label attached to the sensor cable or on the bag/stickers of the sensor.

6.3.2 Air Calibration

Select **Calibrate Air** for starting an air calibration. Then choose the type of temperature compensation during the calibration:

- a) For automatic temperature compensation of the **Calibration Temperature** with the temperature sensor connected to the **FireSting®-GO2** meter, select **Sensor** and confirm with **Ok**.
- b) A **Fixed** Calibration Temperature can be entered with the UP and DOWN buttons after the temperature of the calibration standard was measured e.g. with a third-party temperature meter.



NOTE: Ensure constant calibration conditions! If the calibration is performed with a **Fixed** temperature, the temperature in the calibration standard must be measured and kept constant!

Now the **Calibration Medium** of the air calibration standard needs to be defined as **Ambient Air** or **Water**, depending on the environmental sample under investigation.



It is recommended to perform the calibration in the same medium as the one in the sample.

6.3.3 Calibration in Ambient Air

Calibration in ambient air is recommended, if the measurements on the sample are done in the gas phase. During the calibration, the atmospheric pressure and the relative humidity of the ambient air will be read automatically from the internal air sensor (chapter 3.1.4). These readings are needed in order to calculate the actual oxygen partial pressure in the ambient air.

Therefore, it is important that both the **FireSting®-GO2** device and the connected oxygen sensor are exposed to identical environmental conditions.

Position the oxygen and the temperature sensor (if selected) close to the air inlets on the right side of the **FireSting®-GO2** display. Ensure that the oxygen and temperature sensor are completely **dry**; otherwise, the relative humidity around the sensor will differ from the measured humidity inside the **FireSting®-GO2**.

It is strongly recommended that the device and the sensors are placed for >30 min. under constant environmental conditions before the calibration is performed.

Now **Wait for Steady State** until the sensor readings are stable. Then press **SET AIR** and the current oxygen sensor reading is taken for the air calibration. After the completion of the air **calibration**, the system returns to the Calibration menu, showing now the date of the air calibration.

CALIBRATION
Sensor Code XD7-530-200
Calibrate Air 27 Sep 2016
Calibrate 0% not cal.

Note: SET AIR is only active if the oxygen sensor readings are within the expected range for the connected sensor type. If **SET AIR** is replaced by "out of range", check or replace the calibration standard and the entered **Sensor Code**. Repeat the calibration.

6.3.4 Calibration in Air Saturated Water

Calibration in air saturated water is recommended, if the measurements are done in aqueous samples. Refer to chapter 12.1 concerning preparation of appropriate calibration standards. This calibration mode will automatically read the atmospheric pressure from the internal air sensor inside the **FireSting®-GO2**. This reading is needed to calculate the actual oxygen partial pressure in the ambient air.

It is important that the sensor in the calibration standard is exposed to the same atmospheric pressure as the **FireSting®-GO2**.

Now insert the oxygen sensor into the calibration standard. If **Sensor** was selected for the calibration temperature (see above), then insert also the connected temperature sensor into the calibration standard. Now **Wait for Steady State** until the sensor readings are stable.

CALIBRATE AIR
Wait for Steady State then press SET AIR
91.56%air sat. 23.1 °C
CANCEL SET AIR

Note: If using retractable needle-type sensors (e.g., OXR50, OXR230, OXR430), it is important that the sensor tip is extended!

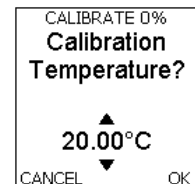
Then press **SET AIR** and the current oxygen sensor reading are taken for the air calibration. After the completion of the air calibration, the system returns to the Calibration menu, showing now the date of the air **calibration**.

Note: **SET AIR** is only active if the oxygen sensor readings are within the expected range for the connected sensor type. If **SET AIR** is replaced by "out of range", check or replace the calibration standard and the entered **Sensor Code**. Repeat the calibration.

6.3.5 0% Calibration

Refer to chapter 12.2 concerning preparation of appropriate 0% calibration standards. Select Calibrate 0% for performing a **0% calibration**. Now choose the type of temperature compensation during the 0% calibration:

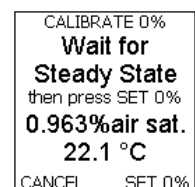
a) For automatic temperature compensation of the **Calibration Temperature** with the temperature sensor connected to the **FireSting®-GO2** meter, select **Sensor** and confirm with OK.



b) A **Fixed** Calibration Temperature can be entered with the UP and DOWN buttons after the temperature of the calibration standard was measured e.g. with a third-party temperature meter.

NOTE: Ensure constant calibration conditions! If the calibration is performed with a **Fixed** temperature, the temperature in the calibration standard must be measured and kept constant!

Now insert the oxygen sensor into the 0% calibration standard. If **Sensor** was selected for the calibration temperature, then insert also the connected temperature sensor into the calibration standard. Now **Wait for Steady State** until the sensor readings are stable.



Note: If using retractable needle-type sensors (e.g., OXR50, OXR230, OXR430), it is important that the sensor tip is extended!

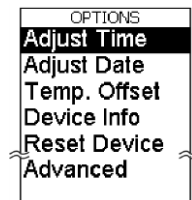
Then press **SET 0%** and the actual oxygen sensor reading is taken for the 0% calibration. After the completion of the 0% calibration, the system returns to the Calibration Menu, showing now the date of the 0% calibration.



Note: **SET 0%** is only active if the oxygen readings are within the expected range for the connected sensor type. If **SET 0%** is replaced by "**out of range**", check or replace the calibration standard and repeat the calibration.

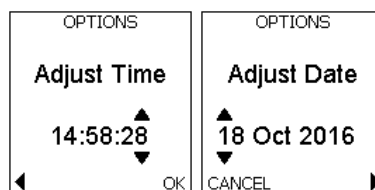
6.4 Options Menu

In the Options Menu several device and sensor parameters can be adjusted. Furthermore, device information can be retrieved and a reset of the device can be performed.



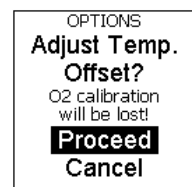
6.4.1 Adjust Time and Date

Please note that it is recommended to **Adjust** the local **Time and Date** before the calibration of the connected sensor (see chapter 6.3) and before logging is started (see chapter 7.1). Adjust them by moving the cursor with the BACK and OK buttons, and by adjusting each item with the UP and DOWN buttons.

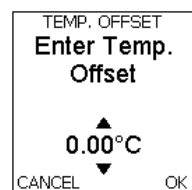


6.4.2 Temperature Offset

It is recommended to check the reading of the PT100 temperature sensor periodically in a water bath of known temperature. This is especially important if a concentration unit (like $\mu\text{mol/L}$ or mg/L) was selected for the oxygen readings (see chapter 6.2.3). A manual **Temp. Offset** can be entered for a 1-point calibration of the temperature sensor (default: 0).



It is also possible to prepare a water-ice-mixture giving 0°C, where at least 50 mm of the temperature sensor tip is submerged. Wait for steady state, read the measured temperature in the top screen of the Live Mode, and enter it as a negative **Temperature Offset**. After this, a new calibration of the connected oxygen sensor must be performed (see chapter 6.3).



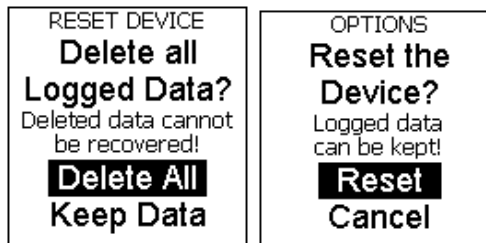
Changing the temperature offset will lead to a loss of the oxygen sensor calibration.

6.4.3 Device Info and Reset Device

Information concerning the unique ID number of the device, the number of saved log files, the used space of the internal device memory (MB) and the firmware version can be obtained by selecting **Device Info**.



Reset Device can be used in order to reset all settings and calibrations. Additionally, it can be selected, whether to delete also all log files on the internal device memory (**Delete All**) or to keep them (**Keep Data**).



Selecting **Delete All** will irrevocably delete all logged data on the internal device memory!

6.5 Advanced Menu

The sub-menu **Advanced** includes advanced features only for advanced users with special instructions from **PyroScience**.



It is **not** recommended to change these advanced parameters without the advice of **PyroScience**!

7 DATA LOGGING

Before starting data logging on the internal device memory, ensure that the following steps have been performed:

- Adjustment of **Time and Date** (see chapter 6.4.1)
- Adjustment of the sensor **Settings** (see chapter 6.2)
- **Calibration** of the connected oxygen sensor (see chapter 6.3)

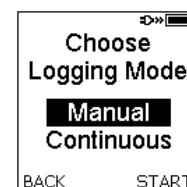
7.1 Start Logging

In order to start the logging, select **Start Logging** in the main menu (see chapter 4.5) and confirm with OK. Here, a **Manual** (see chapter 7.1.1) and a **Continuous** (see chapter 7.1.2) logging mode can be selected.

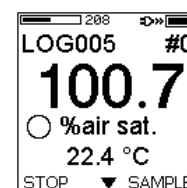


7.1.1 Manual Logging

Select the logging mode **Manual** and press the OK button. Now data points are logged each time the OK button (SAMPLE) is pressed. However, the top screen of the logging mode shows additionally live readings with 2s sample period. These live readings are NOT logged.



Please refer to chapter 7.2 for a description of the information shown on the display during the logging.

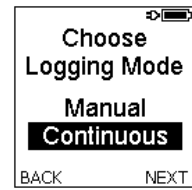


To exit the manual logging mode, press STOP. A confirmation screen will appear. Press again STOP for about 1 second, thereby returning to the Live Mode.

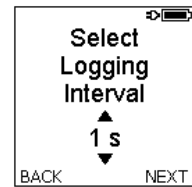


7.1.2 Continuous Logging

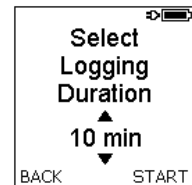
Select the logging mode **Continuous** and press the OK button. In this mode data points are periodically logged with adjustable sample intervals and total logging duration.



Select the **Logging Interval** (1 s, 2 s, 5 s, 10 s, 30 s, 1 min, 2 min, 5 min, 10 min, 30 min, 1 hour, 2 hours or 4 hours) and press NEXT.

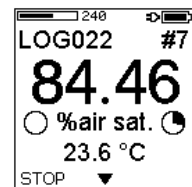


Select the **Logging Duration** (1 min, 2 min, 5 min, 10 min, 30 min, 1 hour, 2 hours, 6 hours, 12 hours, 1 day, 2 days, 4 days, 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year or Non-Stop) and press NEXT.

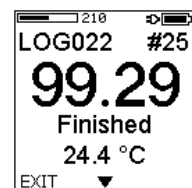


Now the logging is started. Please refer to chapter 7.2 for a description of the information shown on the display during the logging.

In case of selecting a finite logging duration, the logging is automatically finished at the end of the logging duration. Now press EXIT for returning to the Live Mode.



In case **Non-Stop** was selected for the **Logging Duration**, the logging needs to be actively stopped by pressing STOP. Also, if a finite **Logging Duration** was entered, the logging can be terminated at any time by pressing STOP. A confirmation screen will appear. Press then again STOP for about 1 second, thereby returning to the Live Mode.



7.2 Logging Mode

Each time a new logging is started, a new log file (LOGxxx) is generated and numbered sequentially upwards (e.g., LOG001, LOG002, LOG003 etc.). In this log file, each recorded data point is numbered sequentially upwards (#xxx). The log file and the last logged data point number are underneath the status line in the top screen of the Logging Mode. The top screen shows further the last logged readings from the oxygen and the temperature sensor. Please note, if Manual Logging was selected, then additionally live readings with 2s sample period are shown here. But data points are only logged each time the OK button (SAMPLE) is pressed.

Progress circles next to the oxygen unit provide feedback when the next data point will be logged (left progress circle) and about the remaining total logging time (right progress circle).

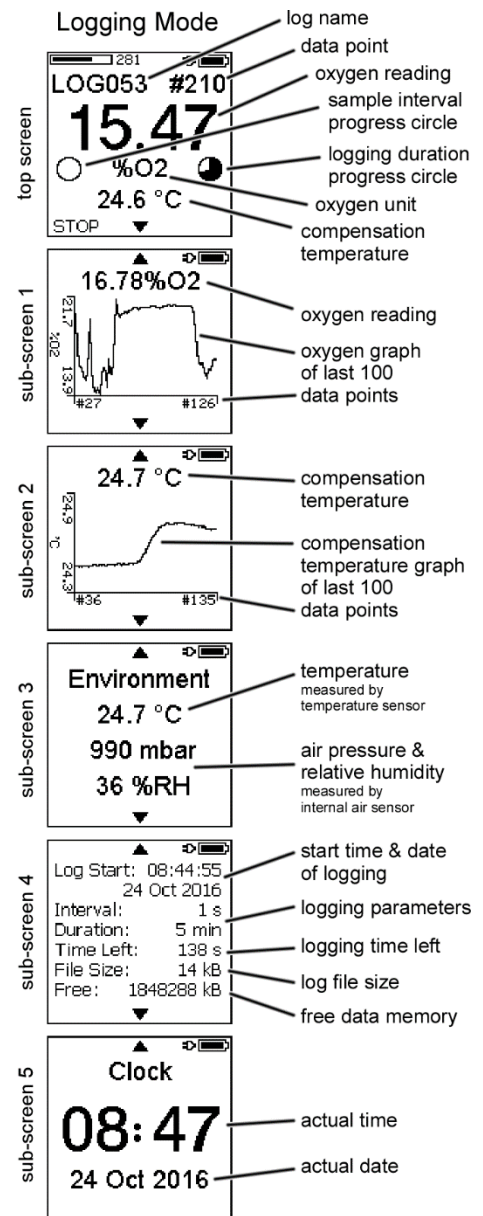
In sub-screen 1 the last 100 logged data points of the oxygen sensor readings are displayed in a graph. The last logged value is shown additionally as a numerical value.

In sub-screen 2 the last 100 data points of the compensation temperature are displayed in a graph. The last logged compensation temperature is shown additionally as numerical value.

Sub-screen 3 shows information concerning the **Environment**, including the readings of the temperature sensor (if connected), as well as the air pressure (mbar) and relative humidity (%RH) measured by the internal air sensor.

Sub-screen 4 includes all details of the actual log file, like the start of the logging (**Log Start** with time and date), the actual log **File Size** and **Free** device memory available. For the **Continuous** logging mode, additional information concerning the adjusted **Logging Interval** and **Duration** are shown, as well as the **Time Left** for the remaining logging duration.

The last sub-screen 5 shows the clock with the actual device time and date.



8 STANDBY MODE

If no buttons are pressed in the Live Mode within 5 min, the device enters the Standby Mode. Here the device clock is shown in the display. In the Standby Mode the measurements are stopped in order to save lifetime of the connected oxygen sensor. To return to the Live Mode, any button can be pressed, opening the top screen of the Live Mode with the actual readings of the connected sensors.

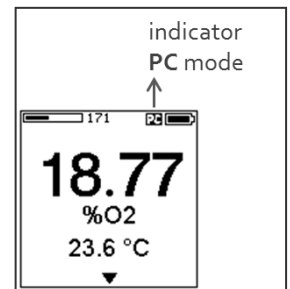
Note, that in the Logging Mode or in the PC Mode, the system will not switch into the Standby Mode.



9 PC MODE

For managing the logged data saved on the internal device memory, the **FireSting®-GO2** meter needs to be connected to a Windows PC with the included USB cable, on which the software **FireSting®-GO2** Manager was installed (see chapter 10.1).

After start of the software **FireSting®-GO2** Manager on the PC, the connected **FireSting®-GO2** meter is in the PC Mode. This is indicated in the status line of the device display.



In the PC Mode, only the UP and DOWN buttons are active for scrolling between top and sub-screens of the Live Mode. Access to the menu is blocked. However, now the **FireSting®-GO2** meter can be controlled completely by the **FireSting®-GO2** Manager software on the PC. It offers an extended functionality compared to the LCD user interface, including log file download, log file deletion, and log file inspection.

10 FIRESTING®-GO2 MANAGER

The log files saved in the internal device memory of the **FireSting®-GO2** can be downloaded and inspected on a Windows PC using the software **FireSting®-GO2** Manager. Additionally, the **FireSting®-GO2** Manager software offers most features similar to the ones given in the LCD user interface (adjusting settings, performing calibrations, options).

10.1 Software Installation

IMPORTANT: Do not connect the **FireSting®-GO2** to your PC before the **FireSting®-GO2** Manager software has been installed. The software will install automatically the appropriate USB-drivers.

- **System requirements:** PC with Windows 7 / 8 / 10 (recommended) / 11 and min. 700 MB free disk space
- Download the correct software in the downloads tab of your purchased device on www.pyroscience.com
- Unzip and start the installer and follow the instructions
- Restart your PC after software installation and connect the **FSGO2** meter.

10.2 Operation without Connected Device

The **FireSting®-GO2** Manager software can be also used if no **FireSting®-GO2** device is connected to the PC. In this case only the **Log Inspector** window can be opened, offering access onto the already downloaded log files. Please refer to chapter 10.4 for more details.

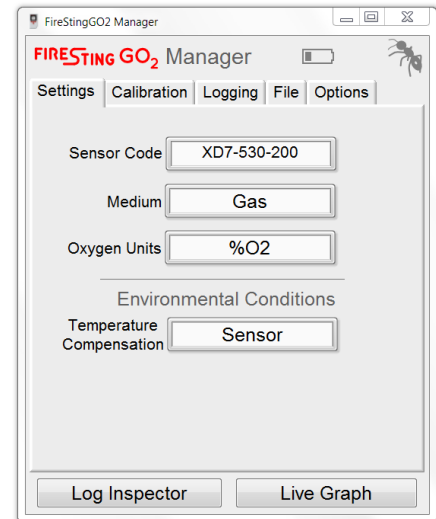
10.3 Operation with Connected Device

First connect the **FireSting®-GO2** meter to the PC with the included micro-USB cable, now start the software **FireSting®-GO2** Manager. The **FireSting®-GO2** will switch into the PC mode, indicated by the "PC" symbol in the upper right corner of the LCD display.

The main window of the **FireSting®-GO2 Manager** offers 5 different tabs (**Settings, Calibration, Logging, File and Options**) for controlling the **FireSting®-GO2** (more details below).

The battery symbol in the top line indicates the battery charging status of the connected **FireSting®-GO2** device. An animated battery symbol indicates that the charging is in progress. As soon as the animation stops, the charging is completed.

The buttons in the bottom line open the **Log Inspector** and the **Live Graph** window (more details below).

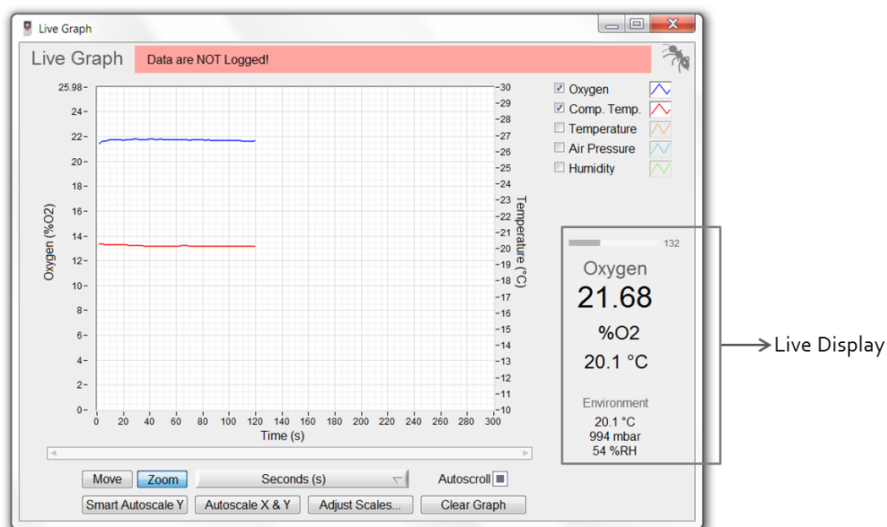


The **FireSting®-GO2 Manager** allows full control on the device, offering most features similar to the LCD user interface of the **FireSting®-GO2**. Before starting live measurements or data logging, following steps need to be done:

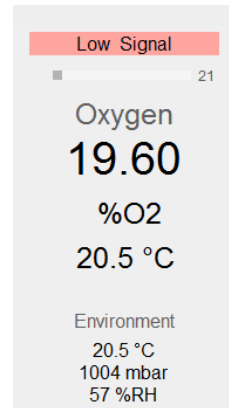
- Get accustomed to the **Live Graph** window (chapter 10.3.1)
- Adjust the sensor **Settings** (chapter 10.3.2)
- Perform an oxygen sensor **Calibration** (chapter 10.3.3)
- Perform live measurements or start **Logging** (chapter 10.3.6)

10.3.1 Live Graph Window

The Live Graph window is opened by clicking on the **Live Graph** button in the main window. In the Live graph window, all current sensor readings are displayed numerically in the **Live Display**. Furthermore, different parameters can be displayed in the graph of the Live Graph window.



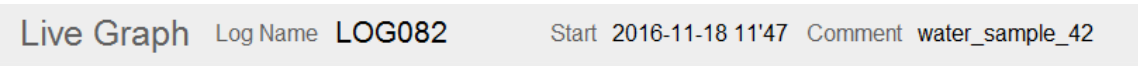
The Live Display shows numerical live readings of all sensors comprising oxygen, compensation temperature, temperature (if a temperature sensor is connected), and the readings of the internal air sensor (air pressure, relative humidity).



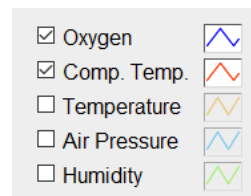
Above the oxygen value, an additional bar graph and a numerical value show the so-called "signal intensity". It provides important information on the actual condition and remaining lifetime of the connected oxygen sensor. Potential warnings (see chapter 11) are displayed above the bar graph.

If data logging is not active, the warning "**Data are NOT logged!**" is shown above the graph. Data displayed in the Live Graph are then NOT saved to a log file!

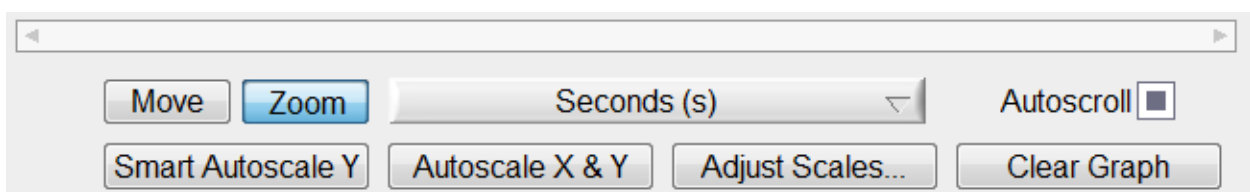
If data logging is active, the **Log Name**, the **Start** time of the logging and the **Comment** entered before the start of the logging, are displayed above the graph.



As default shown in the Live Graph are the current readings for oxygen and for the compensation temperature (Comp. Temp.). To show or hide other parameters in the Live Graph, click on the small rectangular buttons next to the respective parameters.



The color and appearance of each graph can be changed by clicking on the color-control next to the respective parameter, opening a pop-up menu. With **Common Plots**, **Color**, **Line Style**, **Line Width**, **Interpolation**, and **Point Style** the chart appearance can be changed.



The visible time frame of the live graph can be moved with the scroll bar below the graph. With the button Move, the user has the possibility to click onto the chart and **move** the whole area while keeping the mouse button pressed. To zoom into a certain part of the graph, click on the button Zoom and select a rectangular area with the pressed mouse button.

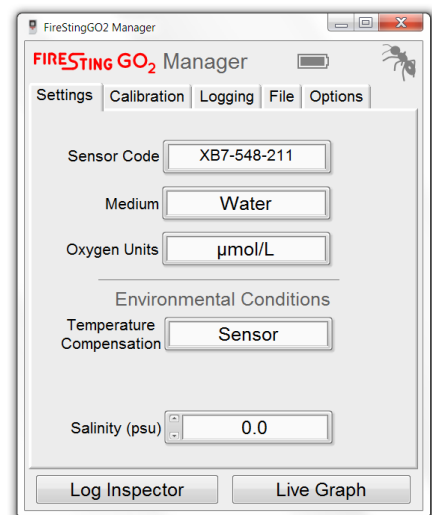
To select the unit of the x-axis Time, click on the button **Seconds (s)** (default) and select the appropriate unit as **Seconds (s)**, **Minutes (min)**, **Hours (h)**, **Relative Time (HH:MM:SS)**, **Absolute Time (HH:MM:SS)** or **Absolute Time & Date**. The activated **Autoscroll** button ensures that the latest data points are always within the visible range of the live graph. Switching off the **Autoscroll** button allows inspection of older data with the scroll bar.

Smart Autoscale Y will trigger an autoscale of the y axes with "smart" ranges for better readability. **Autoscale X & Y** performs a classical autoscale of all x and y axes. Click on **Adjust Scale** in order to adjust all scales manually by entering the maximum, minimum, and the increment (tag spacing) for all x and y axes.

The graph can be cleared with the button **Clear Graph**. This will not affect the saved data in the log file.

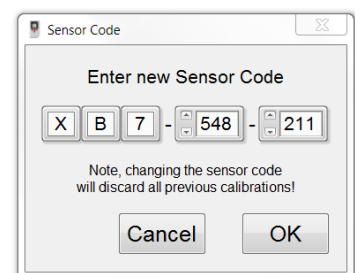
10.3.2 Settings

Open the **Settings tab** to adjust the sensor settings. Here, the **Sensor Code**, the **Medium** of the sample, the **Oxygen Units** of the measurements and the environmental conditions, including the **Temperature Compensation** and, if applicable, the **Salinity (psu)** of the sample under investigation have to be adjusted.



The Settings can only be adjusted if data logging is not active.

Enter the **Sensor Code** written on the label attached to the sensor cable or on the bag/stickers of the oxygen sensor by clicking on the field **Sensor Code**, therewith opening the **Sensor Code** window. Adjust each position of the respective **Sensor Code** and click on OK.



Changing the **Sensor Code**, e.g. in case of connecting a new sensor, requires a new calibration of the oxygen sensor!

Then define the medium of your sample by clicking in the field **Medium** and selecting **Gas or Water**, depending on the environmental sample under investigation. Then select the appropriate **Oxygen Units** for the measurements. Please note that different oxygen units can be selected for the Medium **Gas** (%O₂, hPa, Torr, dphi) and **Water** (%air saturation, mL/L, µmol/L, mg/L, µg/L, hPa, Torr, dphi).

Now the **Environmental Conditions** in the sample need to be defined. The possible modes of **Temperature Compensation** during the oxygen measurements include temperature measurements in the sample with the connected PT100 temperature **Sensor**. Alternatively, the measurements can be performed with a fixed sample temperature. In this case the temperature needs to be measured in the sample and entered as **Fixed Temperature** (°C).

Environmental Conditions

Temperature Compensation	Fixed
Fixed Temperature (°C)	20.0
Salinity (psu)	0.0

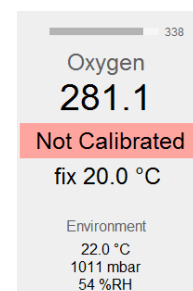
IMPORTANT: For measurements with a **Fixed** temperature, the temperature in the sample must be measured and kept constant during the entire measurement!

For measurements in saline samples (e.g. seawater) using an oxygen concentration unit like µmol/L or mg/L, the salinity of the sample must be measured and entered in the field **Salinity (psu)**. For measurements in gas samples this value has no relevance (and is not shown).

10.3.3 Calibration

The oxygen sensor is calibrated in the **Calibration** tab. If a sensor is not yet calibrated, a warning **Not Calibrated** replaces the oxygen unit in the live graph.

The oxygen sensor can be calibrated at two calibration points:
 (1) in ambient air or in air saturated water (**Calibrate Air**), and/or
 (2) at 0%O₂, i.e., in an anoxic calibration standard (**Calibrate 0%**).





For highest precision it is recommended to calibrate both calibration points. However, if the expected measuring range is close to one of the calibration points, then a 1-point calibration might be sufficient. For example, if the expected measuring range in a liquid sample is 95-100% air sat., then a 1-point calibration at air saturated water is typically sufficient. In this case the 0% calibration is taken from the factory calibration encoded in the **Sensor Code**.

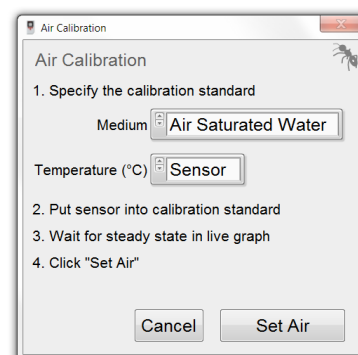
It is recommended to perform the calibration at conditions close to the environmental conditions during the measurements.

For security the Calibration tab repeats the **Sensor Code** entry, which is in fact identical to the **Sensor Code** entry given in the Settings tab (chapter 10.3.2). Double check the entered **Sensor Code** is identical to the one written on the label attached to the sensor cable or on the bag/stickers of the sensor.

10.3.4 Air Calibration

Click on the button **Calibrate Air** to open the **Air Calibration** window. This will also automatically open the Live Graph window (see 10.3.1).

(1) Choose Calibration Medium. Specify the **Medium** of the calibration standard. If the measurements will be done in the gas phase, it is advised to choose **Ambient Air** and to continue with step (2A). If the measurements will be done in aqueous samples, it is advised to choose **Air Saturated Water** and to continue with step (2B).



(2A) Calibration in Ambient Air. Ambient air serves as a simple standard (ca. 20.95%O₂ in dry air). In order to determine the precise oxygen partial pressure in ambient air, the atmospheric pressure and the relative humidity will be read automatically from the internal air sensor (chapter 3.1.4).

Ensure that both the **FireSting®-GO2** device and the connected sensors are exposed to identical environmental conditions. Position the sensor tips in close proximity to the **FireSting®-GO2** device.

Ensure that the oxygen and the temperature sensor are completely dry; otherwise, the relative humidity around the sensors will differ from the measured humidity inside the **FireSting®-GO2**.

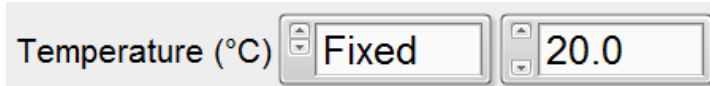
It is strongly recommended that the device and the sensors are placed for >30 min. under constant environmental conditions before the calibration is performed.

(2B) Calibration in Air Saturated Water. Please refer to chapter 12.1 concerning preparation of an appropriate calibration standard. Note that this calibration mode will automatically read the atmospheric pressure from the internal air sensor inside the **FireSting®-GO2**, which is needed for calibration. Therefore, the calibration standard must be exposed to the same atmospheric pressure as the **FireSting®-GO2** device.

Insert the sensors for oxygen and temperature (if selected for automatic temperature compensation) into the calibration standard. It is important that the sensor in the calibration standard is exposed to the same atmospheric pressure as the **FireSting®-GO2**.

Note: If using retractable needle-type oxygen sensors (e.g., **OXR50, OXR230, OXR430**), it is important that the sensor tip is extended when the calibration value is taken.

(3) Temperature Compensation. Select now the mode of temperature compensation used during air calibration by clicking on Temperature (°C). For automatic temperature compensation with the temperature sensor connected to the **FireSting®-GO2** device, select Sensor.

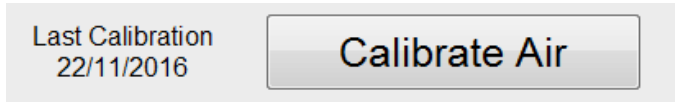


Alternatively, a Fixed calibration temperature can be entered after the temperature of the calibration standard was measured e.g. with a third-party temperature meter.

NOTE: Ensure constant calibration conditions! If the calibration is performed with a **Fixed** temperature, the temperature in the calibration standard must be measured and kept constant!

(4) **Wait for Steady State** until the oxygen and temperature readings are stable by observing the Live Graph window (see 10.3.1).

(5) **Calibrate** by clicking on **Set Air**. The current oxygen sensor reading is taken for the air calibration and the date of the last calibration is updated in the Calibration tab.

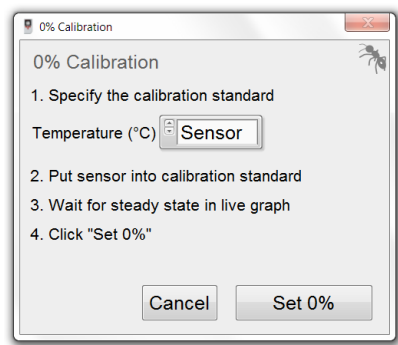


Note: A calibration is only possible if the oxygen sensor readings are within the expected range for the connected sensor type. If the warning "Calibration out of expected range" is shown, the calibration is discarded. Check or replace the calibration standard and perform a new calibration.

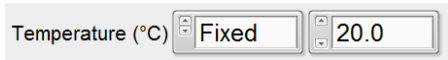
10.3.5 0% Calibration

Refer to chapter 12.2 how to prepare an appropriate 0% calibration standard. Click on **Calibrate 0%** in the Calibration tab. This will open the **0% Calibration** window and the Live Graph window (see 10.3.1).

(1) Temperature Compensation. Select now the mode of temperature compensation used during 0% calibration by clicking on **Temperature (°C)**. For automatic temperature compensation with the PT100 temperature sensor connected to the **FireSting®-GO2** device, select **Sensor**.



Alternatively, a **Fixed** calibration temperature can be entered after the temperature of the calibration standard was measured with a third-party temperature meter.



NOTE: Ensure constant calibration conditions! If the calibration is performed with **Fixed** temperature, the temperature in the calibration standard must be measured and kept constant!

(2) Put Sensors into Calibration Standard. Now insert the oxygen sensor into the calibration standard. If **Sensor** was selected for the calibration temperature (see above), then insert also the connected temperature sensor into the calibration standard.

Note: If using retractable needle-type sensors (e.g., **OXR50, OXR230, OXR430**), it is important that the sensor tip is extended when the calibration value is taken.

(3) Wait for Steady State until the oxygen and the temperature readings are stable by observing the Live Graph window (see 10.3.1).

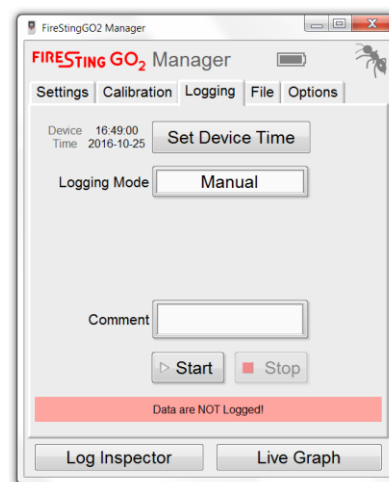
(4) Calibrate by clicking on **Set 0%**. The current oxygen sensor reading is taken for the 0% calibration and the date of the last calibration is updated in the Calibration tab.

Note: A calibration is only possible if the oxygen sensor readings are within the expected range for the connected sensor type. If the warning "Calibration out of expected range" is shown, the calibration is discarded. Check or replace the calibration standard and perform a new calibration.

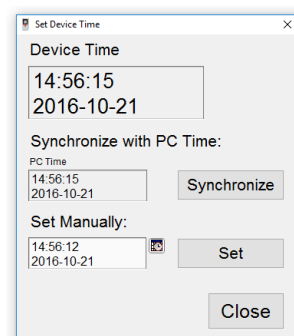
10.3.6 Data Logging

Before starting data **Logging**, adjust the sensor **Settings** and complete a sensor **Calibration**. To deploy the device after logging has been started, please ensure that the **FireSting®-GO2 Manager** software is closed before the device is disconnected.

Even if the **FireSting®-GO2** is operated with the **FireSting®-GO2 Manager** software, the logged data are always saved within the device memory of the **FireSting®-GO2**. After finalization of the logging, the log file can be downloaded from the device to the PC. This feature ensures that the device can be disconnected without problems from the PC, even when logging is active. A typical scenario is that the device is configured and calibrated with the **FireSting®-GO2 Manager**, then logging is started and the device is disconnected and deployed at the measurement location. Later when the measurements are completed, the device is again connected to the PC, and the logged data are downloaded and inspected. The following steps must be done for data logging:



(1) Device Time. Data logging is managed in the **Logging** tab of the main window. First check the current device time (i.e. the time of the internal clock in the **FireSting®-GO2**) shown in this tab. The time and date information for the logged data are always related to this device time (and not the PC time). If it is incorrect, click on **Set Device Time**. This opens a window for adjusting the device time. Clicking on **Synchronize** will set it to the PC Time. Alternatively, the time and date can be adjusted manually. For this, edit the time and date below "Set Manually", and click on **Set**.



(2) Logging Mode. Select the **Logging Mode** as **Manual** or **Continuous**. In the **Manual** logging mode the user has to trigger the logging for each single data point. Go on with step (5). In the **Continuous** logging mode the device will automatically log data points in defined time intervals.

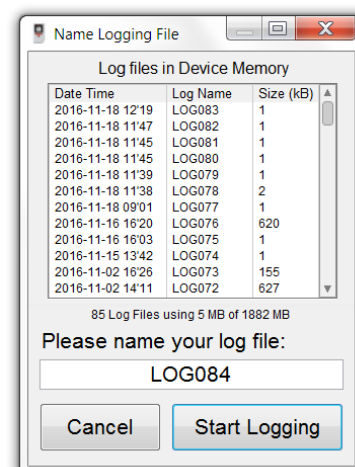
(3) Logging Interval (only for continuous mode). Select the sampling **Interval** used during the logging as 1 s, 2 s, 5 s, 10 s, 30 s, 1 min, 2 min, 5 min, 10 min, 30 min, 1 h, 2 h or 4 h. It is advised to choose this interval not unnecessarily too small, in order to increase the battery run time, and to avoid too large log files.



(4) Logging Duration (only for continuous mode). The logging **Duration** can be set to 1 min, 2 min, 5 min, 10 min, 30 min, 1 h, 2 h, 6 h, 12 h, 1 d, 2 d, 4 d, 1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year or to Non-Stop.

(5) Comment. Enter optionally a **Comment**, which will be saved in the header of the log file as soon the logging is started.

(6) Start Logging. Click now on **Start** which opens a separate window **Name Logging File**. This window displays the log files saved in the device memory, including Date and Time, the Log Name, the Size (in kB), as well as the total number of Log Files and the used Device Memory (MB). The software automatically generates a new log file with the default name „LOGxxx” numbered sequentially upwards (e.g. LOG001, LOG002, LOG003, etc.). If wished, this default file name can be changed by the user in the field **Please name your log file** (8 characters possible).



After clicking on **Start Logging**, the **Live Graph** window opens (see chapter 10.3.1) and the tabs Settings, Calibration and Options in the main window are de-activated and cannot be changed during the logging. The **Log Name**, the **Start** time of the logging and the optional **Comment** are now displayed in the bottom line of the Logging tab.

(6a) Manual Logging Mode. Logging of a single data point is now done manually by clicking on the button **Sample**. A single data point is then saved to the log file and added to the graph in the Live Graph window. The **FireSting®-GO2** performs in this logging mode additional intermediate measurements with 2 seconds interval which are displayed only in the Live Display (see 10.3.1) but NOT in the Live Graph. These intermediate measurements are NOT saved to the log file.



(6b) Continuous Logging Mode. Data logging is now done automatically with the chosen logging **Interval** and logging **Duration**. The logged data are displayed in the Live Graph window.

(7) Finish Logging. Data logging can be always stopped by pressing the button **Stop**. Additionally the logging is automatically finished in the continuous Logging Mode, as soon the total logging Duration has elapsed. After data logging is finished, the respective log file is automatically downloaded. As soon the download is finished, the logged data will be shown in the **Log Inspector** (see chapter 10.4.1).

10.3.7 Options

The **Options** tab contains information concerning the **FireSting®-GO2 Manager** (soft-ware version) and the connected **FireSting®-GO2** device (Device ID, firmware version). The **Device ID** is a unique identification number specific for each single device. The header of each log file contains this Device ID. This way each log file can be unequivocally assigned to a specific **FireSting®-GO2** device. The following subsections describe the other feature within the **Options** tab.

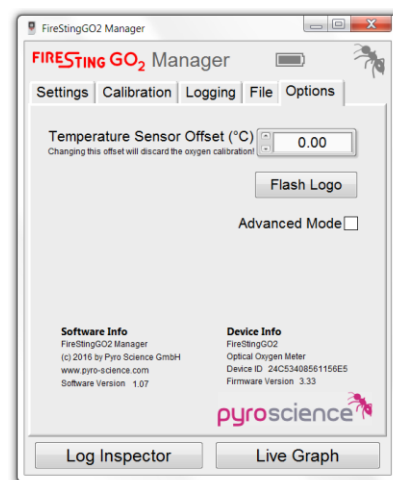
10.3.8 Temperature Sensor Offset

It is recommended to check the reading of the temperature sensor periodically in a water bath of known temperature at steady state. This is especially important if a concentration unit (like $\mu\text{mol/L}$ or mg/L) was selected for the oxygen readings (see chapter 6.2.3).

A **manual Temp. Offset** can be entered for a 1-point calibration of the temperature sensor (default: 0).

Changing the temperature offset requires new calibration of the connected oxygen sensor afterwards.

For a detailed description how to determine the temperature offset of the sensor, please refer to chapter 6.4.2.



10.3.9 Flash Logo

The button **Flash Logo** causes a short flashing (ca. 1 sec) of the **PyroScience** logo on the display of the **FireSting®-GO2** meter. The flashing of the logo can help to assign a specific **FireSting®-GO2 Manager** software window to the corresponding **FireSting®-GO2** meter, if more than one device is connected.

10.3.10 Advanced Mode

The **Advanced Mode** comprises advanced features only for advanced users with special instructions from **PyroScience**. It is **NOT** recommended to change these advanced parameters without the advice of **PyroScience**!

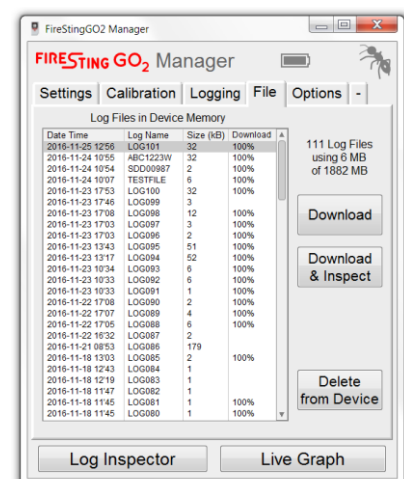
By activating the **Advanced Mode**, a new small tab is displayed in the main window, which enables direct access to low level parameters only relevant for advanced applications. Furthermore, the **Advanced Mode** enables to monitor the fundamental raw data of the oxygen measurement, which comprises the phase shift **dphi** (see chapter 14.3) and the signal intensity in the Live Graph and the Log Inspector.

10.4 Log Inspector and File Management

The actual data logging is always done on the internal device memory of the **FireSting®-GO2**. The **File** tab in the main window provides a list of all log files currently saved in the device memory. First after a log file has been downloaded, it can be inspected within a separate window called **Log Inspector**, which contains a list of all downloaded log files currently saved on the PC hard disk. For opening this window manually click on the **Log Inspector** button in the main window.

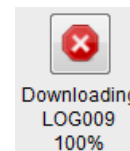
10.4.1 File Management

For the management of the log files saved in the device memory, click on the tab **File** in the main window. Here, the **Log Files** in the **Device Memory** of the connected **FireSting®-GO2** meter are shown in a file list with details about the Date and Time, the Log Name, the Size (kB) and the Download status (%) of the log files. Clicking on the header of a column will sort the list alphabetically for this respective column. Repeated clicking on the same column header will reverse the sorting order.



10.4.2 Downloading Log Files from the Device to the PC

To download one or several log files from the device to the PC, the respective log files must be selected by clicking on them in the **File** tab. Multiple log files can be selected by pressing additionally the CTRL or SHIFT buttons on the PC keypad. With the button **Download**, the selected log files are then downloaded to an automatically generated folder **PyroScience/ Log Files/ FireSting®-GO2 Device ID xxx** within the default user document folder on the Windows PC. It is recommended to keep this default folder unchanged. During downloading, the progress of the download is indicated and can be stopped by clicking on the red stop button.



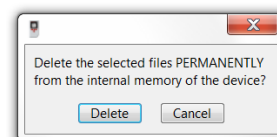
Note, that when an actual data logging is finished while the device is operated with the **FireSting®-GO2 Manager**, then the download of this actual log file is automatically triggered.

The downloaded data files can be now inspected in the **Log Inspector** window (see chapter 10.4.4).

The button **Download & Inspect** has essentially the same functionality as the **Download** button. The only difference is, that only a single data file can be downloaded, and that the Log Inspector automatically opens, as soon the download is finished.

10.4.3 Deleting Log Files from the Device Memory

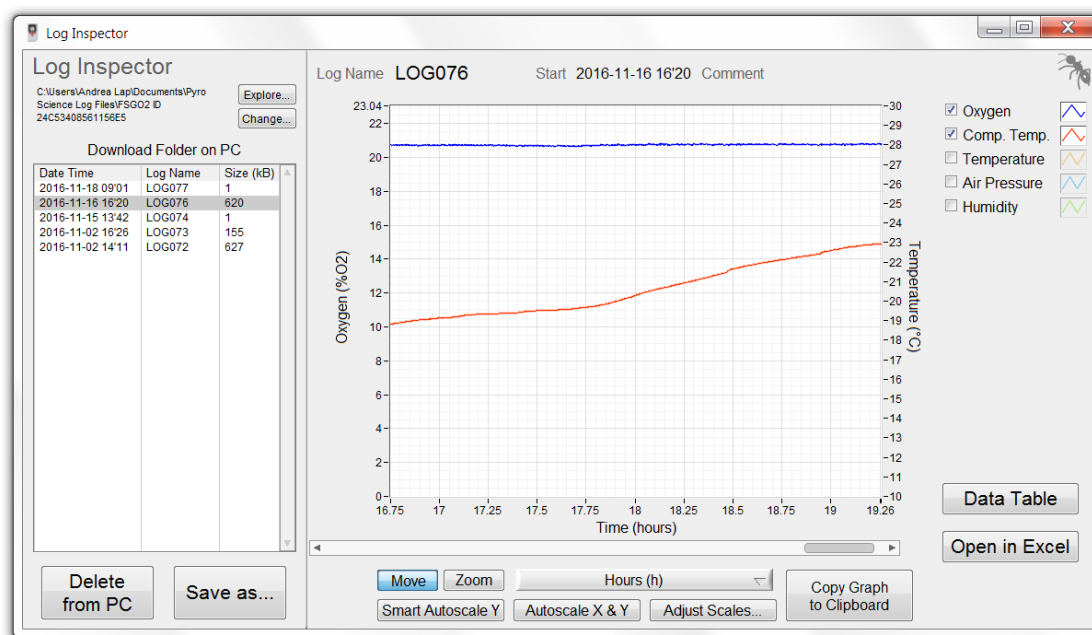
In order to delete log files from the device memory, select one or multiple log files in the **File** tab list and click on **Delete from Device**. Multiple log files can be selected by pressing additionally the CTRL or SHIFT buttons on the PC keypad. Please note that the selected files are permanently deleted from the internal memory of the device and cannot be retrieved anymore.



NOTE: Deleted log files are not saved in a recycle bin! Do not forget to download the log files to the PC before deleting them from the device memory.

10.4.4 Log Inspector Window

The Log Inspector window is opened manually by clicking on the **Log Inspector** button in the main window. Here only the log files are listed, which have been downloaded from the device to the **Download Folder** on the PC. The left section of the **Log Inspector** window lists the downloaded log files in a table with relevant details (Date and Time, the Log Name and the file Size (kB)). Above this list, the file path of the default download folder on the PC is indicated.



Note: The default location of the download folder contains the **Device ID** (see chapter 10.3.7), which ensures that the downloaded files can be unequivocally assigned to a specific **FireSting®-GO2** device. It is advised not to change this download location, especially if several devices are operated in parallel. Advanced users might choose a custom download folder by clicking on **Change**.

The button **Explore** opens the current download folder within the Windows operation system. This feature is not needed for standard procedures. But it allows for advanced users direct access to the log files (tab separated text files).

IMPORTANT if using the button **Explore**: It is strongly recommended not to change the log file names or their content within this download folder, in order to assure a smooth operation with the **FireSting®-GO2 Manager**. It is recommended first to **copy** log files from this folder to another location, before processing them.

Alternatively, to the **Explore** button, the **Save as...** button can be used to choose a custom file name and location (e.g., on the desktop). This will save a copy of the respective log file (tab separated text file).

In order to delete log files within the download folder on the PC, select one or multiple log files in the file list and click on **Delete from PC**. Multiple log files can be selected by pressing additionally the CTRL or SHIFT buttons on the PC keypad. Please note that the selected files are permanently deleted from the PC and cannot be retrieved anymore.

By selecting a log file in the **Download Folder** list, the logged data for this specific log file are automatically shown in the graph visible in the right section of the **Log Inspector** window. The header of the graph includes the **Log Name**, the **Start** time of the logging and the **Comment**, if entered before the start of the logging. Please refer to chapter 10.3.1 for the diverse features available for manipulating the graph appearance.

The actual log file content can be optionally displayed in a text table by clicking on **Data Table**. Or it can be directly exported to Microsoft Excel by clicking on **Open in Excel** (only possible if Microsoft Excel is installed on the PC).

To copy a screenshot of the current graph to the Windows clipboard, click on **Copy Graph to Clipboard**. Now this screenshot can be pasted (CTRL+V) to many other Windows programs (e.g., Microsoft Word or Excel).

11 WARNINGS

The following warnings are potentially displayed in the status line of the LCD screen of the **FireSting®-GO2** (see chapter 11). If the **FireSting®-GO2** is operated with the **FireSting®-GO2 Manager** software, the warnings are also shown in the Live Graph window (chapter 10.3.1).

11.1 Oxygen Sensor Warnings

A reasonable oxygen sensor shows signal intensities well above 50 (typically 50-500)¹. If the signal intensity drops below 50, the warning **Low Signal** is shown, indicating that the sensor might get degraded soon. But for contactless sensors it might indicate that the distance between the optical fiber and the sensor spot is too large. In order to increase the signal intensity, advanced users might increase the intensity of the excitation light (red light flashes coming out of the oxygen port) by changing the second letter of the **Sensor Code** (details in 14.4).

Low Signal: Measurements are still possible with potentially decreased performance.

If no oxygen sensor is connected or if the sensor is broken or damaged, the warning **No Signal** will be shown in the status line / Live Display.

No Signal: Please check whether the sensor cable is connected or replace the sensor, the tip might be broken / bleached.

The Warning **Too High** indicates that there might be too much **ambient light on the sensor tip or on the sensor spot. Or there might be an incorrect Sensor Code entered in the device or software.**

¹ Note: Exceptions are trace oxygen sensors. During the air calibration at 21% O₂, these sensors show a very low signal intensity (as low as 10). But the signal intensity will strongly increase when a trace oxygen sensor is applied within its specified range of 0-10% O₂.

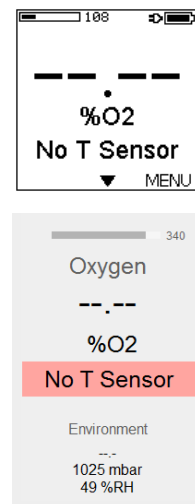
Too High: Avoid direct sun light exposure or strong direct illumination with a lamp and darken the surrounding. And/or check the entered **Sensor Code**.

In case of the warning **Bad Ref**, indicating internal problems of the electronics, please contact **PyroScience** for support.

Bad Ref: Please do not continue to measure if a warning is shown!

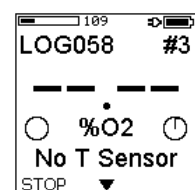
11.2 Temperature Sensor Warning

If the Temperature **Sensor** is activated in the **Settings** (see chapters 6.1.4 and 10.3.2) for automatic temperature compensation of the oxygen measurements, but is **not** connected, broken or nonfunctional, the warning **No T Sensor** is shown in the top screen of the Live Mode (device) and in the Live Graph window of the **FireSting®-GO2 Manager**. While this warning is active, the device cannot provide any valid oxygen readings, as the compensation temperature is missing for calculating the oxygen value. The oxygen reading is then replaced by "--.--". No measurements can be performed until the temperature sensor is connected or exchanged. Alternatively, the **Settings** can be changed to a defined **Fixed** temperature (see chapters 6.2.4 and 10.3.2).



No T Sensor: Check the connection to the temperature sensor. Or replace broken temperature sensor.

Also in the Logging Mode, a missing or non-functional temperature sensor will lead to a disappearance of the oxygen and temperature sensor readings in the corresponding screens of the device and in the Live Display of the **FireSting®-GO2 Manager** software in combination with the **No T Sensor** warning.



However, the log file would still include the phase shift **dphi**, which is the fundamental raw data measured by the **FireSting®-GO2**. If the temperature was recorded

independently in parallel, a re-calculation of the oxygen data can be performed on request.

12 CALIBRATION STANDARDS

12.1 The Air Calibration Standard

The Air Calibration standard can be

- ambient air
- water-vapor saturated air
- air saturated water (100% air saturation)

When inserting fragile needle-type oxygen sensors into the calibration standards, ensure that the sensor tips are not hitting against e.g. the bottom of the flask or any hard object. Always use a proper lab stand for mounting the oxygen sensor!

All air calibration standards described in the following rely on the virtually constant oxygen content in the earth's atmosphere of about 20.95% O₂ in dry air. Slight deviations might be given in closed rooms occupied by many people (or e.g., candles, combustion engines) consuming oxygen. So, if in doubt, ensure a good ventilation of the room with fresh air e.g., by opening a window for some minutes.

Furthermore, the relative humidity of the air causes deviations from the ideal value of 20.95% O₂. Simply speaking, the water vapor in humid air replaces a fraction of the oxygen, resulting in a diminished oxygen level of e.g., 20.7% O₂. For temperatures around and below 20°C, this effect causes fortunately only a maximum deviation of about 0.5% O₂. However, for higher temperatures at 30°C or even 40-50°C, the humidity of the air gets a significant influence on the actual oxygen level. For example, ambient air at body temperature (37°C) with 100% relative humidity contains only 19.6% O₂ compared to dry air with 20.95% O₂.

During the calibration of oxygen sensors, there are two possibilities to take the humidity into account:

- (1) The relative humidity and the temperature of the ambient air must be determined during the calibration.
- (2) The calibration standard is prepared in a closed vessel either filled with water or partly filled with e.g., wet cotton wool or a wet sponge. This ensures a constant humidity of 100% RH and there is no need to measure the humidity.

Option (1) is utilized in the calibration standard "Ambient Air", whereby option (2) is utilized for the calibration standards "Water".

Another parameter even more important for the air calibration standard is the atmospheric pressure. The principle parameter measured by oxygen sensors is not the partial volume (i.e. "% O2"), but the partial oxygen pressure (i.e. "mbar") (see also appendix 11.3). So, an oxygen level of e.g. 20.7% O2 (determined as described above by a given humidity and temperature) is converted internally by the software into a partial pressure of oxygen essentially by multiplying the relative oxygen level with the atmospheric pressure of e.g. 990 mbar:

$$0.207 \quad \times \quad 990 \text{ mbar} \quad = \quad 205 \text{ mbar}$$

giving a partial oxygen pressure of e.g., 205 mbar. This is the essential calibration value used internally by the software. The atmospheric pressure can be influenced 1) by weather changes (e.g., varying between ca. 990 and 1030 at sea level) and 2) by the elevation above sea level (e.g., at 1000 m elevation the typical atmospheric pressure is about 900 mbar compared to 1013 mbar at sea level).

Thus, in summary, there are three important parameters to be known for the air calibration standard:

- Temperature (°C)
- Relative Humidity (% RH)
- Atmospheric Pressure (mbar)

The **FireSting®-GO2** device with the built-in humidity and pressure sensors together with the connected temperature sensor can measure (and compensate) these parameters automatically.

12.1.1 Ambient Air

If ambient air is used as the air calibration standard, there is no need for preparation. The **dry** oxygen sensor, optionally together with the **dry** temperature sensor, is simply exposed to the ambient air. Otherwise, follow the calibration procedures described in chapters 6.3.2 (device) and 10.3.3 (software).

For precise calibration in ambient air, it is important that the measuring tips of the oxygen and the temperature sensor are **completely dry**. Wet sensor tips will cause undefined humidity levels around the sensor tips. And even worse, the evaporation of water drops would cool down the sensor tips causing undefined temperatures.

12.1.2 Water-Vapor Saturated Air

Enclose wet cotton wool into a flask (e.g., DURAN flask) with a lid prepared with holes for the oxygen sensor and a temperature sensor from **PyroScience**. Typically, about 1/3 to 1/2 of the flask volume is filled with the wet cotton wool, while the other volume fraction is left free for inserting the tip of the oxygen sensor, and optionally also the temperature sensor. Follow the calibration procedures described in chapter 5.2.2.

12.1.3 Air Saturated Water

Fill an appropriate amount of water into a flask (e.g., Duran flask) with a lid prepared with holes for inserting the oxygen sensor and a temperature sensor. Stream air through the water for about 10 min with an air stone connected to an air pump (available as commercial equipment for fish aquaria). Alternatively, if no air pump is available, fill water into the flask leaving >50% air in the headspace, close it with a lid and shake the flask strongly for about 1 min. Open the lid shortly for ventilating the headspace with fresh air. Close it again and shake the flask for 1 more minute. Insert the oxygen sensor and the temperature sensor into the flask and ensure that the tips of the sensors are immersed in the water and free of air bubbles. Follow the calibration procedures described in chapter 5.2.2.

Please consider that streaming air through water may cause cooling of the water. Ensure a **correct temperature determination!**

12.2 The 0% Standard

The 0% calibration standard can be

- water mixed with a strong reductant
- nitrogen gas (N₂)

12.2.1 Water Mixed with a Strong Reductant

Fill an appropriate amount of water into a glass flask (e.g., Duran flask) with a lid prepared with holes for inserting the oxygen sensor and a temperature sensor. Add a strong reductant, like sodium dithionite (Na₂S₂O₄) or sodium sulfite (Na₂SO₃) at a concentration of 30 g L⁻¹, creating oxygen-free water by chemical reaction. It is not recommended to use saline water (e.g., seawater) for this, because the high salinity of the water might prevent a proper dissolution of the reductant. Stir the solution until the salt is completely dissolved, then stop the stirring and let the solution stand for about 15 minutes. Ensure that there is **no headspace and no air bubbles in the closed flask**. Then insert the oxygen and temperature sensor into the flask and ensure that the sensor tips are completely immersed into the water and free of air bubbles. Perform the calibration as described in chapter 5.2.3.

Do not store the sensors in this solution and rinse them carefully after calibration with demineralized water. Especially the retractable needle-type sensors (item no. **OXR50, OXR230, OXR430**) need to be rinsed very thoroughly, because salt crystallization within the needle might damage them irreversibly.

12.2.2 Nitrogen Gas

Flush 100% nitrogen gas through a glass flask (e.g., Duran flask) with a lid prepared with holes for inserting the oxygen sensor and a temperature sensor. Ensure that all air has been replaced by the nitrogen gas before performing the calibration. Insert the oxygen sensor and the temperature sensor into the flask, let it equilibrate and perform the calibration as described in chapter 5.2.3.

Ensure that no ambient air enters the flask again during the calibration process. Convictional gas transport is a very fast process! It is therefore advised to keep flushing the flask with nitrogen gas during the complete calibration process!

Please consider that nitrogen gas from gas bottles might be significantly **cooled down** by the decompression process. Ensure a correct **temperature determination** of the calibration standard!

13 SENSOR TYPES

The **FireSting®-GO2** is compatible with a broad range of optical oxygen sensors from **PyroScience**. For an overview of available optical sensor types, please see the website. (www.pyroscience.com)

Sensor	Item	Application
Robust Probes	OXROB...	stirred water, gas
Retractable Tip Micro- & Minisensors	OXR...	water, gas & semi-solid samples
Fixed Tip Micro- & Minisensors	OXF...	water & gas
	OXF...-PT	gas (puncturing septa/packageing)
Bare Fiber Micro- & Minisensors	OXB...	water, gas & custom
Solvent-Resistant Probes	OXSOLV	approved polar and non-polar solvents
	OXSOLV-PTS	approved solvent vapours (puncturing septa)
Sensor Spots	OXSP5	water & gas
Sensor Vials	OXVIAL...	water & gas
Flow-Through Cells	OXFTC...	water & gas
	OXFTCR	

14 APPENDIX

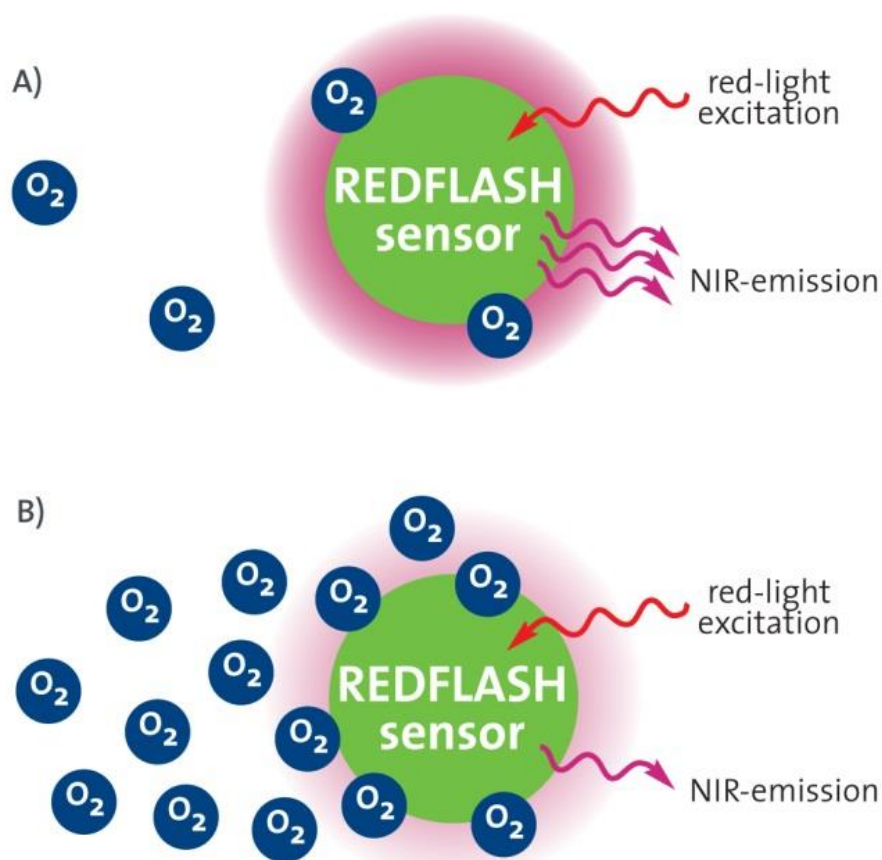
14.1 Specifications of the FireSting®-GO2

Dimensions	150 g
Weight	52 x 97 x 20 mm
Interface	micro-USB 2.0
Memory	4 GB (ca. 40 million data points)
Battery	rechargeable Li-Ion battery (typ. 2 h charging via micro-USB)
System Requirements for FireSting®-GO2 Manager	Windows 7, 8, 10
Operating Conditions	0-50°C, non-condensing
Oxygen measuring principle	Lifetime detection of REDFLASH indicator luminescence
Oxygen Port Connector	1 fiber-optic ST-plug
Excitation Wavelength	620 nm (orange-red)
Detection Wavelength	760 nm (NIR)
Temperature Port	1 channel for 4-wire PT100
Min. Logging Interval	1 sample per second
Typ. Standalone Logging Time (with a fully charged battery)	ca. 1 week for 1 s log interval ca. 2 months for 10 s log interval ca. 6 months for 1 min log interval ca. 1 year for >= 10 min log interv.
Typ. Data File Size	ca. 100 bytes per data point
External Temperature Sensors* Range, Resolution, Precision	-30°C to 150°C, 0.02°C, ±0.5°C
Internal Pressure Sensor Range, Resolution, Precision	300 to 1100 mbar, 0.06 mbar, typ. ±3 mbar
Internal Humidity Sensor Range, Resolution, Precision	0 to 100% rel. humidity (RH), 0.04% RH, typ. ±0.2% RH

*Please note that the oxygen sensors have a different temperature range (typ. 0-50°C specified, -20°C to 70°C not specified).

14.2 Measuring Principle

The **REDFLASH technology** is based on the oxygen-sensitive **REDFLASH indicator** showing excellent brightness. The measuring principle is based on the quenching of the **REDFLASH indicator** luminescence caused by collision between oxygen molecules and the **REDFLASH indicator** immobilized on the sensor tip or surface. The **REDFLASH indicators** are excitable with red light (more precisely: orange-red at a wavelength of 610-630 nm) and show an oxygen-dependent luminescence in the near infrared (NIR, 760-790 nm).



Principle: red light excited REDFLASH indicators show luminescence in the near infrared (NIR), which decreases with increasing oxygen (quenching effect).

A) high NIR emission at low oxygen and B) low NIR at high oxygen

The **REDFLASH technology** impresses by its fast response times, high precision, high reliability, low power consumption and low cross-sensitivity. The red light excitation significantly reduces interferences caused by autofluorescence and reduces stress in biological systems.

14.3 Definition of Oxygen Units

phase shift

dphi

The phase shift **dphi** is the fundamental unit measured by the optoelectronics in the **FireSting®-GO2**. The measuring principle is based on a sinusoidally modulated red excitation light, resulting in a phase-shifted sinusoidally modulated emission in the NIR. This phase shift is measured and converted into oxygen units based on the Stern-Vollmer-Theory. Please note that **dphi** is not at all linearly dependent on the oxygen units, and **increasing** oxygen levels correspond to **decreasing dphi** values, and vice versa! As a thumb of rule, anoxic conditions will give about **dphi=53**, whereby ambient air will give about **dphi=20** for full range oxygen sensors.

partial pressure p_{O_2}

hPa = mbar

Used in: gas and water

For a calibrated sensor, the partial oxygen pressure p_{O_2} in units of **hPa** (equivalent to **mbar**) is the fundamental oxygen unit measured by the **FireSting®-GO2**.

partial pressure p_{O_2}

Torr

Definition: $p_{O_2}[\text{Torr}] = p_{O_2}[\text{hPa}] \times 759.96 / 1013.25$

Used in: gas and water

volume percent p_V

%O2

Definition: $p_V = p_{O_2}[\text{hPa}] / p_{\text{atm}} \times 100\%$

Used in: gas

with p_{atm} : actual barometric pressure

% air saturation A

%air sat.

Definition: $A[\% \text{air sat.}] = 100\% \times p_{O_2} / p_{100O_2}$

Used in: water

with $p_{100O_2} = 0.2095 (p_{\text{atm}} - p_{H_2O}(T))$

$p_{H_2O}(T) = 6.112\text{mbar} \times \exp (17.62 T[^\circ\text{C}] / (243.12 + T[^\circ\text{C}]))$

p_{O_2} : actual partial pressure

p_{atm} : actual barometric pressure

T: actual temperature

$p_{H_2O}(T)$: saturated water vapor pressure at temperature T

Dissolved O2 concentration C μmol/L

Definition: $C [\mu\text{mol/L}] = A[\% \text{air sat.}] / 100\% \times C_{100}(T,P,S)$

Used in: water

with $C_{100}(T,P,S)$: interpolation formula for dissolved oxygen concentration in units of μmol/L at temperature T, atmospheric pressure P and Salinity S.

Dissolved O2 concentration C mg/L = ppm

Definition: $C [\text{mg/L}] = C [\mu\text{mol/L}] \times 32 / 1000$

Used in: water

Dissolved O2 concentration C mL/L

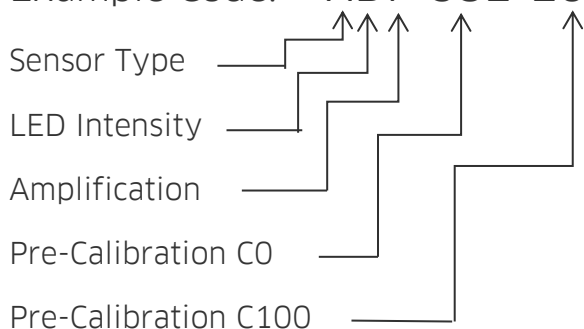
Definition: $C [\text{mL/L}] = C [\mu\text{mol/L}] \times 0.02241$

Used in: water

14.4 Explanation of the Sensor Code

The oxygen sensors are delivered with a **Sensor Code** (written on the label attached to the sensor cable or the bag/stickers of contactless sensors), which must be entered in the Settings (see chapter 5.1.1). The following figure gives a short explanation about the information included in the **Sensor Code**.

Example Code: XB7-532-205



Sensor Type

- Z Oxygen Micro / Minisensor (normal range)
- Y Oxygen Minisensor (normal range)
- X Robust Oxygen Probe (normal range)
- V Oxygen Minisensor (trace range)
- U Robust Oxygen Probe (trace range)

T	Oxygen Sensor Spot / FTC (trace range)
S	Oxygen Sensor Spot / FTC (normal range)
Q	Solvent-Resistant Oxygen Probe
P	Oxygen Nanoprobes

LED Intensity

A	10%	E	40%
B	15%	F	60%
C	20%	G	80%
D	30%	H	100%

Amplification

4	40x
5	80x
6	200x
7	400x

C0 (Pre-Calibration at 0% O₂)

$$dphi0 = C0 / 10$$

C100 (Pre-Calibration at 100% O₂)

$$dphi100 = C100 / 10$$

The values of the pre-calibration are valid for the following calibration conditions:

Partial Volume of Oxygen (% O ₂)	20.95
Temperature at both calibration points (°C)	20.0
Air Pressure (mbar)	1013
Humidity (% RH)	0

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