pyroscience
sensor technology

AquapHOx® Transmitter
Underwater O2, pH, T Meter

MANUAL

O2 pH T

AquapHOx® Transmitter
Underwater O2, pH, T Meter

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1 INTRODUCTION

The AquapHOx® Transmitter family (item no. **APHOX-TX, APHOX-T-PH, APHOX-T-O2**) are transmitters for underwater operation down to 4000 m (**APHOX-TX**) or 100 m (**APHOX-T-PH** and **APHOX-T-O2**) water depth. The AquapHOx® Transmitter platform offers one optical port for a wide range of optical O_2-, pH-, or temperature sensors from PyroScience. A fixed NTC temperature sensor provides automatic temperature compensation of the optical sensors. The digital interface is a RS485-Modbus interface, which can convert to USB via the included USB adapter cable. The electrical interface offers additionally 4 high-resolution analog outputs.

There are several usage scenarios depending on the users´ level of experience:

Option A: The device can be operated via the included USB adapter cable with the **simple and user-friendly Windows software Pyro Workbench**, which is typically used by end-users. This software offers comfortable settings and calibration wizards, as well as advanced logging features. Several modules can be operated in parallel within a single window (see chapter 3).

Option B: The **software Pyro DeveloperTool enables more configuration possibilities** for advanced user. It offers simple settings and calibration procedures, as well as basic logging features. Furthermore, additional advanced settings offer full control of all features of the transmitter (see chapter 4).

Option C: The AquapHOx® Transmitter also features **analog outputs (4-20mA or 0-5V).** Configuration of the analog outputs, sample rate, as well as calibration of the sensors can be performed using the software **Pyro Workbench** or **Pyro DeveloperTool**. (see chapter 5).

Option D: The AquapHOx® Transmitter features a standard **RS485 interface with Modbus RTU protocol**, supporting robust bus systems, supporting up to 247 devices at a single bus with several 100m cable lengths. This very popular communication protocol allows easy integration of the AquapHOx® Transmitter into third party systems (see chapter 6).

2 OVERVIEW

The front of the **AquapHOx®** Transmitter provides the port for connecting optical sensors using the **PyroScience SUB**-connector, the fixed NTC temperature sensor for automatic temperature compensation, and a mounting thread for calibration containers or protection cages for deployment. The backside of the device provides the connector for power supply, RS485-Modbus-communication, and 4 analog outputs (2x 0-5V, 2x 4-20mA).

The housing is dependent on the chosen device. **APHOX-TX** comes with a titanium housing for deployments down to 4000m. **APHOX-T-PH** and **APHOX-T-O2** come with a POM housing capable for deployments down to 100m.

2.1 Optical Port

The AquapHOx® Transmitters are compatible with special PyroScience sensors for underwater applications designated by the appendix '-SUB' in the item number. Any of these sensor heads can be connected to the SUB-connector ("optical port") of the AquapHOx® Transmitter. However, the shallow water versions **APHOX-T-O2** and **APHOX-T-PH** only support sensor heads for the analytes oxygen and pH, respectively. The deep-sea version **APHOX-TX** supports oxygen as well as pH sensor heads. Note, all versions support optical temperature sensor heads (not to mixed up with the fixed NTC temperature sensor).

2.2 Temperature Sensor

Optical oxygen and pH sensors show generally a temperature dependency, which can be automatically compensated by the device. For this purpose, the AquapHOx® Transmitter

offers a high-precision, fast responding NTC temperature sensor. This sensor is fixed to the housing, it cannot be removed.

2.3 Air Pressure Compensation

For **APHOX** devices, the **Pyro Workbench** offers two ways to compensate for deviating ambient air pressure at the water surface. The ambient air pressure can either be entered in hPa as fixed pressure (measured at the water surface), or in approx. meters above sea level.

2.4 Included Accessories

1x USB configuration cable: allows easy calibration and setup with the powerful Windows software packages **Pyro Workbench** or **Pyro DeveloperTool**. Not intended for deployment during sampling.

1x Protection Cage: provides protection of the sensor ports during deployment or transport.

2x Calibration Containers: used for calibration liquids during sensor calibration.

Calibration Capsules: used for preparation of calibration standards.

2.5 Optional Accessories

Sensor protection cage with anti-(bio)fouling net (item: **APHOX®-CAGE-AF**).

Anti-(bio)fouling net for underwater (-**SUB**) pH and oxygen sensor caps (item **APHOX®-CAP-AF**).

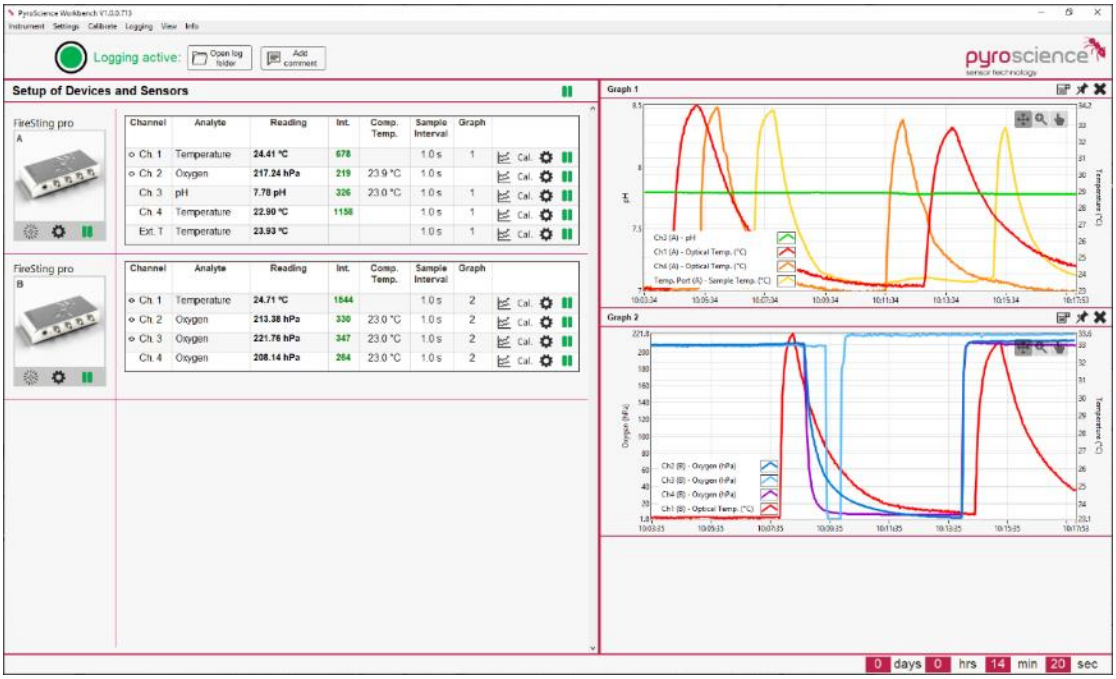
For optimal protection, the anti-(bio)fouling net (copper alloy) for the sensor cap protection cage (item: **APHOX®-CAP-AF**) should be combined with the sensor protection cage for **AquapHOx®** meters (item: **APHOX®-CAGE-AF).** Both protection cages can be purchased separately at any time and replaced once exhausted.

Flow-through-cell (item: **APHOX®-FTC**).

The flow-through cell allows to connect the **APHOX®** devices to a flow path. It can be used fully submerged, as well as in the laboratory, and can be combined with all **PyroScience** cap sensors with **SUB**-connector. Typical use cases are pumped CTD systems, FerryBox Systems, and industrial applications. Please refer to the **APHOX®-FTC** leaflet for product mounting.

3 OPTION A: OPERATING THE TRANSMITTER WITH PYRO WORKBENCH

The AquapHOx® Transmitter can be operated with the user-friendly software **Pyro Workbench**. This software offers comfortable settings and calibration wizards, as well as advanced logging features. Several transmitters can be operated in parallel within a single window.



System requirements: PC with Windows 7/8/10 and min. 1000 MB free disk space.

Do not connect the USB adapter cable to your PC before the software has been installed! The software will automatically install the appropriate USB-drivers.

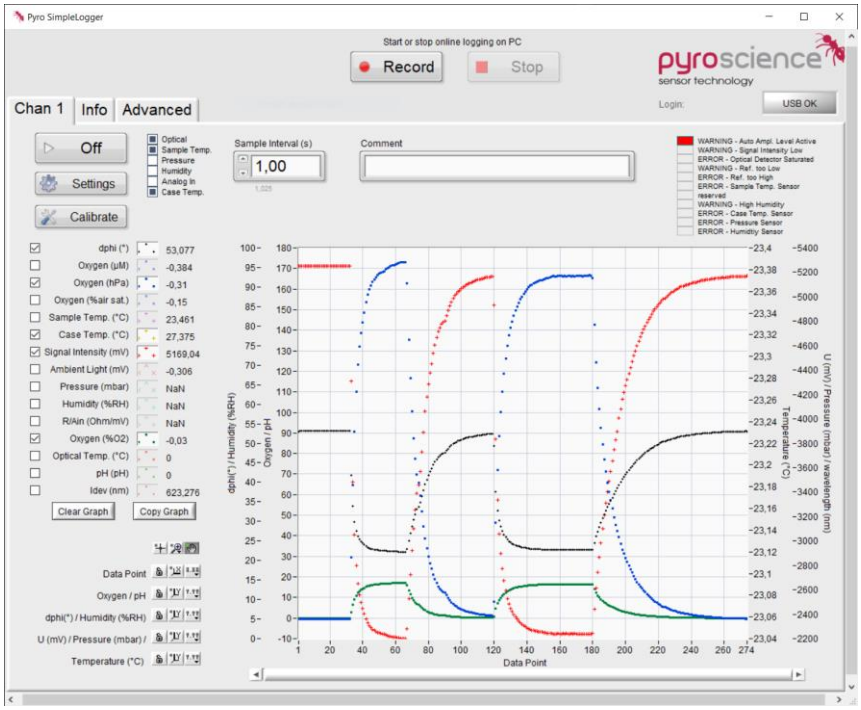
Installation steps:

- Download the **Pyro Workbench** from https://www.pyroscience.com/en/downloads/underwater-devices
- Unzip and start the installer and follow the instructions.
- Connect the Transmitter to your PC with the included USB adapter cable.
- Start the **Pyro Workbench** software.
- Follow the handling instructions in chapter 7.

For more information on the software, please refer to the **Pyro Workbench** manual available at https://www.pyroscience.com/en/downloads/underwater-devices .

4 OPTION B: OPERATING THE TRANSMITTER WITH PYRO DEVELOPERTOOL

The software **Pyro DeveloperTool** offers simple settings and calibration procedures, as well as basic logging features. Furthermore, additional advanced settings offer full control over all features of the module.



System requirements: PC with Windows 7/8/10 and min. 1000 MB free disk space.

Do not connect the USB adapter cable to your PC before the software has been installed! The software will automatically install the appropriate USB-drivers.

Installation steps:

- Download the **Pyro DeveloperTool** from https://www.pyroscience.com/en/downloads/underwater-devices
- Unzip and start the installer and follow the instructions.
- Connect the Transmitter to your windows PC using the USB adapter cable.
- Start the **Pyro DeveloperTool** software.
- Follow the handling instructions in chapter 7.

For more information on the software, please refer to the **Pyro DeveloperTool** manual available at https://www.pyroscience.com/en/downloads/underwater-devices .

5 OPTION C: READ-OUT USING THE ANALOG OUTPUTS

The AquapHOx® Transmitter offers read-out using analog outputs. This can be realized by adjusting the settings and performing sensor calibrations using the PyroScience software **Pyro Workbench** or **Pyro DeveloperTool**.

Analog Output	2x 0-5V, 2x 4-20mA (16 bit each)

The configuration of the device must be done either with the software **Pyro Workbench** or with **Pyro DeveloperTool** as described in the chapters 3 or 4. Please follow the complete instructions given in these chapter.

The configuration window for adjusting the Analog Outputs appears automatically, when you close the PyroScience software. There you can adjust which parameter should be output at which analog output, and you can adjust the scaling. And you have to adjust the so called “broadcast interval”, which represents the sample interval of the measurements given at the analog outputs.

Alternatively in the case of the **Pyro Workbench**, you can open this configuration window by clicking on the top menu bar: settings -> respective device -> Analog output/ broadcast mode.

6 OPTION D: RS485-MODBUS-INTERFACE

The RS485 interface of the module can be connected to a standard Modbus bus. Up to 247 devices can be connected to a single bus consisting of the 4 wires required by the RS485 interface. The Modbus protocol is a popular industrial communication protocol reckoned by its simplicity and robustness. Modbus libraries are available for virtually any programming language. Numerous data logging systems support the Modbus protocol.

Please refer to chapter 8.3 for the electrical specifications and the pin assignment of the RS485-Modbus-interface.

6.1 Modbus RTU

An essential element of the Modbus protocol are slave addresses and registers. Every Modbus device possesses a configurable slave address (range 1-247) and a certain set of registers, which contain e.g., integer numbers. There exist read-write registers (e.g., temperature offset) and read-only registers (e.g. the result of a temperature measurement). The Modbus RTU protocol provides commands, allowing a "master device" (e.g., a PC) to read or write specific registers from a device with a specific slave address.

The **AquapHOx® Transmitter** complies with the "BASIC Implementation Class" of Modbus using the RTU mode. Details can be found in the official documentation "Modbus over serial line specification and implementation guide" provided by the **Modbus - Organization, Inc**. Please refer to the homepage: https://www.modbus.org/. Here you can get all information e.g., how to read and write Modbus registers.

6.2 PyroScience Unified Protocol

All optical meters from PyroScience with firmware generation 4 (i.e., firmware version >= 4.0, introduced in 2020) comply to the so called PyroScience Unified Protocol (PSUP). All further details, especially the Modbus register map, can be found in the reference manual **PyroScience Unified Protocol** available for download on the PyroScience website here:

https://www.pyroscience.com/en/downloads/underwater-devices

7 HANDLING INSTRUCTIONS

This chapter provides general handling instructions, assuming that usage of a PyroScience software (refer to 3 or 4).

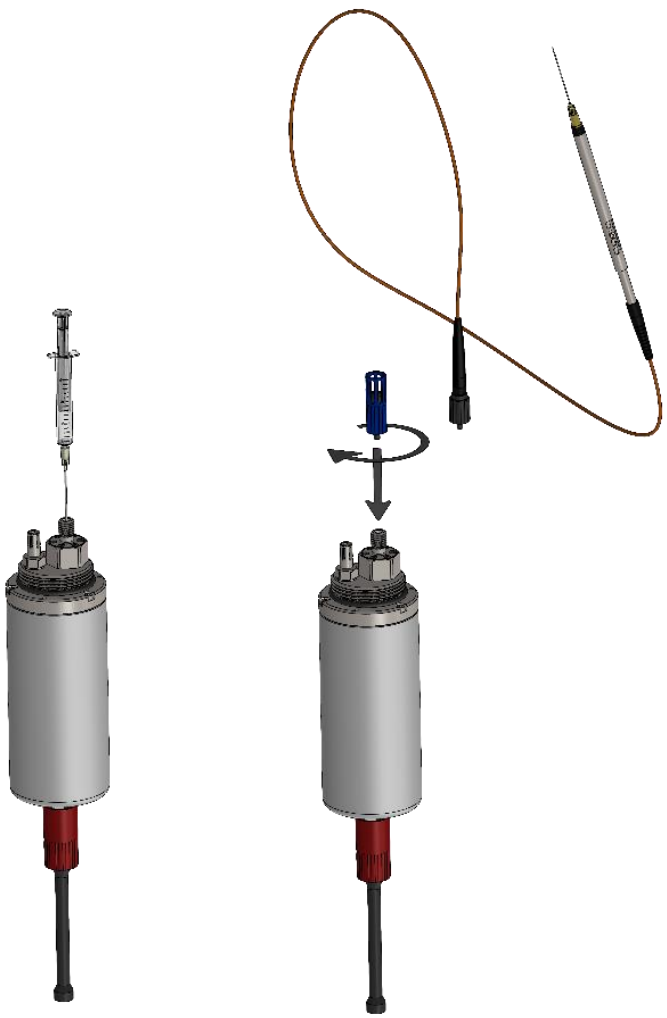
For in-depth information especially on sensor settings and sensor calibration, please refer to the respective **Analyte Sensor Manual** for oxygen, pH or optical temperature sensors available at https://www.pyroscience.com/en/downloads/underwater-devices .

7.1 Connecting the Sensor Head

An index matching liquid inside the connector enhances the sensor signals. Before connecting a sensor, insert the provided Pasteur pipette to the bottom of the connector and fill it completely with deionized water (**NOT seawater**).

Alternatively, and mandatory for the optical fiber with lens (item no. **SPFIB-LNS-SUB/SPFIB-LNS-CL2-SUB**) for read-out of sensor spots, insert the provided Pasteur pipette to the bottom of the connector and fill with **silicone oil**.

The sensor is inserted and secured with the cap nut. Do not use a wrench. It is sufficient to tighten the nut by hand.



7.2 Sensor Settings

Open the settings Window in **Pyro Workbench** or **Pyro DeveloperTool**. Enter the **Sensor Code** of the connected sensor and adjust all further required settings as requested by the respective software.

7.3 Calibration Setup

When using sensor caps, calibration can be performed by screwing the included calibration containers onto the **AquapHOx®** device.

When using fiber-based sensors, please ensure that the temperature sensor of the **AquapHOx®** has the same temperature as your calibration solution.

7.4 Calibration of Oxygen Sensors

The sensor needs to be calibrated in air-saturated water or in air with 100% relative humidity (upper calibration) and optionally in de-oxygenated water (0% calibration).

1-point calibration

- For calibration in **air saturated water**, it is very important that the water is indeed 100% saturated with air. Fill an appropriate amount of demineralized water into a flask. Stream air through the water with an air stone connected to an air pump (available as commercial equipment for fish aquaria) for about 10 minutes.
- When using the calibration container, it is possible to put wet paper tissues or a sponge onto the bottom of the calibration container and screw it on the **AquapHOx®** device to perform a calibration at **air with 100% relative humidity**.
- Enter all required parameters in the software, and perform a sensor calibration.

2-point calibration

- For **0% calibration**, use the 0% calibration capsules from PyroScience, giving 50mL 0% calibration standard (item no.: **OXCAL**).
- For calibration using the calibration container, please dissolve 2 capsules in 100ml deion. water (NOT seawater). Screw the calibration container onto the device and perform the 0% calibration.

7.5 Calibration of pH Sensors

- A one-point calibration is obligatory to start measurements.
- A two-point calibration is highly recommended before every measurement.
- A pH offset-adjustment is recommended only for advanced applications, e.g. measurements in complex media.

If the sensor was previously stored under dry conditions or used for the first time, **wait for at least 60 min to achieve wetting of the sensor** membrane. This is the minimum time. For higher accuracy, it is necessary to condition the sensor for several hours (overnight) in e.g., seawater.

1-point calibration

- Screw the calibration container onto the device (in case of using a **PHCAP**) and let the sensor equilibrate (at least 15 min) in the **stirred** pH 2 buffer solution (freshly prepared using item no. **PHCAL2**). For more information see the pH sensor manual.
- Calibrate the pH sensor.

Important: The pH sensor must stay wet all the time between calibration and measurement. For this purpose, you might keep the calibration container attached to the device.

2-point calibration

- Perform the 1-point calibration as described above.
- Immerse the pH sensor and the temperature sensor into the **stirred** pH 11 buffer solution (freshly prepared using item no. **PHCAL11**). For more information see the pH sensor manual.
- Calibrate the pH sensor.

pH offset adjustment

The pH offset adjustment does NOT replace the required calibration steps as described above. It offers an additional pH-offset adjustment using a buffer solution with exactly known pH value. This can be used if a reference measurement (e.g., spectrophotometric measurement) is available. The pH of this sample needs to be at the PK value of your sensor (pH 7.5 – 8.5 in case of a PK8 sensor). Please refer to the pH sensor manual for more information.

7.6 Calibration of Optical Temperature Sensors

All **AquapHOx®** devices are capable of using PyroScience optical temperature fiber sensors. Calibration of these sensors can be performed by using the internal temperature sensor.

- Click on **Calibrate** and follow the calibration instructions.
- Select the desired calibration against the integrated **NTC Temperature Sensor** or against a **Fixed Reference Temperature**.
- Calibrate the optical temperature sensor.

Important: When using the integrated NTC temperature sensor for the reference temperature, ensure that the connected optical temperature sensors is exposed to the same temperature as the NTC temperature sensor.

7.7 Deployment

If you are using sensors caps (and not fiber-optic sensor heads): Before the actual deployment, it is recommended to keep the sensor caps immersed in the calibration container filled with the respective calibration liquid. This is especially important for pH sensors in order to keep them wet.

Close any software used for configuring and calibrating the device (e.g. **Pyro Workbench**, **Pyro DeveloperTool**). Then disconnect the USB adapter cable.

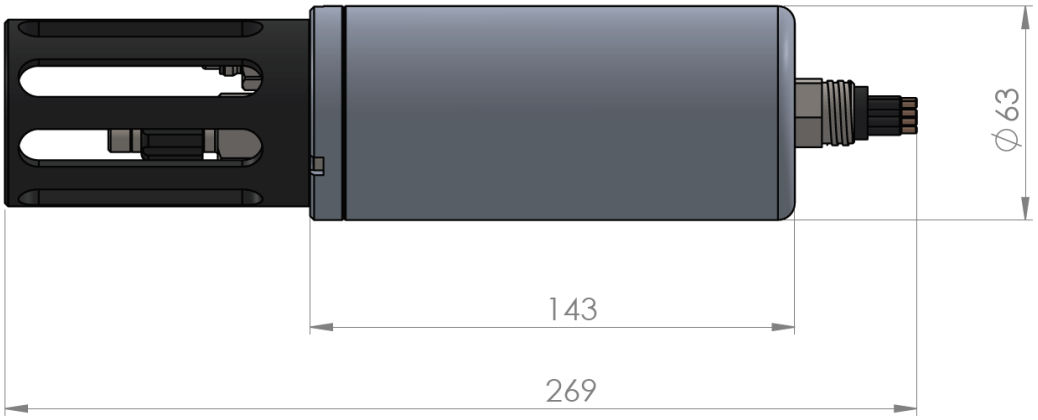
Remove the calibration container shortly before the deployment, and replace it with the protection cage.

Now attach the connector to your setup, either via the RS485-Modbus-interface or via the analog outputs.

In shallow water environments, it is strongly recommended to slip over the **APHOX®-CAP-AF** anti-(bio)fouling net onto the sensor cap and to use the **APHOX®-CAGE-AF** with anti-biofouling net on the **APHOX®** device (instead the included protection cage).

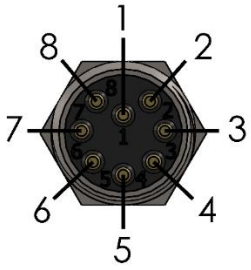
8 APPENDIX

8.1 Dimensions



8.2 Electrical Connector

The pin assignment of the Subconn connector MCBH8M is as follows:



Subconn Pin Nr.	Name	Subconn wire color	Function
1	GND	black	Ground
2	RS485B	white	RS485 Data B
3	VCC	red	Supply voltage
4	U1	green	Analog voltage out 1 (0-5V)
5	RS485A	orange	RS485 Data A
6	U2	blue	Analog voltage out 2 (0-5V)
7	I1	white/black	Analog current out 1 (4-20mA)
8	I2	red/black	Analog current out 2 (4-20mA)

8.3 Device Specifications

For sensor specifications and response times, please refer to the webpages of the different sensor types.

Specifications		
Item No.	APHOX-TX	APHOX-T-PH / APHOX-T-O2
Dimensions	63 x 300 mm	63 x 300 mm
Weight in air	1.31 kg	0.406 kg
Housing Material	Titanium	Polyoxymethylene (POM)
Max. hydrostatic pressure	400 bar (4000m)	10 bar (100m)
Supported analytes	pH, O_2 and optical temperature	APHOX-T-PH: pH and optical temperature APHOX-T-O2: O_2 and optical temperature
Optical sensor connector	PyroScience underwater connector (-SUB)	
Optical sensor port	1	
Compatible optical sensors	Portfolio of optical sensors with underwater connector (-SUB) from PyroScience	
External temperature sensor Resolution Accuracy Typical response time	NTC thermistor for temperature compensation 0.005°C 0.05°C 0.5 s	
Software	Pyro Workbench or Pyro DeveloperTool	
Digital interface	RS485 (USB 2.0 adapter cable included)	
Electrical Connector	Subconn MCBH8M	
Power Supply	5-15VDC (only RS485 / USB) 10-15 VDC (Analog Outputs)	
Analog Output	2x 0-5V, 2x 4-20mA (16 bit each)	
Digital Protocols	Modbus RTU or PyroScience protocol (switchable)	
Data storage	No internal data storage	

Max. sample rate	40 Hz (0.025 s interval)
Power consumption	max. 30mA (+ currents used by analog current outputs)
Operating / storage temperature	-10 – 60 °C Storage -5 – 40 °C Operating
Oxygen sensors	Refer to the separately available specifications for the connected oxygen sensor
pH sensors	Refer to the separately available specifications for the connected pH sensor
Optical temperature sensors	Refer to the separately available specifications for the connected optical temperature sensor

*Please note, that the optical sensors have a different temperature range

8.4 Warnings & Safety Guidelines

In case of problems or damage, disconnect the device and mark it to prevent any further use. Consult PyroScience for advice! There are no serviceable parts inside the device. Please note that opening the housing will void the warranty.

Follow appropriate laws and guidelines for safety in the laboratory, 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 the measurements and of PyroScience buffer capsules.

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

Handle the protection cages with care to avoid injuries! As the anti-(bio)fouling net contains nickel, it is strongly recommended to wear gloves during handling, especially in case of a known contact allergy.

The sensors are not intended for medical or military purposes or any other safety-critical applications. They must not be used for applications in humans; not for in vivo examination on humans, not for human-diagnostic or any therapeutic purposes. The sensors must not be brought in direct contact with foods intended for consumption by humans.
The device and the sensors must be used by qualified personnel only, following the user instructions and the safety guidelines of the manual.

Handle the device with extreme care if there is any suspicion that it was flooded during deployment. Internal pressure might have built up as a consequence. Point the sensor side of the device away from people and material assets at all times, and carefully loosen the Subcon connector to relieve potential internal pressure before sending the instrument to PyroScience for service.

Keep the sensors and the device out of reach of children!

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