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sensor technology

Optical Temperature Sensors

USER MANUAL
OPERATING INSTRUCTIONS

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Optical Temperature Sensors

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1 INTRODUCTION

PyroScience offers fiber-based and contactless optical temperature sensors, as well as a number of combined sensors like flow-through cells respiration vials and sensor vials for simultaneous measurements of temperature, oxygen and pH.

These sensors can be read-out with the following fiber-optic meters from **PyroScience**

- the multi-channel PC-operated **FireSting-O_2** (**FSO_2-Cx** (firmware 4 devices) with **Pyro Workbench** and **FSO_2-x** (firmware 3 devices) with **Pyro Oxygen Logger** software) for optical O_2 and temperature sensors and
- the multi-analyte & multi-channel PC-operated **FireSting-PRO** (with **Pyro Workbench**) for optical pH, O_2 and temperature sensors
- the underwater **AquapHOx** Loggers and Transmitters (with **Pyro Workbench**) for optical pH, O_2 and temperature sensors with underwater connector (option -SUB).

All software versions are available for free download from the **PyroScience** website and must be installed on a Windows PC/laptop before connecting the respective meter for the first time. For details on the read-out devices and their software, please see their respective manuals and handling guidelines.

This manual is intended to provide all necessary information on standard application of optical temperature sensors from **PyroScience**.

For more information concerning advanced applications, please contact us at info@pyroscience.com.

Your **PyroScience** Team

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2 QUICK START

Step 1: Please 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.

Step 2: After successful installation, connect the **PyroScience** read-out device to the Windows PC/laptop with the micro-USB cable.

Step 3: Carefully remove the protective caps from the sensor tip, from the fiber plug and from the optical connector(s) at the **FireSting** read-out device.

Step 4: Connect the **PyroScience** temperature sensor(s) to the **optical channel connector(s)** of the device.

Step 5: **For calibration of optical temperature sensors,** connect an appropriate Pt100 temperature sensor to the temperature port. Alternatively, a fixed temperature can be entered (needs to be measured and kept constant).

Step 6: Start the **PyroScience** software by clicking on the short-cut on your desktop.

Step 7: Enter all required **Sensor Settings** for each connected sensor**,** including the **sensor code, sample interval, measuring mode** and, for contactless sensors, also the **fiber length (m)**.

Step 8: Perform a 1-point **Calibration** of the optical temperature sensor. As reference temperature, select either the connected Pt100 temperature sensor (needs to be calibrated first, see chapter 8.4) or enter a fixed temperature at constant temperature conditions (e.g. in a water bath).

Step 9: Start measurements and activate **Data Logging**.

3 SENSOR SETTINGS

Each optical temperature sensor comes with an individual **Sensor Code**, containing important information for optimal sensor settings and for calibration. The first letter of the sensor code defines the sensor type. Therefore, it is important to enter the Sensor Code of the connected sensor into the **Sensor Settings** of the respective software. The number of the channel tab must correspond with the channel number at the **FireSting** read-out device.

> **Important:** Enter the correct **Sensor Code** for sensors connected to a channel at a **FireSting** read-out device. The sensor code can be found on the label attached to the cable (fiber-based sensors) or on the bag of contactless sensors (see example below).

Next the **Measuring Mode** needs to be entered (refer to the **Pyro Workbench** or **FireSting-O2** (firmware 3) manual for further information). This can be adjusted gradually between low drift and low noise of the sensor signal by moving the arrow with the mouse along the scale. An intermediate mode is default.

The **Unit** of the temperature readings is **°C** (centigrade).

4 SENSOR CALIBRATION

Ensure that the correct **Sensor Code** has been entered in the settings (refer to chapter 3).

The 1-point calibration of optical temperature sensors can be performed against two different reference temperatures:

- the temperature measured by the external **Pt100 Temperature Sensor** (item **TDIP15** or **TSUB21**)
- a **Fixed Temperature** that needs to be determined and entered in the software (must be kept constant)

Note: For precise optical temperature sensor calibration using the External Temperature Sensor, it needs to be determined manually if the external (Pt100) temperature sensor has an offset. In case of an offset, the Pt100 temperature sensor needs to be calibrated first (see Appendix 8.4) before calibrating the optical sensor.

If a Manual Temperature was selected, the temperature in the sample/calibration standard must be measured, adjusted and kept constant (needs to be controlled)! Ensure constant and defined conditions!

- Gas measurements (only in combination with oxygen sensors): the sensor should be calibrated in ambient air at defined temperature
- Measurements in aqueous/water samples: the sensor has to be calibrated in water at defined temperature

Note: It is strongly recommended to perform the calibration at conditions close to the environmental temperature during measurements. Ensure constant temperature during calibration.

4.1 Calibration procedure

> **NOTE**: Calibration of the optical temperature sensor is only possible if the **correct Sensor Code** has been entered in the **Settings.**

Calibration should be performed following the instructions of the software (**Pyro Workbench**) or read-out device manual. It is generally recommended to perform a 1-point calibration in gas (*water*) for gas (*water*) measurements.

> **Important**: The device and sensors must be **placed for >30 min. under constant temperature conditions** before the calibration is performed.

For a calibration with the external temperature sensor (item no. **TDIP15** or **TSUB21**), ensure that the external temperature sensor is placed close to and exactly at the same temperature conditions as the optical temperature sensor.

For calibration against a fixed/manual temperature (°C), use a calibrated incubator (for measurements in the gas phase) or water bath of constant and known temperature (for measurements in water/aqueous samples).

When the sensor is placed into the calibration medium (air or water), wait until the sensor reading is stable by observing the graph and the numerical display of the temperature sensor reading. If all readings have reached their steady-state, calibrate the optical temperature sensor accordingly.

A completed calibration is indicated by the green indicator.

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5 SENSOR APPLICATION

PyroScience optical temperature sensors can be applied in gas phases and aqueous solutions, and are typically used for two different purposes:

- for precise and fast temperature measurements in water
- for true temperature compensation of **PyroScience** optical oxygen and pH sensor readings

Specific application and calibration instructions for different sensors are listed in the following table.

5.1 Fiber-based Sensors

Sensor item	Sensor-specific application instructions
TPR430	**Application**: water & gas & semi-solid samples **Calibration**: 1-point calibration **Note**: Handle with care to avoid injuries! Extend sensor tip for calibration and measurements.
TPF1100	**Application**: water & gas and semi-solid samples (only in combination with item **OXF1100**) **Note**: Handle with care! Unprotected fragile sensor tip.
TPB430	**Application**: water & gas & custom application **Calibration**: 1-point calibration **Note**: Handle with care, especially during custom integration! Unprotected fragile sensor tip. Avoid breakage!
TPIMP500	**Application**: water & gas & semi-solid samples & custom housings **Calibration**: 1-point calibration **Note**: Handle with care, especially during custom integration! Unprotected fragile sensor tip. Avoid breakage!

5.2 Contactless and combined sensors

Sensor item	Sensor-specific application instructions
TPSP5 	**Application:** water & gas (gas only with item **OXSP5**) **Calibration:** 1-point calibration **Features:** optical isolation **Sterilization:** 70% ethanol (EtOH), 70% isopropanol (ISPP), can be autoclaved (details on request) **Note:** Mind air bubbles! Glue carefully with silicone glue and let dry for 24h.
TPFLOW… 	**Application:** water & gas **Calibration:** 1- or 2-point calibration* **Features:** optical isolation **Sterilization:** 70% EtOH, 70% ISPP **Note:** Flow rate 1-500 mL/min. Remove air bubbles! Clean regularly.
TOVIAL… 	**Application**: water & gas **Calibration**: 1-point calibration for temperature sensor, 1- or 2-point calibration for oxygen sensor (see oxygen sensor manual) **Features**: optical isolation **Sterilization:** 70% ethanol (EtOH), 70% isopropanol (ISPP) **Note**: Remove air bubbles! Determine specific volume before measurements. Ensure stable temperature conditions.
PHTOVIAL … 	**Application:** water **Calibration**: 1-point calibration for temperature sensor, 1- or 2-point calibration in specified buffers/oxygen calibration standards (see oxygen and pH sensor manual) **Features**: optical isolation **Note**: Remove air bubbles! Determine specific volume before measurements. Ensure stable temperature conditions.

TOFTC2 	**Application:** water & gas **Calibration**: 1-point calibration for temperature sensor, 1- or 2-point calibration for oxygen sensor (see oxygen sensor manual) **Sterilization:** 70% ethanol (EtOH), 70% isopropanol (ISPP) **Note**: Liquid flow rate of 20-500 mL/min recommended. Remove air bubbles! Clean regularly.

6 STERILIZATION, CLEANING AND STORAGE

6.1 Sterilization

Refer to the specifications on the respective **PyroScience** website.

The temperature sensor spots (item no. **TPSP5**) can be autoclaved. More details on request. The temperature sensor spots and the combined sensors can be treated with 70% ethanol and 70% isopropanol.

All temperature sensor spots can be treated with UV light at a wavelength of 254 nm for 30 minutes, ca. 60 cm from the light source (max. 600 mW*s/cm2).

> **Important:** Do not use bleach, acetone or any solvent/agent not approved by **PyroScience**!

6.2 Cleaning and Storage

After the measurements, the sensor tip of the needle-type and bare fiber sensors should be rinsed carefully with demineralized water. The sensors can further be cleaned with 3% H2O2 and soap solution, followed by thorough rinsing with demineralized water.

After cleaning, let dry and put on the protective cap/tubing for storage in a dry, dark and secure place at room temperature. Put the black caps on the plug of the fiber to prevent that light is entering the fiber possibly causing photo-bleaching of the indicator.

For retractable sensors and application in samples with dissolved salts (e.g. seawater), the sensor must be cleaned thoroughly with demineralized water to prevent salt crystallization in the needle which can cause breaking of the sensor tip. **After drying**, retract the sensor tip into the needle and put on the protective cap onto the needle to protect the sensor tip and to avoid injuries.

> Store the sensor in a dry, dark and secure place at room temperature.

7 RELATED DOCUMENTS

Related documents for more detailed instructions on fiber-optic read-out devices, software and optical sensors are available:

- manual for logger software "**Pyro Workbench**" (Windows)
- manual for multi-analyte meter **FireSting-PRO**
- manual for oxygen meter **FireSting-O_2** (**FSO2-Cx**, firmware 4)
- manual for oxygen meter **FireSting-O_2** (**FSO2-x**, firmware 3 with **Oxygen Logger software**)
- manual for the **AquapHOx** Loggers or Transmitters
- manual for optical pH sensors
- manual for optical temperature sensors

8 APPENDIX

8.1 Temperature Measuring Principle

Optical temperature sensors rely on thermal quenching of photoluminescence. In this physical process, luminescent properties of the material are reversibly affected by temperature. The sensor response times are only limited by the dimensions of the sensor and are ultra-fast (<0.1 s in water), like in case of fiber-optic minisensors.

The utilized temperature-sensitive material is specially optimized to be fully compatible with the innovative **REDFLASH** technology from **PyroScience**, being excitable with orange red light (610-630 nm) and showing emission in the near infrared part of the spectrum. Importantly, the optical temperature sensors are characterized by extreme photo-stability, which enables virtually unlimited number of measurements, and does not show interferences with gases (such as oxygen) and ionic species.

8.2 Explanation of the Sensor Code

The temperature sensors are delivered with an attached sensor code which must be entered into the Settings (refer to chapter 3). The following figure gives a short explanation of the information given in the sensor code.

Example Code: DG6-310-479

Sensor Type

LED Intensity

Amplification

C0

C100

Sensor Type

C Optical Temperature Minisensor (**Thermoblue**)
D Optical Temperature Sensor Spot/FTC (**Thermogreen**)

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

OPTICAL TEMPERATURE SENSORS

C0 and **C100** values needed for calibration

8.3 Available sensors and read-out devices

8.3.1 FireSting devices

Sensor Type	Compatible read-out devices FSO_2-Cx/FSO_2-x	$FSGO_2$	FSPRO
TPR430	✓	✗	✓
TPF1100	✓	✗	✓
TPB430	✓	✗	✓
TPIMP500	✓	✗	✓
TPSP5	✓ with SPFIB-BARE/ SPFIB-LNS	✗	✓
TPFLOW	✓ with SPFIB-BARE	✗	✓
TOFTC2	✓ with SPFIB-BARE	✗	✓
TOVIAL4 / TOVIAL20	✓ with SPFIB-BARE	✗	✓
PHTOVIAL20	✓ with SPFIB-BARE	✗	✓

8.3.2 PICO devices

Sensor Type	Compatible read-out devices PICO-T
TPSP5	✓ with PICFIB2 / PICROD2
TPFLOW	✓ with PICFIB2
TOFTC2	✗

8.3.3 SUB-connector Devices

Sensor Type	Compatible read-out devices APHOX-x
TPR430-SUB	✓
TPF1100-SUB	✓
TPB430-SUB	✓
TPROBSC-SUB	✓

8.4 Pt100 Temperature Sensor Calibration

For precise absolute temperature readings and precise calibration of optical temperature sensors, an optional **1-point calibration of the external temperature sensor** Pt100 is recommended (except for **AquapHOx** devices).

For this, check the reading of the external temperature Pt100 probe periodically in stirred water / water bath / incubator of known temperature at steady state. It is also possible to prepare a water-ice-mixture giving 0°C, where at least 50 mm of the Pt100 temperature probe tip is submerged.

IMPORTANT: After calibration of the Pt100 temperature sensor, a new optical sensor calibration must be performed.

WARNINGS AND SAFETY GUIDELINES

Before using PyroScience oxygen sensors, carefully read the instructions and user manuals for the respective PyroScience read-out device. The manuals are available for download on www.pyroscience.com

Prevent mechanical stress (e.g. scratching) to the sensing surface at the tip of the temperature sensor! Avoid strong bending of the fiber-optic cables. They might break!

Ensure that the complete sensing surface at the tip is always covered by the sample and is free of air bubbles, and that liquid samples are stirred.

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

PyroScience **temperature sensors and read-out devices 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 therapeutic purposes. The sensors **must not** be brought in direct contact with foods intended for consumption by humans.

The sensors must 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 PyroScience temperature sensors and read-out devices out of reach of children! Store the temperature sensors in a secure, dry and dark place at room temperature.

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