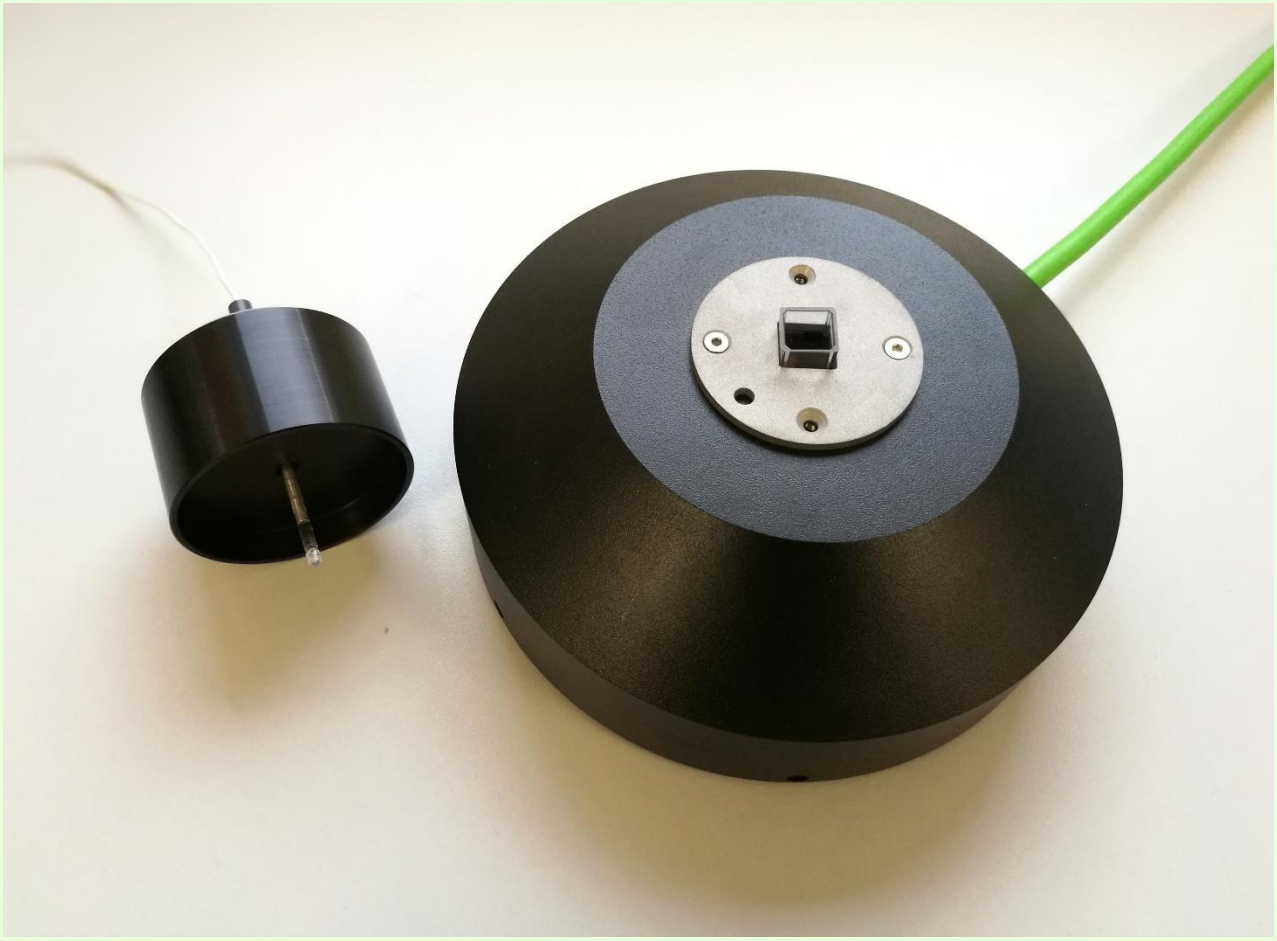
Oxygen detector module

Instruction Manual and User's Guide

Please read this manual before operating this product



PHOTON SYSTEMS INSTRUMENTS

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1 GENERAL INFORMATION

The oxygen detector module is an accessory device to Fluorometer FL60000 series which serves for monitoring of oxygen evolution in parallel with chlorophyll fluorescence measurement. The module consists of two parts – oxygen electrode (Fig. 1a) and AD converter (Fig. 1b).

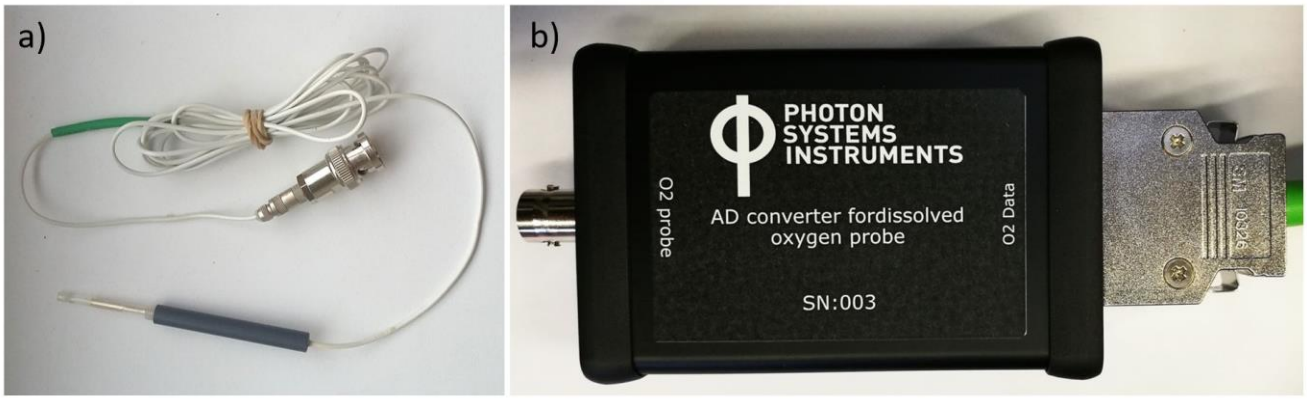

Fig. 1 Oxygen detector module components.

	Please note that the magnetic stirrer is necessary for proper function of the oxygen detector module.

1.1 OXYGEN ELECTRODE

The oxygen probe is a Clark type polarographic oxygen electrode. Its small size (and low oxygen consumption) is convenient for measurement of oxygen concentration in small volumes of solutions. The electrode is supplied by the company eDAQ. The operating manual is included inside the original electrode package. For more information, visit the manufacturer's website https://www.edaq.com/ET1120_Micro-Oxygen-Electrode.

1.2 AD CONVERTOR

The AD converter converts the AD signal from the electrode and provides digital readout. This module has two connectors:

- **O_2 data** connect the detector with **Channel 2** of the Fluorometer control unit via serial cable
- **O_2 probe** is the input for Oxygen electrode

1.3 AUXILARY PARTS OF OXYGEN MODULE

Serial cable

Serial cable serves for data transfer between Oxygen Detector and Fluorometer Control Unit.

Oxygen electrode holder (Fig. 2)

The holder ensures correct positioning of the oxygen electrode in the cuvette. The electrode membrane shoul be placed close to the stirring bar for fast response of dissolved oxygen measurement.

Fig. 2 Oxygen electrode holder.

1.4 FIRMWARE UPDATE

This procedure is not needed in case that Oxygen detector is delivered with Fluorometer at the same time. The manufacturer ensures that compatible firmware is loaded in FL control unit. Based on this firmware the Oxygen detector module can be operated.

Information about supported extensions are available on touchscreen display > Setup >About (Fig. 3).

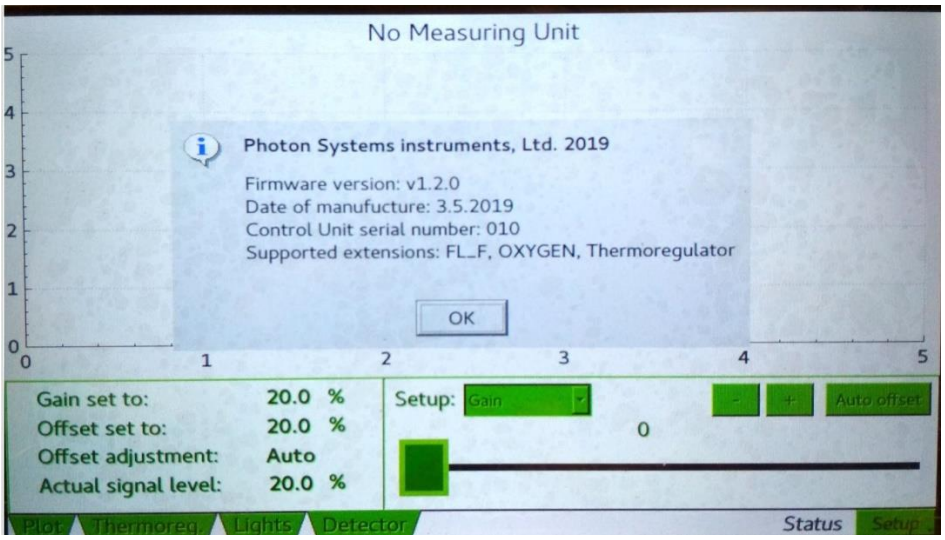

Fig. 3 Table with information about supported extensions.

	In case the Oxygen detector was ordered additionally, your FL 6000 control unit probably does not support it. Please follow FW Updating guide on USB stick for activation of Oxygen module function.

2 PROTOCOL FOR DISSOLVED OXYGEN MEASUREMENT

The simultaneous measurement of the dissolved oxygen and the chlorophyll fluorescence is provided by a customized protocol. The protocol is designed as a **Light curve protocol** comprising 5 light phases of different light intensities, predefined in ascending manner, with QY measurements at the end of each light phase (see graphs in Fig. 4 and Fig. 5). The dissolved oxygen is continuously read over the whole duration of the protocol.

The dissolved oxygen protocol consists of 5 equally long time periods with different light intensities. Light intensities are predefined to following levels:

0% (0 µmol.m^{-2}.s^{-1}),

8% (± 50 µmol.m^{-2}.s^{-1}),

10% (± 100 µmol.m^{-2}.s^{-1}),

13% (± 200 µmol.m^{-2}.s^{-1})

18% (± 400 µmol.m^{-2}.s^{-1}).

	Please note that the actinic light intensities mentioned above are approximate due to conversion between units in % and absolute light measurement in µmol.m^{-2}.s^{-1}. It is possible to change the intensities with respect to character of the sample. If so, please follow the light calibration specification for your measuring unit.

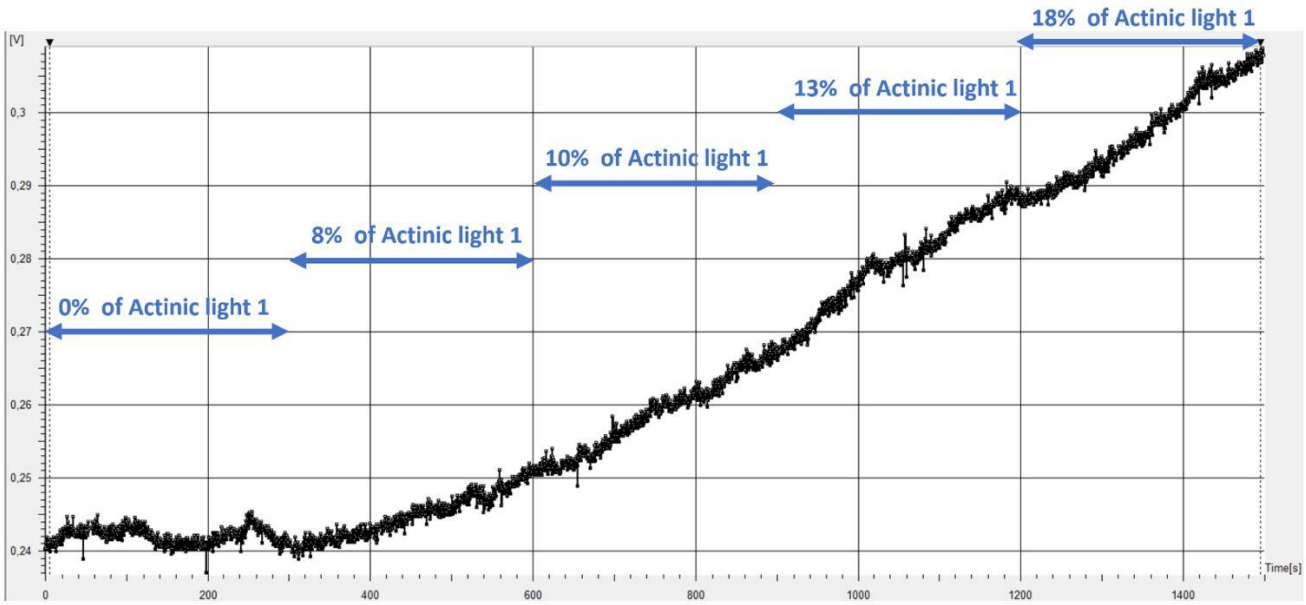

Fig. 4 Example of dissolved oxygen measurement on Chlorella vulgaris culture.

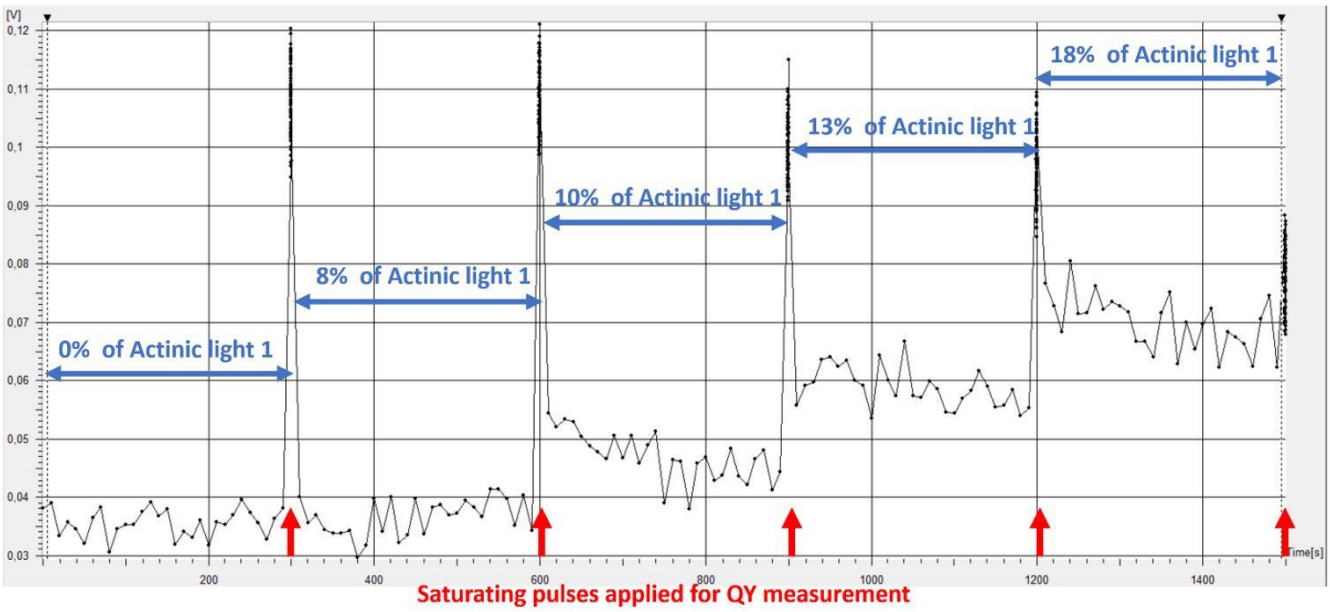

Fig. 5 Example of fluorescence measurement on Chlorella vulgaris culture.

2.1 PROTOCOL DESCRIPTION

The dissolved oxygen protocol is a custom protocol and does not correspond to any Wizard in the Fluorometer SW. The protocol is imported as follows:

1. Click on icon **New Experiment** on the top bar (Fig. 6). Window with blank experiment opens.

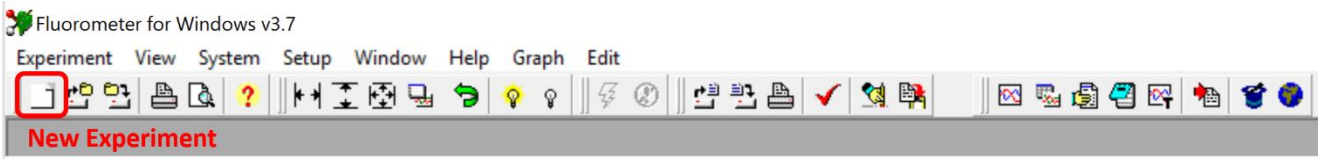

Fig. 6 Opening of new experiment.

2. Click on icon **Load Protocol** (Fig. 7).

Fig. 7 Protocol loading.

3. **Select** the required **protocol** (Fig. 8). Please note that protocols are saved in format *file name.p.*

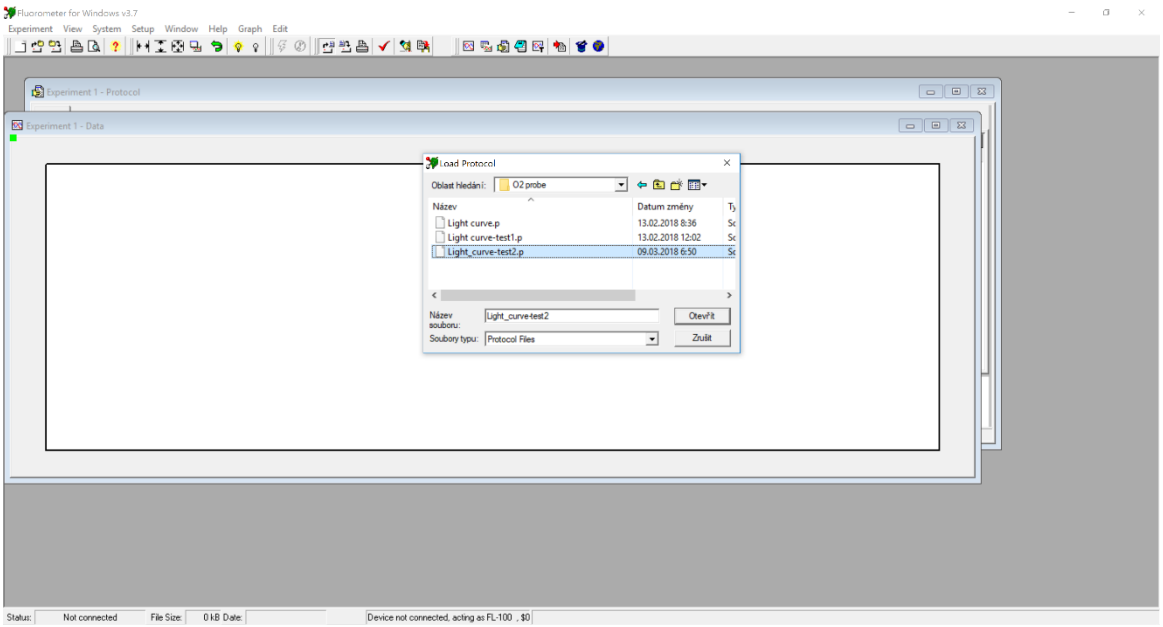

Fig. 8 Protocol selection.

2.2 PROTOCOL SYNTAX

Modifications of this protocol needs to be done directly in the protocol syntax window. Important variables are highlighted and described below.

Header

```
; Kautsky Effect - generated by wizard
; Version MS 2.4.0.0
MeasuringFlash=4us
MeasurDelay=3.5us
ActinicFlash=0us
AuxDuration=600s      ; Act. light interval
PreFlash=10us         ; PreFlash
include default.inc          ; Include standard options, don't remove it !
include detector.inc
;include thermoregulator.inc
M_Voltage=25Num       ;Measuring Flash 1 (Red) Intensity[0.0-100.0], test the optimal intensity using Meter protocol and avoid the actinic effect
F_Voltage=0Num        ; Actinic Flash Intensity[0.0-100.0]
A1_Voltage=0Num               ; Actinic light 1 (Red) Intensity[0.0-100.0]
A2_Voltage=0Num               ; Actinic light 2 (Blue) Intensity[0.0-100.0]
FAR_RED_Voltage = 0Num                ; FAR RED preillumination intensity[0.0-100.0]
;
```

Settings

```
;******************** Settings ***************************************
;
Stirrer_disable = 0          ;=0 enable stirrer during measurement, =1 disable
FAR_duration = 0;preillumination interval in seconds
Period = 300s             ;length of one  actinic light level in seconds
Stop=5*Period             ;last measurement after actinic light start

;---- SUPERPULSE ------------
Superpulse1_voltage = 80Num               ;intensity of superpulse 1 (red) <0,100%>
Superpulse_duration = 0.9s              ;length of the superpulse in sec,max. 1 sec
Fmax_time = 1s                          ;first Fmax pulse time
```

Predefined actions – related only to superpulses intended for Fm measurement

```
;***************** Predefined Actions ******************************************
;
; Fmax ACTION DEFINITION
Action Fmax_exp begin
 <0us>=>DA3(Superpulse1_voltage)
 ;<0us>=>DA5(Superpulse2_voltage)
 <50ms,60ms..Superpulse_duration-10ms>=>mfm1sub
 ;<Superpulse_duration>=>DA3(A1_Voltage)
; <Superpulse_duration>=>DA5(A2_Voltage)
end
;
```

Initialization

```
;***************** Initialization ***********************************
;
Experiment_duration = Stop+1ms+10ms          ;total experiment duration
include init.inc                             ;Initialization before experiment start
;
```

Actions

```
;***************** Actions ******************************************
; ACTINIC LIGHT ---------
<1ms>=>A1(Stop)

<0s>=>DA3(0)                                 ;intensities of actinic lights in percentage
<1*Period>=>DA3(8)
<2*Period>=>DA3(10)
<3*Period>=>DA3(13)
<4*Period>=>DA3(18)


; Ft  MEASUREMENT --------
;
<0s,10s..Stop>=>mfm1sub                      ; Ft reading every 10s
;
; O2  MEASUREMENT --------
<0ms,200ms..Stop>=>m2                        ; O2 reading every 200ms
;
; Fm MEASUREMENT --------
<1*Period - Fmax_time, 2*Period - Fmax_time, 3*Period - Fmax_time, 4*Period - Fmax_time, 5*Period - Fmax_time>=>Fmax_exp
 ;                                           ; Fm measurement before the end of light period
; MAGNETIC STIRRER  --------
<0s, 10s..Stop>=>A6(5s)                      ; stirrer switched ON every 10 s for 5s,
;
; End
```

	It is recommended to keep the magnetic stirrer timing (5s ON/5s OFF). Continuous operation of the stirrer causes sample heating, which affects the measurement results.

2.3 SIGNAL CONVERSION

Signal of dissolved oxygen is read in relative values – in voltage. It is recommended to perform calibration measurement, which enables recalculation of relative values to accurate dissolved oxygen amount in your liquid sample. The calibration measurement should include measurement of at least **two samples with defined oxygen concentration**. It is recommended to measure oxygen-free water and water with usual oxygen concentration.

	Please note that dissolved oxygen concentration in water is affected by water temperature.

Oxygen-free water

This calibration solution can be prepared in several ways. Here we presented two options:

a) Water bubbled with N_2 – use standard drinking water and bubble it for few minutes (based on the volume) before measurement.
b) Water with addition of sodium hydrosulfide ($Na_2S_2O_4$) – this chemical works as oxygen scavenger and removes all dissolved oxygen from the water.

Calibration protocol

Light curve protocol can be use also for calibration measurement. Only signal of the oxygen probe is important for the calibration, ignore fluorescence data. It is recommended to shorten the time period to e.g. 50s, time period is repeated 5 time in the protocol (total duration 250s).

```
;********************* Settings ***************************************
;
Stirrer_disable = 0          ;=0 enable stirrer during measurement, =1 disable
FAR_duration = 0;preillumination interval in seconds
Period = 50s                 ;length of one  actinic light level in seconds
Stop=5*Period                ;last measurement after actinic light start
```

Procedure

Prepare solutions for calibration (e.g. oxygen-free water and standard drinking water). Keep the probe submerged for at least 2 minutes in each calibration solution during the calibration measurement. In the graph (Fig. 9) is shown how the dissolved oxygen concentration has changed. For calculation use values of the curve where the signal is stable. Based on these two values calculate equation describing the correlation between relative values and oxygen concentration.

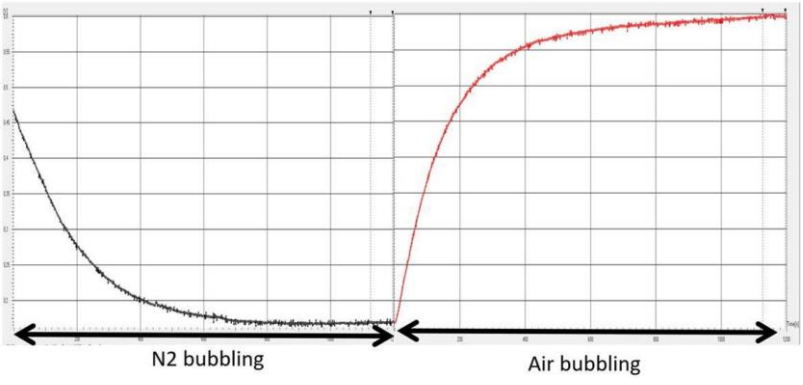

Fig. 9 Calibration measurement – oxygen-free solution bubbled with N2 (black) and solution bubbled with air (red).

3 WARRANTY TERMS AND CONDITIONS

- This Limited Warranty applies only to the Oxygen detector module device. It is valid for one year from the date of shipment.
- If at any time within this warranty period the instrument does not function as warranted, return it and the manufacturer will repair or replace it at no charge. The customer is responsible for shipping and insurance charges (for the full product value) to PSI. The manufacturer is responsible for shipping and insurance on return of the instrument to the customer.
- No warranty will apply to any instrument that has been (i) modified, altered, or repaired by persons unauthorized by the manufacturer; (ii) subjected to misuse, negligence, or accident; (iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions supplied by the manufacturer.
- The warranty is return-to-base only, and does not include on-site repair charges such as labor, travel, or other expenses associated with the repair or installation of replacement parts at the customer's site.
- The manufacturer repairs or replaces faulty instruments as quickly as possible; the maximum time is one month.
- The manufacturer will keep spare parts or their adequate substitutes for a period of at least five years.
- Returned instruments must be packaged sufficiently so as not to assume any transit damage. If damage is caused due to insufficient packaging, the instrument will be treated as an out-of-warranty repair and charged as such.
- PSI also offers out-of-warranty repairs. These are usually returned to the customer on a cash-on-delivery basis.
- *Wear & Tear Items* (such as sealing, tubing, padding, etc.) are excluded from this warranty. The term *Wear & Tear* denotes the damage that naturally and inevitably occurs as a result of normal use or aging even when an item is used competently and with care and proper maintenance.

4 TROUBLESHOOTING AND CUSTOMER SUPPORT

In case of troubles and for customer support, please, visit **FAQ** on our websites, write to **support@psi.cz** or contact your local distributor.