TriOS
Optical Sensors

enviroFlu

Operating instructions

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1 General information

1.1 Introduction

Welcome to TriOS. We are delighted that you have chosen our enviroFlu immersion sensor.

enviroFlu is an immersion probe for measuring oil in water. The measuring principle of UV fluorescence used is many times more sensitive than the conventionally used infrared scattering or absorption methods. This makes it possible to determine even the smallest traces of polycyclic aromatic hydrocarbons (PAH).

In this manual you will find all the information you need for commissioning the enviroFlu. Technical specifications as well as detection limits and dimensions can be found in chapter 7.

Please note that the user is responsible for complying with regional and national regulations for the installation of electronic devices. Any damage caused by incorrect use or unprofessional installation is not covered by the warranty.

All sensors and accessories supplied by TriOS Mess- und Datentechnik GmbH must be installed and operated in accordance with TriOS Mess- und Datentechnik GmbH specifications. All parts have been designed and tested according to international standards for electronic instruments. The device complies with international standards for electromagnetic compatibility. Please use only original TriOS accessories and cables to ensure smooth and professional use of the devices.

Read this manual carefully before using the device and keep it for future reference. Before using the sensor, make sure that you have read and understood the safety precautions described below. Always ensure that the sensor is operated correctly. The safety precautions described on the following pages are intended to ensure problem-free and correct operation of the device and the associated accessories and to prevent you, other persons or devices from being harmed.

NOTICE

If translations differ from the original German text, the German version is binding.

Software updates

This manual refers to software version 1.80 and higher. Updates include troubleshooting and new functions and options. Devices with older software versions may not have all the functions described here.

Copyright notice

1.2 Health and safety instructions

This manual contains important information on health and safety regulations. This information is marked in accordance with the international specifications of ANSI Z535.6 (“Product safety information in product manuals, instructions and other collateral materials”) and must be followed. The following categories are distinguished:

⚠ DANGER

Danger / Will cause serious injury or death

⚠ WARNING

Warnings / May cause serious injury or death

⚠ CAUTION

Caution / May cause moderate injury

NOTICE

May lead to material damage

Tip / Useful information

Electromagnetic waves

Devices that emit strong electromagnetic waves can influence the measurement data or cause the sensor to malfunction. Avoid operating the following devices in the same room as the TriOS sensor: cell phones, cordless phones, transceivers or other electrical devices that generate electromagnetic waves.

⚠ CAUTION

Never look directly into the light source without suitable UV protection! The UV light can irreversibly damage your eyes.

Reagents

Follow the manufacturer's safety and operating instructions when using reagents. Observe the applicable Ordinance on Hazardous Substances for Reagents (GefStoffV)!

Biological safety

Liquid waste may be biologically hazardous. You should therefore always wear gloves when handling such materials. Observe the currently valid Biological Substances Ordinance (BioStoffV)!

Waste

When handling liquid waste, the regulations for water pollution, drainage and waste disposal must be observed.

1.3 Warning notices

This sensor has been developed for use in industry and science. It should only be used to measure aqueous solutions such as drinking water, process waste water, river water or seawater.

NOTICE

Sensors made of stainless steel are not made for use in seawater or high chloride concentrations (corrosion). Only sensors made of titanium can be used here.

- Sensors made of stainless steel must be cleaned immediately after contact with salt water or other corrosion-causing substances (e.g. acids, alkalis, chlorine-based compounds). The material resistance should be tested for each application.
- The sensor has seals made of NBR (acrylonitrile butadiene rubber). Sealing rings made of other materials may be used on individual request. Before operation, ensure that the measuring medium does not damage the seals.
- Do not cut, damage or modify the cable. Make sure that there are no heavy objects on the cable and that the cable does not kink. Ensure that the cable does not run close to hot surfaces.
- If the sensor cable is damaged, it must be replaced with an original part by TriOS Mess- und Datentechnik GmbH customer support.
- Do not place any unsuitable objects on the (optical) measurement window while the measurement process is running, as this may cause damage to the sensor or falsified measurement results.
- Stop operation of the sensor if excessive heat is generated (i.e. more than lukewarm). Switch off the sensor immediately and disconnect the cable from the power supply. Please contact your dealer or TriOS technical support.
- Never attempt to disassemble or modify any part of the sensor unless specifically described in this manual. Inspections, modifications and repairs may only be carried out by the device dealer or TriOS authorized and qualified specialists.
- Devices from TriOS Mess- und Datentechnik GmbH comply with the highest safety standards. Repairs to the devices (which include the replacement of the connection cable) must be carried out by TriOS Mess- und Datentechnik GmbH or an authorized TriOS workshop. Incorrect, improper repairs can lead to accidents and injuries.

NOTICE

TriOS does not guarantee the plausibility of the measured values. The user is always responsible for monitoring and interpreting the measured values.

1.4 User and operating requirements

The enviroFlu fluorometer was developed for use in industry and science. The target group for operating the enviroFlu is technically experienced specialist personnel in companies, sewage treatment plants, waterworks and institutes.

The application often requires the handling of hazardous substances. We assume that the operating personnel are familiar with the handling of hazardous substances due to their professional training and experience. In particular, the operating personnel must be able to correctly understand and implement the safety markings and safety instructions on the packaging and in the package inserts of the test kits.

1.5 Intended use

The intended use of the enviroFlu is exclusively to carry out fluorometric measurements as described in this manual. In this respect, the enviroFlu fluorometer is an immersion sensor that is used under water or with flow-through cells. Please observe the technical data of the accessories. Any other use is considered improper.

This device has been developed for use in research and industry. It may only be used to measure the fluorescence of aqueous liquids such as process wastewater, river water or seawater. The use of other media can damage the sensor. For the use of the enviroFlu in media other than those specified here, please contact the technical support of TriOS Mess- und Datentechnik GmbH (support@trios.de).

NOTICE

Avoid any contact with the measurement window, as it can become scratched or dirty. As a result, the functionality of the device is no longer guaranteed.

According to current scientific knowledge, the device is safe to use if it is handled in accordance with the instructions in this operating manual.

NOTICE

Damage caused by improper use is excluded from the warranty.

1.6 Disposal instructions

At the end of its service life or useful life, the device and its accessories can be returned to the manufacturer (see address below) for disposal in an environmentally friendly manner. Proof of prior professional decontamination must be provided in the form of a certificate. Please contact us before returning the device for further details.

Address of the manufacturer:

TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
26180 Rastede
Rastede, Germany
Phone: +49 (0) 4402 69670 - 0
Fax: +49 (0) 4402 69670 - 20

1.7 Certificates and approvals

The product meets all requirements of the harmonized European standards. It therefore meets the legal specifications of the EU directives. TriOS Mess- und Datentechnik GmbH confirms the successful testing of the product by affixing the CE mark (see appendix).

The enviroFlu also has type approval in accordance with MEPC.340(77) and MEPC.259(68) for monitoring PAH concentrations as specified in the regulations. Please note the restrictions on the use of the enviroFlu (see chapter 4.4 and appendix).

2 Introduction

Measurement of hydrocarbons

Hydrocarbons occur frequently in the environment and varying concentrations of hydrocarbons in waste water are not uncommon. Hydrocarbons can occur free-floating as particles, emulsified, dissolved or adsorbed on suspended solids. By definition, hydrocarbons are chemical compounds that are composed exclusively of hydrogen and carbon. They are generally divided into 3 main classes: aliphatic, alicyclic and aromatic hydrocarbons. Only aromatic hydrocarbons fluoresce so that they can be detected with the enviroFlu.

Due to their persistence, toxicity and ubiquitous distribution, PAHs are of great importance as pollutants in the environment. Nowadays, an increasing burden of hydrocarbons is observed in our waters, mainly due to industrial processes and human influences. The natural ability of water to break down hydrocarbons is being overstretched and the environmental consequences are burdening drinking water, fish stocks, microorganisms and much more.

Typical anthropogenic causes of hydrocarbon inputs include, for example, the processes involved in refining crude oil into gasoline, lubricants, kerosene, diesel, etc. In addition, the resulting trade products enter the environment through discharges from road asphalt, fuel storage (e.g. at airports and in workshops), means of transport (bilge water), cooling water systems, production facilities such as automotive, plastics and steel factories and many more.

The UV fluorescence method is a sensitive method for detecting aromatic hydrocarbon compounds in water. Fluorescence is generally understood to be a phenomenon in which part of the radiation absorbed at a certain wavelength by the compound of interest is re-emitted at a higher wavelength. Certain compounds, including the aromatic hydrocarbons, absorb energy when the water is excited by light at a certain wavelength in the UV range and re-emit this light at a higher wavelength. This happens by increasing the energy level of individual electrons of the atoms.

The energy sent back (in the form of light) is lower in energy and is therefore recognized as light of a higher wavelength. Each individual compound has a specific wavelength range during re-emission that is typical for the respective compound, so that the compound in question can be detected by measuring the fluorescent light at these wavelengths. Detection limits for online measurement values in the low µg/L range are therefore possible via fluorescence.

Like all TriOS sensors, the enviroFlu is pre-calibrated and supplied in the LOW channel so that the sensor is ready for immediate use. The LOW channel offers a low amplification, whereby it is also possible to switch to the HIGH channel, which offers a high amplification (small measuring range).

2.1 Variants

enviroFlu is available in three different variants, which are characterized by different hardware features: enviroFlu HC, enviroFlu HC MB and enviroFlu BT. In addition, enviroFlu HC and enviroFlu HC MB are also each available with the measuring ranges 500 and 5000, which are permanently assigned and cannot be changed at a later date.

enviroFlu HC

enviroFlu HC has both an analog (4...20 mA / 0-5 VDC) and a digital (RS-232) interface and communicates exclusively via the TriOS data protocol. It is available in two variants with different measuring ranges: enviroFlu HC 500 offers a measuring range of up to 500 µg/L PAH, whereas the enviroFlu HC 5000 version has a measuring range of up to 5000 µg/L PAH. Where reference is made to enviroFlu HC in this document, the information also applies to the enviroFlu HC MB version, unless explicitly stated otherwise.

enviroFlu HC MB

enviroFlu HC MB has different hardware and has a digital RS-485 interface that communicates via the Modbus RTU protocol. The analog interface is omitted here. Two variants with different measuring ranges are also available here: enviroFlu HC MB 500 offers a measuring range of up to 500 µg/L PAH, whereas the enviroFlu HC MB 5000 version has a measuring range of up to 5000 µg/L PAH.

enviroFlu BT

enviroFlu BT is recommended for the detection of monoaromatics (benzene, toluene and xylene, also known as BTX). It has the same features as the enviroFlu HC, but is equipped with different filter sets and measures in a measuring range of 0 to 10,000 µg/L.

All variants have switchable amplification and can therefore measure in HIGH and LOW channels. The variants can also be ordered with different housing materials such as stainless steel, titanium, deep sea housing and acid-resistant housing. Both a SubConn connector and a fixed cable with a length of 0.5 m, 2 m, 5 m and 10 m are available as connection options.

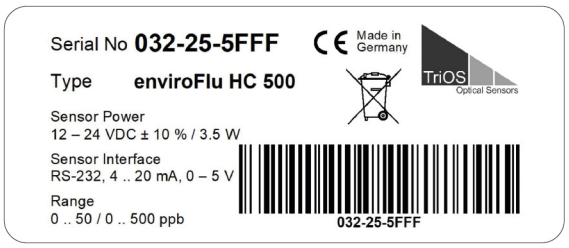
2.2 Product identification

All TriOS Mess- und Datentechnik GmbH products are provided with a product label that clearly shows the product designation.

There is also a type plate on the device with the following information, which you can use to clearly identify the product:

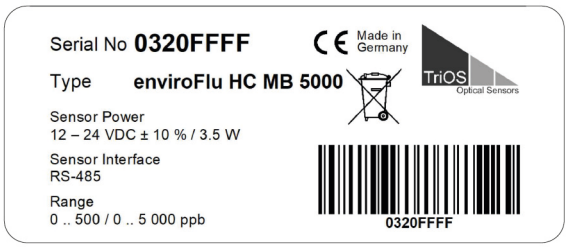
enviroFlu HC

Serial number
Product type
Power supply
Interface
Measuring range



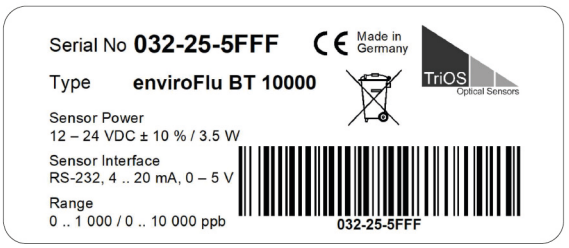
enviroFlu HC MB

Serial number
Product type
Power supply
Interface
Measuring range



enviroFlu BT

Serial number
Product type
Power supply
Interface
Measuring range



The nameplate also contains the product barcode, the TriOS Optical Sensors logo and the CE quality mark.

Please note that the specifications given here are for illustrative purposes only and may vary depending on the product version.

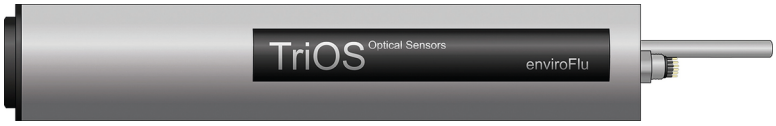
2.3 Scope of delivery

The delivery includes the following components:

1. Sensor
2. Operating instructions
3. Accessories (if applicable)

Keep the original packaging of the device for possible return for maintenance or repair purposes.

2.4 Measuring principle and structure

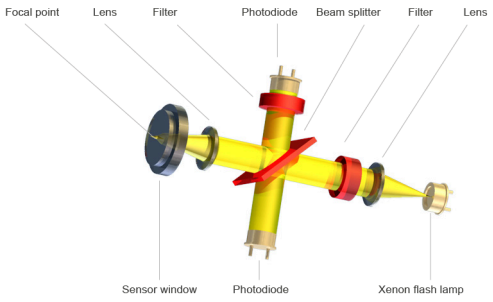


For optimal use of the sensor, it is inevitable to know and understand the idea and theory on which the sensor is based. The following is a thorough overview of the measuring principle, the optical arrangement and the subsequent calculation.

The enviroFlu HC immersion fluorometer detects polycyclic hydrocarbons in real time by directly measuring the fluorescence emissions in a sample. The PAHs are excited by a highly efficient xenon flash lamp. A high-quality interference filter is used to select the wavelength required to excite the PAH fluorescence.

A small proportion of the excitation light is reflected by a dichroic beam splitter (short-wave pass) and used as a reference signal to evaluate fluctuations in the excitation energy.

Structure of the sensor



The excitation beam is focused by a lens onto a point approx. 2 mm in front of the window. The fluorescent light is collected by the same lens, reflected by the dichroic beam splitter due to its longer wavelength and finally detected by a UV-sensitive photodiode. An interference filter (center wavelength: 360 nm) is used to block scattered light and select the fluorescent light. A specially developed circuit eliminates the influence of ambient light (constant light suppression). The figure above shows the basic optical configuration.

With enviroFlu BT, an interference filter with a center wavelength of 305 nm is used.

3 Commissioning

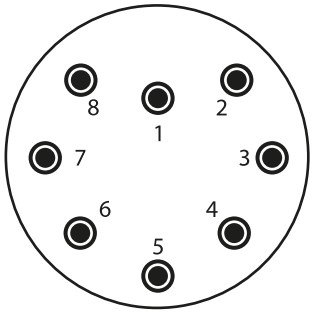
This chapter deals with the Commissioning of the sensor. Pay particular attention to this section and follow the safety precautions to protect the sensor from damage and yourself from injury.

Before putting the sensor into operation, make sure that it is securely fastened and that all connections are made correctly.

3.1 Electrical installation

The enviroFlu is supplied with a male SubConn 8-pin underwater connector or a fixed cable with an M12 industrial plug.

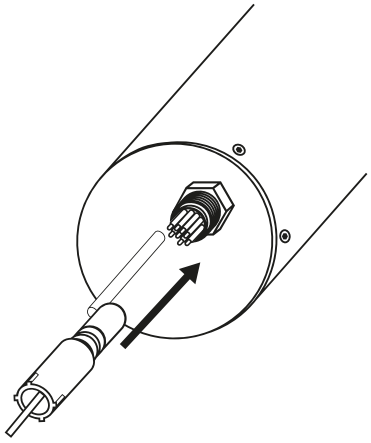
3.1.1 SubConn-8pin connector



Face view (male)

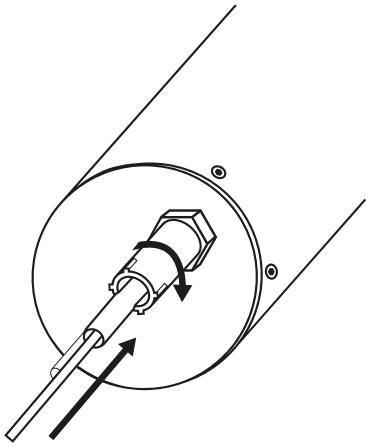
Assignment for enviroFlu HC & BT	Assignment for enviroFlu HC MB
1. GROUND (power + serial interface)	1. GROUND (power + serial interface)
2. RS-232 RX (commands)	2. RS-485 A
3. RS-232 TX (data)	3. RS-485 B
4. POWER (12-24 VDC)	4. POWER (12-24 VDC)
5. VOUT: 0-5 VDC	5. DO NOT CONNECT
6. iout: 4...20 mA	6. DO NOT CONNECT
7. ANALOG GROUND	7. DO NOT CONNECT
8. DO NOT CONNECT	8. DO NOT CONNECT

Step 1



Plug the connector end of the connection cable onto the connector plug by aligning the pins with the slots on the cable.

Step 2

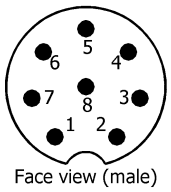


In the next step, turn the locking sleeve clockwise to secure the plug end to the bulkhead connector.

NOTICE

Do not bend the connection back and forth when inserting or removing it. Insert the connector straight and use the locking sleeve to tighten the pin contact.

3.1.2 Fixed cable with M12 industrial plug



Face view (male)

Assignment for enviroFlu HC & BT	Assignment for enviroFlu HC MB
1. RS-232 RX (commands)	1. RS-485 A
2. RS-232 TX (data)	2. RS-485 B
3. VOUT: 0-5 V	3. DO NOT CONNECT
4. ANALOG GROUND	4. DO NOT CONNECT
5. IOUT: 4...20 mA	5. DO NOT CONNECT
6. DO NOT CONNECT	6. DO NOT CONNECT
7. ground (power + serial interface)	7. GROUND (power + serial interface)
8. power (12-24 VDC)	8. POWER (12-24VDC)

3.2 Interfaces enviroFlu

The enviroFlu fluorometer has a digital interface (RS-232 or RS-485) and two analog outputs (RS-232 only; see pin assignment in the previous section).

3.2.1 Digital interfaces

The digital interface is an RS-232 interface that works with the TriOS data protocol and the Modbus RTU interface is an RS-485 interface.

The interfaces must be configured as follows (9600, 8N1):

RS-232
- Baud rate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: none
- Flow control: Software (XON / XOFF)

RS-485
- Baud rate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: none
- Flow control: none

A detailed description of the data protocol commands can be found in the appendix.

enviroFlu HC MB does not have an analog interface.

3.2.2 Analog interfaces

The enviroFlu has two analog interfaces. The 0-5 V output and the 4...20 mA output are linear to the measuring range. The unit of the measured values is µg/L PAH (or anisole equivalent for enviroFlu BT). To convert the values of the mA analog output accordingly, the following formula must be used:

$$PAH\ [\mu g/L] = \frac{analog\ value\ [mA] - 4\ [mA]}{16\ [mA]} \cdot upper\ limit\ of\ the\ measured\ value^*$$

To calculate the values of the 0-5 V output, the following formula is used.

$$PAH\ [\mu g/L] = \frac{analog\ value}{5} \cdot upper\ limit\ of\ the\ measured\ value^*$$

*As a rule 500 µg/L PAH or 5 000 µg/L PAH (for enviroFlu BT 10 000 µg/L)

3.3 Measurement

enviroFlu can perform a measurement in two different channels - the HIGH channel with high amplification for the small measuring range, and the LOW channel with low amplification for the large measuring range. TriOS always delivers the devices in the LOW channel.

An enviroFlu HC 500 is therefore preset at the factory in the measuring range 0 - 500 µg/L, an enviroFlu HC 5000 in the measuring range 0 - 5 000 µg/L and an enviroFlu BT in the measuring range 0 - 10 000 µg/L.

Device type and measuring range

Device type	Measuring range LOW channel	Measuring range HIGH channel
enviroFlu HC (MB) 500	0 - 500 µg/L PAH	0 - 50 µg/L PAH
enviroFlu HC (MB) 5000	0 - 5 000 µg/L PAH	0 - 500 µg/L PAH
enviroFlu BT 10000	0 - 10 000 µg/L PAH	0 - 1 000 µg/L PAH

As soon as a direct power supply to the enviroFlu is established, the measurements start in “Continuous” mode. For each measured value, 12 measurements are triggered and the average value is output, for which the enviroFlu requires around 5 seconds.

3.3.1 Connection without controller

If enviroFlu is to be integrated directly into a process control system (PCS), the pin assignment for SubConn or fixed cable described in chapter 3 “Commissioning” should be observed.

For integration into a DCS, we recommend using one of the two analog outputs. These are designed for 4...20 mA or for 0-5 VDC as described in chapter 3 “Commissioning” and can be used for analog data transmission.

Other alternatives without a controller are data communication via the TriOS protocol or Modbus RTU:

- enviroFlu HC and enviroFlu BT use the TriOS protocol for data communication. In the appendix of this manual you will find a detailed description of the interface settings and the TriOS protocol commands.
- enviroFlu HC MB supports the Modbus RTU protocol for data communication. The appendix of this manual contains a detailed description of the interface settings and possible Modbus RTU commands.

3.3.2 Connection to the TriBox3

If enviroFlu HC or enviroFlu BT are to be connected to a TriBox3, the COM port to which the sensor is to be connected must be reconfigured to the TriOS protocol:

“Sensor” → “Select COM port” → under “Protocol” → select “TriOS” (all other settings are set automatically by the TriBox3).

The sensor can now be connected and should be recognized by the controller. The “Continuous” mode is temporarily deactivated.

When connecting an enviroFlu to a TriBox3 for the first time, the sensor type is specified as “undef” (not identified) under “Sensor” → “enviroFlu”.

The device type must be set under “Sensor” → “enviroFlu_XXXX” → “Device type”. You can choose between “500” or “5000”. “Undef” stands for not identified.

Attention: The device type should not be confused with the measuring range.

NOTICE

enviroFlu BT has a measuring range of up to 10 000 µg/L. The measurement results must be multiplied by a factor of 2 after the measurement. “Sensor” → “Select parameters” → Enter “Scaling”. The parameter name for enviroFlu BT can be changed from TriBox3 software version 1.5.4.

NOTICE

enviroFlu HC MB supports the Modbus RTU protocol, the COM port can therefore remain configured to the factory settings RS-485 and Modbus RTU. enviroFlu HC MB automatically transmits the device type (500 or 5000).

The display settings can now be made (see TriBox3 manual).

3.3.3 Connection to the TriBox mini

If enviroFlu is to be connected to a TriBox mini, the COM port to which the sensor is to be connected must be configured to the TriOS protocol and RS-232:

“Sensor” → “Select COM port” → Protocol: “TriOS” → Hardware mode “RS-232” → Set flow control: “Software”.

The sensor can now be connected and should be recognized by the controller. The “Continuous” mode is temporarily deactivated.

When connecting an enviroFlu to a TriBox mini for the first time, the sensor type is not yet recognized.

Switch to service mode: “Options” → Service mode"

The device type can be set with “Sensor” → “enviroFlu_XXXX” → “Device type”. You can choose between “500” or “5000”.

Attention: The device type should not be confused with the measuring range.

NOTICE

enviroFlu BT has a measuring range of up to 10 000 µg/L. The measurement results must be multiplied by a factor of 2 after the measurement. “Sensor” → “Select parameter” → Enter “Scaling”. The parameter name remains PAH and cannot be changed.

NOTICE

enviroFlu HC MB supports the Modbus RTU protocol, the COM port can therefore remain configured to the factory settings RS-485 and Modbus RTU. enviroFlu HC MB automatically transmits the device type (500 or 5000).

The display settings can now be made (see TriBox mini manual).

4 Application

The enviroFlu can be operated with all TriOS controllers. You will find notices for correct installation in the respective controller manual.

NOTICE

Never transport the sensor just hanging on the cable.

4.1 Normal operation

4.1.1 Diving operation

For diving operation, the enviroFlu can be completely or partially immersed in the water / measuring medium. For a correct measurement, the measurement window must be completely submerged. A distance of at least 10 cm should be maintained in front of the measurement window in order to obtain a correct measurement. Objects or surfaces that are close to the measurement window would reflect the fluorescence signal and the measured value would be too high.

Use the mounting rod with a shackle and a stainless steel chain or steel wire to suspend the device in the medium. Do not carry or pull the sensor by the sensor cable. The mounting rod cannot be used with a cable length of 0.5 m.

The enviroFlu can also be attached to the pool edge or a float using suitable hydraulic clamps (see illustration below). Make sure to use suitable brackets with an inner diameter of 68 mm (not for the deep sea version). To protect the housing tube from excessive punctual pressure, mount the clamps close to the device covers. Suitable brackets can be obtained from TriOS.

Attachment to the shackle

Fastening with hydraulic clamps

When immersing the sensor, make sure that there are no air bubbles in front of the sensor discs. If there are air bubbles in front of the window, shake the sensor carefully until the bubbles are removed.

4.1.2 Cleaning system

Nano-coating

All TriOS optical windows are equipped with an innovative anti-fouling technology to prevent dirt and deposits on the optical windows: Nano-coated windows in combination with compressed air cleaning.

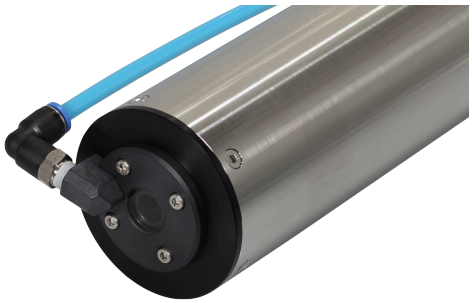
Windows without nano coating

Windows with nano coating

The wettability of the surface on the coated glass is significantly lower. This effect is caused by the nano-coated surface of the glass, to which no dirt adheres. In combination with compressed air cleaning, the windows are kept clean for even longer, which reduces the cleaning effort and extends the service life of the sensor.

Compressed air cleaning

The enviroFlu can be modified with the optional compressed air cleaning head. The head has an air outlet directly on the disk of the device and a hose fitting for connecting compressed air.
TriOS controllers have software-controlled valves that can be set to fixed flushing intervals. The compressed air flushing head may be operated with a pressure of 3 bar to 6 bar.



NOTICE

The optimum pressure for compressed air cleaning is between 3 and 6 bar. The total length of the hose should not exceed 25 meters. Suitable hoses are available from Trios (polyurethane, 6 mm outer diameter, 4 mm inner diameter)

To connect the hose to the pressure flushing head, carefully push the hose into the connection. To disconnect it again, press the blue retaining ring towards the connection and pull the hose out. If necessary, secure the hose to the device and the cable with cable ties to prevent uncontrolled flailing of the compressed air hose. A tight-fitting air hose, which is also fixed to the sensor, prevents tangling.

NOTICE

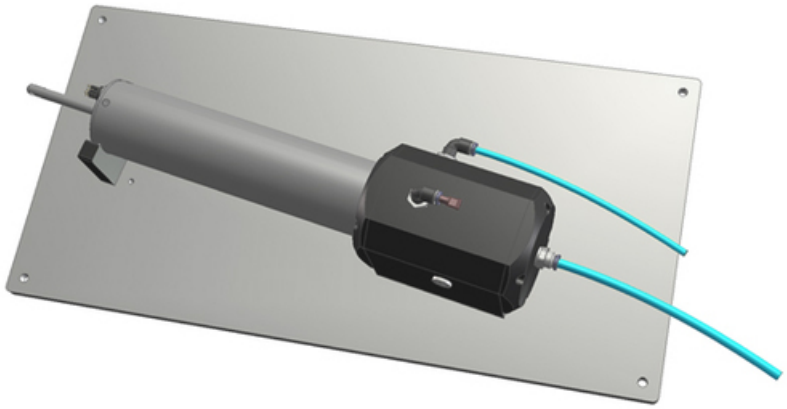
The pressure must not exceed 7 bar! Valve damage could occur!

4.1.3 Float

The float is the ideal solution for applications with fluctuating water levels.

4.2 Bypass installation

With the optional flow cell, the enviroFlu can be installed as a bypass. Together with the flow cell, a panel is available on which the enviroFlu and the flow cell can be easily mounted.



NOTICE

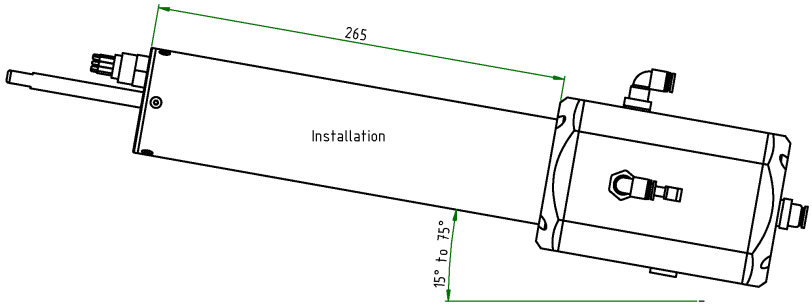
The maximum pressure in the flow cell must not exceed 1 bar. Make sure that the sensor is installed in the correct position to ensure a free flow of water and avoid air in front of the window. When using an enviroFlu in an EGC Water Analyzer, other holders are used. This means that a higher pressure can be used there.

Follow the steps below to install the enviroFlu in the flow cell:

1. Remove the pressure ring of the flow cell with o-ring by loosening the four screws with the 4 mm Allen key provided (6 mm for the newer FlowCell).
2. First slide the pressure ring onto the enviroFlu, then the o-ring and insert the enviroFlu into the flow cell (see example illustration). The device must protrude between 265 mm and 275 mm from the flow cell and must not cover any inlet or outlet inside.
   On newer FlowCell models, there is a small ledge inside which determines the position of the sensor. In this case, the sensor only needs to be pushed in as far as the ledge and is automatically in the correct position.
   A stop bracket on the panel ensures that the sensor is positioned correctly in the flow cell. Make sure that the sealing ring is well seated and not damaged. Suitable o-rings are available as spare parts from TriOS.
3. When the position of the enviroFlu is correct, tighten the screws.

Use the illustrations as a guide to install the flow cell correctly.

The FlowCell together with the enviroFlu should be mounted at an angle between 15° and 75° to the horizontal.



To avoid air bubbles, the outlet should be at the top and the inlet at the bottom. Tighten the screws of the flow cell hand-tight using the appropriate Allen key to prevent leaks and ensure a free flow of water.

To connect the hose to the flow cell, carefully push the hose into the connection. To disconnect it again, push the blue locking ring towards the connection and pull the hose out.

NOTICE

To avoid damage, you should check the FlowCell regularly when using it in pH ranges < 4.

NOTICE

The flow cell cannot be combined with compressed air cleaning.

NOTICE

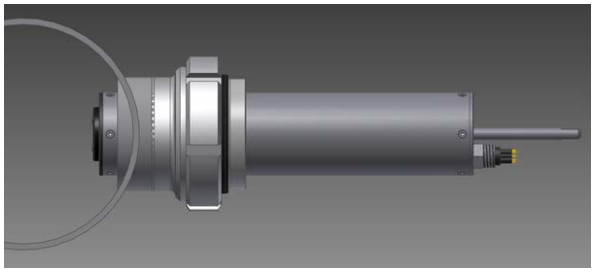
Negative pressure can damage the sensor.

4.3 Pipe installation

The enviroFlu in the version with pre-mounted flange DN80 (DIN11851) can be installed directly in the pipe. In the case of an earthed pipe, no additional earthing of the enviroFlu housing is required (as long as no in-

sulation is fitted between the pipe and the sensor). Pipe installation is also possible in conjunction with compressed air cleaning (DN100).

The available DN80 flange solution from TriOS is shown in the illustration below.



4.4 Operation with ship approval according to IMO regulations

The enviroFlu HC has a type approval according to IMO regulations MEPC.340(77) and MEPC.259(68) for monitoring the PAH concentration in the effluent water of exhaust gas cleaning systems. The PAH-p value measured by enviroFlu corresponds to µg/L $_{PAHphe}$ equivalent. The enviroFlu HC covers the flow rates described below for the discharge of waste water (see table below).

PAHphe $_{concentration}$ as a function of flow rate according to MEPC.340(77)

Flow rate [t / MWh]	Discharge concentration limit value [µg/L PAHphe equivalents]	Sensor type	Measuring range
0...1	2250	Ultraviolet only*	
2,5	900	Ultraviolet only*	
5	450	enviroFlu HC 5000	0 - 800 µg/L PAHphe $_{eq.}$
11,25	200	enviroFlu HC 5000	0 - 800 µg/L PAHphe $_{eq.}$
22,5	100	enviroFlu HC 5000	0 - 800 µg/L PAHphe $_{eq.}$
45	50	enviroFlu HC 5000	0 - 800 µg/L PAHphe $_{eq.}$
		enviroFlu HC 500	0 - 80 µg/L PAHphe $_{eq.}$
90	25	enviroFlu HC 5000	0 - 800 µg/L PAHphe $_{eq.}$
		enviroFlu HC 500	0 - 80 µg/L PAHphe $_{eq.}$

*Alternative measurement methods can be used with the approval of the administration.

The measuring range depends on the specified wash water flow rate and can be adapted to the requirements according to resolution MEPC.340(77) of November 26, 2021:

“2021 Guidelines for exhaust gas cleaning systems” - Section 10: “Discharge Water”

“Guidelines for exhaust gas cleaning systems 2015” (Section 10: “Discharge water”)

The use of UV measurement technology is recommended for all discharge flow rates ≤ 2.5 t / MWh. Under the supervision of DNV, it has been demonstrated that the enviroFlu HC is suitable for flow rates ≥ 5 t / MWh. For this approval, the specifications as described in 4.4.1 - 4.4.5 must be complied with.

4.4.1 Specifications according to MEPC.340(77)

The ship approval assumes an operating temperature between 5 °C and 55 °C. The above measuring ranges can be warranted at temperatures from 5 °C to 40 °C.

4.4.2 Installation

The enviroFlu HC can be mounted directly into a pipe (either with the special flange version of the enviroFlu HC or on-site installations by the customer). In the case of a grounded pipe, no additional grounding of the enviroFlu housing is required (as long as there is no insulation between the pipe and the sensor). The avail-

able standardized flange solution from TriOS is shown in the illustration on p. 16. Please ensure a minimum distance of 10 cm between the measurement window and the inside of the pipe during installation.

With the flow cell (FlowCell), the enviroFlu HC can be installed as a bypass (see chapter 4.2).

Make sure that the housing of the enviroFlu is earthed for this type of application!

4.4.3 Electrical installation

Applications with ship approval as mentioned above must be set up with an enviroFlu HC with a fixed cable of maximum 5 m length. The shielded cable has an M12 industrial plug as connection.

The sensor must be connected to an external control unit for power supply (12 VDC or 24 VDC) and recording of measurement data.

The shielding of the M12 industrial plug must also be earthed (see chapter 3.1.2 M12 industrial plug).

4.4.4 Data conversion

The unit of the measured values is µg/L $_{PAKphe}$ equivalent. To convert the values of the mA analog output accordingly, the following formula must be used:

$$PAH_{phe}eq\ [\mu g/L] = \frac{analog\ value\ [mA] - 4\ [mA]}{16\ [mA]} \cdot upper\ limit\ of\ the\ measured\ value$$

4.4.5 Turbidity correction

A turbidity correction of the measured values is absolutely necessary. The enviroFlu must measure simultaneously with a turbidity sensor. The measured values of the $_{PAKphe}$ equivalent must be converted using the following equation for turbidity correction. This formula must be implemented in the software of the controller or logger.

Calculation of the turbidity-corrected measured value $_{I0}$ in µg/L $_{PACphe}$ equivalent:

$$_{I0} = I \cdot (0.018 \cdot x - 0.00004 \cdot {}^{x2} + 1)$$

Measured values of enviroFlu = I [µg/L $_{PAHphe}$ eq], as calculated in the formula under 4.4.4

Turbidity = x [NTU], value of the TTurb*

Turbidity-corrected measured value = $_{I0}$ [µg/L $_{PAHphe}$ eq]

*For turbidity values from 220 FNU, x=220 is used in the calculation

5 Calibration

Creating a generally valid calibration for PAH in water is an impossible task. The main reason for this is that PAHs have very different water solubilities and fluorescence yields. The fluorescence spectra of different PAHs have their maxima at different wavelengths. This is further complicated by the fact that most samples consist of a mixture of different PAHs. Diesel or gasoline, for example, contain a wide range of polycyclic aromatic hydrocarbons and their composition varies not only due to the manufacturing process, but also due to the type of crude oil used.

TriOS has therefore developed its own calibration standard for PAH fluorescence - the TriOS Fluorescence Calibration Standard (TFCS) - which is used in the manufacturer calibration of the enviroFlu HC. This is based on phenanthrene. 10 µg/L phenanthrene generates a signal of 62 µg/L TFCS, which means that the enviroFlu measures 62 µg/L.

The tables in Chapter 5.3 provide an overview of the measurement behavior of enviroFlu HC for various aromatic hydrocarbons dissolved in water compared to the TriOS fluorescence standard TFCS.

5.1 Manufacturer calibration

All TriOS sensors are supplied calibrated. The calibration factors of the enviroFlu are stored in the sensor, i.e. all output values (digital or analog) are calibrated values.

The conversion of the raw value of the fluorescence measurement into substance concentration is explained below.

The scaling factor and offset are stored in the sensor for each measuring range (both LOW and HIGH).

The manufacturer calibration of the enviroFlu is carried out as follows:

- The offset is determined by measuring in ultrapure water (free of humic and fulvic acids, 18.2 MΩcm water)

  A**= Raw - Offset**

- The scaling factor for each measuring range is determined by using the TriOS Fluorescence Calibration Standard (TFCS). A linear approximation is used for the channel with high signal amplification:

  Calibrated = A · lin

- Fluorescence quenching (quenching effects) at high concentrations means that the calibration is no longer linear. Therefore, a quadratic approximation is used for the measurement channel with low amplification (LOW).

  Calibrated = A · lin +^{A2} · square

with

A	Offset-corrected value
Raw	Fluorescence Raw data
offset	Offset value
Calibrated	Concentration of the substance in physical units
lin	Linear factor
square	Square factor

NOTICE

The manufacturer calibration should not be changed!

5.2 Customer calibration

5.2.1 Calibration with measuring media

The sensor can be adapted to laboratory analyses and local conditions with other calibration factors. This is done using the “Custom calibration” function of the controller. To do this, open the submenu under the “Parameters” button in the “Sensor” menu and enter the offset and the scaling factor. The customer calibration or local calibration works in addition to the manufacturer calibration, the values of which are not changed by the customer calibration.

Customer calibration is used to fine-tune the sensor to special media and supplements manufacturer calibration.

The local calibration (Custom Calibrated) is adjusted using the following linear equation:

Custom Calibrated = (Calibrated - Offset) · Scaling

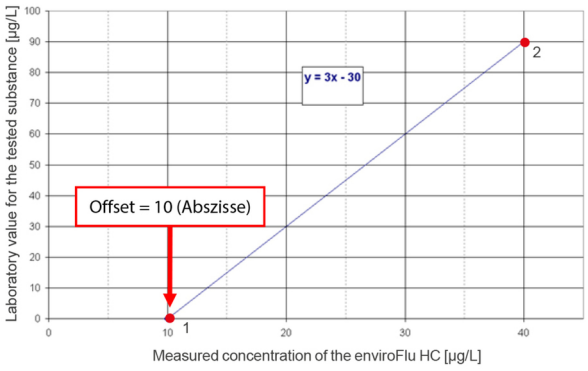
“Calibrated” refers to the original concentration that is output by the fluorometer.

At least two data points consisting of the laboratory value and the sensor value are required for local calibration. To do this, you need a sample that is not contaminated with PAH and a sample that is contaminated with PAH.

1. The sample not contaminated with PAH is used to determine the offset. Ultrapure water with 18.2 MΩ is best suited. Immerse the fluorometer in the uncontaminated liquid. In this special case, the signal directly indicates the value of the offset for the local calibration.

   Offset = measured value1

   If no uncontaminated sample is available, the equation listed under 5. offers another option.
2. Now immerse the sensor in the contaminated medium and note the measured value2 that the fluorometer outputs and carry out a laboratory analysis of the sample.
3. Create a diagram as shown below and connect the two data points with a straight line. The Slope of the straight line is the scaling factor.



4. The scaling factor can be calculated using the following equation:

$$Skalierungsfaktor = \frac{Labor}{Messwert2 - Offset}$$

with *laboratory* for the laboratory values and *measured value* for the values output by the sensor.

This means for the example in the picture above:

$$Scaling\ factor = \frac{90\ \mu g/L}{(40 - 10)\ \mu g/L} = 3$$

5. If no sample not contaminated with PAH is available, you need at least two samples with as different PAH contamination as possible. In this case, the scaling factor is calculated first.

$$scaling\ factor = \frac{(lab2 - lab1)}{(measuredvalue2 - measuredvalue1)}$$

Calculation of the offset without zero point measurement (1.) :

$$offset = measuredvalue2 - \frac{lab2}{Scaling\ factor}$$

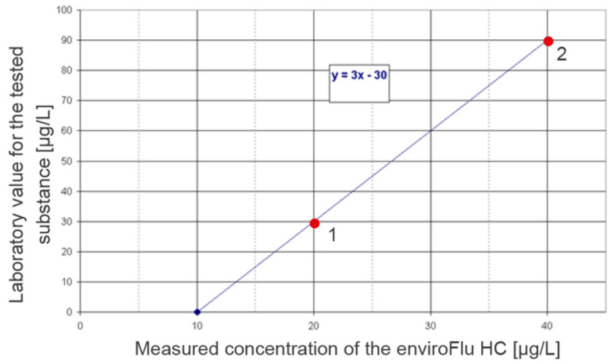
Measured value2 should be significantly greater than measured value1.

The offset is also determined by the abscissa of the straight line (X-axis intersection).

This means for the example given:

$$scaling\ factor = \frac{90 - 30}{40 - 20} = 3$$

$$offset = 40 - \frac{90}{3} = 40 - 30 = 10$$



An offset caused by ageing can be eliminated by customer calibration up to the limits listed in the table below. If the offset determined in this way is greater than in the following table, either the sample is contaminated or the measurement window is defective. If this can be ruled out, there is a defect in the sensor.

Measuring range	Offset to air PAH (max.)	Measuring range	Offset to air PAH-p (max.)
0 - 50 µg/L PAH	20 µg/L PAH	0 - 8 µg/L PAH-p	3.22 µg/L PAH-p
0 - 500 µg/L PAH	60 µg/L PAH	0 - 80 µg/L PAH-p	9.68 µg/L PAH-p
0 - 5000 µg/L PAH	200 µg/L PAH	0 - 800 µg/L PAH-p	32.26 µg/L PAH-p

5.2.2 Calibration with DryCAL

Measuring principle and design

DryCAL-0 and DryCAL-1 consist of a fluorescent glass cylinder embedded in a holder and protected by a glass pane.

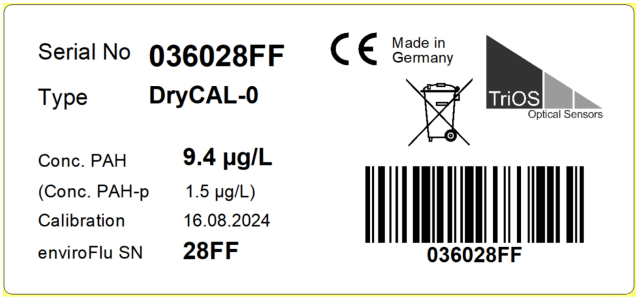
The measurement is carried out using the UV fluorescence method. The particles integrated in the glass are excited by the UV light of the enviroFlu's highly efficient xenon flash lamp at 254 nm. These particles emit a defined fluorescence signal at 360 nm, which is detected by the sensor. The special shape of the DryCAL ensures precise application and prevents the penetration of ambient or extraneous light.

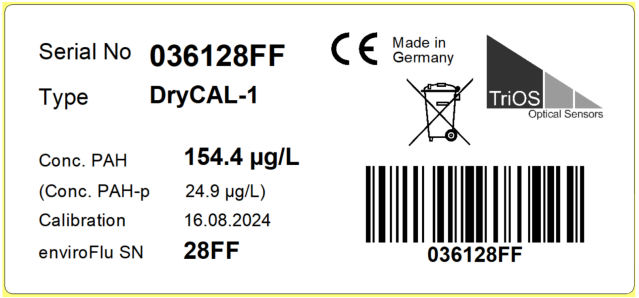
Parameters

The DryCAL set was developed for testing the measurement of polycyclic aromatic hydrocarbons (PAH) with the enviroFlu HC. The enviroFlu detects PAH in a measuring range of 0 - 50 µg/L, 0 - 500 µg/L or 0 - 5 000 µg/L (enviroFlu HC 500, enviroFlu HC 5000).

Each individual DryCAL generates a signal that corresponds to a specific concentration, which is noted on the type plate. The serial number of the corresponding enviroFlu is also noted. The picture shows an example of such type plates.

- DryCAL-0 for measuring the zero value (offset)
- DryCAL-1 for measuring the Slope (scaling)





Warning notices

- The DryCAL set has been developed for use in industry and science. It can only be used with the associated enviroFlu.
- It is used to check the function and is used when calibration is required.
- Only use the DryCAL set in air. Use in other media can damage the product.
- Protect the DryCAL set from environmental influences. Never expose it to sunlight, precipitation or dust.
- Store the DryCAL set in a dry place and preferably in the transport box supplied.
- Never attempt to dismantle or modify the DryCAL set. Inspections, modifications and repairs may only be carried out by the appliance dealer.
- If a visual inspection reveals fissures, scratches or cracks on the glass, the DryCAL set should be sent to TriOS Mess- und Datentechnik GmbH together with the associated enviroFlu for inspection.
- The DryCAL set must always be sent in for maintenance together with the enviroFlu.

DryCAL application

The DryCAL set can only be used together with the respective enviroFlu HC 500 or enviroFlu HC 5000. Both products have been precisely matched to each other in the manufacturer's laboratory so that the measured value can only be checked in combination with the corresponding enviroFlu. The serial number of the corresponding sensor is printed on the type plate. The zero value (offset) is determined with DryCAL-0 and the Slope (scaling factor) with DryCAL-1.

NOTICE

The calibration with DryCAL-0 (offset) should first be carried out in both channels (HIGH and LOW) of the respective enviroFlu. For the subsequent calibration of the Slope (DryCAL-1), the enviroFlu must be set to the 500 channel.

Procedure

1. Check DryCAL-0 and DryCAL-1 for scratches and dust. If both DryCALs are clean, you can first place them on a clean, lint-free cloth with the glass side facing down.
2. To calibrate the sensors, the TriBox3 must be set to maintenance mode.
3. Thoroughly clean the front area of the enviroFlu (see chapter 6).
4. The measurement window should be free of dirt and fingerprints. If possible, use optical, lint-free paper for cleaning. For heavier soiling, you can also use acetone. You can use the empty acetone bottle supplied in the DryCAL set. When cleaning, make sure that the optical window is not scratched and no longer has a coating.
5. Once cleaning is complete, calibration of the sensor can begin.
6. Follow the instructions of the TriBox3 calibration wizard (from version 1.5.2). For other variants, use the form attached to the DryCAL quick guide for the calculation of offset and scaling.
7. If offset and scaling have already been set for the sensor, this must be reset to offset = 0 and scaling = 1 before measuring with DryCAL.

Offset (DryCAL-0)

- Place DryCAL-0 on the enviroFlu
- Wait 2 minutes until the measured values become more stable
- Trigger at least 16 measurements (calculate the average value and enter it in the log)
- The difference between the measured value and the printed value is the offset
- Enter the offset in the controller or enter it as a correction factor in your data logger

Slope (DryCAL-1)

- If not already done, switch to the 500 channel (LOW for enviroFlu 500, and HIGH for enviroFlu 5000)
- Place the DryCAL-1 on the sensor
- Wait 2 minutes until the measured values become stable
- Trigger at least 16 measurements (insert the average of the measured values into the log, making sure that the offset is included in the measured values output)
- Calculate the scaling and enter it in the log
- Enter values for the scaling in the controller or as a correction factor in the data logger to adjust the following measured values.

Corrected value = (measured value - offset) · Scaling

NOTICE

For TriBox3 in the EGC WA variant (8-digit hexadecimal serial number starting with 751...), these steps are integrated in the wizard from version 1.4.38.

NOTICE

The Slope in the 500 channel is correct for both channels of the enviroFlu.

5.3 Measuring properties of the enviroFlu

5.3.1 Measurement parameters

Hydrocarbons are divided into 3 main classes: aliphatic, alicyclic and aromatic hydrocarbons. Only aromatic hydrocarbons fluoresce so that they can be detected with the enviroFlu.

Due to their persistence, toxicity and ubiquitous distribution, PAHs are of great importance as pollutants in the environment. The U.S. Environmental Protection Agency (US EPA) has included 16 substances in its list of “priority pollutants”. These substances form a group of organic compounds that all consist of several interconnected aromatic ring systems and have different solubilities depending on their structure.

Parameters PAH and PAH-p

According to IMO MEPC.340(77), the parameter “PAH-phenanthrene equivalent (PAH-phe eq, PAH-p in enviroFlu)” is “...calibrated against a known set of phenanthrene concentrations...”.

The parameter PAH-p is calculated in enviroFlu directly from the PAH with the factor 6.2. enviroFlu HC MB provides the measurement results of PAH and PAH-p in different Modbus addresses. The digital measurement result from enviroFlu HC must be divided by 6.2 to obtain the result for PAH-p.

The **TriBox3**, installed in an **EGC Water Analyzer**, provides both the PAH and PAH-p units.

EPA-PAH	Solubility in water	Solubility in water	Hazard classification			
Naphthalene	32 mg/L at 25 °C	slightly soluble				
Acenaphthylene	3.93 mg/L at 25 °C	almost insoluble				
Acenaphthene	3.8 mg/L at 25 °C	almost insoluble				
Fluorene	1.9 mg/L at 25 °C	almost insoluble				
Phenanthrene	0.73 - 1.6 mg/L at 25 °C	almost insoluble				
Anthracene	1.29 mg/L at 25 °C	insoluble				
Fluoranthene	0.22 mg/L at 25 °C	insoluble				
Pyrene	0.14 mg/L	almost insoluble				
Benzo(a)anthracene	0.044 mg/L at 24 °C	insoluble				
Chrysene	0.006 mg/L at 25 °C	insoluble				
Benzo(b)fluoranthene	0.0012 mg/L at 25 °C	insoluble				
Benzo(k)fluoranthene	0.0122 mg/L	insoluble				

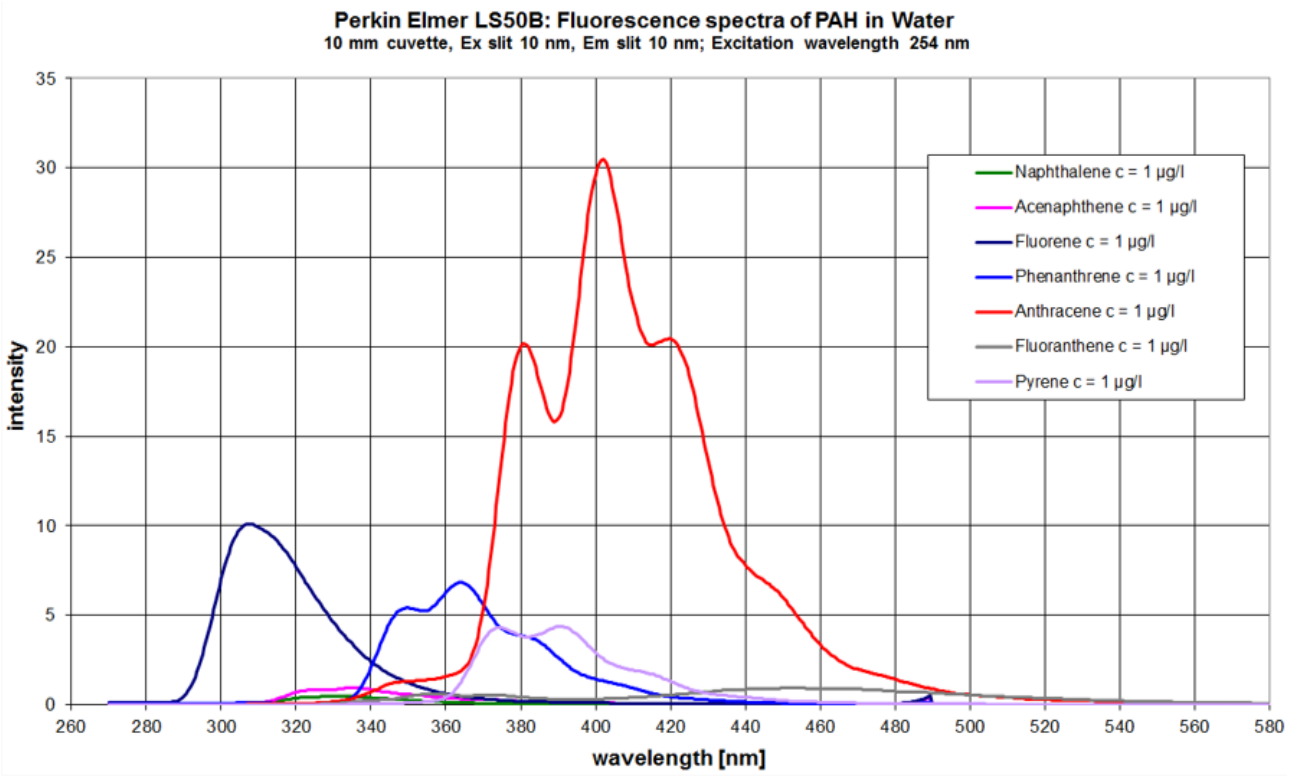
EPA-PAH	Solubility in water	Solubility in water	Hazard classification			
Benzo(a)pyrene	0.0045 mg/L at 15 °C - 30 °C	insoluble				
Dibenzo(a,h)an-thracene	0.0025 - 10-6 mg/L	insoluble				
Indeno(1,2,3-cd)pyrene	0.062 mg/L	insoluble				
Benzo(g,h,i)perylene	0.3 - 10-6 g/L at 20 °C	insoluble				

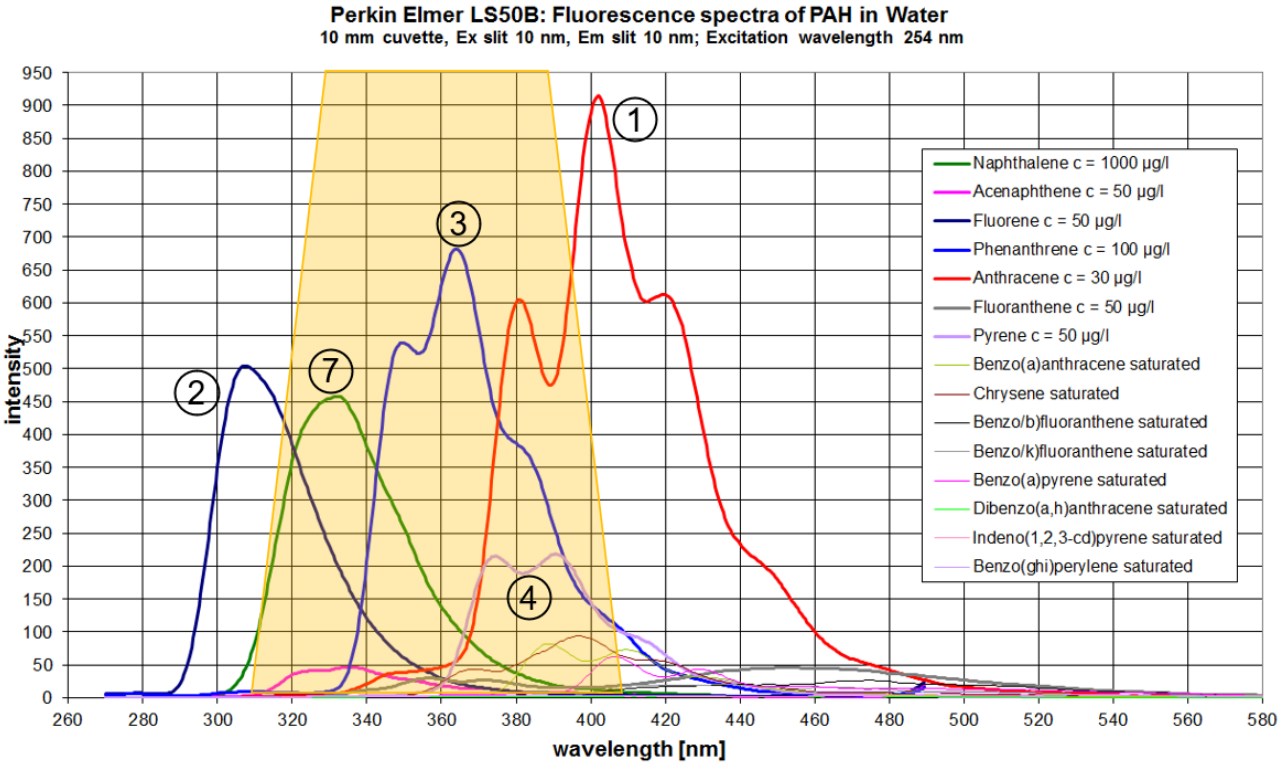
 flammable

 hazardous to health

 hazardous to the environment

 acutely toxic





The intensity of the emission of individual PAHs at 360 nm varies greatly, as does the composition of PAHs in different mineral oils. Therefore, no universal calibration for PAH in water is possible for all areas of application. Naphthalene and phenanthrene have the highest concentration in waste water from exhaust gas cleaning systems on ships and in crude oil. However, as naphthalene is very volatile and the fluorescence signal is also very weak, phenanthrene is used for calibration.

Phenanthrene	Naphthalene
High fluorescence intensity	Low fluorescence intensity
More stable	Less stable
Less volatile	More volatile
Less toxic	More toxic
Almost insoluble	**Poorly soluble**
360 nm ± 50 nm filter fits and hits all PAHs	The proposed filter will not capture all PAHs
Easier to handle	Difficult to handle

With enviroFlu, excitation takes place at 254 nm and detection at 360 nm. In a sample, you always get a signal of all PAHs contained and thus have the sum of all fluorescence signals at 360 nm. The unit PAH refers to the average sum of the laboratory results of 16 EPA PAHs.

The following tables show the measured values of enviroFlu for the detection of PAH, various aromatic substances and various oils dissolved in distilled water. The conversion factors of different aromatic hydrocarbons in relation to the TriOS fluorescence calibration standard are given. These factors are only indicative of a possible measurement result of enviroFlu HC for a specific concentration of a PAH, as these factors were measured for a single concentration and not for the entire calibration curve. The data may vary slightly from sensor to sensor, as the built-in filters have certain tolerances.

The value of the individual substance is calculated as follows: Measured value of the enviroFlu HC in µg/L PAH multiplied by the PAH-specific factor (see table in 5.3.3) of an individual substance gives the PAH concentration of the individual substance.

$c_{env} \cdot \text{factor} = c_{PAK}$

Or the concentration of an individual PAH (e.g. phenantrene) divided by the PAH-specific factor (see table in 5.3.3) gives the measured value of the enviroFlu HC µg/L PAH.

$c_{PAK} \div \text{factor} = c_{env}$

Example:

1 µg/L TFCS = 1 PAH, produces the same measured value as 0.16 µg/L phenanthrene

1 µg/L TFCS = 1 PAH, produces the same measured value as 0.27 µg/L anthracene

Other PAHs that are not among the 16 environmentally harmful PAHs classified by the US EPA can also occur in waters. These also fluoresce and are detected by enviroFlu HC. These include PAH isomers, alkylated PAHs and PAHs with heteroatoms (N-, S-, O-atoms bound).

NOTICE

Substances with a high conversion factor are poorly or not at all soluble in water. The fluorescence properties of various substances may differ from those of the TFCS.

5.3.2 Methods for comparative measurements

Dissolving oil in an aqueous medium is problematic due to the low solubility of oils in water. It is also difficult to simulate real conditions in the laboratory.

In reality, oil in water is dissolved by

- Long exposure time
- Flow
- Wind and wave action
- Solubilizers

Various methods are used in the laboratory to dissolve oil in water:

To dissolve oil in water in the laboratory, 1 - 2 drops of oil are pipetted onto the surface of 1 - 2 L of water to create approximately real conditions. This solution should be stirred for 24 hours. The organic phase can then be separated with a separating funnel and measured with the enviroFlu.

For another method, a stock solution of oil in ethanol is prepared first. An aliquot of this can be added to the water.

Notes on the following tables:

a) Type of solution:
   1) directly
   2) Solution of the substance in a stock solution of ethanol for dilution with distilled water
   3) Two drops of oil in 2 L dist. Water for 24 hours.
b) 1 µg/L TFCS corresponds to x µg/L substance
c) TFCS = TriOS fluorescence calibration standard

5.3.3 Measurement behavior for EPA-PAH

The EPA PAHs are the 16 most important polycyclic aromatic hydrocarbons. These 16 substances have been assessed by the US EPA as the highest priority pollutants due to their toxicity and ubiquitous occurrence.

The first table provides an overview of the 16 EPA PAHs:

Substance	Conc. in dist. Water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
TFCS [c]					
EPA PAHS	The 16 “most important” PAHs, determined by the US EPA				
Naphthalene	500	2	134	3,73	
Acenaphthylene				-------	No fluorescence
Acenaphthene	50	2	26,8	1,87	
Fluorene	50	2	81,4	0,61	
Phenanthrene	8	2	50	0,16	
Anthracene	30	2	112	0,27	
Fluoranthene	50	2	26,9	1,86	
Pyrene	50	2	115	0,44	
Benzo(a)anthracene	10	2	8,7	1,15	
Chrysene	5	2	7,42	0,67	
Benzo(b)fluoranthene	saturated	2	0,57		
Benzo(k)fluoranthene	saturated	2	0,01	-------	Barely soluble in water
Benzo(a)pyrene	saturated	2	1,74	-------	Barely soluble in water
Dibenzo(a,h)anthracene	saturated	2	1,09	-------	Barely soluble in water
Indeno(1,2,3-cd)pyrene	saturated	2	0,37	-------	Barely soluble in water

Substance	Conc. in dist. Water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
Benzo(g,h,i)perylene	saturated	2	0,05	-------	Barely soluble in water

5.3.4 Measurement behavior of alkylated PAHs and PAHs with heteroatoms

The following table lists the measurement behavior for a selection of alkylated PAHs and PAHs with heteroatoms.

Substance	Conc. in dist. water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
1-Methylnaphthalene	250	2	72,1	3,47	
2-Methylnaphthalene	250	2	127	1,97	
Carbazole	50	2	448	0,11	
Dibenzofuran	50	2	48,3	1,04	
Dibenzothiophene	50	2	20	2,5	

5.3.5 Measurement behavior with different oils

Different oils show varying measurement results, as shown in the table below using a few examples.

Substance	Conc. in dist. water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
Gasoline					
Esso Super gasoline	5000	2	35,6	140	
Kerosene					
Jet A1	10000	3	23,8	420	
Diesel oils					
Diesel Esso	500	2	39,2	12,8	
Diesel Esso	5000	3	139	36	not completely dissolved
Heating oil	10000	3	264	37,9	Not completely dissolved

Substance	Conc. in dist. water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
Marine diesel oil (MDO)	10000	3	115	87	not completely dissolved
Marine diesel oil (MGO)	10000	3	187	53	not completely dissolved
Heavy oils					
Heavy fuel oil	20000	3	107	187	not completely dissolved
IFO 80-100	20000	3	318	31	not completely dissolved
Crude oils					
Crude oil Brent (North Sea)	10000	3	139	72	Not fully dissolved
Crude oil Karachaganak (Kazakhstan)	10000	3	89,3	112	Not fully dissolved
Crude oil Forties (British North Sea)	10000	3	131	76	Not fully dissolved
Crude oil Debno (Poland)	10000	3	100	100	Not completely dissolved
Crude oil Ob Bay (Russia)	10000	3	109	92	Not fully dissolved
Crude oil Albacora Leste (Brazil)	10000	3	176	57	Not completely dissolved
Lubricants					
Hydraulic oil	8000	3	4,39	1822	hardly soluble in water
Shell Omala 320	15000	3	23,3	644	hardly soluble in water
Shell 1662	15000	3	2,29	6550	insoluble in water
Motoroil BP	15000	3	1,28	7812	insoluble in water

Lubricants are often synthetic and not mineral oils. As they are practically insoluble in water, detection with enviroFlu is usually not possible. Edible oils do not contain PAHs and therefore cannot be measured with enviroFlu.

5.3.6 Measuring behavior with monoaromatics

The enviroFlu HC cannot be used for the detection of most monoaromatics such as benzene, toluene and xylene (BTX). The use of enviroFlu BT is recommended here.

Substance	Conc. in dist. water	Type of solution	Output enviroFlu HC	Factor x	Comment
	[µg/L]		[µg/L]		
Benzene	200000	1	1,93	104000	
Toluene	20000	1	2,11	9500	
p-Xylene	20000	1	18,3	1093	
Chlorobenzene	20000	1	0,25	------	Value below detection limit
Fluorobenzene	10000	1	4,86	2058	
Propylbenzene	10000	1	0,77	13000	
Styrene	1000	1	305	3,28	
Phenol	4300	1	58,7	73	
Biphenyl	538	2	293	1,84	

The following table shows the measurement behavior of an enviroFlu BT with monoaromatics.

Substance	Conc. in dist. water	Type of solution	Output enviroFlu BT	Factor x	Comment
	[µg/L]		[µg/L]		
Anisole	10000	1	10000	1	
p-Xylene	2000	2	684	3	
Toluene	10000	1	768	32	
Benzene	10000	1	96	100	

Different methods of dissolving oil in water and different concentrations lead to different factors. Therefore, the factors in the above table are only to be understood as a notice of a possible measurement result under the specified conditions.

5.3.7 Interferences

Colored Dissolved Organic Matter - CDOM

In natural environments, humic and fulvic acids, also known as yellow substances or CDOM (colored dissolved organic matter), can interfere with PAH detection. Therefore, depending on the application and the required PAH detection limit, a correction of the fluorescence measurement value may be necessary. This correction can either be made using a fixed correction factor (provided the concentration of the substances interfering with the measurement is constant) or with the help of a second fluorometer with special wavelength settings for humic and fulvic acids.

Temperature

The warmer the sample or the measuring medium, the less fluorescence occurs.

Quenching effects

Fluorescence quenching at high concentrations means that the calibration is no longer linear.

6 Malfunction and maintenance

To ensure error-free and reliable measurement, the device should be checked and maintained at regular intervals. To do this, the sensor must first be cleaned.

6.1 Cleaning and care

Deposits (fouling) and dirt depend on the medium and the duration of exposure to the medium. Therefore, the degree of soiling depends on the application. For this reason, it is not possible to give a general answer as to how often cleaning of the sensor is necessary.

Normally the system is kept clean by the nano-coated window and additionally by the air purification system. If the soiling is too severe, the following instructions should be followed.

NOTICE

Damage caused by improper cleaning is not covered by the warranty!

6.1.1 Housing cleaning

⚠ CAUTION

Please use protective goggles and gloves when cleaning the sensor, CAUTION especially if acids or similar are used for cleaning.

To loosen solid dirt, we recommend soaking the sensor in a rinsing solution for a few hours. Exposed plug connections should be avoided during any cleaning so that they do not come into contact with water. For this purpose, please always ensure that the locking cap of the connector is firmly closed during cleaning. Please inform yourself thoroughly about the risks and safety of the cleaning solution used.

If the sensor is very dirty, additional cleaning with a float may be necessary. You should exercise extreme caution to avoid scratching the glass of the optical path.

In case of calcification, a 10% citric acid solution or acetic acid solution can be used for cleaning.

Brownish dirt or dots may be contamination from iron or manganese oxides. In this case, a 5% oxalic acid solution or 10% ascorbic acid solution can be used to clean the sensor. Please note that the sensor should only come into contact with the acids briefly and then be rinsed thoroughly with water.

NOTICE

Under no circumstances should the sensor be cleaned with hydrochloric acid. Even very low concentrations can damage stainless steel components. In addition, TriOS Mess- und Datentechnik GmbH warns against the use of other strong acids, even if the sensor has a titanium housing.

6.1.2 Cleaning the measurement window

You can clean the window with a lint-free cloth, a clean paper towel or a special optical paper from TriOS Mess- und Datentechnik GmbH with a few drops of acetone. Make sure that you do not touch the window surface with your fingers!

To make cleaning the optical windows easier, TriOS Mess- und Datentechnik GmbH offers a cleaning set with acetone and special optical cleaning paper.

NOTICE

Do not use harsh cleaning solutions, spatulas, sandpaper or cleaning agents containing abrasive substances to remove stubborn dirt.

6.2 Maintenance and inspection

The enviroFlu has a xenon flash lamp that emits UV light. To check the function of the flash lamp, you can first listen for the click that the flash lamp emits during operation. You can also hold a white sheet of paper in front of the measurement window. You should then recognize blue fluorescent light in flashes on the paper.

The zero point should be checked regularly. Make sure to keep a distance of more than 20 cm between the measurement window and the surroundings. If the sensor is correctly calibrated, a value close to zero is output in ultrapure water (free of humic and fulvic acids, 18.2 MΩcm water). In air, a low offset is normal, as enviroFlu is calibrated as an immersion sensor. If this is not the case, return the device to the manufacturer for recalibration. For return information, read chapter 6.4.

Depending on the measuring range, the following offset values in air are to be classified as normal:

Measuring range	Offset to air PAH (max.)	Measuring range	Offset to air PAH-p (max.)
0-50 µg/L PAH	20 µg/L PAH	0-8 µg/L PAH-p	3.22 µg/L PAH-p
0-500 µg/L PAH	60 µg/L PAH	0-80 µg/L PAH-p	9.68 µg/L PAH-p
0-5 000 µg/L PAH	200 µg/L PAH	0-800 µg/L PAH-p	32.26 µg/L PAH-p

To a certain extent, an offset can be eliminated by customer calibration in accordance with chapter 5.2.

As changes in the device and the calibration can occur over time, it is recommended to return the sensor to the manufacturer for recalibration and cleaning every two years. When used with DryCAL, this period can be extended to 4 - 5 years. Error-free measurement can only be guaranteed by regularly checking the calibration. A return shipment should be made every four years to replace the lamp and recalibrate the sensor. It is necessary to replace the lamp as it is exposed to a high energy load and its light intensity can decrease after approx. four years of continuous operation.

6.3 Troubleshooting

It is currently not possible to repair the enviroFlu adequately on site. To rectify the fault, the sensor must be returned to the manufacturer, taking into account the procedure including requesting an RMA number.

6.4 Return shipment

Please note the procedure for your return.

If you wish to return the sensor or the device, please contact technical support first. To ensure a smooth return process and to avoid incorrect shipments, every return shipment must first be reported to technical support. You will then receive a numbered RMA form, which you must complete in full, check and return to us.

Please stick this form with the number clearly visible on the outside of the return package or write it in large letters on the packaging. This is the only way your return can be correctly assigned and accepted.

Please note! Returns without an RMA number cannot be accepted and processed!

Please note that the sensor or the device must be cleaned and disinfected before shipping.

Use the original packaging to ensure that the goods are sent undamaged. If this is not available, ensure that safe transportation is guaranteed and that the sensors are secured with sufficient packing material.

7 Technical data

7.1 Technical specifications

Measurement technology

Measurement technology	Light source: flash lamp + filter	Detector: photodiode + filter
Parameters HC	254 nm	360 nm
Parameter BT	254 nm	305 nm
Measuring principle	fluorescence	

Measuring range / parameters

sensor	Parameters	Measuring range	Detection limit
enviroFlu HC (MB) 500	PAH	0-50 µg/L, 0-500 µg/L	0.3 µg/L*
	Oil in water	0-1.5 mg/L, 0-15 mg/L typ.	9 µg/L**
enviroFlu HC (MB) 5000	PAH	0-500 µg/L, 0-5 000 µg/L	0.5 µg/L*
	Oil in water	0-15 mg/L, 0-150 mg/L typ.	15 µg/L**
enviroFlu BT	BTX	0-1 000 µg/L, 0-10 000 µg/L	20 µg/L*

*related to the high degree of amplification **dependent on the type of oil

Accuracy of measured value	± (5 % + detection limit)

Resolution

sensor	Measuring range	Measuring range Resolution
enviroFlu HC (MB) 500	0-50 µg/L 0-500 µg/	0.0122 µg/L 0.122 µg/L
enviroFlu HC (MB) 5000	0-500 µg/L 0-5 000 µg/L	0.122 µg/L 1.22 µg/L
enviroFlu BT	0-1 000 µg/L 0-10 000 µg/L	0.244 µg/L 2.44 µg/L

Sensitivity

sensor	Measuring range	Sensitivity
enviroFlu HC (MB) 500	0-50 µg/L 0-500 µg/	0.2 µg/L 0.2 µg/L
enviroFlu HC (MB) 5000	0-500 µg/L 0-5 000 µg/L	0.2 µg/L 1 µg/L
enviroFlu BT	0-1 000 µg/L 0-10 000 µg/L	TBD TBD

Response time (T90 / T100)	≤ 10 s
Temperature compensation	No
Turbidity compensation	No (only possible via TTurb on the TriBox3)
Data logger	No
Measuring interval	≥ 5 s
Cross sensitivities	Turbidity, DOM

Interface

enviroFlu HC	Digital: RS-232 (TriOS protocol) Analog: 4...20 mA, 0 - 5 V
enviroFlu HC MB	Digital: RS-485 (Modbus RTU) Analog: not available
enviroFlu BT	Digital: RS-232 (TriOS protocol) Analog: 4...20 mA, 0 - 5 V

Power supply	12-24 VDC (± 10 %)
Power consumption	≤ 3,5 W
Connection	SubConn 8-pin or fixed cable with M12 connector

Material

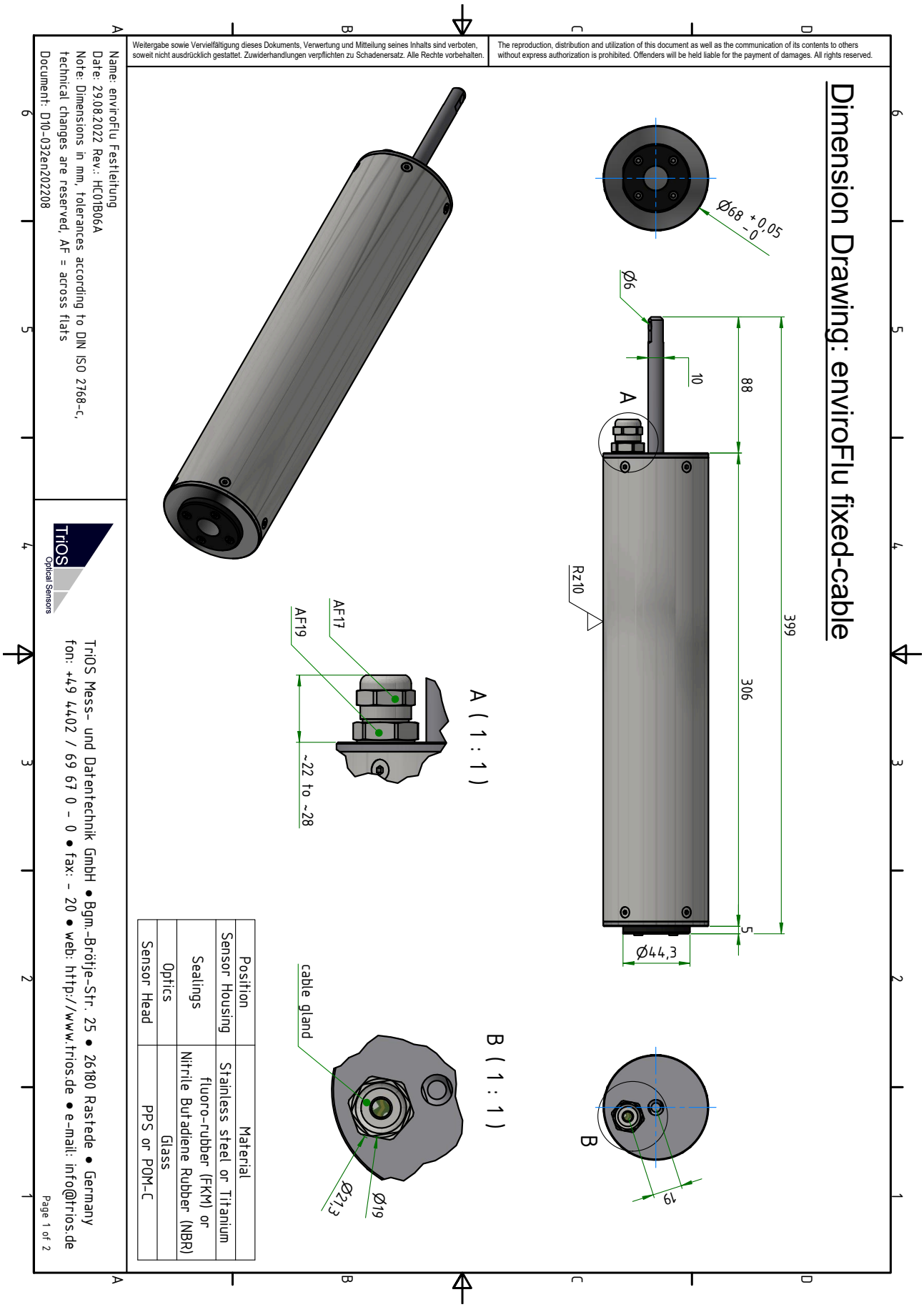
Housing	Stainless steel (1.4571 / 1.4404), not suitable for permanent use in seawater; Titanium (3.7035); Deep sea version: Titanium (3.7035)
Measuring head	POM black with synthetic quartz glass, not suitable for pH values < 4 Deep sea version: cover titanium, pressure ring POM Acid-resistant version: PPS

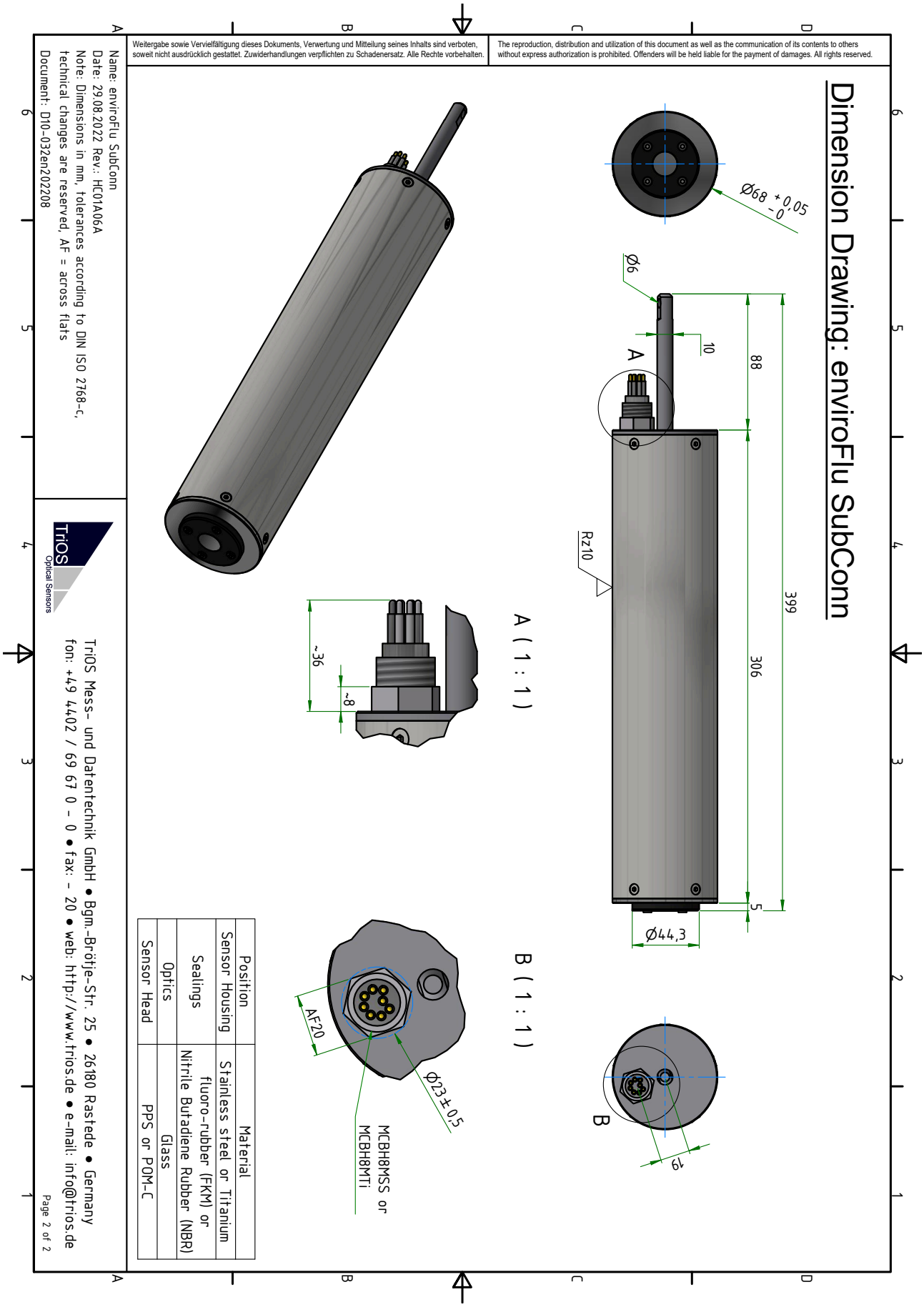
Dimensions (L x Ø)		311 mm x 68 mm Deep sea version: 314 x 78 mm	~12.2 " x 2.6 " Deep sea version: ~ 12.4 " x 3.1 "
Weight	**VA**	~ 2.7 kg	~ 6 lbs
	TI	~ 1.9 kg Deep sea version: ~ 3.9 kg	~ 4.2 lbs Deep sea version: ~ 8.6 lbs

Ambient temperature	-5...+55 °C +2...+40 °C for specified measurement accuracy	23...131 °F 35.6...104 °F
Sample temperature	+2...+40 °C (in situ) +2...+40 °C (in FlowCell)	35.6...104 °F 35.6...104 °F
Relative humidity	0 to 95 %, non-condensing	
Storage temperature	-20...+80 °C	-4...176 °F
Max. Max. pressure	with SubConn: 30 bar	435 psi
	with fixed cable: 3 bar	43.5 psi
	in flow unit (FlowCell): 1 bar, 2...4 L/min	14.5 psi, 2...4 L/min
	Deep sea version: 600 bar	8702 psi
Inflow velocity	0.1...10 m/s	
Storage conditions	-20...+80 °C	-4...176 °F
	Relative humidity 0 to 95 %, non-condensing	
Transportation conditions	as storage conditions	
Protection type	Sensor side: IP68 Controller side: IP65 / IP67	sensor: NEMA 6P controller: NEMA 6
Operating altitude	max. altitude 2000 m	6562 ft

Maintenance effort	≤ 0.5 h/month typical
Calibration/maintenance interval	24 months, manufacturer calibration can be extended to 4 - 5 years when used with the associated DryCAL set.
System compatibility	TriBox3, TriBox mini, Modbus RTU
Warranty	1 year (EU & US: 2 years)

7.2 Outer dimensions




Dimension Drawing: enviroFlu SubConn
Ø68 +0,05 -0
Ø6
10
88
399
306
5
Ø44,3
Rz10
A
B
A (1 : 1)
B (1 : 1)
~36
~8
AF20
Ø23±0,5
MCBH8MSS or
MCBH8MTi
19
Position
Material
Sensor Housing
Stainless steel or Titanium
Sealings
fluoro-rubber (FKM) or
Nitrile Butadiene Rubber (NBR)
Optics
Glass
Sensor Head
PPS or POM-C
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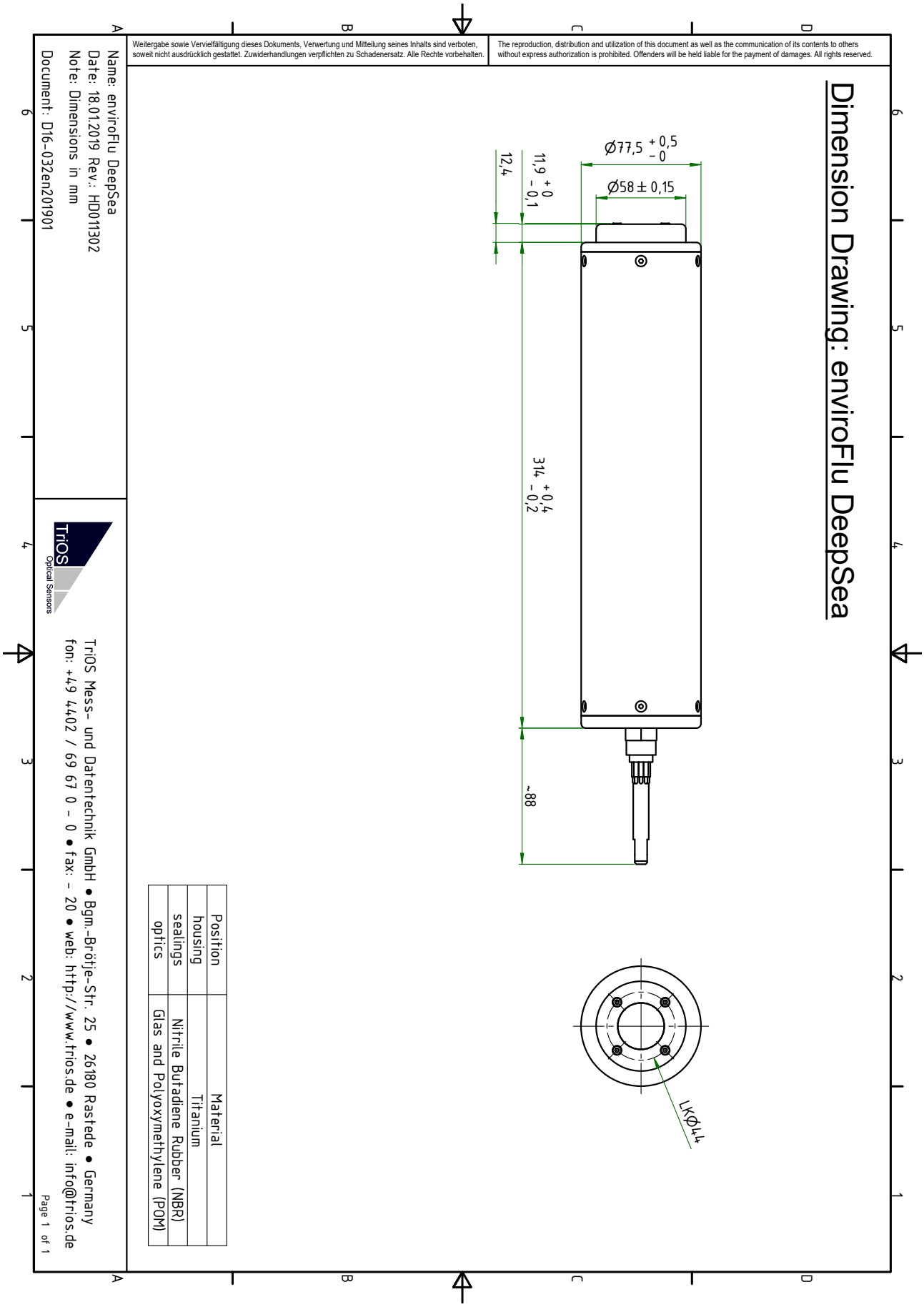
The reproduction, distribution and utilization of this document as well as the communication of its contents to others without express authorization is prohibited. Offenders will be held liable for the payment of damages. All rights reserved.
Name: enviroFlu SubConn
Date: 29.08.2022 Rev.: HC01A06A
Note: Dimensions in mm, tolerances according to DIN ISO 2768-c, technical changes are reserved, AF = across flats
Document: D10-032en202208
TriOS Optical Sensors
TriOS Mess- und Datentechnik GmbH • Bgm.-Brötje-Str. 25 • 26180 Rastede • Germany
fon: +49 4402 / 69 67 0 – 0 • fax: – 20 • web: http://www.trios.de • e-mail: info@trios.de
Page 2 of 2


Dimension Drawing: enviroFlu DeepSea
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Ø77,5 +0,5 -0
Ø58 ± 0,15
12,4
11,9 +0 -0,1
314 +0,4 -0,2
~88
LKØ44
Position
housing
sealings
optics
Material
Titanium
Nitrile Butadiene Rubber (NBR)
Glas and Polyoxymethylene (POM)
Name: enviroFlu DeepSea
Date: 18.01.2019 Rev.: HD011302
Note: Dimensions in mm
Document: D16-032en201901
TriOS Optical Sensors
TriOS Mess- und Datentechnik GmbH • Bgm.-Bröije-Str. 25 • 26180 Rastede • Germany
fon: +49 4402 / 69 67 0 - 0 • fax: - 20 • web: http://www.trios.de • e-mail: info@trios.de
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8 Accessories

8.1 Solids standards

8.1.1 SolidCAL HC

Fast function and calibration validation

SolidCAL solid matter secondary standards can be used to carry out quick function and calibration checks of the enviroFlu for PAH detection. The easy handling of the SolidCAL ensures a quick and precise check of the device, even directly on site. A standard is available for every TriOS fluorometer - for the enviroFlu also in different concentrations.

For correct use of the SolidCAL, please be sure to observe the associated operating instructions

8.1.2 DryCAL

The DryCAL set is a solid matter standard, consisting of DryCAL-0 and DryCAL-1, for calibration of the TriOS fluorometer enviroFlu HC. The set is precisely calibrated to the measuring properties of the sensor assigned to it. The advantage lies in the simple and uncomplicated application without the use of reagents. It is also virtually maintenance-free due to the materials used, but should always be sent in with the enviroFlu for maintenance or repair in the event of a return shipment.

Reliable detection of polycyclic aromatic hydrocarbons (PAH) with the enviroFlu can therefore be guaranteed over a long period of time.

8.2 Controller

The enviroFlu can be connected to all TriOS controllers. Below you will find an overview of the available TriOS devices:

8.2.1 TriBox3

Digital 4-channel display and control unit with integrated solenoid valve for compressed air control

TriBox3 is a measuring and control system for all TriOS sensors. The device offers 4 sensor channels with selectable RS-232 or RS-485 function. In addition to Modbus RTU, various other protocols are available.
A built-in valve allows the use of compressed-air cleaning for the sensors. The TriBox3 also offers various interfaces, including an IEEE 802.3 Ethernet interface, an IEEE 802.11 b/g/n interface, a USB port and 6 analog outputs (4...20 mA).
An integrated relay can be used to trigger alarms or control external devices. Low power consumption, a robust aluminum housing and a range of interfaces makes it suitable for all applications in environmental monitoring, drinking water, wastewater treatment plants and many other areas.

8.2.2 TriBox mini

Digital 2-channel controller

Die TriBox mini is an controller with two digital sensor inputs and two 4...20 mA outputs and represent a cost-effective alternative to analog measuring points.
The TriBox mini is compatible with all TriOS sensors.
All stored measured values and diagnostic data can be read out via an integrated web browser.

8.3 Protective cage

Protection against coarse interfering factors

The sensor can be equipped with a protective cage to protect the measuring window from coarse dirt. The recesses in the Material (POM) make it possible to keep out disturbing factors floating in the waters, such as leaves etc., while still allowing enough water to pass through.

9 Warranty

The warranty period for our devices within the EU and the USA is 2 years from the date of invoice. Outside the EU it is 1 year. Excluded from the warranty are all normal consumables
(depending on the product, e.g. light sources or windows).

The guarantee is subject to the following conditions:

- The appliance and all accessories must be installed as described in the relevant manual and operated in accordance with the specifications.
- Damage caused by contact with aggressive and material-damaging substances, liquids or gases, as well as transport damage, are not covered by the guarantee.
- Damage caused by improper handling and use of the appliance is not covered by the warranty.
- Damage caused by modification or unprofessional attachment of accessories by the customer is not covered by the warranty.

NOTICE

Opening the device will void the warranty!

10 Technical support

If you have a problem with a TriOS sensor / a TriOS device, please contact TriOS technical support.

We recommend sending in sensors every 2 years for maintenance and calibration. To do this, please request an RMA number from technical support.

Contact technical support:

E-mail: support@trios.de
Phone: +49 (0) 4402 69670 - 0
Fax: +49 (0) 4402 69670 - 20

To enable us to help you quickly, please send us the sensor ID number (serial number with 8 digits, consisting of letters and numbers, e.g. 6700003F) by e-mail.

11 Contact us

We are constantly working on improving our devices. Please visit our website for the latest news.

If you have found a fault in one of our devices or programs or would like additional functions, please contact us:

Technical Support:	support@trios.de
General questions/sales:	sales@trios.de
Website:	www.trios.de

TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
26180 Rastede
Rastede, Germany

Telephone	+49 (0) 4402 69670 - 0
Fax	+49 (0) 4402 69670 - 20

12 Keyword index

N

O

P

Q

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W

13 FAQ - Frequently asked questions

1. **I can't see the excitation light from the sensor, is the sensor damaged?**

   Please never look directly into the light beam, this is UV light which can seriously damage the eyes! The enviroFlu has a xenon flash lamp which emits UV light. Use a white sheet of paper and hold it in front of the device. You should then see blue fluorescent light in flashes on the paper.

2. **For which applications are the titanium versions of the sensors intended?**

   Titanium is lighter than stainless steel and has a higher resistance to corrosion. Seawater is a very harsh environment for sensors and even stainless steel is never 100% protected against corrosion. The titanium version is especially recommended for use in seawater, waste water and industrial applications, as titanium has a high resistance to corrosion. The titanium version is also suitable for cable winch mountings or mobile monitoring stations due to its low weight.

3. **What inflow velocity is recommended?**

   0.1 m/s to 10 m/s (see technical specifications in chapter 7)

4. **How much space must there be in front of the optical window in order to take a correct measurement?**

   We recommend at least 10 cm of space between the measurement window and the edge or bottom of the vessel.

5. **What is the conversion factor for the oil in water measurement and how can I display oil in water?**

   The scaling factor is 30. The oil in water parameter is only output via the TriBox mini NET. The other controllers do not have the option of outputting this parameter directly. In the TriBox3, you can enter the scaling factor and change the name in the display to obtain the oil in water display.

6. **How do I connect enviroFlu HC or enviroFlu BT to a TriBox mini?**

   To connect enviroFlu to a TriBox mini, the COM port must be set as follows:
   Hardware mode: RS232, **Protocol:** TriOS, **Flow control:** Software

14 Appendix

14.1 CE declaration of conformity

CE

TriOS Optical Sensors

Hersteller/Manufacturer/Fabricant: TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
D- 26180 Rastede

Konformitätserklärung
Declaration of Conformity
Déclaration de Conformité

Die TriOS GmbH bescheinigt die Konformität für das Produkt
The TriOS GmbH herewith declares conformity of the product
TriOS GmbH déclare la conformité du produit

Bezeichnung Product name Designation	**enviroFlu**
Typ / Type / Type	**HC 500, HC 5000** **HC MB 500, HC MB 5000** **BT 10000**
Mit den folgenden Bestimmungen With applicable regulations Avec les directives suivantes	2014/30/EU EMV-Richtlinie 2011/65/EU RoHS-Richtlinie + (EU) 2015/863 + (EU) 2017/2102
Angewendete harmonisierte Normen Harmonized standards applied Normes harmonisées utilisées	EN IEC 61326-1:2021 EN 61010-1:2010 +A1:2019 +A1:2019/AC:2019 EN IEC 63000:2018
Datum / Date / Date	Unterschrift / Signature / Signature
21.05.2024	R. Heuermann

D05-032yy202405

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14.2 Ship approval according to IMO regulations

DNV approval

DNV

TYPE APPROVAL CERTIFICATE

Certificate no.:
TAA00002FB
Revision No:
2

This is to certify:

that the Miscellaneous Transmitter

with type designation(s)
PAH Sensor enviroFlu-HC 500, enviroFlu-HC 5000, PAH Sensor enviroFlu-HC MB 500, enviroFlu-HC MB 5000

issued to
TriOS Mess- und Datentechnik GmbH
Rastede, **Germany**

is found to comply with
DNV rules for classification – Ships, offshore units, and high speed and light craft

Application:

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV.

Temperature	**A**
Humidity	**B**
Vibration	**A**
EMC	**A**
Enclosure	**B (IP68)**

Issued at **Hamburg** on **2024-03-12**
This Certificate is valid until **2029-02-04**.
DNV local unit: **Hamburg – CMC North/East**

for **DNV**

Approval Engineer: **Jens Dietrich**

.....

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

Job ID: **262.1-030654-3**
Certificate no.: **TAA00002FB**
Revision No: **2**

Product description

UV-fluorometer for detection of PAH (Polycyclic Aromatic Hydrocarbons) in water.
Power supply: 12…24VDC (+/-10%)
Interface, analog output: 4…20mA or RS485, Modbus RTU (MB variant)
Connector: M12 industrial connector with up to 5m fixed mounted cable
Material: Measuring head: POM black with fused silica, PPS black.
Housing: Stainless steel 1.4571 titanium

Hardware version: V3.0
Software version: V1.80

Version	Component	Measurement	Smallest range	Typical range
enviroFlu-HC 500, enviroFlu-HC 500 MB	PAH	Fluorescence	0 – 50 µg/l	0 – 500 µg/l
	$PAH_{(phe\ equivalents)}$	Fluroescence	0 – 8 µg/l	0 – 80 µg/l
enviroFlu-HC 5000, enviroFlu-HC 5000 MB	PAH	Fluorescence	0 – 500 µg/l	0 – 5000 µg/l
	$PAH_{(phe\ equivalents)}$	Fluroescence	0 – 80 µg/l	0 – 800 µg/l

The measuring range is depending on the wash water flow rate and can be adjusted in accordance with the requirements of Resolution MEPC.259(68) “2015 Guidelines for exhaust gas cleaning systems - Section 10 “Wash water” as well as Resolution MEPC.340(77) “2021 Guidelines for exhaust gas cleaning systems”, Chapter 10 “Discharge Water”
The enviroFlu is intended for installation on-board vessels operating an exhaust gas cleaning system (EGCS). The enviroFlu is found to be in compliance with the requirements of

- Resolution MEPC.259(68) adopted on 15 May 2015
  2015 Guidelines for exhaust gas cleaning systems”, Chapter 10 “Wash water”
- Resolution MEPC.340(77) adopted on 26 November 2021
  “2021 Guidelines for exhaust gas cleaning systems”, Chapter 10 “Discharge Water”

enviroFlu-HC 500/5000 meet the following requirements:

- Definition of Phenanthrene equivalent (MEPC.340(77), 2.3.1, Table 3)
- Principle of detection for PAH PHE Eq (MEPC.259(68) and MEPC.340(77), 10.1.3.3)
- Measurement range for PAH PHE Eq (MEPC.259(68) and MEPC.340(77), 10.1.3.3)
- Turbidity influences on PAH PHE Eq (MEPC.259(68), 10.2.3 and MEPC.340(77), 10.2.4)

The operating temperature is from 5°C to 55°C, whereas the specified detection limits are only valid in the temperature range between 5°C to 40°C.

Application/Limitation

The Type Approval covers hardware listed under Product description. When the hardware is used in applications to be classed by DNV, documentation for the actual application is to be submitted for approval by the manufacturer of the application system in each case. Reference is made to DNV rules for classification of ships Pt.4 Ch.9 Control and monitoring systems.

The sensor needs to be connected to a monitoring unit providing:
-sufficient protection to potential surges to the PAH sensor
-sufficient protection to superimposed conducted low frequencies to the PAH sensor
The monitoring unit needs to be sufficiently protected against conducted emissions emitted by the PAH sensor.

Product certificate
If specified in the Rules, ref. Pt.4 Ch.9 Sec.1, the control and monitoring system in which the above listed hardware is used shall be delivered with a product certificate. For each such delivery the certification test is to be performed at the manufacturer of the application system before the system is shipped to the yard. The test shall be done according to an approved test program. After certification the clause for software control will be put into force.

Software control
All changes in software are to be recorded as long as the system is in use on board. Documentation of major changes is to be forwarded to DNV for evaluation and approval before implemented on board. Certification of modified functionality may be required for the particular vessel.

Job ID: **262.1-030654-3**
Certificate no.: **TAA00002FB**
Revision No: **2**

Correct on-board configuration and integration into the wash water monitoring system will still be subject to verification against the requirements of MEPC.259(68) / MEPC.340(77), for each delivery and is to be tested during commissioning after installation.
The enviroFlu sensor shall be installed, operated and calibrated in accordance with the requirements and intervals as specified in the operating instructions. Air bubbles in the wash water flow at the place of $PAH_{(phe\ equivalent)}$ measurement should be avoided. In case the turbidity of the wash water is above 5 NTU, the enviroFlu-HC must be compensated for turbidity otherwise $PAH_{(phe\ equivalent)}$ deviates more than 5%.

Tests carried out

Applicable tests according to DNV CG-0339, 2021.
Tests according to the relevant parts of the referenced MEPC resolution.

Marking of product

Manufacturer name, product type, serial number, interface, power supply, measurement range.

Periodical assessment

The scope of the periodical assessment is to verify that the conditions stipulated for the type are complied with, and that no alterations are made to the product design or choice of systems, software versions, components and/or materials.

The main elements of the assessment are:

- Ensure that type approved documentation is available
- Inspection of factory samples, selected at random from the production line (where practicable)
- Review of production and inspection routines, including test records from product sample tests and control routines
- Ensuring that systems, software versions, components and/or materials used comply with type approved documents and/or referenced system, software, component and material specifications
- Review of possible changes in design of systems, software versions, components, materials and/or performance, and make sure that such changes do not affect the type approval given
- Ensuring traceability between manufacturer's product type marking and the type approval certificate

Periodical assessment is to be performed after 2 years and after 3.5 years. A renewal assessment will be performed at renewal of the certificate.

END OF CERTIFICATE

14.3 Data protocol

enviroFlu HC // **TriOS Daten Protokoll**

TriOS Datenprotokoll

Im Auslieferzustand ist die serielle RS-232 Schnittstelle des enviroFlu mit folgenden Einstellungen konfiguriert:

- Baudrate: 9600
- Datenbits: 8
- Parität: keine
- Flusskontrolle: Software (Xon / Xoff)

Datenübertragung

Jedes Datenpaket startet mit 0x23 und endet mit 0x01. Da Software-Flusskontrolle verwendet wird, müssen die dafür verwendeten Zeichen, sowie Datenpaketbeginn (0x23) und Ersatzzeichen (0x40) maskiert werden.

Maskierung von Bytes

Wenn die Zeichen #, @, 17, 19 in den zu sendenden Daten vorkommen, dann müssen die entsprechenden Bytes maskiert werden, um nicht fehlinterpretiert zu werden. Tab. 1 zeigt die Maskierung für das TriOS Protokoll.

Tabelle 1: Maskierung von Bytes für Datenübertragung

Zeichen	Beschreibung	Ersatz
@ (40hex)	Start für Ersatz	0x40 0x64
# (23hex)	Datenpaketbeginn	0x40 0x65
Xon (11hex)	Xon	0x40 0x66
Xoff (13hex)	Xoff	0x40 0x67

So kann eine Seriennummer (Bsp. SN# 12DF) wie folgt gesendet und empfangen werden. Dieses ist nur ein Beispiel für die Maskierung und kein korrektes TriOS Datenprotokoll.

Gesendet: 0x23 0x53 0x4E (0x23 → **0x40 0x65**) 0x20 0x31 0x32 0x44 0x46 0x01

Empfangen: 0x23 0x53 0x4E (0x40 0x65 → 0x23) **0x20 0x31 0x32 0x44 0x46 0x01**

0x23 [Datenpaketbeginn] **0x53** [S] **0x4E** [N] **0x23 / 0x40 0x65** [#] **0x20** [Leerstelle] **0x31** [1] **0x32** [2] **0x44** [D] **0x46** [F] **0x01** [Datenpaketende]

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enviroFlu HC // TriOS Daten Protokoll

Senden von Befehlen

Ein Befehl besteht immer aus 8 Bytes, wie in Tabelle 2 dargestellt. Dabei kann Byte 4 für Instruktionen an den enviroFlu genutzt werden (Tabelle 3).

Tabelle 2: Befehle senden (8 Bytes) bei einem Gerät an einer Schnittstelle

Byte	Name	Beschreibung	Beispiel	Interpretation
0	Datenpaketbeginn	0x23	0x23	Start
1	Device ID 1		0x00	
2	Device ID 2		0x00	
3	i2c Adresse		0x00	
4	Instruktion		0x78	Einstellung
5	Parameter 1		0x05	Kanal
6	Parameter 2		0x00	High
7	Datenpaketende	0x01	0x01	

*Tabelle 3: Einstellungen an Byte 4 (Befehl **0x78**) ändern*

Name	Parameter 1	Parameter 2
Kanal auswählen	0x05	0 = high; 1 = low
Auto Verstärkung (automat. Wechsel HIGH / LOW)	0x06	0 = aus; 1 = ein
Continuous Mode	0x0f	0 = aus; 1 = ein

enviroFlu wird mit folgenden Konfigurationen ausgeliefert:

- LOW-Kanal
- Die Autoverstärkung ist werksseitig deaktiviert. Eine Aktivierung wird vom Hersteller nicht empfohlen
- Der Continuous Mode ist auf „ein“ eingestellt

Hierbei ist es wichtig zu wissen, dass der LOW-Kanal (geringe Verstärkung) einen größeren Messbereich, und der HIGH-Kanal (hohe Verstärkung) einen kleineren Messbereich abdeckt.

Für die beiden enviroFlu HC Versionen bedeutet dies:

HC 500	**LOW:** 0 – 500 µg/L
	HIGH: 0 – 50 µg/L
HC 5000	**LOW:** 0 – 5 000 µg/L
	HIGH: 0 – 500 µg/L

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enviroFlu HC // **TriOS Daten Protokoll**

Mögliche Befehle an den Sensor

Diese Befehle gelten nur dann, wenn ein Sensor direkt an einen COM-Port angeschlossen ist.

Query senden

Der Query Befehl wird dazu genutzt die Seriennummer, Firmware Version und die Gerätekonfiguration des Sensors abzufragen. Als Antwort wird ein Query Datenpaket geschickt, welches in Tabelle 4 näher erläutert ist.

Senden: 0x23 0x00 0x00 0x00 0xB0 0x00 0x00 0x01

Messungen Triggern

Um eine Messung auszulösen oder eine Messung zu beenden, werden folgende Befehle an den Sensor gesendet:

Messung auslösen: 0x23 0x00 0x00 0x00 0xA8 **0x00 0x81** 0x01

Messung beenden: 0x23 0x00 0x00 0x00 0xA8 **0x00 0x82** 0x01

Continuous Mode einstellen

Um fortlaufende Messungen zu triggern oder die fortlaufenden Messungen zu beenden, werden folgende Befehle an den Sensor gesendet:

Einschalten: 0x23 0x00 0x00 0x00 0x78 **0x0F 0x01** 0x01

Ausschalten: 0x23 0x00 0x00 0x00 0x78 **0x0F 0x00** 0x01

Kanal einstellen

Soll der Sensor nur im HIGH- oder im LOW-Kanal messen, müssen folgende Befehle gesendet werden:

HIGH-Kanal: 0x23 0x00 0x00 0x00 0x78 **0x05 0x00** 0x01

LOW-Kanal: 0x23 0x00 0x00 0x00 0x78 **0x05 0x01** 0x01

Auto Verstärkung einstellen (wird vom Hersteller nicht empfohlen)

Wenn der Sensor automatisch vom LOW → HIGH oder HIGH → LOW Kanal wechseln soll, können folgende Befehle gesendet werden:

Einschalten: 0x23 0x00 0x00 0x00 0x78 **0x06 0x01** 0x01

Ausschalten: 0x23 0x00 0x00 0x00 0x78 **0x06 0x00** 0x01

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Daten vom Sensor empfangen

Antwort auf einen Messtrigger

0x23 0x00 0x00 0x00 0x00 0x00 0x00 **0x83 0x07** 0x01

Die Bytes **0x83 0x07** beinhalten die Information zum Verstärkungsmodus, sowie den Rohwert der Messung.

Das obere Halbbyte aus Byte 7 (0x**8**3) zeigt an, in welchem Kanal gemessen wurde. In diesem Beispiel wurde im LOW-Kanal gemessen. Im HIGH-Kanal wäre an der Stelle eine 0.

Das untere Halbbyte aus Byte 7 (0x8**3**), sowie Byte 8 (0x**07**) bilden den Rohwert der Messung.

12 Bit entspricht dabei dem digitalen Maximalwert von 4095.

Um daraus die Konzentration zu berechnen, kann die folgende **Formel zur Berechnung der PAK-Konzentration** verwendet werden:

$$PAK = Verstärkung \cdot \frac{Rohwert_{High} \cdot 256 + Rohwert_{Low}}{4095} \ \mu g/L$$

$$PAK = 500 \cdot \frac{3 \cdot 256 + 7}{4095} \ \mu g/L$$

$$PAK = 94{,}63 \ \mu g/L$$

Mit:

Verstärkung = oberes Halbbyte aus Byte 7: 0x**8**3 → hier: LOW-Kanal: 500

$Rohwert_{High}$ = unteres Halbbyte aus Byte 7: 0x8**3** → 3

$Rohwert_{Low}$ = Byte 8: 0x**07** → 7

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Antwort auf einen Query

0x23 0x60 0x00 0x00 0xFF 0x00 0x00 0x2A 0x68 0x80 0x01 0x05 0x03 0x0C 0x28 0x02 0xB9 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x01

Die Antwort des Sensors auf einen Query beinhaltet neben der Seriennummer und der Firmware weitere Statusinformationen des Sensors, wie sie in Tabelle 4 dargestellt sind.

Tabelle 4: Mögliche Antwort auf einen Query

Byte	Name	Beschreibung	Zeichen [hex]	Interpretation
0	Datenpaketbeginn	Start	23	
1	DeviceID 1	Bit [**7, 6, 5**] Anzahl zusätzlicher Datenbytes [hex→ binär → Anzahl Datenbytes] • 0x00 → 000 → 2 • 0x20 → 001 → 4 • 0x40 → 010 → 8 • **0x60 → 011 → 16** • 0x80 → 100 → 32 • 0x0A → 101 → 64 • 0x0C → 110 → 128 • 0x0E → 111 → 256 Bit [4] = immer NULL Bit [3, 2, 1, 0] = Device ID	**6**0	Gibt die Anzahl der gesendeten Bytes ab Byte 7 an; Binär: **011**0 0000
2	DeviceID 2		00	Hier 0
3	Modul ID		00	EEProm = 0
4	Datenpaket-Typ	FF: Informationsdatenpaket FE: Fehlerdatenpaket	FF	Informationsdatenpaket
5	Reserviert		00	Immer 0
6	Reserviert		00	Immer 0
7	Seriennummer [Uint16]	Seriennummer Low Byte	2A	Teil 2 Seriennummer
8		Seriennummer High Byte	68	Teil 1 Seriennummer
9	Firmware [Uint16]	Firmware Low Byte	80	Teil 2 Firmware
10		Firmware High Byte	01	Teil 1 Firmware
11	Reserviert	Ignorieren	05	Nicht beachten
a...x	N Datenbytes	individuelle Information (Einstellungen)	03 0C 28 02 B9 00 00 00 00 00 00	Beinhaltet Sensortyp, Anzahl Messungen für Mittelung und diverse Stati
X+1	Datenpaketende	Ende	01	

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Erläuterung zu Tabelle 4:

Byte 7+8:	**Seriennummer**:	682A
Byte 9+10:	**Firmware**:	1.80
Byte 11:	**Reserviert**:	05
Byte 12:	**Sensortyp**:	0x03 → enviroFlu
Byte 13:	**Anzahl Mittelungen**:	0x0C → dezimal 12
Byte 14:	**Status**:	0x28 → binär 0010 1000
	→ Continuous mode ON	
	→ Auto amplification mode ON	
	→ High amplification mode	
Byte 15+16:	**Lampenintensität**:	
	Wertebereich von 0–4095 bei 12 Bit	
	0x02 0xB9 → dezimal 697	

Bytes 17–22 dienen nur dem Auffüllen des Informationsdatenpaketes.

X+1:	**Datenpaketende**

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14.4 Modbus RTU

Software version

This Modbus protocol refers to software version 1.0.8 and higher

Serial interface

On delivery, the serial interface of the enviroFlu HC MB is configured to RS-485 with the following settings:

- Baud rate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: none

Data types

Data type name	register	format
Bool	1	false: 0x0000, true: 0x0001
Uint8	1	8-bit unsigned integer. Values: 0x0000 - 0x00FF
Uint16	1	16-bit unsigned integer. Values: 0x0000 - 0xFFFF
Uint32	2	32-bit unsigned integer. Values: 0x00000000 - 0xFFFFFFFFFF
Float	2	IEEE 754 32-bit floating point number
Char[n]	$[\frac{n}{2}]$	ASCII character string with n characters
Uint16[n]	n	Field with n Uint16 values
Float[n]	2n	Field with n float values

Functions

enviroFlu HC MB supports the following Modbus functions:

Name	Code	Description / Use
Read multiple registers	0x03	Read serial number, firmware version, configuration, calibration and measurement data
Write multiple registers	0x10	Write configuration data
Write single register	0x06	Triggering a measurement
Report slave ID	0x11	Read serial number and firmware version

Standard Modbus server address

On delivery, the enviroFlu sensor is set to address 1 (0x01).

Read / Write multiple registers (0x03 / 0x10)

The following table describes the Modbus register assignment:

Name	R/W	Address	Data type	Data type Description
Modbus slave address	RW	0	Uint16	The Modbus slave address of the enviroFlu HC MB. Valid IDs: 1...247. If an invalid ID is written, an illegal data value exception is returned.
Measurement timeout	R	1	Uint16	The time in [10-1 s] of a running individual measurement process. In continuous mode, this is always 0.
Device serial number	R	10	Char[10]	8-digit serial number of the enviroFlu HC MB.
Firmware version	R	15	Char[10]	The version number of the installed firmware
Sensor type	R	20	Char[10]	enviroFlu Type, either HC MB 500 or HC MB 5000.
Static Continuous Mode	RW	100	Bool	Activates or deactivates the continuous mode of the connected enviroFlu HC MB. The configuration is saved permanently and is still available after a restart or shutdown. If this register is written to, the Temporary Continuous Mode (#101) is automatically changed according to the new setting.
Temporary Continuous Mode	RW	101	Bool	Activates or deactivates the continuous mode of the connected enviroFlu HC MB. The configuration is not saved permanently and is lost after a restart or shutdown. After a restart, the setting from Static Continuous Mode (#100) is used instead.
Device Description	RW	106	Char[64]	User-defined text that can be set to identify this device.
Static Low-Amp Mode	RW	140	Bool	Configuration of high and low channel for measurements. 0: Low OFF / High ON (smaller value range) 1: Low ON / High OFF (larger value range) The configuration is saved and is still available after a restart or shutdown. If this register is written to, the Temporary Low-Amp Mode (#141) is automatically changed to correspond to the new setting.
Temporary Low-Amp Mode	RW	141	Bool	Configuration of high and low channel for measurements. 0: Low OFF / High ON (small value range) 1: Low ON/ High OFF (larger value range) The configuration is not saved permanently and is lost after a restart or shutdown. After a restart, the setting from the Static Low-Amp Mode (#140) is used instead.
Average Count	R	142	Uint16	Always 12

Name	R/W	Address	Data type	Data type Description
Checksum / Solid-CAL Factor	R	144	Float	Checksum of the calibration certificate used for SolidCAL validation. This factor is used for SolidCAL parameters (#1012).
Measure Count since boot	R	202	Uint32	Counts the measurements since the last start.
Offset PAH Low Amp Mode1[1,2]	RW	402	Float	This offset is used together with the Scaling PAH (#406) to calculate the scaled version of PAH (for use with DryCAL-0).
Offset PAH High Amp Mode1[1,2]	RW	404	Float	This offset is used together with the scaling PAH (#406) to calculate the scaled version of PAH (for use with DryCAL-0).
Scaling PAH	RW	406	Float	This factor is used together with the offset PAH (#402 or #404) to calculate the scaled version of PAH (for use with DryCAL-1).
Offset PAH-p Low Amp Mode1	RW	408	Float	This offset is used together with the Scaling PAH-p (#412) to calculate the scaled value of PAH-p.
Offset PAH-p High Amp Mode1	RW	410	Float	This offset is used together with the scaling PAH-p (#412) to calculate the scaled value of PAH-p.
Scaling PAH-p	RW	412	Float	This factor is used together with the offset PAH-p (#408 or #410) to calculate the scaled value of PAH-p.
Offset Oil Low Amp Mode1	RW	414	Float	This offset is used together with the scaling oil (#418) to calculate the scaled value of oil.
Offset Oil High Amp Mode1	RW	416	Float	This offset is used together with the scaling oil (#418) to calculate the scaled value of oil.
Scaling Oil	RW	418	Float	This factor is used together with the offset oil (#414 or #416) to calculate the scaled value of oil.

1 Note that this offset is subtracted and not added.

2 Measured offset values from DryCAL-0 are inserted here. As delivered, the enviroFlu HC MB is set to Low Amplification Mode (see #140 for an explanation of Low Amplification Mode). To measure the offset in High Amplification Mode, write 0 to register #140 or #141. For more details on the calibration process, please refer to the DryCAL installation quick guide.

Name	R/W	Address	Data type	Data type Description
PAH in µg/L	R	1000	Float	PAH value measured with the enviroFlu HC MB
PAH in ppb	R	1002	Float	PAH value measured with the enviroFlu HC MB
PAH-p in µg/L	R	1004	Float	PAH-p value calculated on the basis of the measured PAH value
PAH-p in ppb	R	1006	Float	PAH-p value calculated on the basis of the measured PAH value
Oil in mg/L	R	1008	Float	Oil value calculated on the basis of the measured PAH value
Oil in ppm	R	1010	Float	Oil value calculated on the basis of the measured PAH value
SolidCAL in µg/L	R	1012	Float	PAH value, corrected by the checksum (#144) of the certificate
Scaled PAH in µg/L	R	1500	Float	Calculated from PAH (#1000) using the user-defined scaling (#406) and the offset of the current amp mode (#402, #404), with the formula Scaling*(PAH offset).
Scaled PAH in ppb	R	1502	Float	Calculated from PAH (#1002) using the user-defined scaling (#406) and the offset of the current amp mode (#402, #404), with the formula Scaling*(PAH-Offset).
Scaled PAH-p in µg/L	R	1504	Float	Calculated from PAH-p (#1004) using the user-defined scaling (#412) and the offset of the current amp mode (#408, #410), with the formula Scaling*(PAH-p-Offset).
Scaled PAH-p in ppb	R	1506	Float	Calculated from PAH-p (#1006) using the user-defined scaling (#412) and the offset of the current amp mode (#408, #410), with the formula Scaling*(PAH-p-Offset).
Scaled Oil in mg/L	R	1508	Float	Calculated from Oil (#1008) using the user-defined scaling (#418) and the offset of the current amp mode (#414, #416), using the formula scaling*(Oil-offset).
Scaled oil in ppm	R	1510	Float	Calculated from Oil (#1010) using the user-defined scaling (#418) and the offset of the current amp mode (#414, #416), using the formula scaling*(Oil-offset).

Write single register (0x06)

The “Write single register” function can be used to trigger a measurement.

Designation	Address	Address Description
Trigger measurement	1	A single measurement is triggered when the device is idle and any value other than 0 is written.

Designation	Address	Address Description
		If the sensor is currently measuring or continuous mode is switched on, a “Slave device busy” exception is returned. No further measurement is triggered.

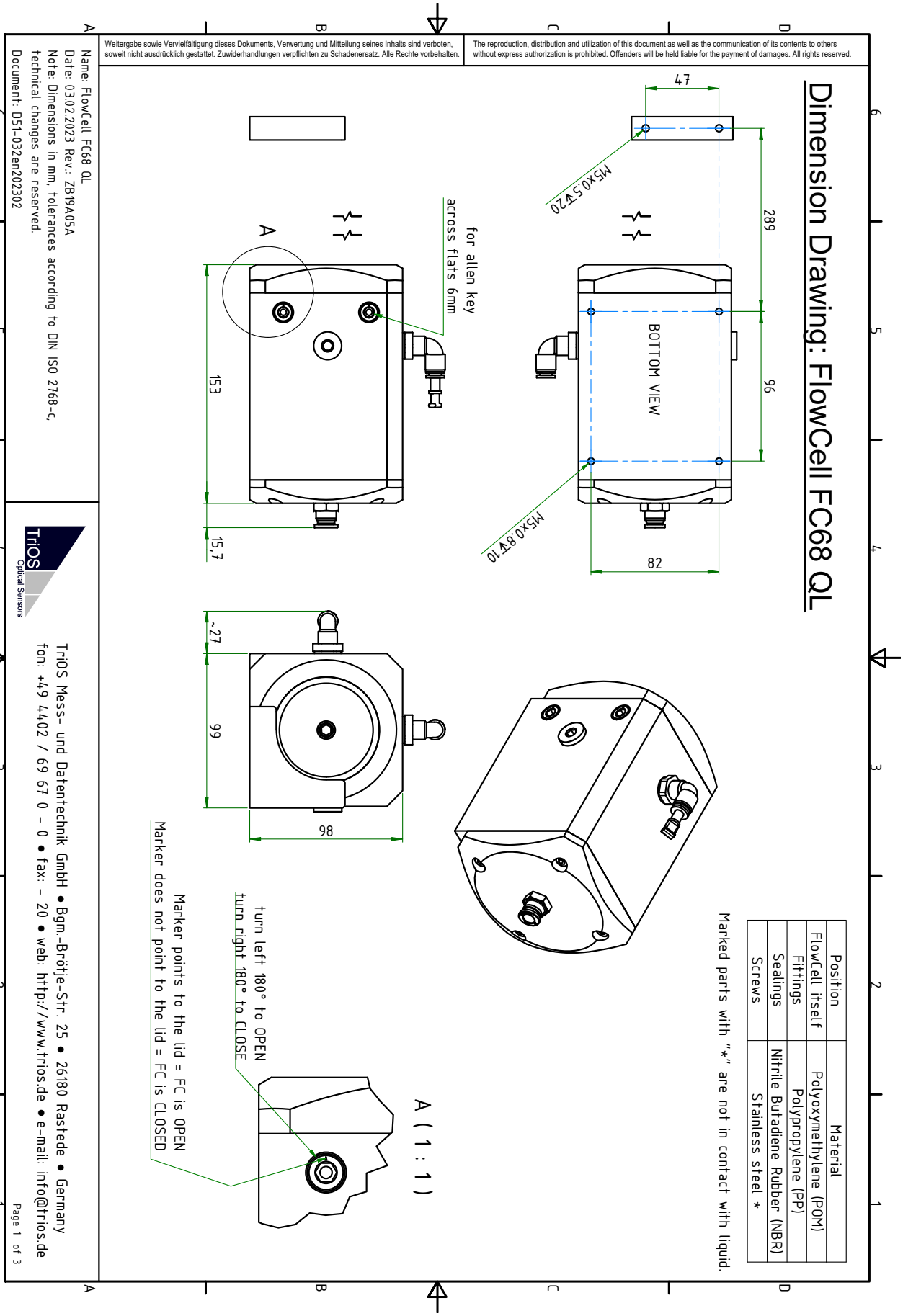
Report slave ID (0x11)

The production company, the sensor name, the serial number and the firmware version are each answered as a zero-terminated ASCII string.

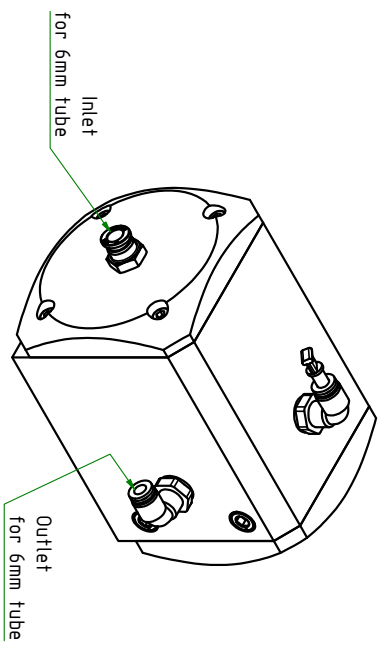
Example:

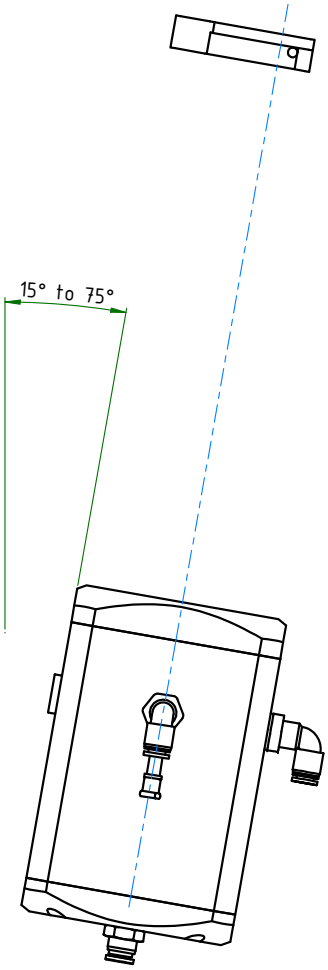
T	R	I	O	S	0x00	e	n	v	i	r	o	F	I	u	0x00	0	3	2	0	2	4	9	C	0x00	1	.	0	.	8	0x00

14.5 FlowCell dimensions

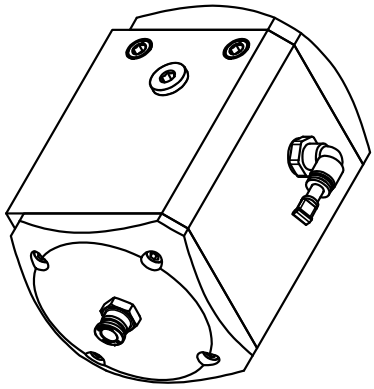


Dimension Drawing: FlowCell FC68 QL





Installation (1 : 2)



Thread-size for all plugs: G1/4" x 10

Name: FlowCell FC68 QL
Date: 03.02.2023 Rev.: ZB19A05A
Note: Dimensions in mm, tolerances according to DIN ISO 2768-c, technical changes are reserved.
Document: D51-032en202302

TriOS Optical Sensors

TriOS Mess- und Datentechnik GmbH • Bgm.-Brötje-Str. 25 • 26180 Rastede • Germany
fon: +49 4402 / 69 67 0 – 0 • fax: – 20 • web: http://www.trios.de • e-mail: info@trios.de

TriOS Mess- und Datentechnik GmbH
Bgm.-Brötje-Str. 25 · 26180 Rastede · Deutschland
Tel +49 (0)4402 69670-0
Fax +49 (0)4402 69670-20
info@trios.de
www.trios.de