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General Information // enviroFlu

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Commis-

1 General Information

1.1 Introduction

Welcome to TriOS.

We are glad that you have chosen to purchase our enviroFlu immersion sensor.

enviroFlu is an immersion probe for the measurement of oil in water. The measurement principle of UV fluorescence used by this probe is many times more sensitive than conventional infrared scattering or absorption processes. It is therefore possible to determine even the slightest traces of polycyclic aromatic hydrocarbons (PAHs).

In this manual, you will find all the information you need to commission the enviroFlu. Technical specifications, detection limits and dimensions can be found in chapter 7.

Please note that the user is responsible for complying with local and national regulations on the installation of electronic devices. Any damage caused by incorrect use or unprofessional installation will not be covered by the warranty. All sensors and accessories supplied by TriOS Mess- und Datentechnik GmbH must be installed and operated in accordance with the specifications provided by TriOS Mess- und Datentechnik GmbH. All parts were designed and tested in accordance with international standards on electronic instruments. The device meets the requirements of the international standards on electromagnetic compatibility. Please use only original TriOS accessories and cables to ensure reliable and correct operation of the devices.

Before using the device, read the manual carefully, and keep this manual on hand for future reference. Before commissioning the sensor, please make sure that you have read and understood the following safety precautions. Always make sure that the sensor is operated correctly. The safety precautions described on the following pages should ensure the reliable and correct operation of this device and any additional associated devices and should prevent injuries to yourself or other persons and damage to other equipment.

NOTICE If the translation is at all different from the original German text, the German version is binding.

Software Updates

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

Copyright Notice

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1.2 Health and Safety Information

This manual contains important information about health and safety rules. This information is labelled according to the international specifications of ANSI Z535.6 ("Product safety information in product manuals, instructions and other collateral materials") and must be strictly followed. The following are distinct categories:



Electromagnetic waves

Devices that radiate strong electromagnetic waves can influence the measurement data or result in a malfunction of the sensor. Avoid using the following devices in the same room as the TriOS sensor: mobile phones, cordless phones, transmitters/ receivers and other electrical devices that produce electromagnetic waves.

Reagents

Follow the safety and operating instructions of the manufacturer when using reagents. Observe the valid Hazardous Materials Ordinance for reagents (German GefStoffV)!

Biological safety

Liquid waste may be a biohazard. Therefore, you should always wear gloves when working with such materials. Please observe the currently valid biological agents regulation! (German BioStoffV)

Waste

When handling liquid waste, observe the regulations on water pollution, drainage and waste disposal.

1.3 Warnings

This sensor has been developed for use in industry and science. It should only be used for the measurement of aqueous solutions, e.g. process waste water, river water or sea water.

NOTICE

Stainless steel sensors are not intended for use in sea water or in high chloride concentrations (corrosion). Only sensors made of titanium can be used in these cases.

- Sensors made from stainless steel must be cleaned immediately after coming into contact with salt water or other corrosive substances (e.g. acids, alkalis, chlorine-based connections).
- The material resistance should be checked after every use.
- The sensor has seals made of FPM (fluororubber; NBR for DeepSea version). Sealing rings made from
 other materials may be used upon individual request. Before operation, please ensure that the measured
 medium does not damage the seals.
- Do not cut, damage or change the cord. Make sure there are no heavy objects on the cable and that the cable is not folded. Make sure that the cable is not anywhere near hot surfaces.
- Do not place any unsuitable objects in front of the measuring window while the measuring process is running, as this can cause damage to the sensor or falsified measuring results.
- Stop operation of the sensor if excessive heat develops (i.e. if it is hot to the touch). Switch off the sensor
 immediately and unplug the power cord from the power supply. Please contact your dealer or the TriOS
 customer service.
- Never try to disassemble or modify a part of the sensor if such a procedure is not explicitly described in this manual. Inspections, modifications and repairs may only be carried out by the dealer or by qualified experts authorized by TriOS.
- If the sensor cable is damaged, it must be replaced with an original part by the customer service of TriOS Mess- und Datentechnik GmbH.
- Devices from TriOS Mess- und Datentechnik GmbH meet the highest safety standards. Repairs to the device which involve the replacement of the connecting cable) must be carried out by TriOS Mess- und Datentechnik GmbH or by a workshop authorized by TriOS. Defective, 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 the monitoring and interpretation of the measured values.

1.4 User and Operating Requirements

The enviroFlu fluorometer has been developed for use in industry and science. The implementation of fluorometric specifications with test kits often requires the handling of hazardous substances.

We assume that the operating personnel are familiar with dealing with dangerous substances based on their professional training and experience. Operating personnel must be able to correctly understand and implement the safety labels and information on the packaging and in the package inserts of the test kits.

1.5 Intended Use

The purpose of the enviroFlu is exclusively the implementation of fluorometric measurements as described in this manual. For this purpose, the enviroFlu fluorometer is an immersion sensor, which is used underwater or with flow cells. Please note the technical data of the accessory parts. Other uses do not comply with the intended use.

enviroFlu // General Information

This device is for use in research and industry. It may only be used for the measurement of the fluorescence of aqueous fluids such as process waste water, river water or sea water. The use of other media can damage the sensor. For the use of the enviroFlu in other media than those specified in this manual, please contact the customer service of TriOS Mess- und Datentechnik GmbH (support@trios.de).

NOTICE Avoid touching the optical window, since these can become scratched or dirty. If this happens, the functionality of the device can no longer be guaranteed.

According to current scientific knowledge, the device is safe to use when it is handled according to the instructions in this user manual.

1.6 Disposal Information

At the end of the device's life or use, the device and its accessories can be returned to the manufacturer for environmentally friendly disposal for a fee. (See address below.) The preceding professional decontamination of the device must be proven with a certificate. Please contact us for more details before you send the device back.

Address of manufacturer:

 TriOS Mess- und Datentechnik GmbH

 Bürgermeister-Brötje-Str. 25

 D-26180 Rastede

 Germany

 Telephone:
 +49 (0) 4402 69670 - 0

 Fax:
 +49 (0) 4402 69670 - 20

1.7 Certificates and Approvals

This product meets all of the requirements of the harmonised European standards. It therefore meets the legal requirements of the EU guidelines. TriOS Mess- und Datentechnik GmbH confirms the successful testing of the product by affixing the CE marking. (see Annex)

The enviroFlu has a type approval according to IMO regulation MEPC.340(77), as well as MEPC.259(68) for the monitoring of PAH concentrations, as specified in the regulations. Please note the restrictions of use of the enviroFlu (see chapter 4.4 and Annex).

The sensor also officially adheres to the Russian national quality and safety requirements, which was tested and confirmed by the GOST certificate (see Annex).

Introduction // enviroFlu

2 Introduction

Hydrocarbons often occur in the environment and changing hydrocarbon concentrations in waste water are not unusual. Hydrocarbons can occur as freely floating particles, emulsified, dissolved or adsorbed to suspended particles. By definition, chemical compounds that consist exclusively of hydrogen and carbon are considered hydrocarbons. In general, these are divided into 3 main categories: aliphatic, alicyclic and aromatic hydrocarbons. Only aromatic hydrocarbons fluoresce, making them detectable with the enviroFlu.

Due to their persistence, toxicity and ubiquitous distribution, PAHs are of great importance as pollutants in the environment.

Nowadays, our waters are observed to be increasingly burdened by hydrocarbons, which is mainly a result of industrial processes and human factors. The natural ability of water to breakdown hydrocarbons is overextended, and the environmental impact puts stress on drinking water, fish stocks, microorganisms etc. Typical anthropogenic causes of hydrocarbon contributions include processes in the refining of crude oil into gasoline, lubricants, kerosene, diesel, etc. In addition, the resulting trade products making their way through outflows from street asphalt, fuel storage (e.g. at airports and workshops), transportation (bilge water), cooling water systems and production sites such as automotive, plastic and steel factories, and many other ways into the environment.

The UV fluorescence method is a sensitive method of detecting aromatic hydrocarbon compounds in water. Fluorescence is generally defined as a phenomenon in which a part of the radiation absorbed by the compound of interest at a certain wavelength is radiated out again at a higher wavelength. Certain compounds, including aromatic hydrocarbons, absorb energy when the water is excited by light of a specific wavelength in the UV range and send this light out again at a higher wavelength. This occurs by increasing the energy levels of single electrons of the atoms. The returned energy (in the form of light) is of lower power and is therefore detected as light of a higher wavelength. During re-radiation, each individual compound has a specific wavelength range that is typical for the respective compound, so that the compound in question can be detected by measuring the fluorescence light at these wavelengths. Via fluorescence, detection limits for online measurements in the low µg/L range are therefore possible.

Like all TriOS sensors, enviroFlu is pre-calibrated and delivered in the LOW channel, so that the sensor is immediately ready for use. The LOW channel offers a low amplification, but it is also possible to switch to the HIGH channel, which offers a high amplification.

2.1 Variants

enviroFlu is available in three different versions, which are characterised 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 0–500 μ g/L and 0–5,000 μ g/L, which are permanently assigned and cannot be subsequently changed.

enviroFlu HC has both an analogue (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 versions with different measuring ranges: enviroFlu HC 500 offers a measuring range from 0 μ g/L to 500 μ g/L PAH, whereas the enviroFlu HC 5000 version has a measuring range from 0 μ g/L PAH. If enviroFlu HC is mentioned in this document, the information also applies to the enviroFlu HC MB version, unless explicitly stated otherwise.

enviroFlu HC MB has different hardware and has a digital RS-485 interface that communicates via the Modbus RTU protocol. The analogue interface is omitted here. Here, too, two versions with different measuring ranges are available: enviroFlu HC MB 500 offers a measuring range from 0 µg/L to 500 µg/L PAH, whereas the enviroFlu HC MB 5000 version has a measuring range 0 µg/L to 5,000 µg/L PAH.

enviroFlu // Introduction

enviroFlu BT is recommended for the detection of monoaromatics (benzene, toluene and xylene, also called BTX). It corresponds to the enviroFlu HC in terms of equipment, but is equipped with other filter sets and measures in a measuring range from $0 \ \mu g/L$ to $10,000 \ \mu g/L$.

All variants have a switchable amplification and can thus measure in HIGH and LOW channel. In addition, the variants can be ordered with different housing materials such as stainless steel, titanium, deep-sea housing and acid-resistant housing. Connection options include a SubConn connector as well as a permanently mounted cable with lengths of 0.5 m, 2 m, 5 m and 10 m.

2.2 Product Identification

All TriOS Mess- und Datentechnik GmbH products have a rating plate, which clearly shows the product designation.

There is also an rating plate on the sensor with the following information that you can use to uniquely identify the product:



In addition to the product bar code, the rating plate includes the TriOS Mess- und Datentechnik GmbH logo and the CE quality label.

Please note that the specifications given here are for illustration purposes only and may be different depending on the version of the product.

Introduction // enviroFlu

2.3 Scope of Delivery

The shipment contains the following components:

- Sensor
- Operating instructions
- Accessories (if applicable)

Keep the original packaging of the device in case it needs to be returned for maintenance or repairs.

2.4 Measurement Principle and Design

TriOS ^{Optical Sensors}	enviroFlu	
		Г

The following is an overview of the measurement 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. The selection of the wavelength necessary to excite the PAH fluorescence is carried out by a high-quality interference filter.

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



The excitation beam is focused by a lens on a point about 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 (centre wavelength: 360 nm) is used to block scattered light and to select the florescent light. A specially developed circuit eliminates the influence of the existing ambient light (ambient light suppression). The above illustration shows the basic optical configuration.

The enviroFlu BT uses an interference filter with a centre wavelength of 289 nm.

3 Commissioning

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

Before the sensor is put into operation, it is important to ensure that it is securely attached and all of the connections are connected 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 8-pin Connector



Connect the male end of the connecting cable into the connector on the enviroFlu by making the pins align with the slots of the cable.



The next step is to hand-tighten the locking sleeve to secure the end of the connector into the bulkhead connection.

NOTICE

Do not twist or bend the connector when plugging or unplugging it. Insert the connector straight in and use the locking sleeve to attach the male contact pin.

3.1.2 Fixed Cable with M12 Industrial Plug





Pin assignment for enviroFlu HC MB

Pin assignment for enviroFlu HC and BT

- 1. RS-232 RX (commands)
- 2. RS-232 TX (data)
- 3. VOUT: 0-5 V
- 4. ANALOG GROUND
- 5. IOUT: 4-20 mA
- 6. DO NOT CONNECT
- 7. GROUND (Power + Ser. Interface)
- 8. POWER (12-24VDC)

2. RS-485 B 3. DO NOT CONNECT

1. RS-485 A

- 4. DO NOT CONNECT
- 5. DO NOT CONNECT
- 6. DO NOT CONNECT
- 7. GROUND (Power + Ser. Interface)
- 8. POWER (12-24VDC)

3.2 Interfaces

The enviroFlu has a digital interface (RS-232 or RS-485), as well as two analog outputs (only with RS-232; for pin assignment, see 3.1.1 or 3.1.2).

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 commands of the data protocols can be found in the appendix.



3.2.2 Analog Interfaces

The enviroFlu has two analog interfaces. The 0-5 V output as well as the 4-20 mA output behaviour is linear to the measuring range. The unit of measurement is $\mu g/L$ PAH. To convert the values of the mA analog output accordingly, the following formula must be used:

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

The following formula is used to calculate the value of the 0–5 V output:

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

*Generally 500 or 5,000 µg/L PAH (10,000 µg/L for the enviroFlu BT)

3.3 Measurement

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

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

Table: 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 voltage supply to the enviroFlu is established, the measurements start in "Continuous" mode. For each measured value, 12 measurements are triggered and the mean value is output, for which enviroFlu requires about 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 PCS we recommend to use 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 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).

Now the sensor can be connected and should be recognized by the controller. The "Continuous" mode is temporarily deactivated.

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

The device type must be set under "Sensor" "enviroFlu_XXXX". "Device type". 500" or "5000" are available for selection. "Undef" stands for not identified.

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

enviroFlu BT has a measuring range from 0 µg/L to 10,000 µg/L. The measurement results must be multiplied by a factor of 2 after the measurement. "Sensor" \rightarrow "Select parameter" \rightarrow 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 consequently remain configured to the factory settings RS-485 and Modbus RTU. enviroFlu HC MB transmits the device type (500 or 5000) automatically.

Now the display settings can be made (see TriBox3 manual).

3.3.3 Connection to 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" \rightarrow "Select COM port" \rightarrow Protocol: "TriOS" \rightarrow Hardware mode: "RS232" \rightarrow Set flow control: "Software".

Now the sensor can be connected and should be recognized. The "Continuous" mode is temporarily deactivated.

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

Switch to the service mode: "Options" \rightarrow "Service mode".

With "Sensor" \rightarrow "enviroFlu_XXXX" \rightarrow "Device type" the device type can be set. 500" or "5000" can be selected.



NOTICE

enviroFlu BT has a measuring range from 0 μ g/L to 10,000 μ g/L. The measurement results must be multiplied by a factor of 2 after the measurement. "Sensor" \rightarrow "Select parameter" \rightarrow Enter "Scaling". The parameter name remains PAH and cannot be changed.

NOTICE

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

Now the display settings can be made. These can be found in the TriBox mini manual.

4 Use

The enviroFlu can be operated with all TriOS controllers. Instructions for correct installation can be found in the relevant controller manual.

NOTICE Never transport the sensor by holding the cable.

4.1 Normal Operation

4.1.1 Diving Operation

For immersion operation, the enviroFlu can be completely or partially immersed in the water / measuring medium. To make a correct measurement, the measuring window must be completely immersed. A distance of at least 10 cm in front of the measuring window should be maintained in order to obtain a correct measurement. Objects or surfaces close to the measuring 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 a steel wire to position the device in the medium. Do not use the sensor cable to carry the device, and do not pull on the cable.

The enviroFlu can also be attached to the edge of the pool or to 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 pipe against excess pressure at certain points, install the brackets close to the device covers. Fitting brackets can be obtained from TriOS.

Service



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

enviroFlu // Use

General Information

4.1.2 Cleaning System

Nano-coating

All of the optical windows from TriOS are treated with a nano-coating.



Window with nano-coating



Window without nano-coating

Wetting of the surface of the coated glass is significantly lower. This effect is caused by the nano-coated surface of the glass, to which dirt cannot adhere. In combination with compressed air cleaning, the cleaning effort is reduced and the sensor gets longer service life because the windows are kept clean over a long period of time.

Compressed air cleaning

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



NOTICE

The optimum pressure for compressed-air cleaning is 3 to 6 bars. 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 compressed air cleaning head, carefully push the hose into the connection. To remove the hose, press the blue locking ring in the direction of the connection and pull the hose out. Secure the hose to the device and the cable with cable ties if necessary to avoid uncontrolled hits and movement of the compressed-air hose. A tight-fitting air hose, which is also fixed to the sensor, avoids tangles.

NOTICE The pressure should not exceed 7 bars! This may damage the valve!

Use // enviroFlu

4.1.3 Float

The float is the ideal solution for fluctuating water levels.



4.2 Bypass

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



The maximum pressure in the flow cell must not exceed 1 bar. Make sure that the sensor is installed in the correct position to guarantee the free flow of water and to 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:

- Remove the pressure ring of the flow cell with O-ring by removing the four bolts with a 4 mm (new Flow-Cells 6 mm) Allen key.
- 2. First, slide the pressure ring onto the enviroFlu, then the O-ring. Next, plug the enviroFlu into the flow cell (see example p. 15). The device must protrude out of the flow cell between 265 mm and 275 mm, i.e. it should not cover the inflow or outflow from the inside. On newer FlowCell models there is a small ledge inside which defines the position of the sensor. Here the sensor only has to be inserted up to the shoulder and is automatically in the correct position. On the panel, a bracket provides for the correct positioning of the sensor in the flow cell. Make sure that the seal ring is positioned correctly and is not damaged. Suitable O-rings can be obtained from TriOS.
- 3. When the enviroFlu is positioned correctly, tighten the bolts.

enviroFlu // Use



Refer to the illustrations to correctly install the flow cell. The FlowCell and the enviroFlu should be mounted at an angle of between 15° and 75° from the horizontal. To avoid air bubbles, the drain should be at the top and the inlet at the bottom. Hand-tighten the flow cell screws with the appropriate Allen wrench to prevent leaks and allow water to flow freely.



To connect the hose to the flow cell, gently push the hose into the connector. To remove the hose, press the blue locking ring in the direction of the connection and pull the hose out.



Use // enviroFlu

4.3 Tube Installation

The enviroFlu in the version with pre-mounted flange DN80 (DIN11851) can be mounted directly in the pipe. In the case of a grounded pipe, no additional grounding of the enviroFlu housing is required (as long as no insulation is mounted 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 figure below.



4.4 Operation with Type Approval according to IMO Regulations

The enviroFlu HC has a type approval according to IMO regulation MEPC.340(77) as well as MEPC.259(68) for monitoring the PAH concentration in the discharge water of exhaust gas cleaning systems. The measured value PAH-p of enviroFlu corresponds to μ g/L PAH_{phe} equivalent. The enviroFlu HC most of the set flow rates for the inflow of discharge water (see table below).

PAH concentration in relation to the flow rate according to MEPC.340(77)

Flow rate [t/MWh]	Inflow concentration limit value [µg/L PAH _{phe} equivalents]	Sensor type	Measurement range
01	2,250	ultraviol	ett only*
2.5	900	ultraviol	et only*
5	450	enviroFlu HC 5000	0–800 μ g/L PAH _{phe} eq.
11.25	200	enviroFlu HC 5000	0–800 μ g/L PAH _{phe} eq.
22.5	100	enviroFlu HC 5000	0–800 μ g/L PAH _{phe} eq.
45	50	enviroFlu HC 5000	0–800 μ g/L PAH _{phe} eq.
45	50	enviroFlu HC 500	0–80 µg/L PAH _{phe} eq.
00	25	enviroFlu HC 5000	0–800 $\mu\text{g/L}\ \text{PAH}_{\text{phe}}$ eq.
90	20	enviroFlu HC 500	0–80 µg/L PAH _{phe} eq.

*Alternative measurement technologies may be used with the agreement of the Administration.

The measurement range depends on the specified discharge water flow and can be adapted to the requirements referred to in regulation MEPC.340(77) dated 26 November 2021:

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

German

"Richtlinien für Abgasreinigungssysteme 2021" (Absatz 10: "Ablaufwasser")

It was demonstrated under the supervision of the DNV that the enviroFlu HC could be used for flow rates \geq 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)

With the marine certification, an operating temperature of between 5 °C and 55 °C is required. The above measurement ranges can be guaranteed at temperatures between 5 °C and 40 °C.

4.4.2 Mounting

The enviroFlu HC can be mounted directly in the pipe (either with the special flanged version of the enviroFlu HC or installation by the customer on-site). In the case of a grounded tube, no additional grounding of the enviroFlu housing is required (as long as there is no insulation between the tube and the sensor). The standardised flange solution available from TriOS is shown in the figure on p. 16. Please ensure a minimum distance of 10 cm between the measuring window and the inside of the pipe when installing the device.

With the flow cell, the enviroFlu HC can be installed as a bypass. Please refer to chapter 4.2.

For this type of application, make sure that the housing of the enviroFlu is grounded!

4.4.3 Electrical Installation

Applications with ship approval as mentioned above must be set up with an enviroFlu HC (MB) with permanently installed 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 the measurement data.

The shielding of the M12 industrial connector must also be earthed (cf. chapter 3.1.2 M12 industrial connector).

4.4.4 Data Conversion

The unit of measurement is μ g/L PAH_{phe} 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

Correction of the measured values for turbidity is absolutely necessary. The enviroFlu must simultaneously take measurements with a turbidity sensor. The measured values of the PAH_{phe} equivalent must be converted using the following equation for turbidity correction. This formula must be implemented in the software of the controller or the logger.

Calculation of the measured value corrected for turbidity I_0 in µg/L PAH_{phe} equivalent:

$$I_0 = I \cdot (0.018x - 0.00004x^2 + 1)$$

Measured values of the enviroFlu = I [μ g/L PAH_{phe} eq], as calculated in the formula in 4.4.4

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

Turbidity corrected measured value = $I_0 [\mu g/L PAH_{ohe} eq]$

*For turbidity values above 220 FNU, x=220 is calculated.

Calibration // enviroFlu

5 Calibration

Creating a generally valid calibration for PAHs 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 maximums at different wavelengths. In addition, the problem is compounded by the fact that most samples contain a mixture of different PAHs. Diesel and petrol, for example, contain a wide range of polycyclic aromatic hydrocarbons, and their composition varies not only with the production process, but also with the type of crude oil used.

Therefore, TriOS has developed its own calibration standard for PAH fluorescence (the TriOS fluorescence calibration standard (TFCS)), which is used for the manufacturer calibration of the enviroFlu HC. This is based on phenanthrene. 10 μ g/L of phenanthrene generates a signal of 62 μ g/L of TFCS, which means that the enviroFlu measures 62 μ g/L.

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

5.1 Manufacturer Calibration

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

The conversion of the raw value of the fluorescence measurement in the substance concentration is carried out by using the following equation.

For each measurement range (LOW as well as HIGH), the scaling factor and offset are stored in the sensor.

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

The offset is determined by measuring in ultra-pure water (free of humic and fulvic acid, 18.2 MΩcm water)

A = Raw - Offset

 The scaling factor for each measurement range is determined by using the TriOS fluorescence calibration standard (TFCS). For the channel with high signal gain, a linear approximation is used:

Calibrated = $A \cdot lin$

 Fluorescence quenching (quenching effects) at high concentrations means that the calibration is no longer linear. Therefore, for the measuring channel with a small gain (LOW), a quadratic approximation is used.

Calibrated =
$$A \cdot lin + A^2 \cdot square$$

wileie.	
A	offset corrected value
Raw	fluorescence raw data
Offset	offset value
Calibrated	concentration of the substance in physical units
lin	linear factor
square	quadratic factor

The manufacturer calibration should not be changed!

enviroFlu // Calibration

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 "Parameter" button in the "Sensor" menu and enter Offset and Scaling. The customer calibration or local calibration supplements the manufacturer calibration. The manufacturer calibration values are not changed by the customer calibration.

The customer calibration can be used as a fine adjustment of the sensor for special media and supplements the manufacturer calibration.

The local calibration (*Custom Calibrated*) is adjusted using a linear equation. Two constants will be needed for this, the scaling factor and the offset, which can be used according to the following equation:

Custom Calibrated = (Calibrated – Offset) · Scaling

with Calibrated as the original concentration, which is output by the fluorometer.

Local calibration requires at least two data points, i.e. a laboratory value and a sensor value. The easiest way to do this is to use a non-PAH-contaminated sample and a PAH-contaminated sample.

 The non-PAH-contaminated sample is used to determine the offset. Most suitable is ultrapure water with 18.2 MΩ. To do this, immerse the fluorometer in the fluid that is not contaminated. In this specific case, the signal gives the value of the offset directly for the local calibration.

Offset = measuredvalue1

If a non-contaminated sample is not available, the equation in point 5 below offers another option.

- 2. Now immerse the sensor in the contaminated medium and note down measuredvalue2, which is output by the fluorometer, and do a laboratory analysis of the sample.
- 3. Make a diagram like the one shown below and connect the two data points with a straight line. The slope of the straight line is the scaling factor.



Measured concentration of the enviroFlu HC $\left[\mu g/L\right]$

Calibration // enviroFlu

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

scaling factor =
$$\frac{lab}{measuredvalue2 - offset}$$

Where lab is the laboratory value, and measuredvalue is the value output by the sensor.

For the previous example in the figure, this means:

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

 If a non-PAH-contaminated sample is not available, at least two samples with very different levels of PAH contamination are needed. In this case, first calculate the scaling factor as follows:

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

measuredvalue2 should be significantly larger than *measuredvalue1*. The offset can also be found using the abscissa of the straight line (intersection with X axis). For the above example, this means:



An offset due to ageing can be compensated by a customer calibration up to the limits listed in the table below. If the offset determined in this way is greater than the value in the following table, either the sample is dirty or the measuring window is dirty. If this can be excluded, then the sensor is defective.

Measurement range	Offset in air PAH (max.)	Measurement range	Offset in 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

General

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 performed using the UV fluorescence method. The particles integrated in the glass are excited by the UV light of the highly efficient xenon flash lamp of the enviroFlu 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.

Parameter

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

Each individual DryCAL generates a signal corresponding to a specific concentration, that 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)



Warnings

- The DryCAL set has been developed for use in industry and science. It can only be used with the assigned enviroFlu.
- It is used to check the function and is used in case of a necessary calibration.
- · Only use the DryCAL set in air. Use in other media may damage the product.
- Protect the DryCAL set from environmental influences. Never expose it to sun, rain or dust.
- Store the DryCAL set in a dry place and preferably keep it in the transport box provided.
- Never try to disassemble or modify the DryCAL set. Inspections, modifications and repairs may only be carried out by the device dealer.
- If fissures, scratches or cracks are visible on the glass during the visual inspection, the DryCAL set should be sent to TriOS Mess- und Datentechnik GmbH together with the assigned enviroFlu for inspection.
- The DryCAL set must be sent in for maintenance together with the enviroFlu.

Application DryCAL



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



Calibration with DryCAL-0 (offset determination / zero value) should first be performed 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.

Application

- 1. Check DryCAL-0 and DryCAL-1 for scratches and dust. If both DryCAL are clean, you can first place them with the glass side down on a clean, lint-free cloth.
- 2. To calibrate the sensors the TriBox3 must be set to maintenance mode.
- 3. Clean the front area of the enviroFlu thoroughly (see enviroFlu manual, Chapter 6).
- 4. The measuring 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 bottle supplied in the Dry-CAL set for acetone. When cleaning, make sure that the optical window is not scratched and no longer has any coating.
- 5. When the cleaning is finished, the calibration of the sensor can be started.
- Follow the instructions of the calibration wizard of the TriBox3 (version 1.4.38 or higher). For other variants use the form attached to the DryCAL short manual for the calculation of offset and scaling.
- 7. If an offset and scaling is already set for the sensor, this must be reset to Offset = 0 and Scaling = 1 before measurement with DryCAL.

enviroFlu // Calibration

- 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 average value and enter it in the protocol)
 - · The difference between the measured and printed value is the offset
 - · Enter offset into the controller or enter it as a correction factor into your data logger
- Slope (DryCAL-1)
 - If not already done, change to the 500 channel (low for enviroFlu 500, and high for enviroFlu 5000)
 - · Place the DryCAL-1 on the sensor
 - · Wait until the measured values become stable
 - Trigger at least 16 measurements (insert average value of the measured values into the protocol, make sure that the offset is included in the output measured values)
 - · Calculate gradient and enter in the protocol
 - Enter values for the slope into the controller or as correction factor into the data logger to adjust the following measured values.

Corrected value = (measured value - offset) · slope

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

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

5.3 Measurement Properties of the enviroFlu

5.3.1 Measurement Parameters

By definition, hydrocarbons are chemical compounds composed exclusively of hydrogen and carbon. As a rule, they 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. In the 1980s, the U.S. Environmental Protection Agency (US EPA) therefore included 16 substances in the list of "priotiry pollutants". These 16 substances form a group of organic compounds, all of which consist of several linked aromatic ring systems and have different solubilities depending on their structure.

Parameters PAH and PAH-p

According to the definition of the 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 directly from PAH with a factor of 6.2. **enviroFlu HC MB** provides the measurement results of PAH and PAH-p in different Modbus addresses. The digital measurement result of **enviroFlu HC** needs to be divided by 6.2 to get the result for PAH-p.

Installed in an EGC Water Analyzer, the TriBox3 with 8-digit serial number offers both, PAH and PAH-p units.

Calibration // enviroFlu

EPA-PAH	Solubility in water	Solubility in water	Danger classification
Naphthalene	32 mg/L at 25 °C,	Hardly soluble	(أي الأي الأي الأي الأي الأي الأي الأي ال
Acenaphthylene	3.93 mg/L at 25 °C	Almost insoluble	$\langle \rangle$
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	(ب) 🚯
Anthracene	1.29 mg/L at 25 °C	Insoluble	(ا
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	الله الله
Chrysene	0.006 mg/L at 25 °C	Insoluble	الله الله الله الله الله الله الله الله
Benzo(b)fluoranthene	0.0012 mg/L at 25 °C	Insoluble	الله الله الله الله الله الله الله الله
Benzo(k)fluoranthene	0.0122 at/L	Insoluble	
Benzo(a)pyrene	0.0045 mg/L at 15–30 °C	Insoluble	(ب 🚯 🚯
Dibenzo(a,h)anthracene	0.0025 · 10 ⁻⁶ mg/L	Insoluble	الله الله
Indeno(1,2,3-cd)pyrene	0.062 mg/L	Insoluble	٠
Benzo(ghi)perylene	0.3 · 10⁻ੰ g/L at 20 °C	Insoluble	×.

flammable substances

- hazardous to health
- endangering the environment
- acute toxicity



Perkin Elmer LS50B: Fluorescence spectra of PAH in Water 10 mm cuvette, Ex slit 10 nm, Em slit 10 nm; Excitation wavelength 254 nm

enviroFlu // Calibration





Perkin Elmer LS50B: Fluorescence spectra of PAH in Water

The emission intensity of individual PAHs at 360 nm varies greatly, as does the composition of PAHs in different mineral oils. Therefore, no universal calibration for PAHs in water is impossible. Naphthalene and phenanthrene have the highest concentration in wastewater from exhaust gas cleaning systems on ships and in crude oil. Since naphthalene is very volatile and the fluorescence signal is 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	hardly soluble	
360 nm +/- 50 nm filter fits and hits all PAHs	proposed filter won't hit all PAH	
easier to handle	hard to handle	
<u> </u>		



enviroFlu excitates light at 254 nm and detects the fluorescence signal at 360 nm. In a sample, one always obtains a signal of all contained PAHs and thus has the sum of all fluorescence signals at 360 nm. The parameter PAH refers to the mean sum of the laboratory results of 16 EPA-PAH. The table in chapter 5.3.3 shows the measured values of the enviroFlu for the detection of PAHs, other (aromatic) substances (chapters 5.3.4 and 5.3.6) and various oils dissolved in distilled water (chapter 5.3.5). The conversion factors of different aromatic hydrocarbons in relation to the TriOS fluorescence calibration standard (TFCS) are given. These factors are only reference points for a possible measurement result of the enviroFlu HC for a certain concentration of a PAH, because these factors were measured for a single concentration and not for the entire calibration curve. The information can vary slightly from sensor to sensor, because the built-in filters have certain tolerances as well.

The conversion is calculated as follows: the measured value of enviroFlu HC in μ g/L PAH multiplied by the PAH-specific factor (see table in 5.3.1) of an individual substance gives the PAH concentration of the individual substance

$$C_{env} \cdot Factor = C_{PAH}$$

or the concentration of a single PAH (e.g. phenanthrene) divided by the PAH-specific factor (see table in 5.3.3) gives the measured value of the enviroFlu HC in µg/L PAH.

$$C_{PAH} \div Factor = C_{em}$$

Example:

1 μ g/L of the TFCS = 1 PAH, produces the same measured value as 0.16 μ g/L of phenanthrene. 1 μ g/L of the TFCS = 1 PAH, produces the same measure value as 0.27 μ g/L anthracene.

In bodies of water, other PAHs may also be present which do not belong to the 16 PAHs classified as environmentally harmful by the US EPA (US Environmental Protection Agency). These also fluoresce and are detected by the enviroFlu HC, including PAH isomers, alkalized PAHs and PAHs with heteroatoms (bound to N-, S-, O-atoms).

NOTICE

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

5.3.2 Methods for Comparison Measurements

The dissolution of oil in an aqueous medium is usually problematic due to the low water solubility of the oils. It is difficult to recreate real-world conditions in the laboratory.

In reality, oil is dissolved in water by the following

- long exposure time
- currents
- wind and wave movement
- solubilising agents

In the laboratory, various methods of dissolving oil in water are used:

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

For another method, a stock solution of oil in ethanol is produced first. From that, an aliquot can be mixed with the water.

Notes on the following tables:

- a: type of solution
 - 1) direct

- 2) solution of the substance in a stock solution made of ethanol to be diluted with distilled water
- 3) two drops of oil in 2 L of distilled water stirred for 24 hours.
- b: 1 $\mu g/L$ of the TFCS corresponds to x $\mu g/L$ of the substance
- c: TFCS = TriOS fluorescence calibration standard

5.3.3 Measuring Behaviour with EPA PAHs

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

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

Substance	Concentra- tion in dest. water	Type of solution	Output enviroFlu HC	Factor x	Notes
	[µg/L]		[µg/L]		
TFCS				1	
EPA PAH	16 "most imp	ortant" PA	Hs, determined. (U	by the US JS EPA)	Environmental Protection Agency
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	8.70	1.15	
Chrysene	5	2	7.42	0.67	
Benzo(b)fluoranthene	saturated	2	0.57		
Benzo(k)fluoranthene	saturated	2	0.01		hardly water-soluble
Benzo(a)pyrene	saturated	2	1.74		hardly water-soluble
Dibenzo(a,h)anthracene	saturated	2	1.09		hardly water-soluble
Indeno(1,2,3-cd)pyrene	saturated	2	0.37		hardly water-soluble
Benzo(ghi)perylene	saturated	2	0.05		hardly water-soluble

5.3.4 Measuring Behaviour with Alkylated PAHs and PAHs with Heteroatoms

In the table below, the measuring behaviour of a selection of alkylated PAHs and PAHs with heteroatoms is listed.

Substance	Concentra- tion in dest. water	Type of solution	Output enviroFlu HC	Factor x	Notes
	[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 Measuring Behaviour with Different Oils

Various oils display varying results, as shown in several examples in the lower table.

Substance	Concentra- tion in dest. water	Type of solution	Output enviroFlu HC	Factor x	Notes
	[µg/L]		[µg/L]		
Petrol					
Esso Super Petrol	5,000	2	35.6	140	
Kerosene					
Jet A1	10,000	3	23.8	420	
Diesel oils					
Diesel Esso	500	2	39.2	12.8	
Diesel Esso	5,000	3	139	36	not completely dissolved
Heating oil	10,000	3	264	37.9	not completely dissolved
Marine diesel oil (MDO)	10,000	3	115	87	not completely dissolved
Marine diesel oil (MGO)	10,000	3	187	53	not completely dissolved
Heavy oils					
Heavy oil	20,000	3	107	187	not completely dissolved
IFO 80-100	20,000	3	318	31	not completely dissolved
Crude oils					
Brent crude oil (North Sea)	10,000	3	139	72	not completely dissolved
Karachaganak crude oil (Kazakhstan)	10,000	3	89.3	112	not completely dissolved
Forties crude oil (British North Sea)	10,000	3	131	76	not completely dissolved
Debno crude oil (Poland)	10,000	3	100	100	not completely dissolved
Ob Bay crude oil (Russia)	10,000	3	109	92	not completely dissolved
Albacora Leste crude oil (Brazil)	10,000	3	176	57	not completely dissolved
Lubricating oils					
Hydraulic oil	8,000	3	4.39	1822	hardly water soluble
Shell Omala 320	15,000	3	23.3	644	hardly water soluble
Shell 1662	15,000	3	2.29	6550	water insoluble
BP Motoroil	15,000	3	1.28	7812	water insoluble

Lubricating oils are often synthetic and not mineral oils. Because they are basically water insoluble, detection with the enviroFlu is often not possible. Edible oils do not contain PAHs and therefore cannot be measured with the enviroFlu.

5.3.6 Measuring Behaviour with Monoaromatics

The enviroFlu HC cannot be used to detect most monoaromatic hydrocarbons, such as benzene, toluene and xylene (BTX). For this, the use of the enviroFlu BT is recommended.

Substance	Concentration in dest. water	Type of solution	Output enviroFlu HC	Factor x	Notes
	[µg/L]		[µg/L]		
benzene	200,000	1	1.93	104000	
Toluene	20,000	1	2.11	9500	
p-Xylene	20,000	1	18.3	1093	
Chlorobenzene	20,000	1	0.25		Value below detection limit
Fluorobenzene	10,000	1	4.86	2058	
Propylbenzene	10,000	1	0.77	13000	
Styrene	1,000	1	305	3.28	
Phenol	4,300	1	58.7	73	
Biphenyl	538	2	293	1.84	

The following table provides the measuring behaviour of an enviroFlu BT with monoaromatic hydrocarbons.

Substance	Concentration in dest. water	Type of solution	Output enviroFlu BT	Factor x	Notes
	[µg/L]		[µg/L]		
Anisole	10,000	1	10,000	1	
p-Xylene	2,000	2	684	3	
Toluene	10,000	1	768	13	
benzene	10,000	1	96	100	

Different methods for dissolving oil in water as well as different concentrations lead to different factors. Therefore, the factors in the table above should only be understood as an indication for 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 substance or CDOM, may 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 be made either via 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 measurement 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 an error-free and reliable measurement, the enviroFlu should be periodically checked and maintained. The sensor must first be cleaned.

6.1 Cleaning and Upkeep

Deposits (vegetation) and dirt depend on the medium and the duration of use in the medium. Therefore, the degree of pollution depends on how the sensor is used. For this reason, it is not possible to give a general answer regarding how often the sensor should be cleaned.

Normally, the system is kept clean by the nano-coated window and, additionally, the pressured air cleaning system. If the contamination is too bad, follow the instructions below.

If you have further questions on this topic, we would be pleased to help you. Please contact our technical support at support@trios.de.

6.1.1 Cleaning the Housing

ACAUTION Please use protective goggles and gloves when cleaning the sensor, especially when using acids, etc.

To loosen dirt, we recommend soaking the sensor for several hours in a rinsing solution. During cleaning, do not let exposed connectors come in contact with water. To prevent contact with water, make sure that the locking cap of the connector is properly locked. Please learn about the risks and the safe handling of the cleaning solution used.

If the sensor is very dirty, additional cleaning with a sponge may be necessary. You should take extreme care to avoid scratches on the measuring window.

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

Brownish dirt or spots can be contamination from iron manganese oxides. For this type of contamination, a 5% oxalic acid solution or a 10% ascorbic acid solution can be used to clean the sensor. Please note that the sensor should only briefly come in contact with the acid, and then it should be thoroughly rinsed.

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

6.1.2 Cleaning the Measuring Window

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

When cleaning the window, a thin film will appear, which can be removed with a soft cloth or clean water. Do not use any aggressive cleaning solutions, scraper, sandpaper or cleaning solutions that contain abrasive substances to remove dirt.

TriOS Mess- und Datentechnik GmbH offers a cleaning set with a bottle for acetone and special optical cleaning paper to simplify cleaning the optical window.

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

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. Furthermore, you can hold a white sheet of paper in front of the measuring window. You should then see blue fluorescent light in flashes on the paper.

The zero point should be checked regularly. For this, make sure to maintain a distance of over 20 cm between the measurement window and the environment. If the sensor is correctly calibrated, a value near zero will be output in ultra-pure water (free of humic and fulvic acid, 18.2 M Ω cm water). In air, a small offset is normal as enviroFlu is calibrated as an immersion sensor. If this is not the case, send the device back to the manufacturer for recalibration. For return information, see chapter 6.4.

Depending on the measurement range, the following offset values for air are still classified as normal:

Measurement range	Offset in air PAH (max.)	Measurement range	Offset in 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

Up to a certain degree, an offset can be calculated from the customer calibration according to chapter 5.2.

Because changes to the device and calibration can occur over time, we recommend recalibration and cleaning of the sensor by the manufacturer every two years. When used with DryCAL this time can be increased to 4–5 years. Only regular inspection of the calibration can ensure error-free measurement. Every four years, the sensor should be returned to replace the lamp and be recalibrated. It is necessary to replace the lamp because it is exposed to a high energy load and its light intensity may decrease after about four years of continuous operation.

Malfunction & Maintenance // enviroFlu

6.3 Troubleshooting

Currently, there is no possibility of repairing the enviroFlu adequately on site. The sensor must be sent back to the manufacturer for troubleshooting. When returning a sensor, always follow the procedure described in chapter 6.4, including provision of the RMA number.

6.4 Returns

Please observe the following instructions when returning items.

If there are any problems with the sensor, please contact TriOS Technical Support (support@trios.de). In some circumstances, they will request log files that you can download from your sensor using a controller. If the technical support cannot solve the problem based on this file, an RMA form with an RMA number will be sent to you. You should include this number in the subject line of the following e-mails. Fill out the form and enclose it with the return shipment. This is the only way your return shipment can be accepted and correctly assigned.

Caution! Return shipments without an RMA number cannot be accepted and processed!

Please make sure that the sensor is cleaned and disinfected before shipping. In order to prevent damage to the goods during shipping, use the original packaging. If this is not available, make sure that safe transport is guaranteed and that the sensor is safely packed with enough packing material.

Should you require further information, please contact the technical support (see chapter 10).

7 Technical Data

7.1 Technical Specifications

7.1.1 enviroFlu	l HC					
Measurement	Light source	Xenon flash lamp + filter (254 nm)				
technology	Detector	Photodiode + filter (360 nm)				
Measurement principle		Fluorescence				
Parameters		PAH, oil				
	enviroFlu HC	PAH: 0–50 µg/L, 0–500 µg/L	PAH: 0–50 ppb, 0–500 ppb			
Measurement	500	Oil: 0–1.5 mg/L, 0–15 mg/L typ.	Oil: 0–1.5 ppm, 0–15 ppm			
range	enviroFlu HC	PAH: 0–500 µg/L, 0–5,000 µg/L	PAH: 0–500 ppb, 0–5,000 ppb			
-	5000	Oil: 0–15 mg/L, 0–150 mg/L typ.	Oil: 0–15 ppm, 0–150 ppm			
Detection limit		enviroFlu HC (MB) 500 0.3 μg/L	enviroFlu HC (MB) 500 0.3 ppb			
Detection mini		enviroFlu HC (MB) 5000 0.5 μg/L	enviroFlu HC (MB) 5000 0.5 ppb			
Measurement	accuracy	±5% FS*				
Reproducibility	y	≤ 0.5% FS*				
Turbidity comp	pensation	No (only possible via TTurb on the T	TriBox3)			
Data logger		No				
Reaction time T100		≤ 10 s				
Measurement interval		≥5s				
Interface digital analog		RS-232 (TriOS protocol)				
		4–20 mA, 0–5 V				
Power consumption		≤ 3.5 W				
Current consu	mption	0.2–0.5 A				
Power supply		12–24 VDC (±10%)				
Required supe	rvision	Typically ≤ 0.5 b/month				
Calibration/ma	intenance	24 months, the manufacturer calibration can be increased to 4–5 years				
interval		when used with associated DrvCAL-Set				
System compa	tibility	analog out (0–5 VDC, 4–20 mA)				
Warranty		1 year (EU: 2 years)	US: 2 years			
		Stainless steel (1.4571/1.4404), not	suitable for permanent seawater use;			
	Housing	titanium (3.7035); DeepSea version: titanium (3.7035)				
Material Measuring head		black POM with synthetic quartz glass, not suitable for pH values < 4				
		DeepSea version: Cover titanium, pressure ring POM				
		Acid-resistant version: PPS	40.0% 0.0%			
Dimensions (L	xØ)	311 mm x 68 mm	~12.2° X 2.6°			
		DeepSea Version: 314 x 78 mm	DeepSea Version: ~ 12.4 x 3.1			
Majabt	stainless steel	~ 2.7 kg	~ b lbs			
weight	titanium	~ 1.9 kg	~ 4.2 lbs			
		DeepSea version: ~ 3.9 kg	DeepSea version: ~ 8.6 lbs			

* FS: Full Scale \triangleq Measurement Range

Technical Data // enviroFlu

	with SubConn	30 bars	~ 435 psig
with fix	with fixed cable	3 bar	~ 43.5 psig
pressure	in flow cell	1 bar, 2 – 4 L/min	~ 14.5 psig, 0.5 to 1 gpm
DeepSea ver- sion		600 bar	~ 8,702.2 psig
Protection type		IP68	NEMA 6P
Sample temperature Ambient temperature		+2 °C to +40 °C	~ +36 °F to +104 °F
		-5 °C to +55 °C (+2 °C to +40 °C for specified accuracy)	~ +23 °F to +131 °F (~ 32 °F to 104 °F for specified accuracy)
Storage to	emperature	–20 °C to +80 °C	~ –4 °F to +176 °F
Inflow velocity		0.1 – 10 m/s	~ 0.33 fps to 33 fps
Max. immersion depth		300 m with SubConn 8-pin underwater connector	~ 984 ft with SubConn 8-pin underwater connector
		30 m with fixed cable	~ 98.4 ft with fixed cable
		optional: 6,000 m DeepSea version	optional: ~ 19,685.04 ft DeepSea version

7.1.2 enviroFlu HC MB

The technical specifications differ from those in 7.1.1 in the following points:

Interface	digital	RS-485 (Modbus RTU)
Internace	analog	Not available

7.1.3 enviroFlu BT

The technical specifications differ from those in 7.1.1 in the following points:

0–1,000 μg/L, 0–10,000 μg/L

7.2 Detection Limit

7.2.1 General detection limits

	Measurement range [µg/L PAH]		Detection limit	
	LOW channel	HIGH channel	in pure water	Calibrated with
enviroFlu HC (MB) 500 (ex: 254 nm, em: 360 nm)	0–500	0–50	0.3 µg/L	TFCS (phenanthrene based)
enviroFlu HC (MB) 5000 (ex: 254 nm, em: 360 nm)	0–5,000	0–500	0.5 µg/L	TFCS (phenanthrene based)
enviroFlu BT (ex: 254 nm, em: 289 nm)	0–10,000	0–1,000	20 µg/L	Anisole solution

ex: excitation; em: emission.

7.2.2 Substance-specific Detection Limits for enviroFlu BT

Detection limits of the enviroFlu BT:

Substance	Detection limit [µg/L]
Anisole	20
p-Xylene	60
Toluene	260
Benzene	2,000



enviroFlu // Technical Data

D01-032en202212 Manual enviroFlu

Technical Data // enviroFlu









enviroFlu // Technical Data

Accessories // enviroFlu

8 Accessories

8.1 Solid Standards

8.1.1 SolidCAL HC

Fast function and calibration validation

With SolidCAL solid secondary standards, function and calibration checks of the enviroFlu for PAH detection can be quickly carried out. The simple handling of the SolidCAL ensures fast and precise checking of the device, also directly on site. A standard is available for every TriOS fluorometer - also for the enviroFlu in different concentrations.

To ensure proper use of the SolidCAL, please refer to the corresponding operating instructions.



8.1.2 DryCAL

The DryCAL set is a solid standard, consisting of DryCAL-0 and DryCAL-1, for calibration of the TriOS fluorometer enviroFlu HC. The set is exactly calibrated to the measuring properties of the sensor assigned to it. The advantage is the simple and uncomplicated application without the use of reagents. In addition, it is virtually maintenance-free due to the materials used, but should always be sent back with the enviroFlu for maintenance or repair.

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



enviroFlu // Accessories

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 pneumatic control

TriBox3 is a measurement and control system for all TriOS sensors. The device provides 4 sensor channels with selectable RS-232 or RS-485 function. In addition to the 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 TCP/ IP and WLAN networks, USB connection and 6 analog outputs (4–20 mA). An integrated relay can trigger alarms or control external devices. Features such as low power consumption, a robust aluminium housing and a range of interfaces make it suitable for all applications associated with environmental monitoring, drinking water, wastewater treatment plants and many other areas.



8.2.2 TriBox mini

Digital 2-channel controller

Mini controller with two digital sensor channels and two 4–20 mA outputs. All of the measured values and diagnostics data that are saved can be selected using an integrated web browser.

One sensor of the same type can be connected.



8.3 Protective Cage

Protection against large interference factors

To protect the measuring window against large particles, the sensor can be fitted with a protective cage. The slots in the POM material keep out floating interference factors, such as leaves, etc., and still allow enough water to flow through.





9 Warranty

The TriOS device warranty within the EU and US is valid for two years from the date of the invoice. Outside of the EU, the warranty period is one year. Normal consumables, such as light sources, are not included in the warranty.

The warranty is subject to the following conditions:

- The device and all accessories must be installed as described in the corresponding manual and must be operated according to the specifications.
- Damage due to contact with corrosive and damaging substances, liquids or gases and damage during transport are not covered by the warranty.
- · Damage due to improper handling and use of the device is not covered by the warranty.
- Damage resulting from modification or unprofessional attachment of accessories by the customer is not
 covered by the warranty

NOTICE Opening the sensor voids the warranty!

Customer Service // enviroFlu

10 Customer Service

If you are having a problem with the sensor, please contact technical support.

We recommend to return the sensor every 2 or 4–5 years for maintenance and calibration. To do this, please request an RMA number from the TriOS technical support.

Technical support contact:

support@trios.de

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

To help us provide you faster service, please send us the sensor ID number by email (the last four digits of the serial number consisting of letters and numbers, e.g. 28B2)

enviroFlu // Contact

11 Contact

We are constantly working to improve our devices. Visit our website for news and information. If you have found an error or bug in one of the devices or programs, please let us know:

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

 TriOS Mess- und Datentechnik GmbH

 Bürgermeister-Brötje-Str. 25

 26180 Rastede

 Germany

 Telephone
 +49 (0) 4402 69670 - 0

 Fax
 +49 (0) 4402 69670 - 20

Contact // enviroFlu

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13 FAQ - Frequently Asked Questions

You can find more FAQs on our website: www.trios.de.

1. I cannot see the excitation light of the sensor. Is the sensor damaged?

Never look directly into the light beam. UV light can caused serious damage to the eyes! The enviroFlu has a xenon flash lamp, which emits UV light. Use a piece of white paper and hold it in front of the device. You should be able to see a florescent blue light flashing on the paper.

2. What applications are the titanium versions of the sensor designed for?

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

3. What is the recommended inflow velocity?

0.1 m/s to 10 m/s (see Chapter 7 - Technical Specifications).

4. How much space must be in front of the optical window to get a correct measurement?

We recommend to have at least 10 cm space between the measuring window and the rim 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 parameter oil in water is only output via the TriBox mini NET. The other controllers do not have the possibility to output this parameter directly. In TriBox3 you can enter the scaling factor and change the name in the display to get 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.

FAQ // enviroFlu

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CE Declaration of Conformity





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

Typ / Type / Type

enviroFlu

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 61326-1:2013 EN 61010-1:2010 +A1:2019 +A1:2019/AC:2019 EN IEC 63000:2018

Unterschrift / Signature / Signatur

Datum / Date / Date

17.05.2022

R. Heuermann

Marine Certification according to IMO Regulations



TYPE APPROVAL CERTIFICATE

Certificate No: TAA00002FB Revision No: 1

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
EMC B
(IP68)

Issued at Hamburg on 2022-06-24 This Certificate is valid until 2024-04-15. DNV local station: Hamburg – CMC North/East

for DNV

Approval Engineer: Jens Dietrich

Joannis Papanuskas Head of Section

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.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.



Job Id: Certificate No: Revision No: 262.1-030654-2 TAA00002FB

DNV

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: Neasuring 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,	PAH	Fluorescence	0 — 50 µg/l	0 – 500 μg/l
enviroFlu-HC 500 MB	PAH _(phe equivalents)	Fluroescence	0 — 8 µg/l	0 – 80 μg/l
enviroFlu-HC 5000,	PAH	Fluorescence	0 – 500 μg/l	0 – 5000 µg/l
enviroFlu-HC 5000 MB	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.

Form code: TA 251

Annex // enviroFlu



Job Id: Certificate No: Revision No: 262.1-030654-2 TAA00002FB 1

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

GOST Certification



TriOS Data Protocol

On delivery, the serial RS-232 interface of the enviroFlu is configured with the following settings:

- baud rate: 9600
- data bits: 8
- · Parity: none
- Flow controll: Software (Xon / Xoff)

Data transmission

Each data frame starts with 0x23 and ends with 0x01.

Since software flow control is used, the characters for Xon and Xoff, as well as data frame start (0x23) and replacement characters (0x40) must be masked.

Masking bytes

If the characters #, @, 17, 19 occur in the data to be sent, the corresponding bytes must be masked in order to be interpreted correctly.

Table 1 shows the masking for the TriOS protocol.

Characters	Description	Replacement
@ (40hex)	Start replacement	0x40 0x64
# (23hex)	Frame start	0x40 0x65
Xon (11hex)	Xon	0x40 0x66
Xoff (13hex)	Xoff	0x40 0x67

Table 1: Masking of bytes for data transmission

A serial number (e.g. SN# 12DF) can be sent and received as follows. This is only an example for masking and not a correct TriOS data protocol.

Sent: $0x23 0x53 0x4E (0x23 \rightarrow 0x40 0x65) 0x20 0x31 0x32 0x44 0x46 0x01$

Received: 0x23 0x53 0x4E (0x40 0x65 \rightarrow 0x23) 0x20 0x31 0x32 0x44 0x46 0x01

0x23 [Data frame start] 0x53 [S] 0x4E [N] 0x23 / 0x40 0x65 [#] 0x20 [Space] 0x31 [1] 0x32 [2] 0x44 [D] 0x46 [F] 0x01 [Data frame end]

Sending commands

A command consists of 8 bytes, as shown in Table 2. Byte 4 can be used for instructions to the enviroFlu (Table 3).

Byte	Name	Description	Example	Interpretation
0	Data frame start	0x23	0x23	Start
1	Device ID 1		0x00	
2	Device ID 2		0x00	
3	i2c address		0x00	
4	Instruction		0x78	Configuration
5	Parameter 1		0x05	Channel
6	Parameter 2		0x00	High
7	Data frame end	0x01	0x01	

Table 2: Send commands (8 bytes) for a device at one interface

Table 3: Change settings on byte 4 (command 0x78)

Name	Parameter 1	Parameter 2
Select channel	0x05	0 = high; 1 = low
Auto amplification (automatic change High / Low)	0x06	0 = off; 1 = on
Continuous Mode	0x0f	0 = off; 1 = on

enviroFlu is delivered with the following configurations:

- Low-channel
- · Auto amplification is deactivated at the factory. Activation is not recommended by the manufacturer
- Continuous Mode is set "on"

It is important to know that the low-channel (low amplification) covers a larger measuring range and the high channel (high amplification) a smaller measuring range.

For both enviroFlu HC versions this means:

HC 500	LOW: 0–500 μg/L
	HIGH: 0–50 μg/L
HC 5000	LOW: 0–5000 µg/L
	НІGH: 0–500 µg/L

Annex // enviroFlu

Commands to the sensor

These commands only apply if a sensor is directly connected to a COM port.

Send Query

The Query command is used to query the serial number, firmware version and the device configuration of the sensor. A query data frame is sent in response (explained in more detail in Table 4).

Send: 0x23 0x00 0x00 0x00 0xB0 0x00 0x00 0x01

Trigger measurements

To trigger a measurement or to end a measurement, the following commands are sent to the sensor:

Start measurement: 0x23 0x00 0x00 0x00 0xA8 0x00 0x81 0x01

End measurement: 0x23 0x00 0x00 0x00 0xA8 0x00 0x82 0x01

Set Continuous Mode

To trigger continuous measurements or to stop continuous measurements, the following commands are sent to the sensor:

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

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

Set channel

If the sensor is only to measure in the High- or Low-channel, the following commands must be sent:

High-Channel: 0x23 0x00 0x00 0x00 0x78 0x05 0x00 0x01

Low-Channel: 0x23 0x00 0x00 0x00 0x78 0x05 0x01 0x01

Set Auto amplification (not recommended by the manufacturer)

If the sensor should automatically change from the Low \rightarrow High or High \rightarrow Low-channel, the following commands can be sent:

On: 0x23 0x00 0x00 0x00 0x78 0x06 0x01 0x01

Off: 0x23 0x00 0x00 0x00 0x78 0x06 0x00 0x01

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Receive data from sensor

Response to a measurement trigger

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

Bytes 0x83 0x07 contain information on the amplification mode and the raw value of the measurement.

The upper half byte of byte 7 (0x83) indicates in which channel the measurement was performed. In this example, the measurement was performed in the low-channel. If the measurement would have been performed in high-channel, a 0 (zero) would be at this position.

The lower half byte of Byte 7 (0x83) and Byte 8 (0x07) form the raw value of the measurement.

12 bits correspond to the digital maximum value of 4,095.

To calculate the PAH concentration, the following formula can be used:

 $\textit{PAH} = \textit{amplification} \cdot \frac{\textit{raw value}_{\textit{High}} \cdot 256 + \textit{raw value}_{\textit{Low}}}{4,095} ~ \mu g/L$

$$PAH = 500 \cdot \frac{3 \cdot 256 + 7}{4,095} \, \mu g/L$$

PAH = 94.63 µg/L

With:

amplification	= upper half byte from byte 7: 0x 8 3	\rightarrow here: Low channel: 500
raw value _{High}	= lower half byte from Byte 7: 0x83	\rightarrow here: 3
raw value _{Low}	= Byte 8: 0x 07	\rightarrow here: 7

Response to a query

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

In addition to the serial number and the firmware, the response of the sensor to a query contains further status information, as shown in Table 4.

Byte	Name	Description	Character [hex]	Interpretation				
0	Frame start	Start	23					
1	DeviceID 1	Bit [7, 6, 5] Number of additional data bytes [hex \rightarrow binary \rightarrow Number of data bytes] • $0x00 \rightarrow 000 \rightarrow 2$ • $0x20 \rightarrow 001 \rightarrow 4$ • $0x40 \rightarrow 010 \rightarrow 8$ • $0x60 \rightarrow 011 \rightarrow 16$ • $0x80 \rightarrow 100 \rightarrow 32$ • $0x0A \rightarrow 101 \rightarrow 64$ • $0x0C \rightarrow 110 \rightarrow 128$ • $0x0E \rightarrow 111 \rightarrow 256$ Bit [4] = always ZERO Bit [3, 2, 1, 0] = Device ID	60	Specifies the number of bytes sent after byte 7; binary: 011 0 0000				
2	DeviceID 2		00	Here 0				
3	Modul ID		00	EEProm = 0				
4	Frame byte	FF: Information frame FE: error frame	FF	Information frame				
5	Reserved		00	Always set to 0				
6	Reserved		00	Always set to 0				
7	Serial number	Serial number Low Byte	2A	Part 2 Serial number				
8	[Uint16]	Serial number High Byte	68	Part 1 Serial number				
9	Firmware	Firmware Low Byte	80	Part 2 Firmware				
10	[Uint16]	Firmware High Byte	01	Part 1 Firmware				
11	Reserved	Ignore	05	Ignore				
ax	N data bytes	Individual information (configuration)	03 0C 28 02 B9 00 00 00 00 00 00 00	Includes sensor type, number of measure- ments for averaging and various status				
X+1	Frame end	Ena	01					

Table 4: Response to a query

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Byte 7+8:	Serial number:	682A
Byte 9+10:	Firmware:	1.80
Byte 11:	Reserved::	05
Byte 12:	Sensor type:	$0x03 \rightarrow enviroFlu$
Byte 13:	Number of Averages:	$0x0C \rightarrow decimal \ 12$
Byte 14:	Status:	$0x28 \rightarrow binär 0010 1000$
	\rightarrow Continuous mode ON	
	\rightarrow Auto amplification mode O	N
	\rightarrow High amplification mode	
Byte 15+16:	Lamp intensity:	
	Value range 0–4,095 at 12 Bit	:
	0x02 0xB9 \rightarrow decimal 697	
Bytes 17-22 are only u	used to fill up the information frame.	
X+1:	Frame end	

Explanation of Table 4:

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Modbus RTU

Software Version

This modbus protocol refers to software version 1.80 and higher.

Serial Interface

At delivery, the sensors serial interface is configured for RS-485 operation using the following setting:

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

Data types

Name	Register	Format
Bool	1	false: 0x0000, true: 0x0001
Uint8	1	unsigned 8-bit integer. Value range: 0x0000 - 0x00FF
Uint16	1	unsigned 16-bit integer. Value range: 0x0000 - 0xFFFF
Uint32	2	unsigned 32-bit integer. Value range: 0x00000000 - 0xFFFFFFF
Float	2	IEEE 754 32-bit floating-point value.
Char[n]	$\left[\frac{n}{2}\right]$	ASCII string of n characters.
Uint16[n]	n	Array of n Uint16 values.
Float[n]	2n	Array of n Float values.

Functions

These Modbus function codes are supported by enviroFlu HC MB:

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

Default Slave Address

At delivery, the sensors Modbus slave address is set to 1 (0x01).

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

The following table describes the Modbus register mapping:

Name	R/W	Address	Data type	Description
Modhus slave address	RW	0	Llint16	The Modbus slave address of the enviroFlu HC MB. Valid IDs: 1247.
NOUDUS Slave audiess	1.00	0	OIIICIO	If an invalid ID is written, returns an illegal data value exception.
Measurement timeout	R	1	Uint16	The timeout in [10-1 s] of a running single measurement process. In continuous mode, this always reads 0.
Device serial number	R	10	Char[10]	8-digit serial number of the enviroFlu HC MB.
Firmware version	R	15	Char[10]	The installed firmware version of the enviroFlu HC MB.
Sensor Type	R	20	Char[10]	enviroFlu-Type, either HC MB 500 or HC MB 5000.
Static Continuous Mode	RW	100	Bool	Enables or disables the continuous mode of the connected enviroFlu HC MB. Configuration is saved permanently and is still available after a reboot or shutdown.
				When this Register is written, Temporary Continuous Mode (#101) will automatically be changed to match the new setting.
Temporary Continuous Mode	RW	101	Bool	Enables or disables the continuous mode of the connected enviroFlu HC MB. Configuration is not saved permanently and will be lost after a reboot or shutdown.
				After reboot, the setting from Static Continuous Mode (#100) will be used instead.
Device Description	RW	106	Char[64]	Custom Text that can be set to identify this device.
				Configuration of High and Low channel for measure- ments.
				0: Low OFF / High ON (smaller value range)
				1: Low ON / High OFF (larger value range)
Static Low-Amp Mode	RW	140	Bool	Configuration will be saved and is still available after a reboot or shutdown.
				When this Register is written, Temporary Low-Amp Mode (#141) will automatically be changed to match the new setting.

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Temporary Low-Amp Mode	RW	141	Bool	Configuration of High and Low channel for measure- ments. 0: Low OFF / High ON (smaller value range) 1: Low ON/ High OFF (larger value range) Configuration is not saved permanently and will be lost after a reboot or shutdown. After reboot, the setting from Static Low-Amp Mode (#140) will be used instead.
Average Count	R	142	Uint16	Always 12
Checksum / SolidCAL Factor	R	144	Float	Checksum of the calibration certificate used for SolidCAL validation. This factor is used for SolidCAL Parameter (#1012)
Measure Count since boot	R	202	Uint32	Counts measurements since last boot.
Offset PAH Low Amp Mode ^{1,2}	RW	402	Float	This offset along with Scaling PAH (#406) is used to calculate the scaled version of PAH (for use with DryCAL-0)
Offset PAH High Amp Mode ^{1,2}	RW	404	Float	This offset along with Scaling PAH (#406) is used to calculate the scaled version of PAH (for use with DryCAL-0).
Scaling PAH	RW	406	Float	This factor along with Offset PAH (#402 or #404) is used to calculate the scaled version of PAH (for use with DryCAL-1).
Offset PAH-p Low Amp Mode ¹	RW	408	Float	This offset along with Scaling PAH-p (#412) is used to calculate the scaled value of PAH-p.
Offset PAH-p High Amp Mode ¹	RW	410	Float	This offset along with Scaling PAH-p (#412) is used to calculate the scaled value of PAH-p.
Scaling PAH-p	RW	412	Float	This factor along with Offset PAH-p (#408 or #410) is used to calculate the scaled value of PAH-p.
Offset Oil Low Amp Mode ¹	RW	414	Float	This offset along with Scaling Oil (#418) is used to calculate the scaled value of Oil.
Offset Oil High Amp Mode ¹	RW	416	Float	This offset along with Scaling Oil (#418) is used to calculate the scaled value of Oil.
Scaling Oil	RW	418	Float	This factor along with Offset Oil (#414 or #416) is used to calculate the scaled value of Oil.

¹ Note that this Offset is subtracted, not added.

² This is where measured offset values of DryCAL-0 are inserted. Upon delivery, enviroFlu HC MB is set to Low Amplification Mode (see #140 for the explanation of Low Amplification Mode). To measure the Offset in High Amplification Mode, write 0 into register #140 or #141. Further details on the calibration process can be found in the Quick Installation Guide of DryCAL.

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PAH in µg/L	R	1000	Float	PAH value measured by the enviroFlu HC MB
PAH in ppb	R	1002	Float	PAH value measured by the enviroFlu HC MB
PAH-p in µg/L	R	1004	Float	PAH-p value calculated based on the measured PAH value
PAH-p in ppb	R	1006	Float	PAH-p value calculated based on the measured PAH value
Oil in mg/L	R	1008	Float	Oil value calculated based on the measured PAH value
Oil in ppm	R	1010	Float	Oil value calculated based on the measured PAH value
SolidCAL in µg/L	R	1012	Float	PAH value, corrected by Checksum (#144) of the certificate
Scaled PAH in μ g/L	R	1500	Float	Calculated from PAH (#1000) using the user-defined scaling (#406) and the offset of the current Amp Mode (#402, #404), using 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), using 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), using 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), using 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)

"Write single register" can be used to trigger a measurement.

Name	Address	Description
		A single measurement is triggered if the device is idle and any value other than 0 is written.
Trigger measurement	1	If the sensor is currently measuring, or continuous mode is on, a slave device busy exception is returned. No additional measurement is triggered.

Report slave ID (0x11)

The production Company, sensor name, serial number and firmware version is replied each as null terminated ASCII string.

Example:

	Т	R	Τ	0	S	0x00	е	n	v	i	r	ο	F	T	u	0x00	0	3	2	0	2	4	9	С	0x00	1		0		8	0x00
--	---	---	---	---	---	------	---	---	---	---	---	---	---	---	---	------	---	---	---	---	---	---	---	---	------	---	--	---	--	---	------

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FlowCell dimensions



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