SF2 ECCR
OPERATION MANUAL

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Congratulations on purchasing your SF2 ECCR rebreather. This unit has been carefully manufactured to exact standards using high quality materials. When used as directed, the SF2 ECCR will make diving more comfortable, enjoyable and exciting.

The SF2 ECCR is intended for use by certified divers who are trained in the use of rebreather systems or those divers who are under the direct supervision of a qualified instructor.

Even if you are experienced in using rebreather systems, we strongly recommend that you take the time to read these instructions. It contains many important safety instructions and techniques that will help to extend the life of your rebreather.

On-line manual can be located on our website www.scubaforce.eu

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The SF2 ECCR is certified according to Module B of the PPE Regulation (EU) 2016/425. The basic health and safety requirements are fulfilled taking EN14143:2013 into account.

Implementing test institute:
DEKRA
Testing and Certification GmbH
Adlerstrasse 29
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We would like to thank Dr. Frank Hartig, Dr. Andrea Köhler and Uwe Breidenstein for providing texts, photos and graphics. And to all the photographers worldwide who keep providing us with fantastic images, thank you.

Copyright

Please read operating instructions carefully before using your rebreather. Operating instructions are not a substitute for a general training manual for rebreather units. You must be properly trained by an authorized SF2 instructor.

Warning, caution and notes
Pay particular attention to all information marked with warning, caution and note according to the following symbols:

WARNING

A WARNING indicates a practice or situation which, if not avoided could result in hazardous or unsafe practices that may result in severe personal injury or death

CAUTION

CAUTION indicates a situation or usage instruction that could damage the product and result in injury to the user.

NOTE

NOTE emphasizes important points, notes, and reminders.

WARNING

These operating procedures contain important instructions for the correct use and care of your new rebreather. It is therefore extremely important that you take the time to read this manual so that you can fully understand and enjoy all of the features of your rebreather. Improper use of your rebreather can result in serious injury or death.

TECHNICAL HELP
If there is any ambiguity in this manual, or if you do not get sufficient answers from your dive shop or diving instructor, please contact us

Safety

Important Safety Instruction

This rebreather is intended for use by certified scuba divers who have completed a rebreather course, or those who are being trained and supervised by a qualified instructor.

WARNING

Follow all instructions and adhere to these safety measures. Incorrect or improper handling of the rebreather can result in serious injury or death.

WARNING

This manual is NOT a substitute for a rebreather training course administrated by a qualified instructor. DO NOT USE a rebreather until you have practiced and perfected practical skills, including emergency skills, in a supervised environment and under the supervision of an instructor who is certified by a nationally recognized diving training organization and authorized to train in SF2 rebreather use.

WARNING

Careless use of the SF2 can cause unconsciousness due to lack of oxygen in any environment without prior warning signs. Careless use of the SF2 at depths underwater greater than 6 MSW (meters of sea water) [20 FSW (feet of sea water)] can cause unconsciousness without warning. Either of these situations can cause serious injury or death. The SF2 is equipped with a sophisticated electronic control system that enables a properly trained user to avoid these situations. It is the sole responsibility of the user to carefully monitor the displays on this system while using the SF2 and to have a knowledge of response measures in the event of a problem.

Welcome to a new, quiet world of diving. With the acquisition of the SF2 ECCR you have taken another big step in your diving development.

New adventures are waiting for you. With a rebreather you can reach regions that were previously unavailable to you.

The SF2 ECCR is one of the most popular and best-selling rebreather devices worldwide. Straightforward design, high reliability, and simple pre dive preparation and post dive follow-up are just a few of the points that have led to the SF2 ECCR having a large fan base among sport, wreck and cave divers. Whenever high reliability and special performance is required, the SF2 is used.

Soon you too will be one of the enthusiastic fans of rebreather diving in general and the SF2 in particular.

But first you have to study and work. Your SF2 diving course will start shortly and within a short period of time you will be confronted with many new theoretical and practical knowledge and skills.

Rebreather diving is fun, but knowledge and skills are important to make it safe. We believe the well-trained diver is one who is willing to commit to continuous learning and safe training programs to perfect his/her skills. Diving equipment, including a rebreather, are tools the diver must learn to master - not the other way around.

Chapter 1 - How the SF2 works

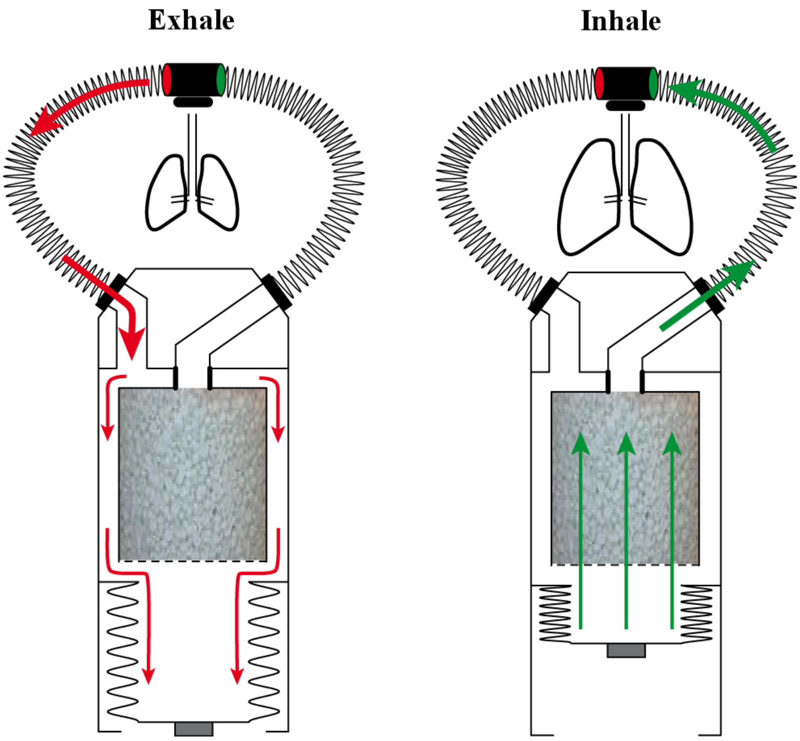
The SF2 belongs to the CCR rebreather category: Closed Circuit Rebreather This describes a completely closed loop system in which only the metabolized oxygen used (consumed) is added, this can be done manually (described as MCCR) or electronically as with the SF2 ECCR.

The SF2 is an ECCR Electronic Closed Circuit Rebreather. The basic principle is actually relatively simple and has been tried and tested for decades. The O2 content in the breathing gas is measured via oxygen sensors - more on this later. If this proportion falls below a pre-set value, oxygen flows into the system via an electronically controlled solenoid valve (solenoid) until it again corresponds to the set value.

What sounds simple in theory is influenced by various factors in practice, for example increasing or decreasing pressure when descending or ascending.

In contrast to the open circuit system, the diver does not release any gas into the environment when diving, so he breathes in a closed loop circuit which explains the name. (If there is overpressure in the system, for example when surfacing, gas is released into the environment even with a closed rebreather.)

Maintaining this circuit is important and must be checked before every dive. With the SF2, the flutter valves, also called directional membranes, are located in the mouthpiece. From the diver's point of view, i.e. with the device on his back, gas flows from right to left.



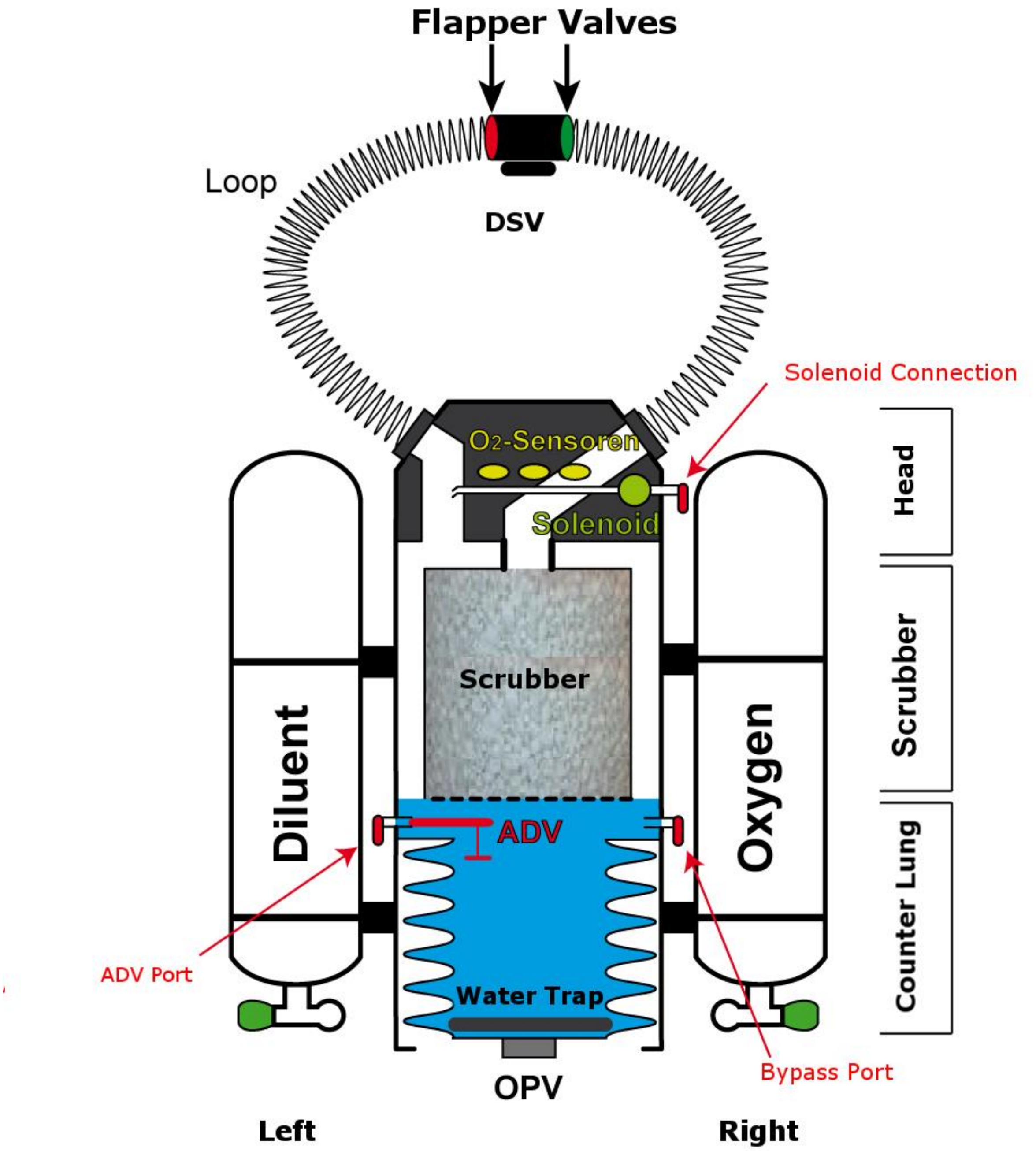
Our body consumes (metabolizes) the oxygen we breathe. This creates carbon dioxide - CO2. We normally release this gas back into the environment when we breathe. But since our breathing circuit is closed, the CO2 also remains in the system. Hypercapnia, i.e. an increase in the level of carbon dioxide in the blood (approx. 45 mmHg) can quickly lead to life-threatening situations, especially under water. To prevent this from happening, the resulting CO2 is bound in a canister with soda lime, which we will also go into briefly later.

Since we can only breathe in a circuit if the gas has a flexible volume in which to collect it, in our body that flexible volume is the lungs. The SF2 has a "counterlung" in the form of a bellows. This type of counterlung configuration is unique in the rebreather world and has various advantages: It is compact, easy to assemble, protected by the lower carbon tube. Last but not least, an important feature of the counterlung is a huge water trap at the lowest point of where the pressure relief valve is located.

This describes the most important components of the SF2 and a rebreather in general. The only thing missing is the gas addition supply. As mentioned at the beginning, the consumed oxygen is added back to the system in pure form. The SF2 has an oxygen cylinder which, again from the perspective of the diver, wearing the device located on the divers' right side. Pure oxygen becomes "toxic" from a depth of about twenty feet (six meters) and can no longer be breathed safely. So the oxygen has to be diluted. In English this is called dilute and that is why the term diluent bottle has established itself. Two gases are used as diluent in the SF2: On the one hand, normal air and, on the other, trimix mixtures, i.e. a gas consisting of oxygen, nitrogen and helium.

The diagram on the next page gives a good overview of the structure of the SF2

SCHEMATIC REPRESENTATION SF2 ECCR



Chapter 2 - The soda lime

The filtering out of the carbon dioxide (CO2) in the rebreather takes place with the help of the soda lime through a chemical reaction. The soda lime reacts with the CO2 in several stages and produces calcium carbonate (lime), water and heat. The moisture and heat in turn enable the calcium reaction.
Put simply, CO2 and calcium hydroxide ultimately result in calcium carbonate. This requires water (approx. 14-18% moisture) and a little sodium hydroxide (approx. 3%) as a reaction accelerator.
Carbon dioxide reacts with water to form carbonic acid. Therefore, a certain basic moisture content of the lime (as well as the moisture in the breathable air) is necessary to start the reaction.

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (carbonic acid)}$$

In a further step, the carbonic acid reacts with the caustic sodium hydroxide to form sodium carbonate. This creates water again.

$$H_2CO_3 + 2\ NaOH \text{ (Natriumhydroxyd)} \rightarrow Na_2CO_3 \text{ (Natriumkarbonat)} + 2\ H_2O$$

Ultimately, the sodium carbonate reacts with the calcium hydroxide to form lime and the sodium hydroxide is regenerated again.

$$Na_2CO_3 + Ca(OH)_2 \text{ (Calciumhydroxyd)} \rightarrow CaCO_3 \text{ (Calciumcarbonat)} + 2\ NaOH$$

The reaction substances water and sodium hydroxide are constantly renewed during the process and are included in the reaction again. Only the calcium hydroxide is consumed and therefore limits the absorption capacity (service life) of the lime. To understand: The soda lime does not bind the CO2 in a gaseous state, e.g. Filter cartridges in the compressor. Due to the completely different type of binding, filter cartridges release the filtered CO2 back into the ambient air over time. The chemical reaction of soda lime, on the other hand, leads to a complete conversion of the gaseous CO2 from the air you breathe into a solid component, calcium carbonate. No gaseous CO2 is present in fresh, wet or used lime.

The exothermic (= heat-releasing) chemical reaction generates heat. You can tell that the scrubber is lukewarm after a dive, even in icy water. This heat prevents the breathing gas from cooling down and significantly minimizes heat loss through the lungs. The lime is used up in layers. The CO2 from the exhaled air flows into the fresh soda lime and immediately reacts to calcium carbonate. If the lime has already been used up a bit, the reaction zone (reacting layer of soda lime) moves further forward accordingly. The soda lime is used up when the reaction zone nears the end of the scrubber. The thickness of the reaction zone depends on various factors such as the type of lime (particle size), reactivity (reaction temperature) and gas flow rate (gas density).

2.1 Lime duration time

The lime life of a scrubber depends on many different factors. The absorption capacity depends primarily on the type or manufacturer, but storage, filling of the scrubber, immersion conditions, temperature, exertion etc. Many factors have a major influence on the nominal values of soda lime durations determined under standard conditions.

2.2 Storage

To start the calcium reaction, moisture is required (CO_2 reacts with water to form carbonic acid). Therefore soda lime contains between 14-20% water. Incorrect storage leads to drying out and thus to a loss of reactivity of the lime. Fresh lime, if it is not stored airtight, will have dried out after 4 weeks at the latest. In addition, the lime would bind the CO_2 from the air and thus lose its absorption capacity. A filled scrubber should therefore not be left standing around for too long. This is okay for a repetitive dive on the weekend, but it should be replaced after 2 weeks at the latest.

2.3 Influence of temperature on the soda lime output

The soda lime output is particularly temperature-dependent. The lower the ambient temperature, the worse the calcium reaction. This means that the soda lime filter performance is significantly lower in cold water than in hot water. A canister filled and used in warm Mexico waters could be used for 6 hours. The same canister filled and used in 37 degrees Fahrenheit (3°C) cold mountain lake would be enough for 3 hours.
At 20 ° C e.g. the lime filtration rate is 100%, at 15 ° C it drops to around 80%, at 10 ° C to around 65% and at 4 ° C to less than 50%.
In terms of temperature-dependent filtering performance, it is essential to note that the filter rate per unit of time is meant here. The lime is not consumed faster in the cold, but only reacts more slowly or the reaction zone becomes larger.

2.4 Influence of exertion on standing time

Another important point for the lime service life is physical activity and thus CO_2 production. This can increase by up to tenfold with exertion and stress! Deep CCR dives in cold water with stress and exertion are therefore high risk factors for a CO_2 breakthrough or for hypercapnia. At rest, a person consumes about 0.3 l / min of oxygen and converts this (depending on the respiratory quotient) into CO_2. When exercising, the O_2 consumption or CO_2 production increases to around 3.0 l / min, top athletes can do even more. An average scrubber holds around 2 kg of lime, so it has an absorption capacity of around 300 l of CO_2 (approx. 150 l / kg). Usually one produces an average CO_2 production of 1.0 - 1.5 l / min during one dive. This means that a fresh scrubber filling lasts for about 200-300 minutes. If the oxygen consumption or CO_2 production doubles due to exertion, the dive time is halved accordingly. Depending on your personal consumption rate, diving conditions (temperature, exertion, stress, etc.) and safety margin, you reduce the dive times.

2.5 Endurance time SF2 Scrubber

According to the soda lime manufacturer, 1 kg of soda lime can bind approx. 110-150 l of CO_2. The approximate lime time can now be calculated using the metabolism. The scrubber of the SF2 can hold up to 2.2 kg. The theoretical CO_2 absorption capacity is about 330 l CO_2. (2.2 x 150). Normally, one produces with 1-1.5 l / min oxygen consumption or CO_2 production, corresponding to physical activity

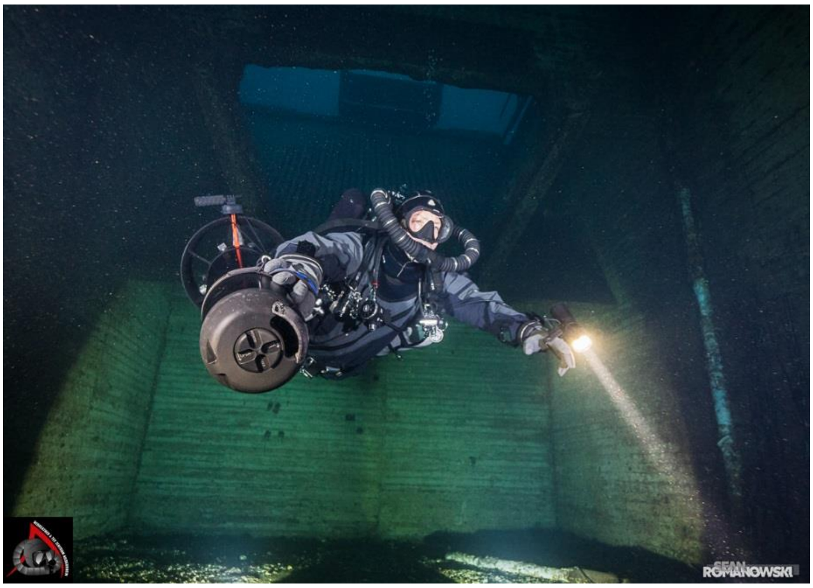
of about 100 watts. That means the theoretical lime filtering time is about 3.5 hours (330 / 1.5 = 220 min).

CAUTION

The lime shouldn't under normal conditions Be used for more than three hours. This is true both for repetitive dives as well as for single dives corridors.

WARNING

Under extreme conditions the limescale is reduced. As part of the certification, the Lime is tested at 40 meters, water temperature of 4° celsius and breathing rate with a volume of 40 liters per minute: Under these conditions the lime life is reduced to 135 minutes.



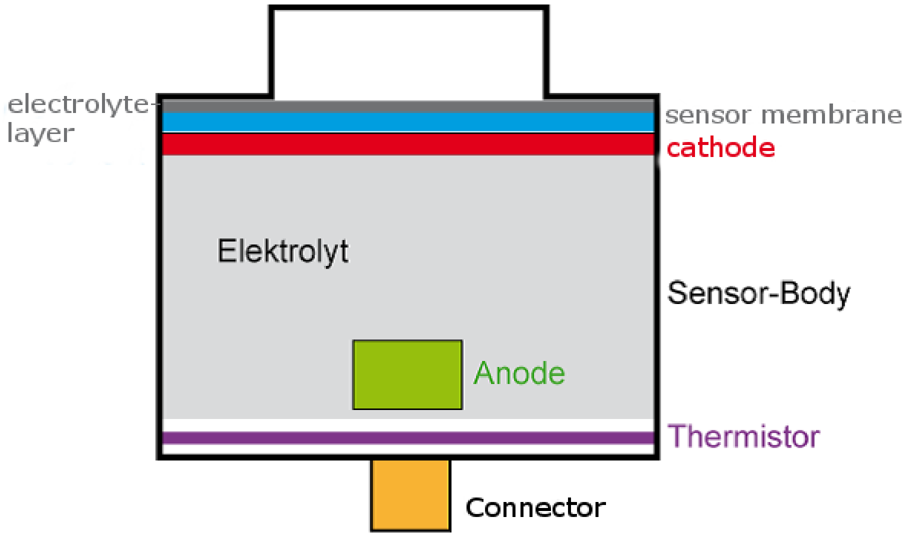
Chapter 3 - Oxygen Sensors

Since the oxygen content in the breathing gas of rebreather systems has to be measured reliably and permanently, oxygen sensors are used for this. To increase the safety and accuracy of the O2 measurement, three oxygen sensors are built into the SF2-CCR. The sensors are located in the head, where they are well protected and yet easily accessible. The measured values are permanently transmitted to the controller, which then regulates the setpoint via the solenoid if necessary. If a sensor becomes defective, it can be voted out by the controller logic.
Nevertheless, two sensors are still available and the dive can be ended.

There are many different types of oxygen sensors, but galvanic oxygen sensors have become established for use in diving for many reasons. These are built as a complete unit and are thrown away and replaced when the internal components are used up.

3.1 Functional principle and structure of a sensor

A galvanic oxygen sensor is a type of fuel cell that converts chemical reaction energy into electrical energy (like a battery). This means that these sensors do not need an external energization voltage, but are the power source themselves. Oxygen reacts with the components of the cell (redox reaction) which creates a current that is proportional to the prevailing oxygen partial pressure.
A cathode transfers electrons to the oxygen (reduction). The resulting hydroxide ions (OH-) migrate in an electrolyte to the anode and there release the electrons again (oxidation of the anode). This means that the anode is chemically changed or used up. The electrons released in the reaction create an electrical current that is directly proportional to the oxygen partial pressure. Practically all oxygen sensors measure the partial pressure and not the percentage of the gas. This also makes sense there the human body also reacts to the actual oxygen partial pressure and not to the percentage in the breathing gas. Only if the ambient pressure is 1 bar and does not vary between calibration and measurement, the percentage display (or fraction) is equal to the partial pressure.



3.2 Influence of pressure
Oxygen sensors usually measure the partial pressure of oxygen and not the percent. The ambient air pressure therefore has a significant influence on the measurement and calibration. At sea level there is an oxygen partial pressure of 0.209 bar. A calibrated oxygen analyzer would show 20.9% accordingly. If the sensor were now exposed to a pressure of 2 bar, it would display 41.8% (corresponding to 0.418 bar), although the air composition has not changed.
In 5000 m, however, it would only show 10.45% (0.1045 bar). As a result, if the sea level changes or if there are strong weather fluctuations, it must be recalibrated. Air pressure fluctuations of 30 mbar due to changes in the weather lead to a measurement error of around 3% (1 mbar pressure change corresponds to an error of 0.1%). This means that the measurement of the oxygen content must always take place under the same conditions as was previously calibrated. Most newer oxygen analyzers, however, have
meanwhile a pressure sensor / barometer has been integrated so that the analyzer corrects pressure fluctuations by itself.

Pressure fluctuations of this magnitude can also occur if the sensor is held directly on a bottle valve or a mouthpiece for measurement. If the gas flow is too high (or if gas flows directly onto the membrane), more gas flows onto the membrane than gas can escape. This causes you "Back pressure" on the membrane, which is registered by the sensor as an increased partial pressure. As a result, this leads to incorrect measured values and can also lead to the destruction of the membrane.
A flow rate of 0.1-5 l / min neither affects the measurement accuracy nor does it destroy the sensor membrane.

In order to be able to compensate for various pressure fluctuations, a compensating membrane is built into most sensors on the back. This is also necessary to cushion volume fluctuations due to temperature changes. But that means that the compensating membrane is always the same Pressure must be exposed like the sensor membrane. If a sensor is installed in such a way that the compensation membrane is not exposed to the ambient pressure, this not only leads to incorrect measured values but also to the destruction of the sensor.

Oxygen sensors behave like a human body underwater. Since the main component of the sensors is a liquid, they absorb gas when descending and release it again when ascending.
To do this, they need time to stabilize. Rapid changes in pressure or temperature can therefore lead to a "DCS" and influence the function of the sensor. Above all, reducing the pressure too quickly can lead to the formation of bubbles in the electrolyte. Bubbles in the sensor prevent the diffusion of the
Oxygen. The oxygen measurement stops and the output drops.

3.3 Influence of moisture and water
Moisture does not directly affect the accuracy of a good sensor. However, the moisture in the gas takes up a certain proportion of the volume and thus also exerts a partial pressure. The partial pressures of the remaining gas components are reduced accordingly and the sensor shows less oxygen
increasing humidity (in the same environment).
However, extreme humidity or even condensation on the sensor surface significantly impair the sensor function. Water on the sensor membrane prevents the diffusion of oxygen so that the sensor becomes inoperable. In environments with extremely high humidity, the membrane should be used before
Calibration or measurement can either be carefully wiped off with a soft, lint-free cloth and / or the sensor held down during the measurement. This can cause drops to form due to the surface tension of the water, which fall downwards. Also the slight (!) Flow of dry gas from a diving cylinder across the Membrane can lead to drying of the moisture.

Rebreather systems in particular have the problem of high gas humidity (due to breathing) and condensation (due to the cold surrounding water). To prevent malfunction of the sensors due to condensation, they are usually built into the head in a special way. During calibration, the humidity would have an influence on the result. But since you (at least When rebreather diving) calibrated with dry diving gases, this problem is usually eliminated. However, due to the high humidity in the circuit, calibration should never be carried out after a dive.

3.4 Aging of oxygen sensors

Oxygen sensors begin to age from the point of production. The rapidity of aging, i.e. the course of the chemical reaction and thus the consumption of the anode depends on the surrounding environment Oxygen content and temperature. Usually, the sensor output in air drops by around 5-10% per year. This means that the output of an R-17 / R-22 sensor drops by approx. 1 mV per year in air (e.g. from 10 mV to 9 mV) or 5 mV in pure oxygen (from 50 mV to 45 mV). If oxygen sensors are stored in pure oxygen, the service life is shortened by about a fifth. In the original packaging, sensors age much more slowly, but they do not rest completely.

NOTE

The aging process of an oxygen sensor does not begin with unpacking but with the date of manufacture!

WARNING

The SF2 sensors have an imprint:
DO NOT USE AFTER - followed by a date.
When the date is reached, the sensor must be replaced.
The use of an expired sensor can lead to dangerous situations.

Chapter 4 - SF2 single components

FRONT VIEW

Accessoires:
Wing, Backplate, Harness, SPG´s

SF2 Components:
Loop, Controller, Fischercable

BACK VIEW

Accessories:
Diluent-and Oxygen Cylinder

SF2 Components:
Lower Carbon Fiber Tube (Counterlung); Upper Carbon Fiber Tube (Scrubber); Head (Electronics and Sensors)

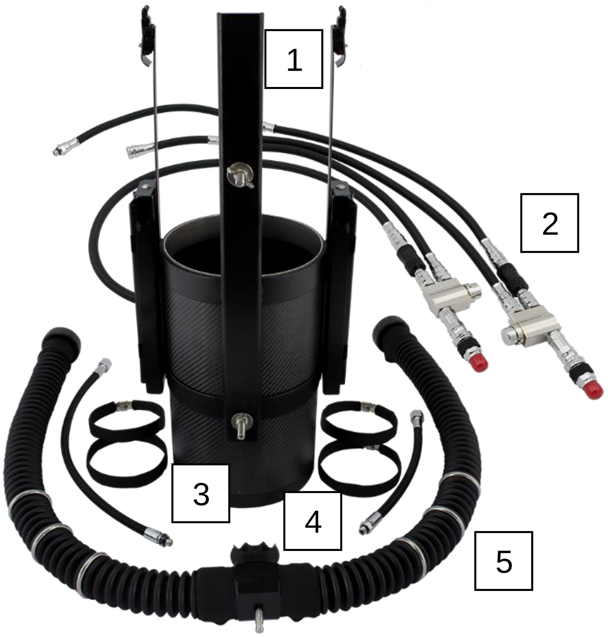
4.1 Head

1. Sensor cover – underneath are the oxygen sensors.
2. Sensor cable
3. Exhalation side – with oxygen injection.
4. Inhale side
5. Battery box
6. Solenoid
7. Oxygen supply connection

4.2 Midpart

1. ADV
2. ADV supply connection
3. Manual injection connection
4. Bellow / Counterlung

4.3 Frame and accessoires



1. Backmount Frame incl. female pony clamps

2. Manual Add Kit incl. Offboard Gas

3. Hose clamps and oxygen hose

4. Hose clamps and diluent hose

5. Breathing Loop with DSV mouthpiece and connectors

Scrubber

Pony Clamp male

3 liter cylinders. The picture shows G5 / 8 valves on both sides. Within the EU, the bottles for the oxygen side are delivered with an M26x2 valve

Chapter 5 – Assembling the SF2

The SF2 is delivered pre-assembled. All essential components are already assembled and checked. However, accessories such as bottles, wings, and regulators still have to be fitted and, in some cases, adapted to personal size (harness). This happens as part of the SF2 diving course under the direct supervision of the diving instructor. This gives practical tips and oversees the correct assembly of all components. This is the only way to ensure proper functioning.

WARNING

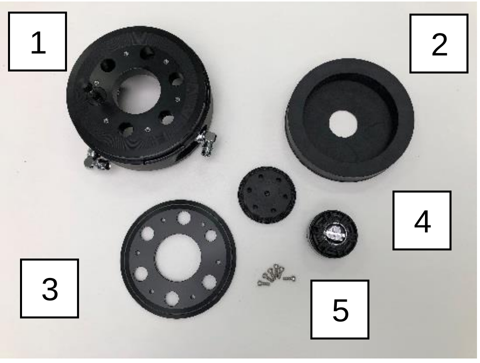
The initial assembly of the SF2 must be under direct supervision by an authorized SF2 instructor. Correct assembly guarantees fault-free function of the device.

5.1 Attaching the cylinders

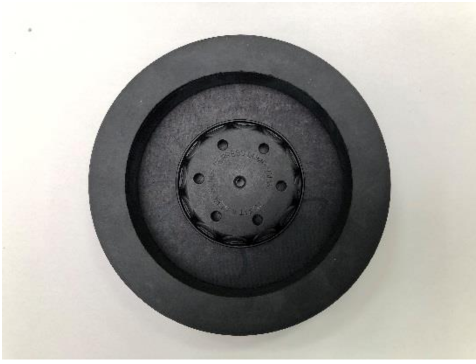
The male pony clamps are attached to the bottles with the help of hose clips. Both the position and the height must be taken into account. (see pictures below)

5.2 Attaching the bellow

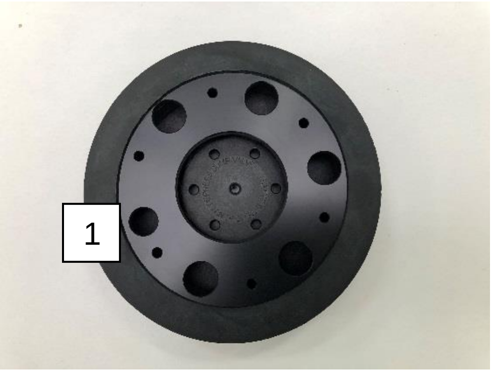
The bellows is fitted on delivery. Nevertheless, it is important to know how it is mounted, as it has to be removed from time to time for cleaning or, in the unlikely event of damage, replaced.



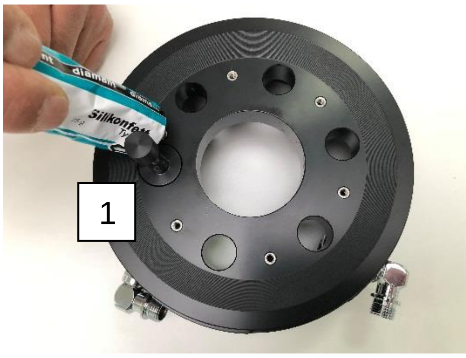
Components of the midpart:
1. Mitpart 2. Bellow 3. Bellow-Washer 4. OPV 5. Screws



First the nut of the OPV must be placed in bellow.



The bellows clamping disc is pushed into the upper ring of the breathing bellows. The curved side points outwards. 1. The slightly smaller opening is later pushed over the pusher by the trigger



The threaded sockets are lightly greased before assembly.
1. Pusher from trigger

The bellow washer disc is attached to the middle part with the help of the screws. The screws are hand-tightened.

The pressure relief valve is screwed into the breathing bellows. Here, too, hand-tight is completely sufficient. The material needs light counter pressure so that it does not turn with it.

5.3 Assembly Scrubber und lower carbon fiber tube

1

The middle part is pushed into the backmount frame. The two gas seals must be positioned between the pony clamps and the plate holder. Then the lime container is placed on the middle part. The O-ring on the lime connection (1) must be checked regularly. Then the upper carbon tube is mounted. Inside the carbon tube there is a sticker with a serial number. This sticker is at the bottom (points towards the middle part).

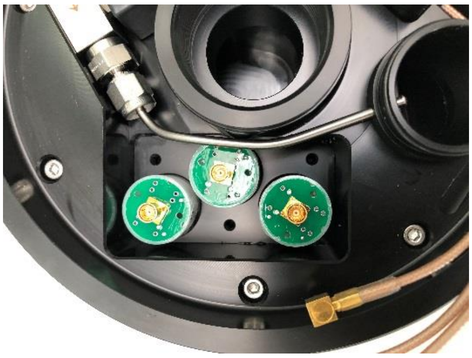
5.4 Assembly battery solenoid

To insert the battery, the battery compartment must first be opened. To do this, the two Allen screws are unscrewed with a suitable key. The battery that powers the solenoid is a standard 9 volt battery. This is connected to the system via a splash-proof connector. Then the screws are tightened again hand-tight.

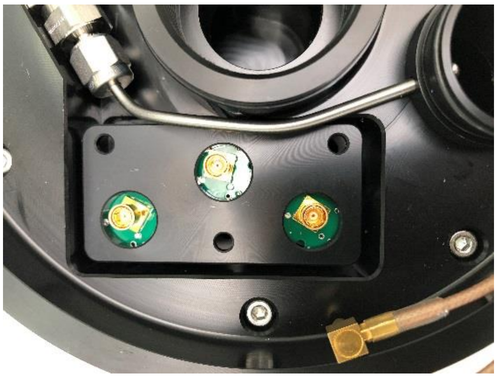
5.5 Assembly Sensors

The following parts are required for the sensor assembly:
3 x oxygen sensor; 3 x O-ring; Sensor cover plate; 3 x screws

First the O-rings are placed in position. When changing the sensors, it often happens that the O-rings get stuck on the old sensors.



The oxygen sensors are simply brought into position



The sensor holder plate has three holes. These must be positioned correctly so that the screws fit.

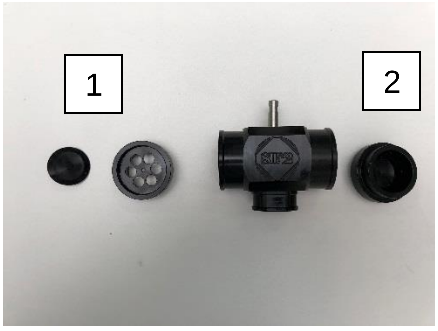
The screws are hand-tightened.

The sensor cables are plugged onto the sensors. The length of the cable determines which cable goes to which sensor.

5.6 Assembly Loop

WARNING

The loop determines the circuit of the device. Therefore it is especially important to assemble this properly. Incorrect assembly can cause serious accidents



1. Valve holder on exhalation side. The directional membrane is carefully mounted as shown in the middle picture. 2. Valve holder, inhalation side. The directional membrane is carefully mounted as shown in the middle picture. Then the valve supports are inserted into the mouthpiece. Exhalation side left / inhalation side right. (Logo position on the mouthpiece as in the photos)

The breathing hoses have different diameters on the two connectors. The side with the larger diameter goes to the mouthpiece and is fastened with the hose.

The connecting pieces of the loop have different diameters to avoid mix-ups. The difference is difficult to tell with the naked eye. It is helpful to push the socket briefly into the head. The exhalation side has the larger diameter, so it does not fit on the inhalation side. The O-ring on the exhale side is also thicker than the one on the inhale side. When the side is determined, the nozzle is pushed into the union nut and fastened with the hose clamp.

The actual SF2 is now fully assembled - the accessories can now be assembled.

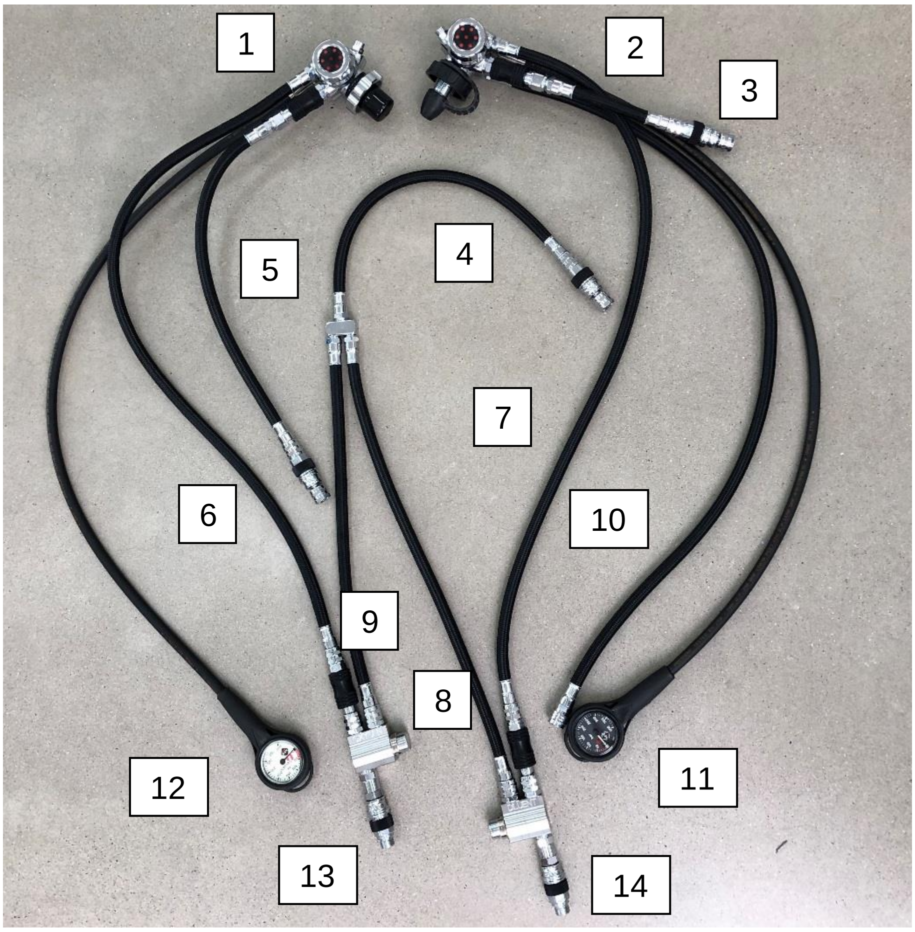
6.0 Assembly accessories

6.1 Manual Add Kit & Off Board Gas

The Manual Add Kit enables the diver to manually control the rebreather in an emergency. The offboard connectors allow external gas to be applied and the rebreather to operate with it.

NOTE

The Manual Add Kit enables the diver to manually control the rebreather in an emergency. The offboard connectors allow external gas to be applied and the rebreather to operate with it.

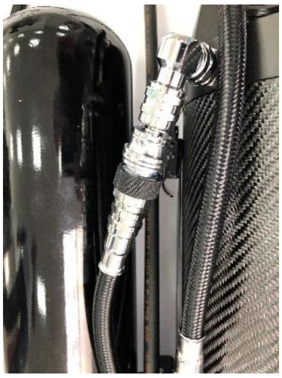


1.1st stage oxygen **2.**11st stage diluent **3.**LP 15 cm (ADV) incl. Flow Stopper und Quick Disconnect **4.**LP 40 cm (Manuall Port) incl. Quick Disconnect **5.**LP 50 cm (Solenoid) incl. Flow Stopper und Quick Disconnect **6.** LP 80 cm (O2 supply Manual Add) incl. Flow Stopper **7.**LP 80 cm (Diluent supply Manual Add) incl. Flow Stopper **8.**LP 50cm (Diluent supply rebreather) **9.LP** 40cm oxygen supply rebreather **10.**Inflator Hose Wing 90 cm **11.**SPG Diluent **12.**SPG oygen**13.** Manual Add Block oxygen with gas connector **14.** Manual Add Block Diluent with gas connector

6.2 Assembly Regulator, Wing & Harness

The assembly of the accessories requires a little manual skill and basic knowledge of diving equipment. Don't try this alone. Your SF2 diving instructor is at your side with words and deeds and, in addition to the assembly, will also carry out the individual size adjustment together with you.

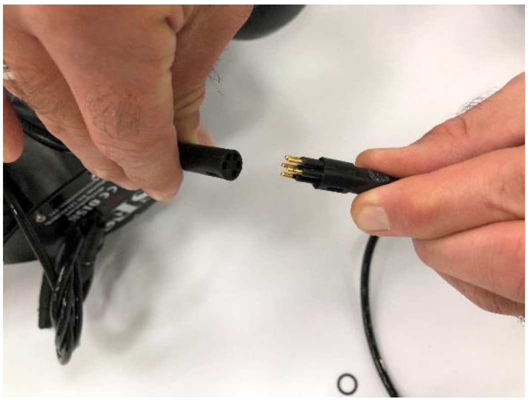
After the bottles have been attached to the SF2, the regulators can be screwed on. It is advisable to put the device down as this makes work easier.
The low-pressure hoses must be unscrewed from the manual adds, as they are a hindrance during assembly.

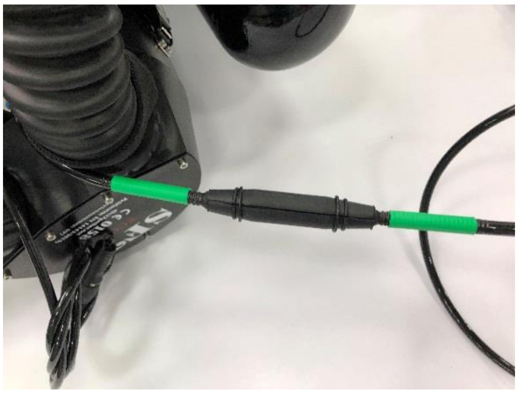


If the low-pressure hoses are equipped with Quick Disconnect, in the “Ready to Dive” variant, they can simply be clicked on. The connectors have a "lock" function that is activated by turning the black ring. This prevents the hoses from accidentally jumping off. Without Quick Disconnect, the hoses are simply tightened hand-tight with an open-end wrench.

To simplify assembly, the wing is attached to the carrier with wing nuts. Then the hoses and the pressure gauges are fed forward through the upper slots of the wing.

Now the backplate with harness can be mounted on the wing. The hoses are carefully guided through the "bungees" on the harness and reconnected to the manual add. Care must be taken to ensure that each hose is connected to the right place, otherwise malfunctions will occur.





The controller of the SF2 has a waterproof plug connection which is secured as shown in the second figure.

NOTE

The quick coupling must NOT be used under water
To be taken apart. In particular in salt water it can
damage the contacts and cause costly repairs.

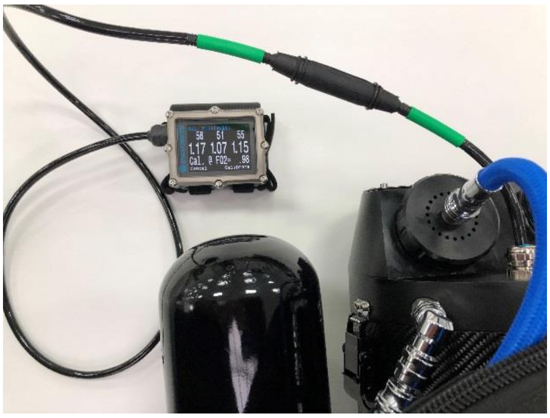
Finally, either the HUD or a Petrel Ext. Is connected to the Fischer socket. There are separate operating instructions for both devices which must also be read carefully. The SF2 ECCR is now ready to dive.

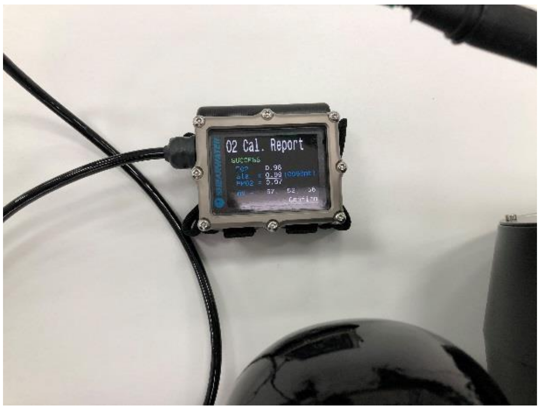
7.0 Calibrating the oxygen sensors

Calibrating the sensors is very important so that the correct oxygen partial pressure of the breathing gas is displayed underwater. In principle, calibration is carried out with pure oxygen and calibration is carried out at least every week or when external circumstances change. If the air pressure changes (e.g. diving in a mountain lake or in the event of large weather fluctuations), it should be recalibrated. Even if maintenance has been carried out on the head, if water has got into the head or if anything was noticeable during the last dive, it must be recalibrated.

There are several reasons for calibrating with pure oxygen. Since with rebreather you usually dive with a set point of 1.0 - 1.3, the calibration with pure oxygen comes closest to the gas mixture. In addition, an error when calibrating with air has greater effects than with pure Oxygen. An error of around 1% with air calibration (e.g. 20% instead of 20.9%) corresponds to a deviation of 5% in pure oxygen (95% instead of 100%). For this reason it is usually also on 98% and not on the actual 100% calibrated, as it must be assumed that the rinsing of the head is not complete or that there is still residual moisture in the system or on the sensor membrane.

The calibration set is required to calibrate the SF2. This consists of a protective cardboard with inflator nipple, an inflator hose and the male coupling of the Quick Disconnect Set. A separate calibration gas is not required, as the SF2's oxygen cylinder can be used.





Flush the head with oxygen for about 5 seconds and then wait about 10 seconds. Repeat this process 2-3 times until the sensors have stabilized. When the sensors stop swaying in their readings, press lightly
Gas flow (0.5-5 l / min) to "Calibrate" and wait for confirmation. Usually the Calibration value set to 98% because it is assumed that there is a certain residual moisture and that the system is not 100% flushed. Calibrate the backup computer / monitor or the HUD in the same way!

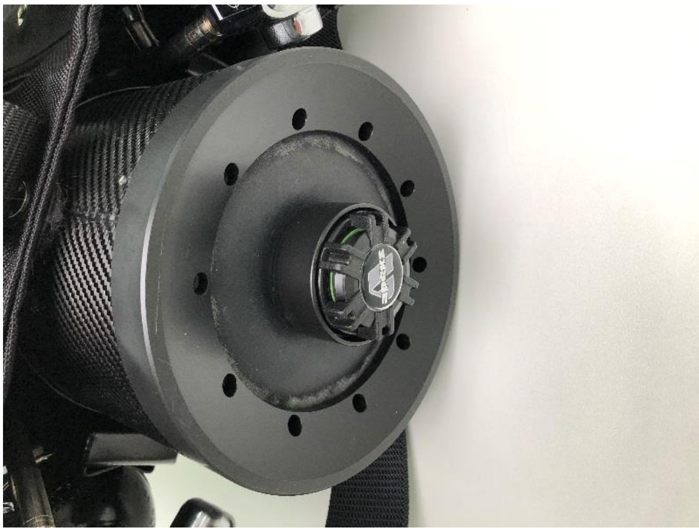
8. Predive safety checks

The function tests and the processing of the checklists are essential for the smooth functioning of the SF2. Even if the pure assembly is done beforehand, the entire diving device must be checked at the dive site and the checklist must be gone through. Important functional tests are the pressure tests for leaks in the system and the control of the hose routing, shut-offs and connections. In addition, all valves (solenoid, ADV, OPV, MAVs) must function properly and the controller must be switched on. Even or especially if you already have a lot of experience with rebreather devices, you should always work through the tests and checks with a short checklist. Checklists and SOPs (standard operating procedures) are also intended for professionals! Here you can learn a lot from aviation and emergency medicine, where they due detailed incident and accident analyzes, checklists have become indispensable.

8.1 Check gas flow / gas direction in the loop

The breathing tube must be checked before every dive as it is the connection between the diver and the SF2. Check the breathing tube for cracks and damage and check the O-rings on the connections. Take the opened mouthpiece in your mouth and seal both openings of the loop one after the other with the palm of your hand. When closing the inhalation side (right), a negative pressure must be created when inhaling, and when exhaling and closing the exhalation side (left), an overpressure must be created. If the breathing kit is tight, it can be screwed onto the head of the SF2. It is not possible to mix up the connections due to the design, but you should still get into the habit of picking up the breathing set correctly immediately. The mouthpiece points to the SF2 with the slide (in closed position) or the small hole for blowing out pointing downwards.

8.2 Positive and negative pressure test



Positive test

With the help of the overpressure test, the entire system is checked for leaks and the function of the overpressure or outlet valve (OPV) of the counterlung is also tested. To do this, tilt the assembled device or lay it down so that the OPV of the counterlung is free. Turn off the OPV and perform the positive pressure test. Put the loop in your mouth, inhale through your nose and exhale through your mouth until the OPV blows off. Close the loop and wait for 1-2 minutes. Now check whether the counterlung is still bulging outwards. Now open the mouthpiece and pay attention to whether the residual pressure has been maintained.

Negative test

With the help of the vacuum test, the entire system is checked again for leaks. The negative pressure test is more sensitive and therefore even more important than the positive pressure test. Put the loop in your mouth, inhale through your mouth and exhale through your nose. Suck the air out of the circuit until a
Negative pressure is created. Close the loop and wait for a few minutes. Now open the mouthpiece and make sure that the negative pressure has been maintained (sound of gas flowing in).

8.3 Assembly Check

• Check all diving cylinders for the correct content (gas) and control the cylinder pressures. This includes not only the oxygen and diluent bottle, but also the argon bottle and all bailout stages.
• Make sure the scrubber has been properly filled and installed.
• Check that the two head clamps, the three D-gas connections (solenoid, ADV and MAV) and the tank brackets are properly locked.
• Check the settings on the controller and the battery charge level.
• Tip the SF2, check the counterlung and check whether the outlet / pressure relief valve on the counterlung is closed. Perform the positive pressure test.
• Stand the SF2 upright and perform the vacuum test.

8.4 Predive-Check

Oxygen side:
• Turn on the controller and breathe out of the loop. Turn on the oxygen bottle and check the function of the solenoid and the solenoid shut-off. Also test whether the controller can keep the setpoint stable. Now check the oxygen MAV and the MAV Shut-Off and finally check the cylinder pressure. • Set the setpoint to 0.19, close the oxygen bottle and breathe out the loop.

Diluent side:
• Turn on the diluent bottle and breathe out the loop until the ADV responds. Also check the function of the ADV shut-off. Now test the Diluent-MAV, the Diluent-MAV Shut-Off and the Wing-Inflator / -OPV. • Finally check the tank pressure.

8.5 Prejump-Check

- Check that your equipment is complete (lamps, masks, buoys, etc.)
- Open the diving tanks and bailout stages.
- Check the inflators (wing and dry suit).
- Switch on the controller and the monitor.
- Set the pO_2 to> 0.7 bar with the oxygen MAV and breathe the loop as a test.

WARNING

Always turn on the controller BEFORE going into the water. The controller only switches itself during the immersion phase automatically. If you swim on the surface and breathe through the loop, life-threatening hypoxia can occur.

LET´S GO DIVING!

9. After the dive

The correct procedure for dismantling and subsequent care is important so that you can enjoy the SF2 for a long time and important components are not unnecessarily damaged.

9.1 Disassembly of the SF2

1. Switch off the device, do not lie down, otherwise the saliva or water from the loop will run into the head (oxygen sensors)!

2. Switch off the controller and the backup computer.

3. After diving in salt water, shower / rinse the entire device with fresh water, preferably under pressure.

4. Unscrew the loop on the exhalation side and let it hang down so that saliva etc. can drain off. Open the mouthpiece.

5. Close the bottles and vent them using MAVs and / or inflator. Disconnect the oxygen solenoid valve connector.

6. Briefly release the tank from the lock so that the head lock can be opened.

7. Take off the head, remove the head cover and check whether the oxygen sensors are moist. If the head is dry, the cover plate can be reinstalled. Tip: When removing the head, pull on the oxygen valve connection and hold against the connection of the MAV feed.

8. Remove the scrubber from the top tube and check whether the scrubber or the upper carbon tube as well as the counterlung is damp / wet on the inside (it is best to shine a lamp into it). If everything is dry and the service life has not yet expired, the scrubber can be used again for a repetitive dive.

9.2 Cleaning the SF2

If another dive is planned, the SF2 can be reassembled. If the diving day is over, however, the SF2 should be completely dismantled so that the individual components can be cleaned and dried.

9. Unscrew the loop completely, rinse it and hang it up to dry.

10. Remove the scrubber and pack it in an airtight bag (labeled with the date and dive time). When the standing time has expired, properly dispose of the used soda lime and clean the soda lime container.

11. Remove the counterlung, wash it out and place it upside down to dry

12. Regularly disinfect the loop, top tube and middle section with counterlung.

9.3 Disinfect

The breathing circuit of the SF2 should be disinfected regularly in order to prevent the components from becoming infected. About every 15-20 diving hours (in tropical or warm regions every 10-15 hours) the breathing set, top tube, middle section and counterlung should therefore be disinfected. EW-80 must be used for disinfection according to the manufacturer's instructions. EW80 was specially developed for the requirements of divers, but also fire brigades, police and military and is therefore particularly suitable for the disinfection of rebreather devices.

9.4 Transport and storage

For the transport of the SF2 e.g. In the car, the oxygen and diluent tanks must be removed and transported separately. Otherwise, the tank brackets on the SF2 could be damaged due to vibrations or lever forces while driving.
The SF2 should be stored in a dry, shady and well-ventilated place. Avoid unnecessary UV or solar radiation and high temperatures.
Remove the soda lime, clean all parts of the SF2 and grease the O-rings. Disinfect the components of the breathing circuit and do not store the loop hanging.

For longer storage times, all batteries (oxygen solenoid valve and controller) and the oxygen sensors should be removed. Broken batteries or oxygen sensors can leak and corrode the contacts or connections.

10. Maintenance

The SF2 is a very robust and low-maintenance rebreather, but it should still be handled with care and regularly serviced. In general, all components must be visually checked regularly and cleaned and cared for accordingly.
In order not to impair the function of the SF2, certain components must be serviced or replaced at regular intervals.
The following maintenance work may be carried out by the user:
Replace the O-rings, the flutter valves, the oxygen sensors and the batteries.

All work on the electronics, the oxygen solenoid valve, the first stages and the body may only be carried out by the manufacturer or an authorized service center.

Regardless of the specified maintenance intervals, used or defective components must be replaced immediately. Use only original spare parts. If other parts are used, the guarantee is void. In addition, there is a risk that malfunctions due to incorrect spare parts could lead to life-threatening incidents or death.

NOTE

The SF2 has to be qualified every 12 months and maintained by a workshop authorized by the manufacturer.

12. Attachment

11.1 Checklist

SF2-CCR Checklist		
ASSEMBLY		
1.	Check all cylinders for content and pressure (O2, Diluent, Argon, Stages	
2.	OPV closed, soda lime checked and installed	
3.	Calibration (if necessary)	
4.	Loop Test	
5.	QD-connections 1+2+3 shut, Pony clamps closed, all hoses tight	
6.	Positive Test	
7.	Negative Test	
PREDIVE-CHECK		
1.	Controller switch on → Loop breathing	
2.	O2 cylinder open → Solenoid / Shut-off check → Solenoid is firing oxygen → O2 MAV / Shut-off check → Pressure check → closing O2 cylinder	O2 Seite
3.	Switch Setpoint to 0.19, Breathe empty loop	
4.	Diluent Tank open → ADV / Shut-off check → DIL MAV / Shut-off check → Wing Inflator → Pressure check → closing DIL Tank	DIL Seite
5.	Check controller settings (plan, gases, battery, functions	
PREJUMP-CHECK		
1.	Equipment check (Light, SMB, Mask etc.)	
2.	Open cylinders, switch on Controller, Inflator connected	
3.	pO2 > 0,7 → Breath from Loop	

12.2 Further operating instructions

To use the SF2 safely, it is essential to read the following operating instructions carefully.
1. Shearwater Petrel Dive Can
2. Shearwater Petrel Ext.
3. SF2 ECCR HUD

If you do not have these operating instructions, you can find them on our website in the download area.

www.scubaforce.eu

Compliance with CE requirements

In accordance with the European standard EN14143, paragraph 8, the following information must be particularly observed:
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- 8.1 This manual contains information that will enable trained and qualified persons to assemble and use the SF2 in a safe manner
- 8.2 This manual was originally written in German
- 8.3 The application of the SF2 is an autonomous recreational diving device. For dives with air and trimix gas. The SF2 is approved for a maximum depth of 40 meters (130 feet) with air diluent or up to 100 m (325 feet) with trimix diluent. The SF2 uses two gas supplies: trimix or air diluent and oxygen; and those generated by breathing, gas mixture mixed by the SF2. The use of the SF2 is restricted to diving underwater only by appropriately trained persons. Detailed instructions on how to assemble the SF2, including descriptions of the individual components, the specific connection between the components and the various safety elements, can be found in this manual.
- The user should be able to understand the risks and to assess the risks associated with the use of the SF2 and the use of this manual in conjunction with qualified training of the SF2 instructor prior to diving. The operating temperature for the SF2 is between a minimum of 4 ° Celsius and a maximum of 34 ° Celsius. Using the device outside of these limits can lead to malfunction. The SF2 is intended for dives that require little to moderate work. Although the SF2 is able to withstand high work rates, this is not its intended purpose. The SF2 is intended to supply the diver with a breathing gas mixture with a partial pressure between 0.4 bar (at least 0.35 bar) and 1.3 bar (maximum 1.5 bar). Depending on the depth of the dive, the oxygen content in the breathing gas should be between 21% and 100%. Nitrogen between 0% and 79% and helium between 0% and 90%, depending on the diluent used, i.e. Air or trimix.

Users should monitor the displays, indicators and alarm systems and react appropriately if the oxygen concentration becomes dangerous. The SF2 requires the monitoring of an LCD display and should therefore only be used in waters with a minimum visibility of at least 30 cm. Using the SF2 in conditions that do not allow the LCD display to be monitored is at increased risk.

- The SF2 contains high pressure oxygen as one of its gas supplies and uses equipment that has been specially cleaned and prepared to handle high pressure oxygen. Accordingly, special care should be taken when handling these gas mixtures, especially when refilling the gas bottles.
- For each component that comes into contact with high pressure oxygen (e.g. regulator on the oxygen side and connected pneumatic parts), more appropriate handling and cleanliness must be guaranteed. Components exposed to high pressure oxygen must be serviced by a qualified service center. Failure to follow these instructions could result in an oxygen fire and serious injury, including death.
- The SF2 requires proper assembly and important safety checks to be performed by the diver prior to diving. Details on both points are contained in this manual.
- Using the SF2 without fully checking the system poses an increased risk for the diver.
- Chapter nine of the manual describes post-dive care and cleaning and instructions for long-term storage of the SF2. It also describes the shelf life of certain components, various safety measures, and the maintenance and inspection intervals. Failure to observe these instructions can damage individual components, which in turn can lead to malfunctions of the SF2
- 8.4 The diluent bottle of the SF2 may only be filled with trimix or air. The helium used must correspond to category 6.0. The oxygen cylinder may only be filled with medical (breathable) oxygen of category 5.1. The SF2 may only be filled with Molecular Sofnolime.
- Any accessories used must be CE certified if they belong to the personal protective equipment category. Additions and changes to the device by third parties are not permitted.
- 8.5 The soda lime life of this device is 135 minutes under the following conditions: diving depth 50 meters; Water temperature 4 ° Celsius, AMV 40 liters / minute.
- There are no findings or medical studies regarding the long-term health effects of rebreather diving. Nevertheless, it is important for the user to keep up to date with current research.