MANUFACTURER'S MANUAL
FOR ASSEMBLY, USE AND MAINTENANCE

rEvo III mCCR model 2014

(rEvo III standard F, mini F, micro FT)
(*optional rEvo III hCCR, rMS)

CE version

Version 0.5.en Paul Raymaekers

changes in *italic*

rEvo REBREATHERS

Warning!

Diving without training is both dangerous and life threatening!
Diving a rebreather without training by a recognised agency is not only stupid but equates to suicide!

A rebreather is a machine and machines break!
Don't ask yourself WHETHER a problem will occur as it is inevitable, ask yourself WHEN it will occur!
Be alert to signs of subtle changes in your rebreather as they are often a sign of pending problems!

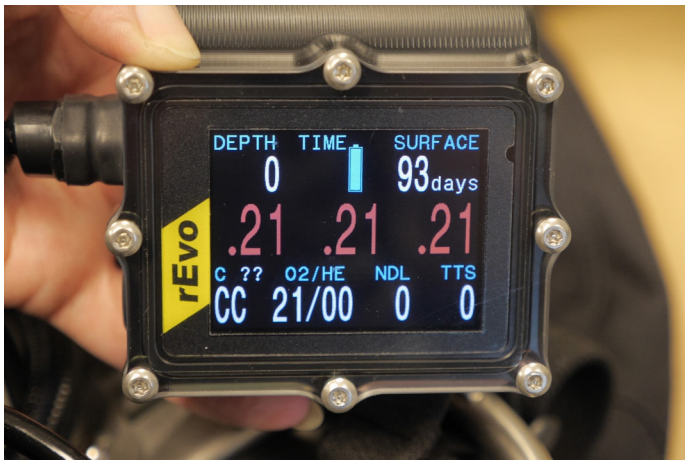
When a problem arises: correct and regulary maintained skills plus their appropriate application will make the difference between life and death!

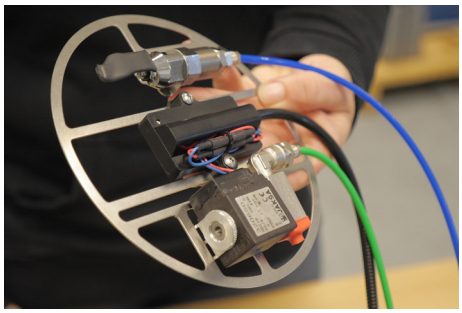
This individual manual does not replace in any way training and does not equip you in any way for rebreather diving !
If you don't understand this warning or you think it is not necessary to take training, then do NOT dive a rebreather, and especially not a rEvo!

The manufacturer and recognised training agencies do not want to be part of stupid behaviour that can kill!

Do not change anything on your unit, as this will void the CE type approval and can turn your unit into a unsafe and dangerous rebreather!

You have been warned!





rEvo III micro FT *rEvo III mini F* *rEvo III standard F*

Chapter 1:
Technical Specifications . 5
Overview of the rEvo III . 6

Chapter 2: rEvo components
2.1 The breathing hoses. 8
2.2 Counterlungs. 9
2.3 ADV. 9
2.4 Orifice. 9
2.5 The scrubbers. 10
2.6 Backplate, Wing & Harness. 11
2.7 Manual addition of oxygen and diluent. 11
2.8 Cylinders with quick release. 12
2.9 Stainless steel carrying handle / (soft) weight fixation. 13
2.10 Upright position. 14
2.11 OPV. 14
2.12 Measuring PPO2 with the rEvodream and the HUDs. 14
2.13 Moisture absorber 15
2.14 Set-point controller (optional) 16
2.15 Scrubber monitor (optional) 17

Chapter 3: Using the rEvo for the first time!
3.1 Mounting the harness and wing. 18
3.2 Fitting the O2 cells. 18
3.3 Assembly and greasing of the O-rings. 20
3.4 Filling the scrubbers. 20
3.5 Calibration of the oxygen cells. 23
3.6 The orifice. 24

Chapter 4: Diving with the rEvo.
4.1 Considerations prior to each dive. 25
4.2 Pre-dive checks. 25
4.3 Immediate pre-dive: wearing the rebreather, immediately before entering the water. 26
4.4 Entering the water, bubble-check, during diving, exiting the water. 27
4.5 Maintenance between several dives on the same day. 28
4.6 Maintenance at the end of the day. 28
4.7 General maintenance 29

Chapter 5 general maintenance

Appendix A: Drills. 31
Appendix B: Always – Never. 32

Addendum 1: Top Marker 33
Addendum 2: Check list 34

Chapter 1: Technical Specifications

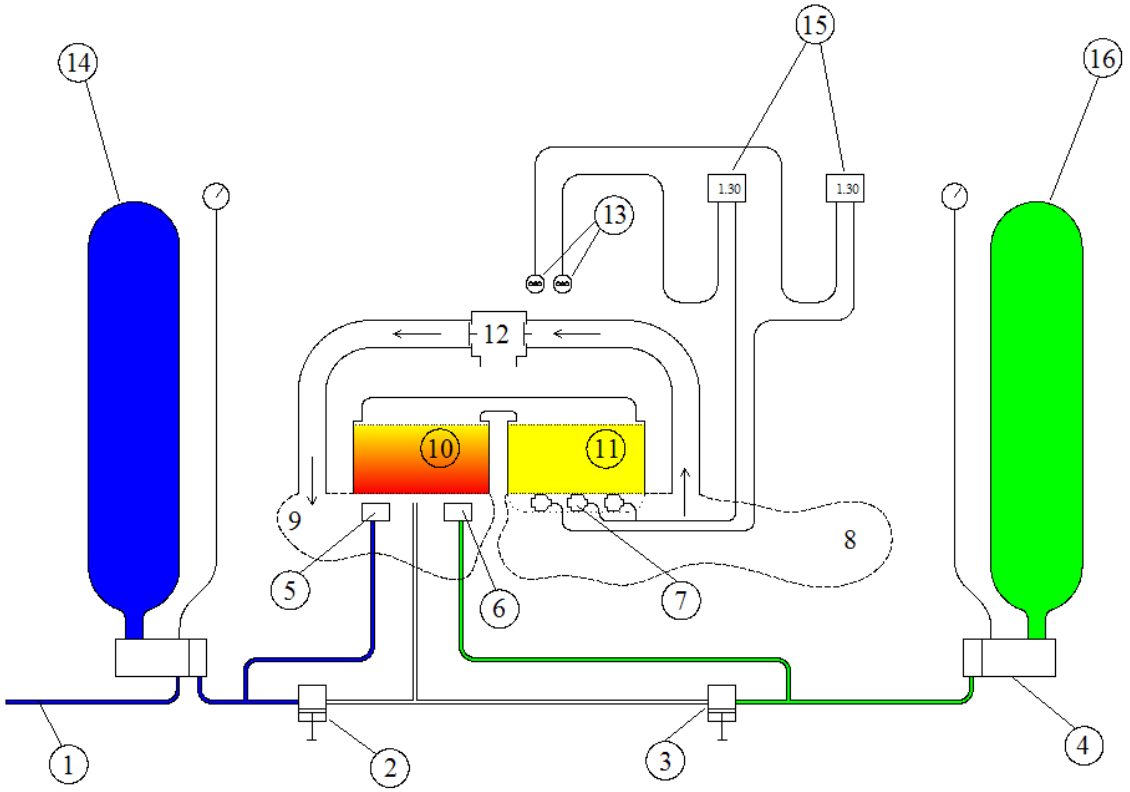
1.1 Limitations of use:

- → This unit is intended to be used by trained people only.
- → The use of the unit is only allowed when an independent alternative gas source is carried at all time by the diver, that can be used at any time during the dive, and that has enough capacity to safely end the dive in case of malfunctioning of the unit.
- → Only oxygen compatible grease like *Tribolube 71* should be used anywhere in the unit.
- → Max certification depth: 40m with diluent air.
- → Max certification depth with trimix or heliox, and PPN2 <= 4.0 bars: *100m*
- → Temperature conditions during use: water temperature minimum 4° Celsius, maximum 34° Celsius.
- → Scrubber endurance: at 40m depth, 4° Celsius, CO2 production of 1.6l/min STPD, 40 RMV (2 liter tidal volume), using 2.7kg *Sofnolime 797*: time until the PPCO2 of the inhaled gas reaches 5mbar: >160 minutes. Time until the PPCO2 of the inhaled gas reaches 10mbar: >170 minutes.
- → Scrubber endurance: at constant depth of 100m, 4° Celsius, CO2 production of 1.6l/min STPD, 40 RMV (2liter tidal volume), using 2.7kg Sofnolime 797, using any trimix or heliox (PPN2 <= 4.0 bars): time until the PPCO2 of the inhaled gas reaches 5mbar: >75 minutes. Time until the PPCO2 of the inhaled gas reaches 10mbar: >85 minutes.
- → Max work rate conditions: 75 RMV at 40m depth, CO2 production of 3l/min during 5 minutes.
- → PPO2 limits during correct use: minimum 0.5 bar, max 1.55 bar.
- → Work of breathing: at 40m depth, 4° Celsius, 75 RMV (3liter tidal volume), using 2.7kg *Sofnolime 797*: <2.05 J/liter in horizontal position and <2.20 in vertical position.
- → Work of breathing: at 100m depth, 4° Celsius, 75 RMV (3liter tidal volume), using 2.7kg Sofnolime 797, using any trimix or heliox (PPN2 <= 4.0 bars) <2.45 J/liter in horizontal position and <2.75 in vertical position.
- → Scrubber content: 2 canisters each containing 1.35kg *Sofnolime 797*.
- → Approved scrubber material: *Sofnolime 797*.
- → Tank content: oxygen and diluent tank: 2 or 3 litre .

1.2 Dimensions and features:

- → Weight of the rEvo ready to dive (full 3 litre steel cylinders, packed canister, stainless steel housing, BCD, backplate = 31 kg (including 2.7 kg absorbent). (micro FT with 2l cylinders: 24 kg)
- → Empty weight (without absorbent and cylinders) = 17.5kg.
- → Size: with steel 3-litre cylinders: 64 x 40 x 18 (cm). (rEvo III standard)
- → Constant oxygen flow by means of an orifice, *manual oxygen, diluent and off board gas addition with front mounted triple MAV (manual addition valve) block*, automatic diluent valve.
- → Two completely independent programmable PPO2 monitors with LED- indication on two HUDs (rEvodream) (mCCR version).
- → Securely attached mouthpiece.
- → Ergonomically integrated backplate to create a minimal static WOB (work of breathing).

Overview of the rEvo III.



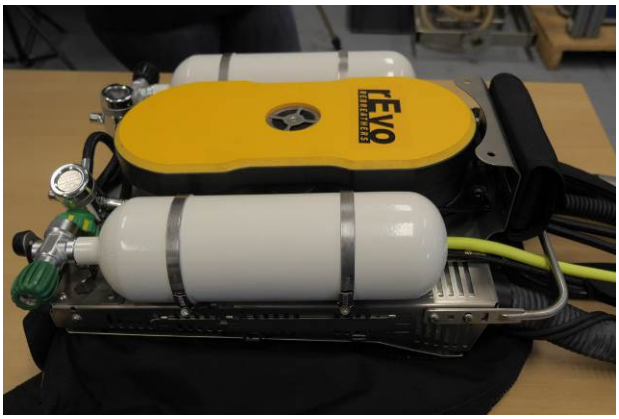
1. Inflator connection.
2. Manual diluent addition valve *(upper button on MAV)*
3. Manual oxygen addition valve *(middle, retracted button on MAV)*
4. Absolute pressure oxygen regulator (APR).
5. Auto diluent valve (ADV).
6. Orifice + one-way valve.
7. Oxygen cells.
8. Inhale lung.
9. Exhale lung.
10. Exhale scrubber (upper canister).
11. Inhale scrubber (lower canister).
12. Mouthpiece.
13. HUD's (LED-indication on mouthpiece).
14. Diluent cylinder.
15. rEvodreams (PPO2 displays).
16. Oxygen cylinder.

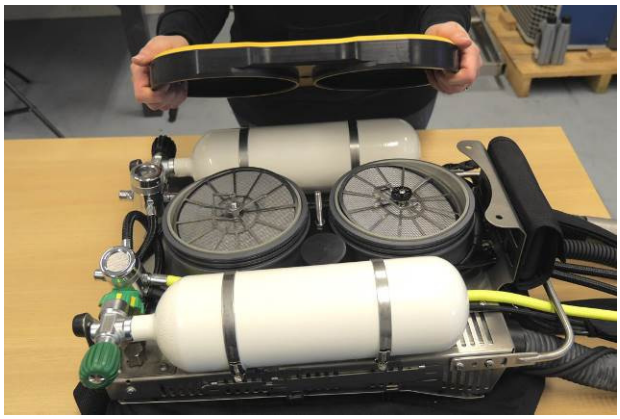
The rEvo III mCCR is a manually operated closed circuit rebreather based on the CMF principle: (constant mass flow). During diving a constant flow of oxygen bleeds into the breathing loop of the rebreather. The flow rate is high enough to provide a diver in rest with a life sustaining breathable oxygen flow. The flow rate can be adjusted to the individual metabolic rate of the diver. But it is kept low enough to be safe. During the dive the diver controls and monitors their PPO2 with the help of the LED-indication of the HUD and their handsets: when needed they can manually add oxygen through the oxygen addition valve to maintain the desired PPO2.
It must be clear that the standard rEvo III mCCR is not an electronically controlled rebreather: there is no computer which decides when oxygen has to be added: that is the role of the diver. If they do not monitor and adjust the PPO2 regularly, this will lead to hypoxia, unconsciousness and ultimately, death.

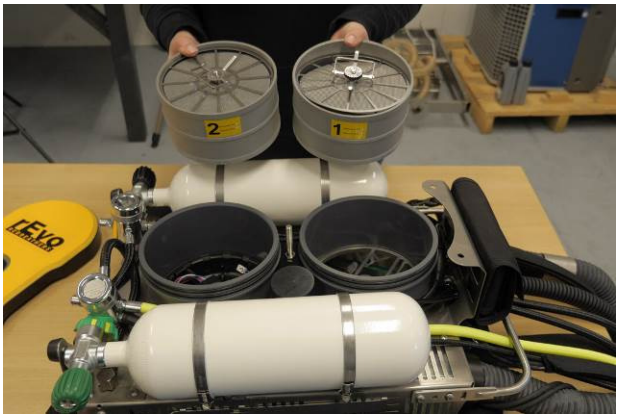
The rEvo III hCCR (non-rMS and rMS) is a fully automatically operated closed circuit rebreather, where the O2 addition is also supported by a constant mass flow orifice: in case of malfunction of the automatic control system, this CMF allows to operate the rebreather identical to a standard mCCR.

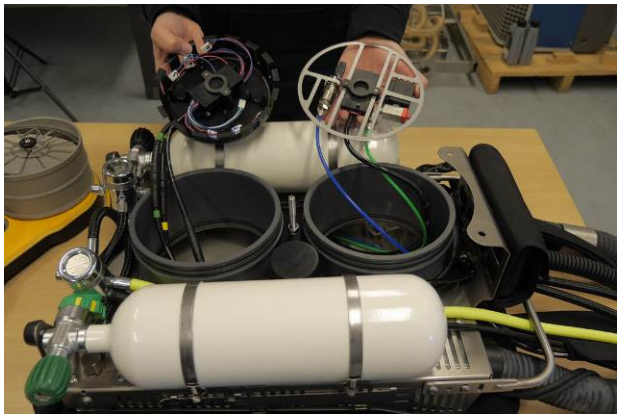
Easy to setup, easy to transport, easy to dive and easy to maintain:

The rEvo III mCCR has been designed with one clear purpose in mind: simplicity in setup, simplicity in use and simplicity in maintenance. The user has access to all rebreather parts. Oxygen cells, ADV, orifice, scrubber-canisters, moisture pads can be reached by demounting the main cover, removing one screw.







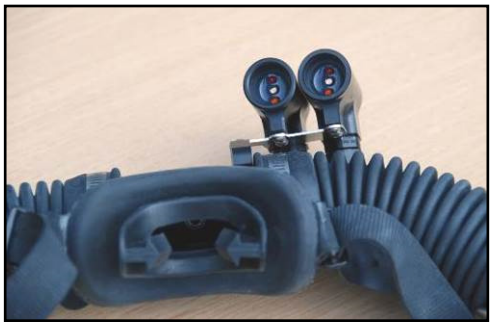


This unique design means that the rebreather has only 4 connections with O-rings used by the diver: 2 for the breathing hoses and 2 for the main cover: the scrubber lid (each with a double o-ring). The risk of leaking, wrong connections, wrong assembly and forgotten o-rings has thus been reduced to a minimum!

Chapter 2: the rEvo component parts: general description

2.1 The breathing hoses:

The breathing hose assembly has been made in such a way that the mouthpiece can be opened and closed in all conditions (very cold and very warm water). A safety attachment strap, a 'gag', has been added to the mouthpiece. When correctly adjusted and for example in the case of unconsciousness, the mouthpiece remains in the mouth of the diver.



Adjustable hose-weights are added to assure a comfortable in-water position of the hoses and mouthpiece. The HUDs are designed to be attached to the mouthpiece. An extra cover goes over the rubber hoses to prevent external damage. (picture: cover protection only mounted on the right hose)

The connections of the breathing hose are clearly marked, so that inhale and exhale side cannot be switched: all connectors on the exhale side are marked with a groove (no groove on the inhale side), plus the diameters of the connections are different, to avoid any faulty connection.

2.2 Counter lungs:

The rEvo counter lungs are made of food-compatible PU, sealed with high frequency welding technology and are permanently elastic. Both counter lungs (inhale and exhale) are back mounted. Both lungs are protected by a liner and are fitted in a stainless steel case. This case is produced in such a way it perfectly fits the back of the diver.
The placement of the counter lungs provide the diver a clear chest-area. The lungs do not limit the movement or the vision of the diver. That way it is easy to work with stages. The case provides excellent lung-protection in hazardous environments like wrecks or caves.

The hoses for manual addition of oxygen and diluent are fed into the exhale lung. The ADV and orifice are also situated in the exhale lung.
The exhale and inhale lung are connected by two serially placed scrubber canisters. Both canisters are thermally isolated by an additional air chamber. The oxygen cells are located beneath the canister in the inhale lung. The flow of the warm gasses in the breathing loop, coming from the second canister, keep the cells dry. An anti-collapse hose is mounted in the inhale lung.

An "over pressure valve (OPV)" is mounted on top of the unit, on the exhale side. The cable entry port is mounted on the inhale lung side.

2.3 ADV:

The "auto-diluent-valve (ADV)" is activated by the pressure created when the exhale lung 'bottoms out' (for example during descent). Diluent is injected into the exhale lung. Access to the ADV is possible for breathing resistance adjustment (when necessary). *See photograph below(2.4 orifice)*

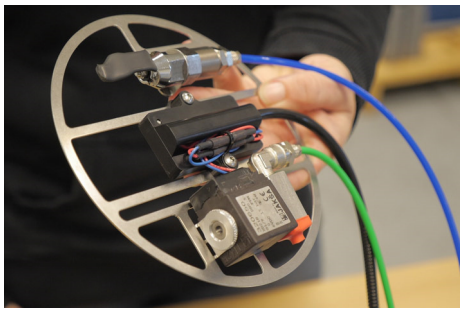
2.4 Orifice:

To guarantee a constant oxygen flow, an orifice is used. This orifice (a small opening situated in the oxygen hose allowing oxygen flowing through) gives, at a fixed inlet pressure, a constant oxygen inflow, independent of the outlet pressure. (Within the manufacturer's limits of use of the rEvo).
The result is a constant flow even when the depth increases. To keep the inlet pressure fixed, a special first stage regulator is used.

The output pressure of the regulator is depth independent ("Absolute Pressure Regulator" (APR)).
The orifice is situated in the exhale lung and is easily accessible for maintenance.

In the mCCR version, on the outside of the orifice a non-return-valve (one-way-valve) is mounted to avoid dirt, moisture or dust, coming from the exhale lung, and which could possibly enter the orifice.

In the hCCR version the orifice and non-return valve is mounted inside the central stem of the solenoid



2.5 The scrubbers:

The scrubbers take care of the "removal" of CO2 from the exhaled gases.
The rEvo has a unique dual scrubber-system consisting of two serially mounted scrubbers. During diving, gas flows from the upper scrubber to the lower scrubber. This configuration has some important advantages: it allows a compact rebreather design, low work of breathing resistance and a higher safety level.

- Compact design: using two scrubbers with a large diameter and low height, results in a limited total thickness of the rebreather (maximum 180 mm at the point where the rebreather is in contact with the back of the diver). This design ensures a perfect streamlining of the diver during diving.

- Low internal breathing resistance: mounting the scrubbers directly on the lungs in the body of the rEvo, results in reducing restrictions in gas flow to a minimum. Most non rEvo-rebreathers have their lungs and canisters connected by tubes or hoses of 30 mm or even less. The rEvo scrubbers are connected to the lungs through an opening of 154 mm diameter, resulting in an extremely low WOB (work of breathing) in a normal diving position.

- Increased safety while using the rebreather: during diving, condensation is kept in the lungs without affecting the scrubber, both in horizontal and vertical position. The risk of channelling is reduced significantly when using two canisters compared to a normal single radial or axial canister.

2.6 Backplate, Wing & Harness:

The rEvo uses an ergonomic split back-plate, a harness and a wing BCD.
The harness, with rotation fittings, is mounted on the split backplate. The shoulder piece is rounded on top of the rebreather, following the curve of the shoulders. The straps of the harness are attached to this shoulder piece.

The lower back piece can be adjusted in height by the user, in order to customize the backplate to the diver's length. The shoulder straps of the harness are threaded through the lower part of the backplate, where they can be connected around the

diver's waist. A rubber protection plate is mounted over the backplates , held in place by the straps.

The construction of the split backplate, the rounded upper section combined with the thin stainless steel case and the built-in wing, afford a perfect fit of the rebreather to the diver's back creating very low drag and optimal streamlining.

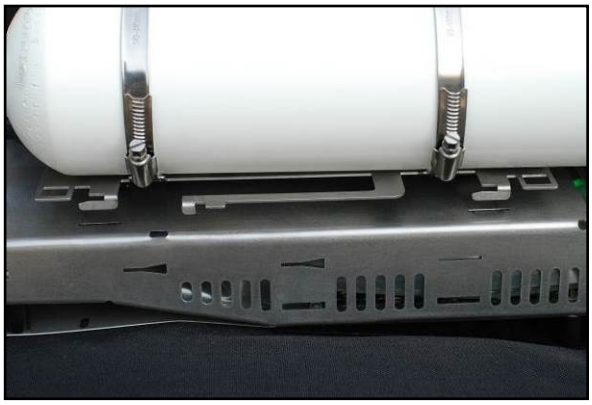
Hydrostatic pressure differences are kept to a minimum due to the counterlungs position close to the diver's back.

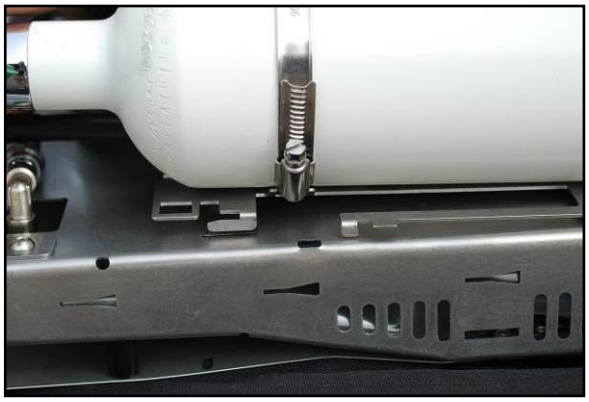
2.7 Manual addition of oxygen and diluent:

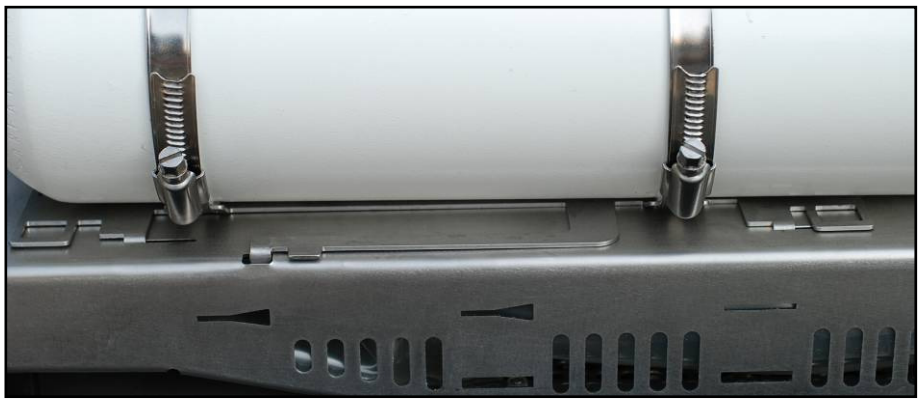
The manual addition of oxygen, diluent and off board gas is done by an easy accessible triple addition block, that can be operated with both hands, and where the oxygen addition button is retracted, so that by tactile sensing there is clear indication where the oxygen addition valve is located.

Oxygen addition during diving only needs to be done in short bursts, while the diver continues breathing on the loop. In this way peaks of PPO2 are avoided.

2.8 Cylinders with quick release:







The cylinders are attached to the stainless *steel or titanium* housing by means of a "quick release" system. This offers a very quick and easy mounting and demounting of the cylinders. This method allow the valves to be immediately and correctly positioned towards the first stages.
On both sides of the housing, slots are provided where 'quick release' clamps can be locked-in to attach small devices such as light canisters. A short and a long clamp are supplied with each rEvo. For larger/heavier items 'quadrolock' clamps are available that lock into 4 slots.

2.9 Stainless steel carrying handle / weight fixation

On top of the rebreather a stainless steel carrying handle is situated which covers the complete width of the rebreather.If necessary two people can simultaneously lift the rebreather. Also, the handle works to protect the hose connectors, the inlet ports and the breathing hose. The handle can easily be removed for travelling.

On top of the rebreather, between the cylinders, a grid is mounted. On this grid a weight pocket (optional) can be attached, where both soft and hard weights can

2.10 Upright position:

The rEvo has been designed in such a way that it can easily stand upright in a detached position, even without cylinders.
Rubber 'feet' are mounted to avoid possible damage to the case.

2.11 OPV:

The 'Over-Pressure Valve' is mounted on the exhale lung, at the top of the rebreather. This valve ensures venting of the rebreather in case of overpressure, for example when an ascent with a closed mouthpiece occurs (in case of open circuit bail-out). The relief pressure is factory set and should not be adjusted.

2.12 Measuring PPO2 with the rEvodream and the HUDs:

mCCR: In order to be able to monitor the PPO2 constantly, each rEvo is equipped with two rEvodreams. Each rEvodream has an LCD display, mounted on the pressure gauge and a HUD. The HUD has three LEDs (orange, green & red) to indicate the PPO2 value. The LCD display is normally used to check and compare the values indicated by the HUD and to calibrate the unit.
The basic philosophy of the rEvodream is that when everything is OK and optimal (correct PPO2), there is a constant permanent light signal (a continuous green in the middle on the HUD: green means: OK, safe). Small deviations over or under the optimal PPO2 will show a short pulse of orange (under, below the green LED) or red (over, above the green LED), together with the constant green LED. This is a small deviation of the optimal zone, but still safe (green is ON!).
When the deviation increases, more orange or red pulses will appear. But as long as the green LED is permanently on, it is still safe to breathe the gas. The increased frequency of the orange and red pulses will attract the attention of the diver. As soon as the PPO2 comes out of the safe zone, the green light disappears and only the orange or red LED is flashing: **this means DANGER!!!**
During normal use the diver will press the O2 manual addition valve when the orange LED flashes shortly, to get back in the 'green-only' zone (by raising the PPO2 slightly).
The rEvodream (on, off, calibration, change settings) can completely be operated by gently knocking on the bottom or side of the housing: there are no external switches or connections whatsoever. This designs guarantees a longer life for the unit and avoids the risk of flooding.

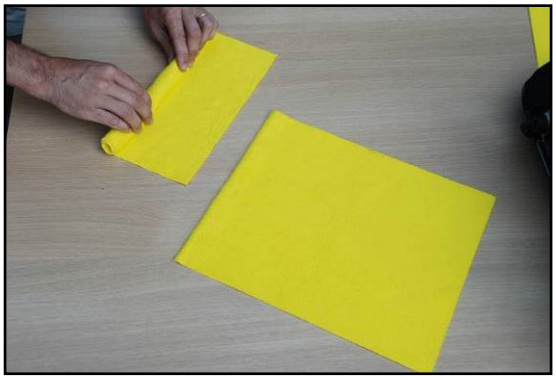
To operate the rEvodream: see separate rEvodream manual.

hCCR: the rEvo III with automatic PPO2 controller is equipped with at least 1 rEvodream. This rEvodream serves as independent and fully redundant PPO2 monitor, that shows you in front of your mask what the control system supplies you.

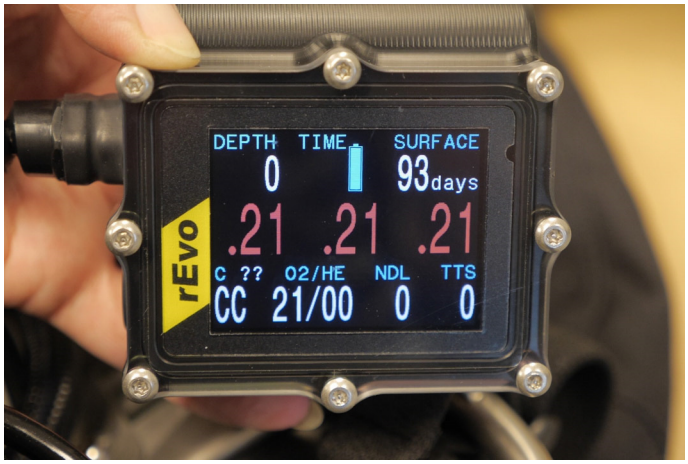
2.13 Moisture absorber

At the bottom of the inhale lung, a moister absorber is installed: this prevents condensation water flowing into the counterlung or getting into the breathing hose. This moisture absorber is rolled into a small tube, and mounted at the bottom of the inhale lung under the non-collaps tube. That way the absorber is blocked and cannot move around in the counter lung.

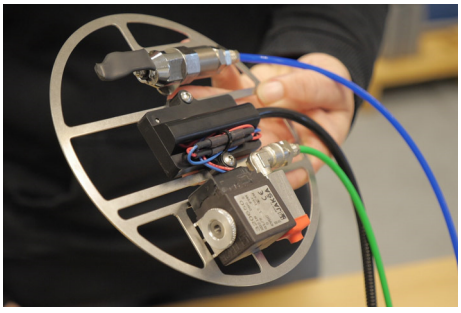
Photos: how to roll moisture absorber and mount it in the counter lung



2.14 Set-point controller (optional)



Set-point controller (optional)
The rEvo can be supplied with set-point controller that automatically maintains a pre-defined PPO2. In this case an automatic valve *(solenoid)* is mounted on the oxygen pressure line, which is piloted by the wrist-mounted controller.
When equipped with this option, the diver no longer has to manually maintain the preferred set-point anymore; he must however verify all the time if the partial pressure of the oxygen he is breathing, is in the correct range! The full user manual and working explanation can be found in the separate manual. *(Shearwater petrel)*



2.15 Scrubber monitor (optional)

The rEvo III can be supplied with a scrubber monitoring system, that informs the user before and during the dive of the remaining time on the CO2 scrubber. This system is incorporated in the rMS (rEvo Monitoring System)

The full explanation of the rMS can be found in the separate rMS manual.

Chapter 3: Using the rEvo the first time!

3.1 Mounting the harness and wing:

When shipped the rEvo is completely assembled. The unit (harness and backplate) needs to be adjusted to the body of the diver. When adjusting the harness the dive suit has to be taken into account. The best position of the unit is when the rEvo is fixed on the diver's back as high as possible: the harness should be fixed closely to the diver's back, so that the curve of the backplate follows the fysical forms of the of the back of the diver as much as possible.

Wrong

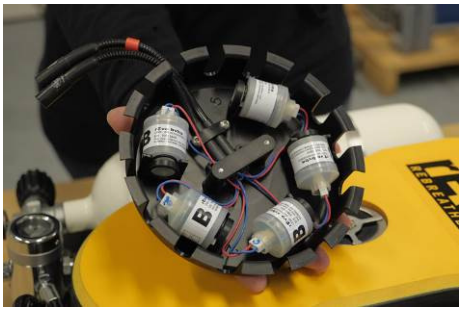
Correct

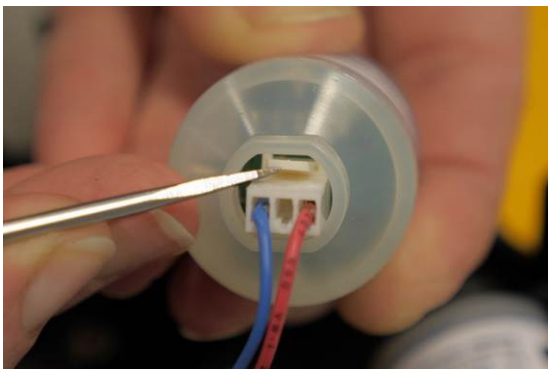
A minimal WOB can only be guaranteed when fixing the rEvo in a correct way. The harness has to be slightly re-adjusted after the first dive in confined waters.

3.2 Fitting the O2 cells:

On an mCCR, minimum 3 oxygen cells should be used during diving: 2 cells mounted on the first rEvodream, 1 cell mounted on the second rEvodream.

On a hCCR, a minimum of 4 sensors are used.





Secure the cell with the black holding screw and connect the right Molex connector to the cell. Be sure that the connector is fitted in the right position (see picture). Do not use force as this may damage the pins on the cell.
In general, ake it a habit to position the cells in the same place and order.
When using only 2 rEvodreams (mCCR), position sensor one and two for the first rEvodream and position number three for the second rEvodream (which is using only one cell). The first rEvodream should be the one on the right oxygen SPG and right HUD. The second rEvodream should be fitted on the left side (and left diluent SPG) and the left HUD. By keeping a fixed position for each cell it will be easier to decide which cell to replace. Note down the date when each specific cell is installed: write the date on the cell itself to know its exact age.
When using a the Shearwater controller, minimum 4 sensors are used: in this case position 1, 2 and 3 are used for the sensors of the controller, position 4 (and eventually5) are used for the rEvodream(s) sensors

How to use and when to replace oxygen cells:

Minimum 3 (mCCR, no Shearwater) or 4 oxygen sensors must be used during diving: this is the way to start up with a new unit. The ultimate date of installation is marked on each cell.
After 6 months an extra cell is added. Following process applies unless a sensor has failed before its 6 months of use: the oldest cell that is still in the unit, is replaced with a new cell, unless a cell clearly reacts slower than the other cells. In that case the slower cell is replaced of course.
If you have to choose between more than one cell to be replaced, change the cell that reacts slower on a sudden increase in PPO2.

As explained further down, at least once every week of diving, cells must be checked for current-limiting at the start of a dive and *at least 30 minutes into the dive (or at the end of the dive)*

Adding a new sensor every 6 months reduces the possibility of losing more than one cell during diving (the sensors in the unit, coming from different production batches, will all have a different diving history after being in use for a while)
The only recommended oxygen sensors to be used are *R22D-rEvo and CR22D-rEvo.*

3.3 Assembly and greasing of the O-rings:

If the O-rings of the cover have not been greased yet, or when the grease is contaminated or the rings are damaged and need to be replaced: remove the four O-rings from their seats, clean them with a lint-free cloth, or use a neutral soap.



Take a small amount of oxygen compatible grease and spread the grease onto the ring by pulling the ring between thumb and forefinger. Be sure that the grease is spread equally over the ring. Be careful not to use too much grease as the excess will be pushed away when replacing the cover onto the canister.

A small amount of grease can also be put onto the inside of the cover after cleaning it first.

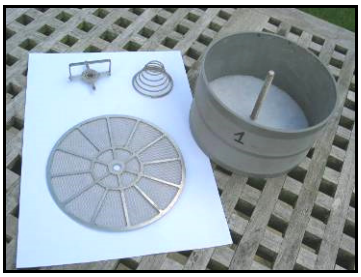
Warning: use only oxygen compatible grease for all O-rings on the rEvo!

The O-rings of the breathing hose connectors can also slightly be greased without removing them (when they are not contaminated: check for sand or dirt traces first, if contaminated remove and clean as above).

3.4 Packing the scrubbers:

Unscrew the handle of the scrubber, take out the spring, remove the grid and the mesh (be sure not to lose any parts). Throw away the used scrubber material and remove the remaining dust by slightly tapping on the canister..
Be sure to take into account local environmental regulations regarding toxic waste!
Make sure the filter stays inside the canister.

Packing the canisters is done best in the open air to avoid scrubber dust. If there is wind be sure to be upwind so that the wind blows any dust away. Position the canister on a horizontal surface: pour the absorbent from a height of approximately 20-30 cm into the cassette. Let the wind carry away the absorbent dust. Keep filling until a small pyramid of absorbent is formed in the canister (keep 1 cm free from the top of the canister).



Gently tap on the side of the canister with one hand, whilst turning it around with the other hand.

When the absorbent has filled up the canister freeing the central screw, put the mesh, grid, spring and handle back in place and turn the screw until the spring is completely compressed (but not over-tightened).



Continue tapping the side of the canister evenly with both hands for about one minute whilst tightening down the grid. Keep on turning until the spring is completely pushed down. Do not overtighten, if you do so your risk you separate the bracket from the crossscrew.
An alternative for the tapping on the side, is gently tapping with the complete canister on a hard surface, just touching with one side of the canister, while pushing with the thumbs on the mesh on top of the canister: on the side of the tapping the sorb will 'settle' faster, so that when rotating the canister during this tapping, the sorb will settle down on the complete circumference of the canister.
The correct filling amount is reached when after correct tapping there is +/- 5 mm between the top of the grid and the top of the canister.
The fresh canister is now ready for use (if you do the cycling, mount it in the lower scrubber cavity of the rebreather!) (for cycling: see FAQ on the website).



To remember which canister has to be positioned on top of the exhale lung, this canister is marked with a 'Top Marker'.

The correct use of the 'Top Marker' is explained in Annex 1

If the canister is not to be used immediately, we advise to put it in a plastic bag or airtight container. This will protect the scrubber material from drying out. If it is too dry, the scrubber will not work properly. Be careful not to expose the canister to (direct) sunlight !

Warning: **never re-use absorbent material** that has been partially used and poured out of the canister!

Note: never try to use the dregs of absorbent in the container: it merely consists of dust. When packing, be careful not to tap the canisters too long or too hard, doing so may turn the granules to dust. This will negatively affect the WOB.

3.5 Calibration of the oxygen sensors:

For proper use of the rEvodreams and the Shearwater electronics, please read the appropriate manual.

When calibrating the oxygen sensors, only pure oxygen should be used. The calibration should be done at 1 atm. *(compensation is possible for calibration at altitude, see manuals)*

Assemble the rEvo completely, be sure that both canisters are placed in the rebreather, packed, the canister with the Top Marker in the upper position, on top of the exhale lung, and that the breathing hoses are connected. Open the oxygen cylinder valve slowly. **(Oxygen valves must ALWAYS be opened slowly, to avoid the danger of oxygen fires caused by adiabatic compression).**

Make sure the diluent valve is closed, and the diluent line depressurised.

Place the mouthpiece in your mouth and suck the lungs to a vacuum (i.e. empty): exhale through your nose. Push the oxygen manual addition valve, inject oxygen until a light overpressure exists on the rebreather and let the abundant gas flow from the corners of the mouth. Stop the oxygen addition, and repeat this cycle 2 more times.

It is important to keep the mouthpiece in the mouth during the procedure and take care that no gas flows back into the rebreather: you need to obtain 100% oxygen in the loop. Close the mouthpiece after the third cycle and take out the mouthpiece of the mouth. Open the mouthpiece a little bit again until you see a small slit inside the mouthpiece: you will notice a small flow coming out of the rebreather: that confirms the rebreather is injecting oxygen into the loop. If the mouthpiece is left closed, the pressure in the rebreather will rise and an incorrect calibration will occur (the loop would be at more than 1 ata). The small flow also indicates that the orifice is not blocked.

Now the calibration procedure of the sensors can start. When the values of the sensors are within the given limits, the calibration can be successfully completed. On the rEvodreams, quick flashing of the green LED will indicate this. The Shearwater will shop the actual PPO2. Leave the valve of the oxygen cylinder open during calibration. When the calibration is finished and you do not intend to dive immediately, then close the oxygen valve must be closed and the loop flushed with air. If the cylinder is not closed, oxygen will keep on flowing into the rebreather resulting the cylinder being empty after a few hours !

To check a correct calibration of the oxygen sensors, vent the unit with air (open the unit, take out the canister on the inhale lung, and expose the oxygen cells to air): the calibration was correct if the displayed values are between 0.20 and 0.22.

To make adjustments or changes to the rEvodream / Shearwater settings, please consult the appropriate manual.

3.6 The orifice:

The gas flow through the orifice is factory set at +/- 0.6liter/min.

It can be useful to do the following measurement (**not during the dive!**). Be sure the oxygen cylinder is full, slowly open the valve and the slowly close it: the pressure on the SPG will slowly drop because oxygen is leaking trough the orifice. Mark the time-interval it needs to get down form 100 bar to 50 bar. You can perform this test every time you have doubts if the orifice is properly functioning (and you do not have access to a flow meter). In case of an obstructed orifice the time-interval needed to drop down the pressure would be much longer. If the flow rate is too high, that time-interval would be much shorter!

Chapter 4: Diving with the rEvo

4.1: Considerations prior to each dive:

* Check the remaining scrubber time: if the time the scrubber has been used and the planned dive time added up exceeds 160 minutes, refill both scrubbers with fresh material.
* Analyse the contents of both the diluent and oxygen cylinders.
* Check the pressure of both cylinders: is it sufficient for the planned dive, even taking into account a worst case scenario?
* Are the batteries of the rEvodreams OK? (did you see a battery indication on the display of the rEvodreams during the previous dive?) If so, replace the batteries, be careful to avoid doing this at the dive site: avoid at all times the possibility of humidity entering the rEvodream's housing.

4.2: Pre-dive:

The use of checklist for assembly, closed check and pre-jump check is mandatory. You can always find the latest version of the checklist on the rEvo website.

* Assemble the regulators.
* Mount the moisture absorber in the inhale lung.
* Be sure that the scrubbers are mounted correctly in the rebreather. Make sure that the inside walls of the scrubber housings are clean, if necessary clean them with a clean towel or lint-free cloth.
* Before replacing the cover, check the general condition of the O-rings. If necessary, clean and grease them.
* Check the correct functioning of the mushroom valves within the breathing-hose assembly: open the mouthpiece, use the palm of your hand to block the exhale side (block the opening of the red connector) and breathe into the mouthpiece: no gas should leave your mouth. Now use the palm of your hand to block the inhale side (black connector) and suck: no gas should enter your mouth. Now close the mouthpiece, block the exhale side with your hand and blow into the inhale side (black connector): no gas should escape from the mouthpiece. Block the inhale side and suck at the exhale side (red connector): no gas should enter the mouthpiece.
* Assemble the breathing-hose: check the O-rings, if necessary clean them and apply some grease. Pay attention to the correct connection of the breathing-hose: the red connector in the p-port with the red button: the gas flow goes anti-clockwise from right to left.
* Do a negative test: make sure that both cylinder-valves are closed, 'vacuum' the rebreather completely, create underpressure resulting the breathing hoses to be contracted and close the mouthpiece: wait for 2 minutes and open the mouthpiece again: there must be a clearly audible 'hiss'. If not, check the rebreather for leaks! (**important**: never do a negative test when the scrubbers are not installed: this will dislocate the counterlungs as they will be 'sucked' into the space of the scrubber canisters)
* Check the correct functioning of the orifice: open the oxygen valve SLOWLY and check if there is no leak there where the oxygen regulator first stage screws into the cylinder valve. Close the valve and note down the time necessary for the oxygen

pressure to drop from 100 to 50 bar. Check if there is a gentle flow noticeable at the mouthpiece (when slightly opened).
* Open the diluent valve and check that there is no leak there where the diluent regulator first stage screws into the cylinder valve.
* Check the functioning of the ADV by breathing in from the mouthpiece.
* Do a positive test: close the mouthpiece entirely and push the button of the manual diluent supply: gas may only escape from the overpressure valve: listen very carefully for gasleaks in possible other places (a second positive test happens in the water during descent: bubble-check at 3/5m) This test can also be carried out in a tub, by closing the rebreather entirely, and immersing it entirely in water at a slight over pressure, when pushing the manual addition valve, gas should only escape from the overpressure valve.
* Check the correct functioning of your bail-out system (alternative or redundant breathing system): mixture, cylinder pressures, proper functioning of the regulators.
* When necessary, program your personal dive computer (not part of required standard equipment) For correct use of dive computers appropriate training is required!

!!!! If you do not intend to dive immediately, close the cylinders and flush the rebreather with air.

4.3: Immediate pre-dive: wearing the rebreather, immediately before entering the water:

* Put the rEvo on your back: take care that all your straps are pulled tight so that the rebreather is positioned as high as possible on your back. The rebreather must be fixed firmly on your back so that it does not swing when you make movements from left to right. When desirable attach the crotch straps: they provide extra stability.
* Attach your independent breathing system (bailout cylinder(s)) to your harness.
* Check the functioning of your independent breathing system: breathe from the regulator(s).
* Open the oxygen valve SLOWLY.
* Check the pressure of the oxygen cylinder.
* Flush the breathing lung 3 times with oxygen (see procedure for calibrating the oxygen cells).
* Start the rEvodreams: when they indicate a PPO2 of between 0.97 and 1.01, you can proceed, if not you must calibrate!
* Open the diluent valve. Test the functioning of the ADV by breathing from the mouthpiece.
* Test the functioning of the inflator: does the wing remain inflated?
* Perform a buddy-check: are all connections OK, the independent breathing system, the pressure on the cylinders, the functioning of the rEvodreams?
* Breathe for 5 minutes on the rebreather (Prebreathe): this is best done while sitting down with the dive mask on. The PPO2 must always be >0.5! Do you feel OK? Compare the readings on the displays of the rEvodreams. Do they match ? (maximum difference of 0.03) Do the indications on the HUD's correspond with the readings on the displays? No sign of a weak battery on the display?

4.4: Entering the water, bubble-check, during diving, exiting the water:

* "ALWAYS DIVE IN GREEN" When entering the water, during diving and leaving the water, both HUD's must ALWAYS show the green LED burning, if not, correct immediately!
* Perform a bubble-check at 3/5 meters: is the rebreather well attached? No components hanging loose? No bubbles?
* During diving, check the readings on the displays regularly: do they correspond with the indication on the HUD's?
* **"ALWAYS KNOW YOUR PPO2".**
* Pay attention to correct positioning in the water: the lowest breathing resistance can be achieved when diving under a slight positive angle: you can easily find the best inclination when the breathing resistance during inhaling and exhaling is approximately equal.
* Be careful to pay special attention to diving with a 'minimum loop volume': inexperienced rebreather divers have the habit of overfilling the counterlungs: this has a negative effect on breathing comfort; because at that moment, at the end of the exhale, you are blowing against an almost full lung. Also a lung which is too full provokes noticable differences in buoyancy. The correct lung volume is reached when during a complete inhalation, the ADV is just not activated. This can be tested by blowing off small quantities of gas through the sides of your mouth or your nose until the correct volume has been reached. Especially during ascent, when the gases in the loop expand, it is important to keep the lung volume to a minimum, so that a correct PPO2 can be maintained by injecting only small bursts of oxygen.
* Make sure you always breathe regularly and deeply: this improves the good absorption of CO2 in the scrubber (as more gas goes through the scrubber). Keeping your breath (breath-holding) must be avoided at all times: you cannot save any gas anyway!
* When the PPO2 drops below the desired value, inject oxygen in short bursts, while constantly breathing the loop: this prevents spikes of high PPO2 in the system.
* Always keep a very close eye on the PPO2 during ascent: due to the decrease of pressure the PPO2 will fall: because of this it is necessary to add oxygen more often compared to diving at constant depth. Avoid fast or uncontrolled ascents. Depending on the depth at which you have been diving, it can be necessary to add oxygen more often, while venting the excess gas.

Note: "Cell-Check"
See also " How to use and when to replace oxygen cells".

It is very important to check the correct functioning of the oxygen cells at regular intervals: cells have the dangerous property of becoming unstable when they get older or more used and are thus unable to indicate high PPO2 values any longer (so-called ' current-limiting '). This means that for example a cell can correctly indicate a PPO2 of 1.3, but when PPO2 increases, the output of the cell will not increase any more. This is of course very dangerous because in case of current-limiting high PPO2 levels are no longer indicated!
To verify the cells the following test can be carried out: (do this together with your buddy so he can keep an eye on you): at a depth of 6 metres, push the manual oxygen addition button: (pay attention that your buoyancy does not increase, if needed let gas escape through the sides of your mouth or nose). Check if the readings on the displays of the rEvodreams indicate at least up to 1.55: the red LED of the HUD will start blinking and the green LED must go out: this indicates a correct functioning of the cells as they can still display a PPO2 higher than the one you will use during diving. Next add diluent manually to bring the PPO2 to a safe level.

* At the end of the dive: always keep the mouthpiece in your mouth and your diving mask on, until you are entirely on dry land: always pay attention that the HUD's green LED's are burning! If you have to remove the mouthpiece at the surface, take care that the mouthpiece is ALWAYS closed before it is removed! If the mouthpiece is removed in the water at the surface and it is left open, the water pressure will immediately force all the gas from the counterlungs out, as a result of which the diver will lose buoyancy and may sink.
* Once on dry land: remove the mouthpiece, close the valves of the cylinders, and take the rebreather off your back.

4.5: Maintenance between several dives on the same day:

* Remove the breathing hose assembly and rinse it with cold or lukewarm water: to do this, close the mouthpiece and pour water into the inhale side (black connector). Let the water leak out. Never use high pressure or very hot water: this will damage the ' mushroom-valves' or membranes in the mouthpiece.
* If the scubbers are not at their end still can give some output, take both scrubbers out of the rebreather and put them in a double plastic bag or an airtight container.
* Rinse the moisture-absorber with fresh water, squeeze all the water out and let it dry, leave the rebreather open to dry, either standing up or laying on its front with the lid side up, (place the carrying frame of the cells out of the inhale lung, so that the inhale lung can dry out too).
* Clearly write down your used scrubber time.

4.6: Maintenance at the end of the day:

* Close the valves of the cylinders.
* Pay attention that the rebreather is completely closed, including the mouthpiece, and rinse the rebreather thoroughly on the outside with fresh water. Inflate the wing by half. Pay attention to rinse all components, the regulators and the inflator buttons. It is also adviced to push the manual addition buttons for oxygen and diluent a few times while spraying water on them, in order to remove any salt and dirt that may have accumulated.
* Turn the rebreather flat on its front and remove the cover: in order not to lose the fixing screw, put it back on the wire grip!
* If you still have remaining scrubber time, take both scrubbers out of the rebreather and put them in a double plastic bag or an airtight container. Never store the scrubbers in a warm place or in direct sunlight, they may dry out completely and become unusable.
* Take both the cell mounting and ADV-fixing out of the scrubber holders and lay them aside, on the cylinders. Remove the moister-pads, squeeze them and rinse them in fresh water. Pour fresh water in both of the lungs of the rebreather and shake the rebreather a number of times, (the breathing hose is still connected and the mouthpiece is closed). Leave the water for 5 minutes in the rebreather, then pour it out, by removing the breathing hose and inclining the rebreather top-down so that the water flows out. Now let the lungs dry. Do not stock the rebreather in direct sunlight for longer periods: this can shorten the lifetime of some of its components.

* Rinse the breathing hose assembly with cold or lukewarm water: close the mouthpiece and pour water into the inhale side. Let the water leak out.
* It is recommended to disinfect the rebreather (both the lungs and the breathing hose) after 5 consecutive diving days. To do so, only use a product that is allowed at

your location (ask your instructor about this). After disinfecting, rinse the rebreather again with fresh water and allow it to dry.

Unless your instructor advises differently, the recommended disinfectant material is a 1% solution of Virkon S. (DuPont).
Make a 1% solution, using cold water, and spray, or pour it into both counterlungs of the rebreather, and both sides of the breathing hoses and in the mouthpiece. Leave it for 10 minutes, and then rinse completely with fresh water. Make sure you don't wet the oxygen cells and the injection grid.
Unless you go diving again, allow the unit to dry out.

Note: to increase the life span of the oxygen cells it is very important to ventilate and dry the rebreather when the unit is not in use for diving ! Experience shows that the lifetime of oxygen cells also depends on the degree of humidity in which they are stored: the dryer, the better! So when not using the rebreather, leave it open as much as possible and store in a dry place. Pay attention, however, not to let insects and other animal life get into your rebreather. (This can be avoided by covering the rebreather with a thin scrim, which nevertheless allows some ventilation).

4.7. General maintenance

Greasing and controlling o-rings (interval):

The interval for greasing the O-rings depends on how intense the unit has been used, and how clean the unit has been kept. If it becomes to difficult to mount the cover on the unit, or to mount the breathing hoses, the O-rings must be cleaned, checked, and when OK, greased and mounted again. The interval between checking and greasing should nevertheless never be longer then one month.

Parts which have contact with oxygen:

All parts which do have contact with oxygen must <u>always</u> be kept in a pure and clean condition. They may not get contaminated with dirt, grease or other substances. Especially pay attention to the connection between the first stage connection and tank valve. This connection is easily liable to becoming dirty.

Maximum service life of the unit and its parts:

The maximum service life of all rubber parts is 10 years. After this time, all rubber parts of the unit (breathing hoses, mouthpiece, O-rings) must be replaced.
If parts of the rebreather are subjected to direct sunlight over a longer period of time, the actual service life will decrease.
If wear is noticed during normal inspection, replace the affected part.

The maximum service life of the internal gas tubing for oxygen is 5 years, and for other gas tubing 10 years.
The service life of the counter lungs is 10 years.
Replacement of internal gas tubing and counter lungs can only be done by the manufacturer or an authorised rEvo service centre. (this can be done during the 5-year inspection at the factory: see further)

All connections with cable ties (the mouthpiece to the DSV and the breathing hoses to the 'screw connections') should be inspected for not having weakened: if so they must be replaced. If there is any doubt, the cable ties must be replaced.

Regulators (first stages) should be serviced each year by a competent service technician. The oxygen regulator must be cleaned for oxygen use.
The preset intermediate pressure for the oxygen first stage is *11.5-12 bar*: this pressure is set to have a CMF of 0.6liter/min. *(The intermediate pressure of the oxygen first stage should never be set higher than 12 bar!)*
The preset intermediate pressure for the diluent first stage is 9-10 bar.

Complete inspection after 5 years:

A complete inspection of the whole unit is recommended every 5 years: for this the unit has to be sent back to the manufacturer, or an authorised rEvo service centre.

Storage instructions:

When not used, the unit must be stored in a dry atmosphere, non-freezing, if possibly at room temperature, but always < 50°C, as continuous high temperatures will degrade materials and specially the oxygen sensors faster.

If for whatever reason the unit is stored at a temperature higher then 50°, the O-rings on the scrubber holders, and the oxygen sensors must be removed, to avoid damage.

Packing suitable for transport:

Make sure the units is wrapped completely in protection foam or a suitable case so that any hard shocks on the unit are avoided.

Appendix A: Drills:

The following scenarios must be practiced during any rEvo training. Your instructor will teach how to react to.

- High PPO2.
- Low PPO2.
- PPO2 low / empty oxygen cylinder.
- PPO2 high / empty diluent cylinder.
- Hissing noise, no change of PPO2.
- Empty diluent cylinder / empty wing.
- Water in the breathing hose.
- Water in the inhale lung.
- Stuck open manual oxygen addition valve.
- Stuck closed manual oxygen addition valve.
- Stuck open manual diluent addition valve.
- Stuck closed manual diluent addition valve.
- ADV stuck open.
- ADV not working.
- Inflator stuck open.
- Broken wing.
- Cells give different readings.
- 1 cell completely dead.
- 2 cells completely dead.
- Head aches, dizziness, feelings of uncertainty.

Appendix B: Always–Never

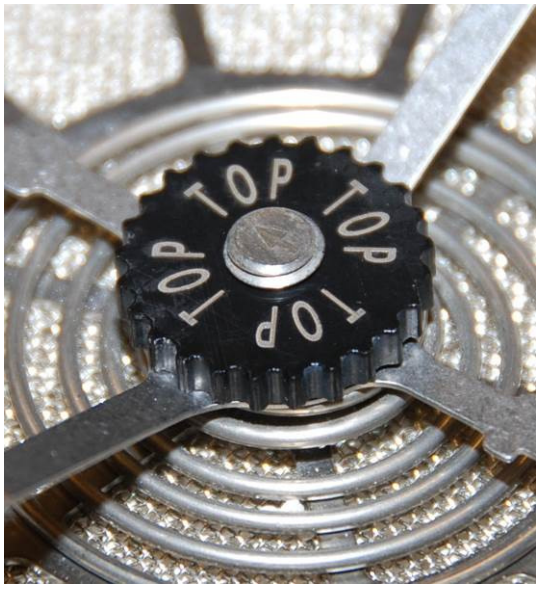
ALWAYS dive with rEvodreams in good shape. Be careful to check them on a regular basis.
ALWAYS read the manual before diving the rEvo for the first time.
ALWAYS get proper rEvo training before diving a rEvo.
ALWAYS do the pre-dive checks.
ALWAYS have enough oxygen and diluent in the cylinders.
ALWAYS carry a bailout system.
ALWAYS maintain the rEvo according to the manufacturer's guidelines.
ALWAYS mark the scrubber time.
ALWAYS position the scrubbers in the same position on the rEvo.
ALWAYS use oxygen compatible grease to maintain your rEvo.

NEVER descend too quickly.
NEVER ascend too quickly.
NEVER dive with a low battery indication on the rEvodreams.
NEVER dive a rEvo when the unit is not 100% functional.
NEVER use outdated absorbent.
NEVER store oxygen cells in inert atmosphere to extend cell life.
NEVER fill the oxygen cylinder with NITROX.
NEVER fill the diluent cylinder with an inert gas or oxygen.

Annex 1

'TOP marker'

To assure that divers don't make errors when exchanging scrubbers, a marker is added on top of the canister on the exhale lung, indicating that that canister is placed on 'TOP' position in the rebreather



When after a dive, you want to exchange one scrubber, (cycle), follow exactly this procedure:
If you make it a habit to immediately empty a canister when you have removed the 'TOP-MARKER', you will not make a mistake when exchanging/filling/replacing canisters. So:

1 - take the top canister, with the 'TOP-MARKER' out of your rebreather
2 - unscrew the 'TOP-MARKER' from the canister and immediately empty that canister.
(you are now sure you emptied the exhausted canister)
3 - screw the 'TOP-MARKER' on the remaining (full) canister, and either put that canister in the upper position of the unit, or if you are finished diving, in a sealed container or plastic bag.
4 - fill up the empty canister, and put it in the lower position of the rebreather, or in a sealed container if you finished diving
5 – fill in your log that you refilled the bottom canister with fresh sorb

Annex 2

Use of the check-list

The rEvo checklist: the use of a check lists during rEvo courses, was already compulsory for some time. To make this easier, we produced a double sided laser engraved checklist, one side containing the 'closed check' and the other side the 'pre-jump check'
Details on the content of the checklist can be downloaded from the website.
The checklist comes with a bolt-snap, so it can stay together with your unit.