Liberty

MANUAL

Content

Introduction

Use of this manual

This user manual is part of the CCR Liberty documentation.

The CCR Liberty is intended to be used exclusively by a trained person who is capable of fully understanding the instructions contained in this manual or is in the process of training with the CCR Liberty in a course accredited by the manufacturer. The initial requirements of such a training course include qualification for diving with trimix recognized by a training agency and sufficient experience with technical diving.

Responsibility of the CCR Liberty user

Strong emphasis was placed on reliability during the development of the CCR Liberty. Individual internal parts are separated in order to minimize the impact that failure of any given part may have on the rebreather's basic functionality. A number of systems have multiple backups. The logic of the CCR Liberty's control never prohibits the start of a dive even in the event that malfunctions are detected; it only indicates the status if able to do so in light of the damage. When cave diving, the inability to submerge can mean not being able to return from a dive; therefore, the CCR Liberty does not impede submersion.

The user must always decide responsibly whether he/she switches to a backup apparatus or even starts a dive with a partially malfunctioning rebreather.

A CCR Liberty user must accept the fact that diving involves risk. Following everything that the user has learned in the CCR Liberty's technical documentation and in training on diving with this rebreather can reduce the risk but cannot eliminate it. Safety when diving is further improved by regular training, methodical education and following good diving practices. Diving with a rebreather requires a far higher degree of carefulness and discipline than diving with an open-circuit apparatus.

If you do not accept the risk and you are not a trained, careful and disciplined diver, do not dive with the CCR Liberty.

The manufacturer does not bear any responsibility for use of the CCR Liberty if the apparatus has been modified in any way that is not stated in this manual or in the technical guidelines issued by the manufacturer.

System of documentation

Version

The technical documentation is subjected to a process of continual development and improvement. Therefore, please regularly check the website at www.CCRLiberty.com for updates.

This manual provides operating instructions for the hardware and software (firmware) version of the CCR Liberty written on the tittle page.

Technical guidelines

The manufacturer can issue technical guidelines. It is strongly recommended that the user regularly checks www.CCRLiberty.com for new guidelines. Registered users will receive notifications by e-mail.

Update of printed documentation

The electronic form of the manual is always available in its complete, updated form.

The electronic and printed forms of the manual may not be completely identical. In case of insignificant changes (correction of minor typing errors, for example), only the electronic version is updated.

User support

Registered users are entitled to technical support. The extent of free support can be limited.

The technical support department at Liberty systems s.r.o. will provide limited support for potential and unregistered users. Prior to submitting a question, please familiarize yourself with the general principles of rebreather diving with trimix and the freely available CCR Liberty technical documentation.

Technical data

Depth limits

The maximum depth for which The CCR Liberty meets the requirements of the Harmonized Standard EN 14143:2013 is 100 m.

Diluent	Max. depth
Air	40 m
tmx 21/35	66 m
tmx 18/45	78 m
tmx (heliox) 10/90	> 78 m

Additional limitation of depth depends on the used diluent, see 72 Tank filling – Diluent.

The CCR Liberty currently is configured with Apeks Environmentally sealed DST4 1st stages, the Maximum Operational Depth of the unit with this 1st stage configuration is 170 m. Beyond 170 meters the gas reduction valves ie. 1st stage regulators MUST be replaced with the Apeks UST4 Environmentally unsealed 1st stage kit.

All components are tested in overpressure 6 MPa (depth 600 m). The depth gauge is checked and calibrated in overpressure 3.5 MPa (depth 350 m). EC Type-examination was performed to a 100 m simulated depth.

Water temperature limits

The CCR Liberty is intended for use in water temperatures above 4 °C and below 34 °C according to the requirements of EN 14143:2013 (Article 5.1).

The minimal temperature is determined through CO_2 scrubber duration tests, which are done at 4 °C.

CO_2 scrubber duration limit

The maximum safe operating period of the sorbent is 168 min, determined by a test in accordance to EN 14143:2013 (Article 6.6.2). During the test 1.6 l/min of CO_2 were added to the breathing loop with ventilation of 40 l/min in water with temperature 4 °C, exhaled gas with temperature 32±4 °C, 40 m depth and limit at $ppCO_2$ 5 mBar.

The sorbent's actual maximum operating period can differ depending on the sorbent, temperature, depth and the diver's physical effort.

In normal conditions scrubber duration is considered to range from 4 h in deep cold water with moderate work to 6 hours for an easy dive. For details see 66 Sorbent service life.

Weight

The total weight of The CCR Liberty, readied for a dive, including fillings, is approx. 37 kg.

For details see 30 Weights of individual parts.

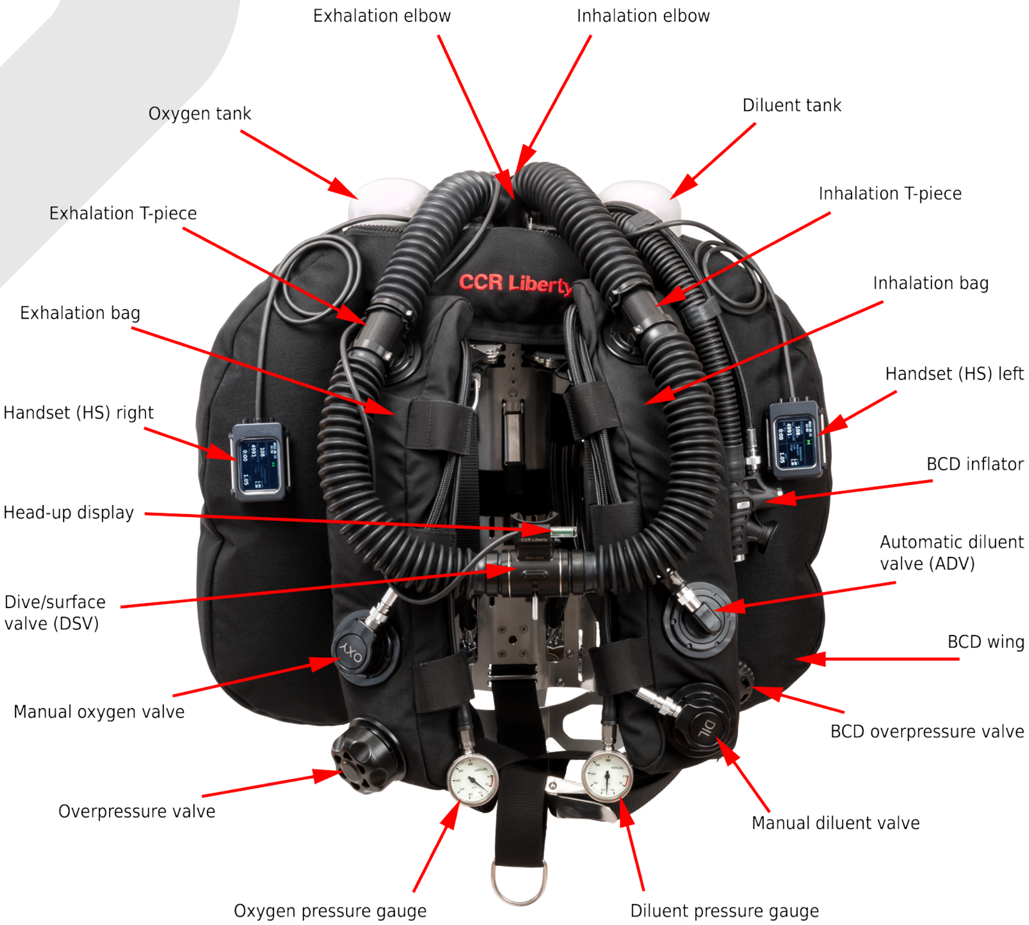
The recommended service intervals are at 1 year, 3 years and 5 years.

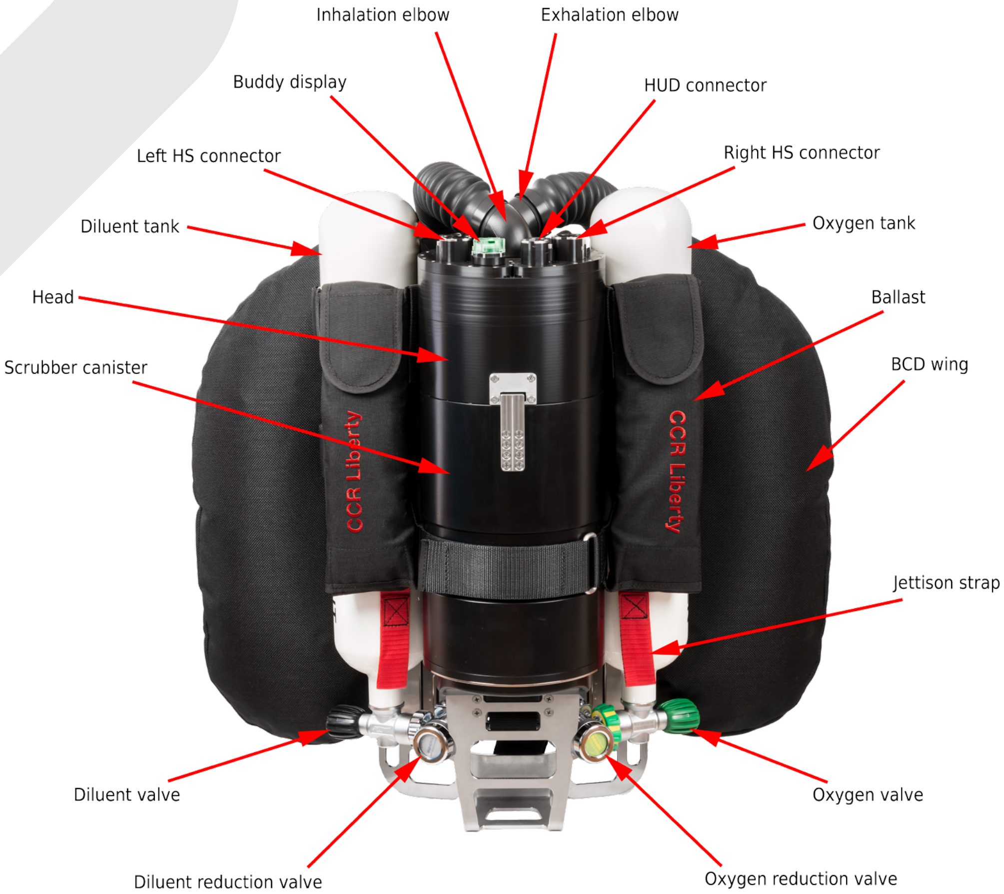
The servicing of the unit can only be performed by authorised service technician or technical centre.

Not performing services at regular intervals may result in voiding your warranty.

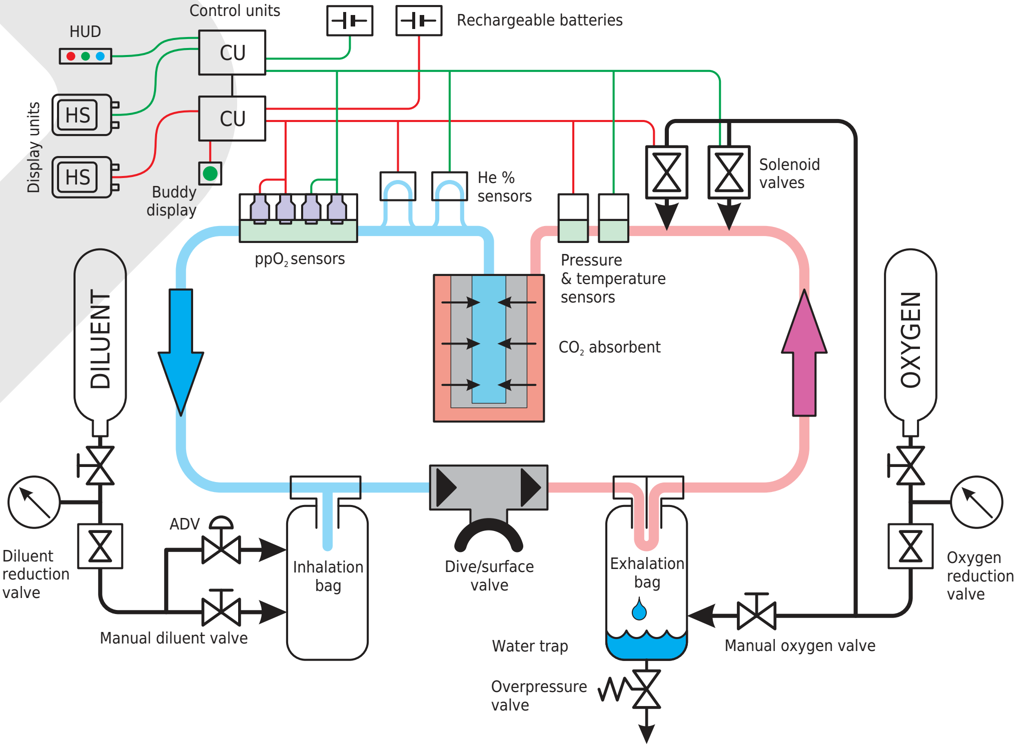
Date of issue: 29. June 2018
CU HW rev. 1.4, HS HW rev. 3.0, FW 2.11
Authors: Adam Procháska, Jakub Šimánek, Aleš Procháska
Published by Liberty systems s.r.o., CCRLiberty.com

1. Technical design




Inhalation elbow
Exhalation elbow
Buddy display
HUD connector
Left HS connector
Right HS connector
Diluent tank
Oxygen tank
Head
Ballast
Scrubber canister
BCD wing
CCR Liberty
CCR Liberty
Jettison strap
Diluent valve
Oxygen valve
Diluent reduction valve
Oxygen reduction valve

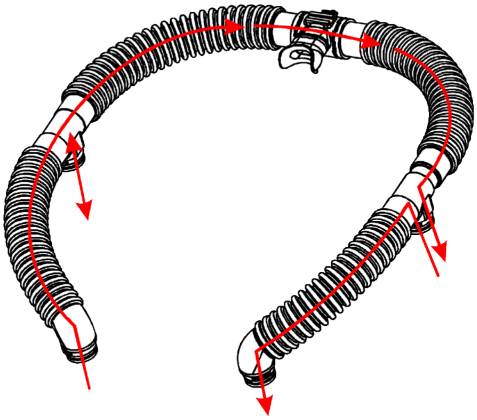
1.1 Basic schematic



The principle of the rebreather consists in recycling the breathing mixture. Carbon dioxide is removed from the exhaled mixture and is again prepared for the next inhalation after replenishment with oxygen. The composition of the breathing mixture changes continuously.

1.2 Dive/surface valve

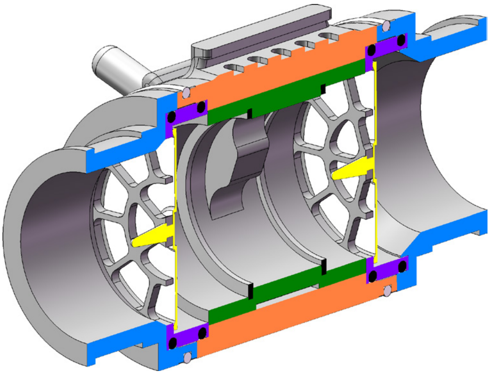
The breathing mixture is delivered to the dive/surface valve (DSV) through the corrugated hose from the left. When inhaling, the mixture passes through the inhalation valve to the mouthpiece and then into the diver's respiratory tract. When exhaling, it passes through the exhalation valve into the corrugated hose on the right.



The direction of the mixture's flow is indicated on the DSV.

1.2.1 Inhalation valve

The inhalation valve ensures that the exhaled mixture cannot directly return to the inhalation bag and is not repeatedly inhaled by the diver without the removal of carbon dioxide and the addition of oxygen.



The inhalation valve is situated within the connection of the left corrugated hose.

A similar mushroom valve can be found in, for example, the exhalation valve of the second stage of the regulator of an open-circuit apparatus.

This is one of the most critical parts of the rebreather. It is difficult to detect a malfunction in this part during a dive, and such a malfunction can lead to loss of consciousness.

1.2.2 Exhalation valve

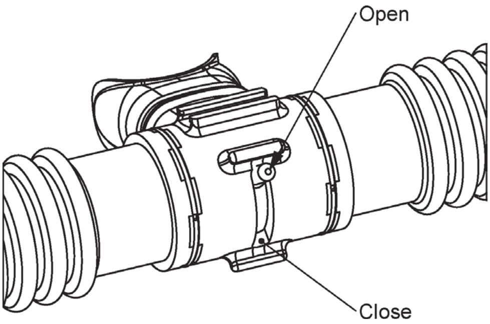
The exhalation valve directs the exhaled mixture via the corrugated hose to the exhalation bag. It ensures that the diver does not directly re-inhale the exhaled mixture.

The exhalation valve is situated within the connection of the right corrugated hose.

Closing the dive/surface valve

If the diver is in the water and not using the DSV, the DSV must be closed. Otherwise, the circuit will be flooded with water.

Closing the DSV is done by using the gate handle in the front part of the DSV. In the open position, the handle is put up; in the closed position, it is down.



1.2.3 Mouthpiece

Tightly sealed mouthpiece in the diver's mouth prevents water from entering into the circuit. The DSV and corrugated hoses function with greater force than the regulator of an open-circuit apparatus. Therefore, an anatomically suitable shape of the rebreather's mouthpiece and proper clenching in the mouth are very important.

We do not recommend using a mouthpiece that can be shaped to the diver's bite after heating. This kind of mouthpiece restricts the movement of the lower jaw, which leads to unilateral stress and will rapidly exhaust the mastication muscles.

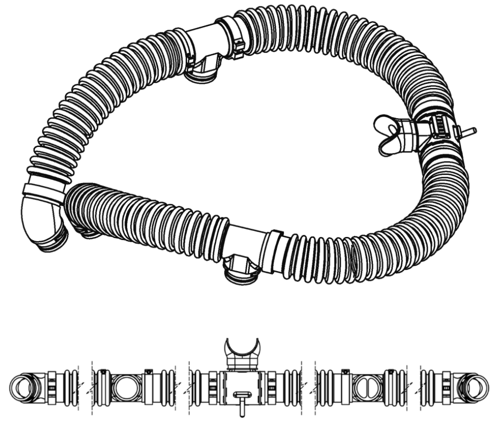
1.2.4 Usage with a full face mask

Even though the mechanical dimensions would allow the connection of the DSV to a full face mask, in a full face mask it is not possible to switch the mixture inlet from an open circuit with an inlet from a rebreather. One of the reasons for this is the necessity of defogging the visor.

Consult with the manufacturer regarding possibilities of connecting the rebreather to a full face mask. Use of such an apparatus will require procedures that deviate from this manual and from standard procedures taught in a course accredited by the rebreather's manufacturer.

1.3 Corrugated hoses and accessories

1.3.1 Hoses

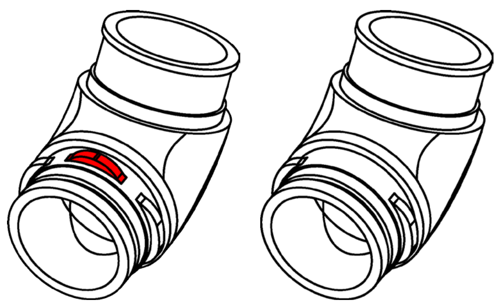


The corrugated hoses are made of EPDM rubber. Compatible chemical agents must be used for cleaning and disinfection (see 92 Cleaning and disinfection).

The corrugated hoses can be damaged if subjected to excessive stress. In particular, it is necessary to avoid perforation, cutting and excessive wear. Avoid long-term deformation of the hose, for example when storing the unit. Do not use the hoses as a handle.

The corrugated hoses are one of the least durable mechanical parts of the CCR Liberty. Pay appropriate attention to protecting them.

1.3.2 Attachment to the head

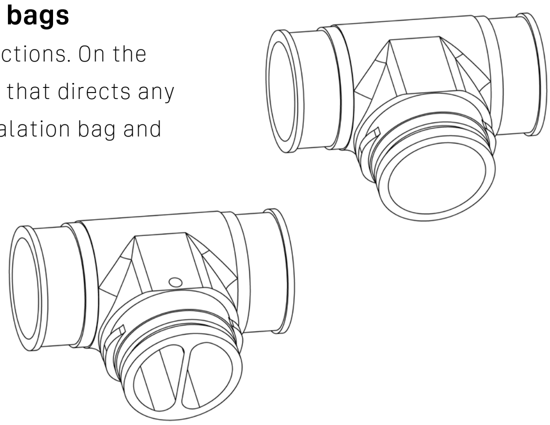


Unlike almost all other bayonet connectors on the CCR Liberty, the bayonet connector on the exhalation side has three protrusions. This prevents incorrect attachment of the hoses.

Elbow on the exhalation side (left) and inhalation side (right).

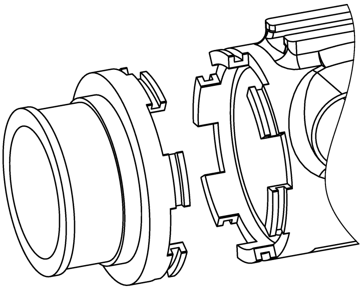
1.3.3 Connection to the breathing bags

The T-pieces have standard bayonet connections. On the exhalation side, the T-piece has a partition that directs any water that has entered the DSV to the exhalation bag and improves the blending of the mixture with oxygen added using the manual bypass valve.



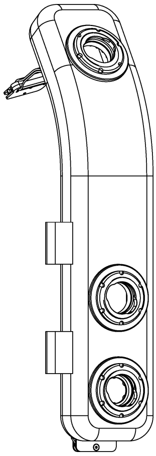
1.3.4 Attachment of the DSV

Attachment to the corrugated hoses is done with axial teeth that fit together and are secured with a wire retaining ring.



The baskets of the mushroom valves are inserted into the connector. When handling the baskets, pay attention to their correct orientation.

1.4 Inhalation bag



The inhalation bag is mounted on the left part of the harness (from the diver's perspective when wearing the CCR Liberty).

The external cover is made from a resilient textile, ensuring mechanical protection. The internal bag is made from polyurethane. It is connected to the breathing circuit with a T-piece via the upper bulkhead with a bayonet connector.

The inhalation bag is affixed to the harness with two stainless-steel buckles and with Velcro flaps. It can be easily removed for cleaning, disinfection and other handling.

See also 92 Cleaning and disinfection.

1.4.1 Automatic diluent valve

The automatic diluent valve (ADV) is mounted in the middle bulkhead with a bayonet connector.

When the volume of the inhalation bag decreases, the ADV is pressed. The ADV then automatically adds diluent to the breathing circuit.

The ADV can be closed by sliding the collar.

The sensitivity of the ADV can be decreased with an additional spring, which is included as a spare part.

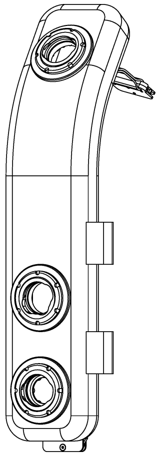
1.4.2 Manual diluent bypass valve

The manual diluent bypass valve is situated in the lower bulkhead of the inhalation bag and is equipped with a bayonet connector.

It is attached to the low pressure (LP) hose with a seatec-style quick-release connector.

It is operated by pressing the center button.

The safety lock prevents diluent valve from accidentally falling out. Follow these steps to remove.

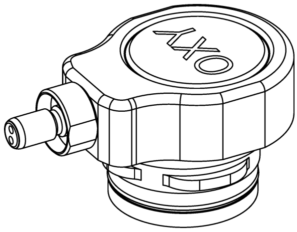


1.5 Exhalation bag

The exhalation bag is situated on the right side of the harness It's design and the way it is connected to the harness and the breathing loop are similar to those of the inhalation bag.

1.5.1 Manual oxygen bypass valve

The manual oxygen bypass valve is situated in the middle bulkhead of the exhalation bag and is equipped with a bayonet connector.

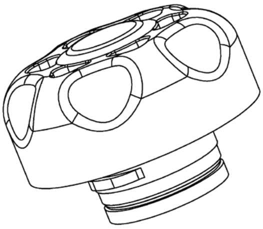


It is attached to the intermediate pressure hose with an oxygen quick-release connector. This connector is like a standard seatec-style quick-release connector with a collar. A standard connector cannot be connected to the oxygen quick-release connector. Though it is possible to connect the oxygen hose to the normal connector. Do not remove the collar from the oxygen connector as connecting the wrong gas to the wrong valve could potentially be dangerous. This is a requirement of the EN 14141 norm.

The bayonet connector on the oxygen bypass valve has three protrusions.

Use oxygen-compatible lubricant for maintenance of the oxygen bypass valve **(We recommend DuPont Krytox GPL-226).**

1.5.2 Overpressure valve



The overpressure valve (OPV) is mounted in the lower bulkhead of the exhalation bag and is equipped with a bayonet connector.

The required overpressure is regulated via rotation. When set to minimal overpressure (by turning counterclockwise), the valve is opened; only a mushroom valve ensures minimal overpressure.

A safety lock prevents the OPV from accidentally falling out. To remove the valve push it in to unlock it and rotate in the direction of the arrows.

1.6 Oxygen tank

1.6.1 Tank

The CCR Liberty uses a three-liter steel tank with 100 mm diameter and 200 bar filling pressure. The original 300 bar filling pressure of the bare tank was changed according to valid technical standards.

The tank is labeled OXYGEN.

The tank is situated on the right from the diver's perspective when wearing the CCR Liberty.

When connecting the oxygen tank to the unit screw in the hand wheel only when the tank is upright. If you straighten the bottle when it is screwed in you will tighten the threads to the point when it will be hard to remove without the usage of tools

For more information on filling, see 73 Oxygen.

1.6.2 Valve

The valve has a M26×2 200 bar outlet connection. The valve is not compatible with standard DIN valves to eliminate possible mix-up between oxygen and diluent bottles, this is a requirement of the EN 14141 norm.

1.6.3 Reduction valve

The CCR Liberty uses an Apeks DST4 first-stage regulator with a specially made low-pressure turret, which is mounted on the backplate. This serves as the lower tank-mounting point; in the middle part, the tank is attached with a Velcro strap.

The Apeks DST4 first-stage regulator comes with an environmentally sealed first-stage kit. This seal causes an operational limitation at a depth of 170 meters. It is recommended that in order to conduct dives beyond 170 meters the diver must replace the first-stage regulator with the Apeks UST4 environmentally unsealed kit.

The reduction valve is equipped with an intermediate-pressure safety overpressure valve.

1.6.4 Pressure reading

The oxygen pressure gauge is situated on the right side; the HP hose runs through an opening in the backplate.

1.7 Diluent tank

1.7.1 Tank

The CCR Liberty uses a three-liter steel tank with 100 mm diameter and 230 bar filling pressure. The original 300 bar filling pressure of the bare tank was changed because a 230 bar valve is used.

The tank is labeled DILUENT.

The tank is situated on the left from the diver's perspective when wearing the CCR Liberty.

For more information on filling, see 72 Diluent.

1.7.2 Valve

The valve has a DIN G 5/8" 230 bar outlet connection.

1.7.3 Reduction valve and pressure reading

The design is similar to that of the oxygen tank, only reversed.

1.7.4 Backup regulator (optional)

The second stage of a regulator may be connected to the output of the first stage of the diluent through LP hose of appropriate length. This regulator can be used as a backup if the diluent at a given depth is breathable (oxygen partial pressure between 0.16 and 1.6 bars).

Having the backup regulator connected to the diluent may be useful for sanity breaths and for prolonged switching to a backup apparatus.

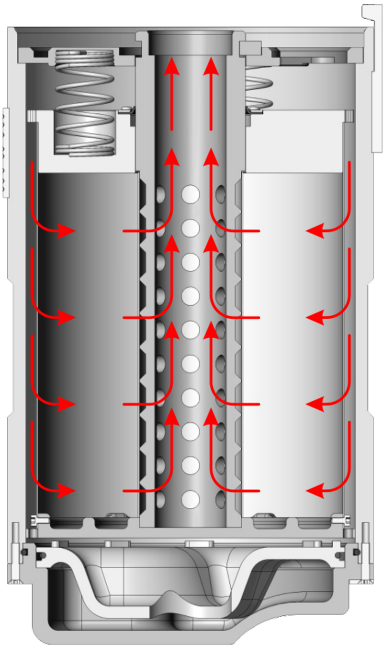
However, it is advised to use the bailout only in special circumstances, for example during extreme shallow dives.

1.8 CO_2 scrubber

The CCR Liberty uses a radial scrubber. The breathing mixture flows from the outside to the center of the scrubber cartridge.

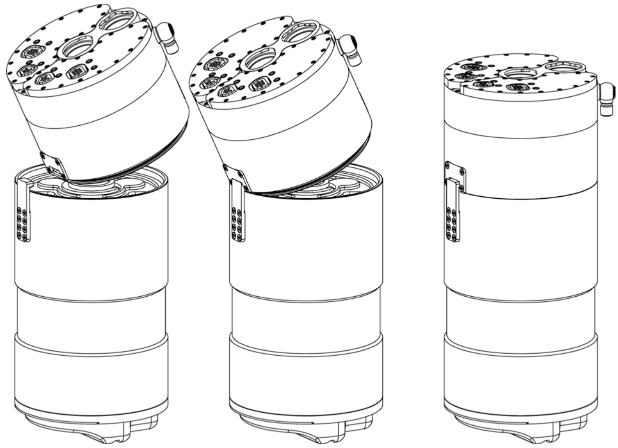
The scrubber consists of a scrubber cartridge inserted into a scrubber canister. A water trap is situated in the lower part of the canister.

The walls of the cartridges consist of external and internal metal mesh. A lid presses down on the scrubber cartridge by means of springs attached to the pressure plate. The pressure plate is fastened to the central tube with a retaining ring.



The scrubber cartridge capacity is approximately 2.5 kg of sorbent. The sorbent volume is approximately 2.82-2.99 l.

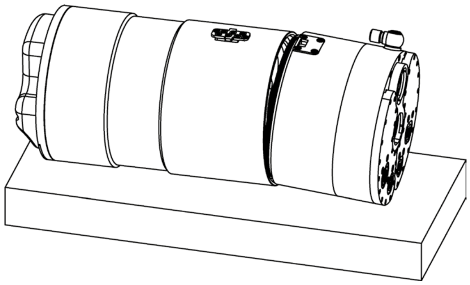
The service life and replacement of the sorbent are described in chapter 66 Replacement of CO_2 sorbent.



1.9 Head

The head is mounted on the CO_2 scrubber canister.

When mounting the head, push the scrubber-canister pin into the opening on the head and close it.



If it is difficult to remove the head, place the rebreather on a hard surface with the pin facing downwards, as shown in the illustration. Press down on the head and the scrubber canister with your hands.

1.9.1 Control units

The control units (hereinafter referred to as the CUs) are independent. A display unit (hereinafter referred to as the HS) is connected to each CU, which each has its own power source, solenoid, temperature gauge and pressure, O_2 partial pressure and He concentration sensors.

If one control unit fails, the other control unit takes over automatically.

CUs and HSs are independent computers communicating via a bus. Each handset displays the results of both CU's activities and is used to control both CUs. Each HS is powered through the corresponding CU. In the event of a malfunction of both handsets, either CUs (or the remaining functional CU) will continue to regulate ppO_2 without change according to the last adjusted setpoint.

If communication between CUs breaks down, each unit controls one solenoid. The control algorithm is sufficiently robust to ensure that any deviations of ppO_2 from the allowed limits will not occur during dual, parallel regulation.

Connection to a personal computer
The memory of operating protocols and content of the memory card can be read using a USB adapter connected to the handset connector as a mass storage device (like a flash drive). The connection to Windows, Mac, Linux, Android and iOS was tested, but there is no guarantee of compatibility with all operating systems and all computers.

During the time of USB connection, the control unit is powered from the USB port and, at the same time, the battery is charged.

Each control unit contains the same dive logs, to download them you only need to connect one control unit to the computer.

1.9.2 Direct measurement of ppO_2

To measure ppO_2 use only DIVESOFT R22D-type sensors. The usage of other sensors from other manufacturers is prohibited.

Two sensors are connected to each CU. All sensors are located on the inhalation side. Both CU have access to all four oxygen sensors as the control units continually exchange the measured data.

The diver can manually exclude a sensor from operation and manually return an excluded sensor to averaging. The manual option has a higher priority than automatic detection of faulty sensors. If all sensors are excluded, the CCR Liberty can be switched to a backup algorithm for calculation of the partial pressure of oxygen indirectly using measurement of the He content (assuming the used diluent contains >20% He).

Circulation of the mixture in the breathing loop is necessary for the measurement accuracy. If the user does not breathe from the rebreather, the mixture in the vicinity of the oxygen sensors can have a different proportion of oxygen than the mixture in different parts of the breathing loop and the displayed data can thus be inaccurate.

A discrepancy can similarly occur in the event of rapid descent, when a larger amount of diluent is added, or when the setpoint is changed to high and ppO_2 in the loop is changing to the new level

The sensors are constantly automatically evaluated. The ppO_2 measured by one sensor is always compared to average of the other sensor. This way each individual sensor is constantly being cross-checked and monitored for possible deviations. If the average deviation of the sensors from the diameter exceeds 0.1 bar, the sensor that deviates most from the average is automatically excluded.

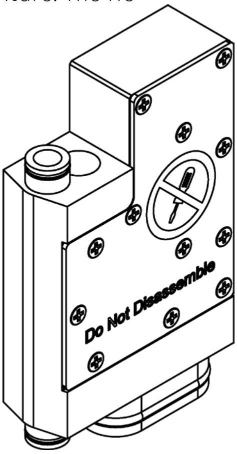
Only one sensor can be automatically excluded at the same time, and the maximum number of automatically excluded sensors is 2. There will always be at least two sensors that the diver has to evaluate by themselves. This procedure is described in Chapter 3.4.4 Monitoring of devices.

WARNING: Sensor exclusion works on the principle of a mathematical algorithm. Despite the efforts of developers to find the ideal risk-control solution, there is still a chance that the excluded sensor will only be the only right one. Always verify your oxygen sensors.

Refer to the chapter "Oxygen sensors" on how to handle and maintain your sensors.

1.9.3 Measurement of He content

The helium concentration is determined by the velocity of sound in the mixture. The He concentration sensors are connected to the inhalation side.



A pressure drop caused by circulation of the mixture in the breathing loop allows the mixture to pass through the sensor. If the user does not breathe from the rebreather, this will not occur and sensor reading may be inaccurate.

If the utilized diluent contains >20% He and its composition is known, the He-concentration measuring function can be used for reverse determination of the concentration of oxygen in the mixture based on the fact that the ratio of inert gases remains constant (process according to patent no. 303577). This principle of measuring the oxygen concentration (and its subsequent automatic conversion on the basis of the known ambient pressure to partial pressure) is used as the backup method of measuring ppO_2 in case all electrochemical ppO_2 sensors malfunction.

Oxygen measuring using helium sensors must be manually turned on in Setup / Faulty sensors / pO2 source. This method is intended for use only in emergency situations. If possible, use bailout apparatus.

The use of helium sensors also depends on Liberty's settings. For the helium sensor function, the "TMX only" must be set in Menu / Setup / Preferences / He Measurement.

For proper functioning of helium sensors, the sensors must be calibrated from time to time. Refer to Calibrating Helium Sensors for the calibration procedure

Always keep your helium sensors dry to ensure their long lifetime and functionality (see also 92 – 3.5.1 Immediately after surfacing).

Do not disassemble the sensors; disassembly can result in irreparable damage.

WARNING: Do not remove the helium sensors from the unit, even when faulty. Their removal will "short -circuit" the scrubber, which won't be able to filter CO_2 from the breathing mixture.

1.9.4 Pressure and depth measurement

Each of the CCR Liberty's control units uses dual pressure sensors. The first sensor, intended for measuring low pressure, is used for determining sea level, for calibration of the ppO_2 sensors, and for improving the accuracy of depth data in shallow depth.

The second sensor is intended mainly for measuring hydrostatic pressure. The maximum scope of the sensor corresponds to the depth of 300 m.

1.9.5 Temperature measurement

The temperature in the breathing circuit is measured by temperature sensors within the pressure sensors. The water temperature sensors are situated in the handsets.

Temperature data serve primarily for correction of the measuring of other quantities. The water temperature shown on the HS display is only approximate.

1.9.6 Solenoids

The control units communicate with each other and, in normal circumstances, open the solenoid valves, which supply oxygen to the breathing circuit.

The solenoids are opened alternately left – right in the interval of 6 s. The solenoid opening is indicated in the dive mode by the equator in the left or right bottom corner of the handset screen.

1.9.7 Power supply

CCR Liberty uses two Li-Ion batteries, one to power each control unit. The minimum service life of Li-Ion batteries is six months. The typical service life of the batteries is two years.

See also 74 Battery charging.

Battery compartments are pressure resistant. If overpressure is formed inside a battery compartment because of battery malfunction or helium diffusion, then an overpressure valve will release excess gases out of the rebreather and into the surrounding water.

1.10 Visual display units

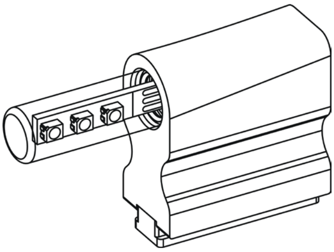
1.10.1 Handsets

The handsets provide the CCR Liberty's user with comprehensive information on the rebreather's status and the course of the dive. All functions of the control units are controlled using the handsets.

The functionality of both handsets is identical. Each handset controls both CUs simultaneously. In the event of a malfunction of one handset, the diver simply uses the other handset. During a dive, it is possible to set a different display mode on each handset.

For more information on handset operation, see 31 Control-unit operation.

1.10.2 Head-up display



The head-up display (HUD) shows the current partial pressure or CCR error status during the dive.

Other statuses are displayed in standby mode, during charging and when the unit is connected to a computer.

If you are not entirely sure what the HUD is displaying, check the parameters on the handset display. Always check it if the HUD displays a warning (outer LED blinks red) or an alarm (all three LEDs flashes red four times).

See the following table for the various HUD signals.

1.10.3 Buddy display

The buddy display shows whether the values of the partial pressure of oxygen are within the range that is suitable for breathing or if an error situation has occurred. The displayed information is intended for the diving partner of the CCR Liberty's user.

Prior to diving, the user of the CCR Liberty must familiarize his/her diving partner with the buddy display's functionality and agree on the emergency procedure to be carried out in the event that the buddy display indicates an error situation.

See the following table for the various buddy-display signals.

HUD and buddy-display signals

Mode	Event / state	HUD signals			BD signals
		LED 1	LED 2	LED 3	
Startup	Initializing components	Binary coded service numbers			
ppO_2 in dive mode[1] (bar; standard)	$ppO_2 < 0.16$	red blinking		red blinking	red blinking
	$0.16 \le ppO_2 < 0.20$	red blinking		red blinking	red
	$0.20 \le ppO_2 < 0.25$	red blinking		red blinking	green
	0.3		7× blue flash		green
	0.4		6× blue flash		green
	0.5		5× blue flash		green
	0.6		4× blue flash		green
	0.7		3× blue flash		green
	0.8		2× blue flash		green
	0.9		1× blue flash		green
	1.0		green		green
	1.1		1× green flash		green
	1.2		2× green flash		green
	1.3		3× green flash		green
	1.4		4× green flash		green
	1.5		5× green flash		green
	1.6		6× green flash		green
	$1.65 < ppO_2 \le 2.0$	red blinking		red blinking	red
	$ppO_2 > 2.0$	red blinking		red blinking	red blinking
Dive mode alarm		4× red flash	4× red flash	4× red flash	no change
Standby (switched off from menu)	Standby		slowly flashing		slowly flashing
	Charging	1. red	2. red	3. red	red
	Charger connected but no power supply	red blinking			red blinking
	Fully charged	green	green	green	green
	Charging failed	red blinking	red blinking	red blinking	red blinking
Mass storage mode (USB adaptor connected)	Reading	green	orange		green
	Writing	red	orange		red intensive
	No action		orange		
Download firmware	Connected	purple	purple blinking	purple	
	Downloading		purple	purple	

1 Indicated ppO_2 value in the range ±0.05 bar

Color blind mode

If you cannot distinguish blue and green LED lights, check “Color blind mode” in Setup → Preferences → Indication. Signals for $1.05 \le ppO_2 \le 1.65$ will be changed according the following table:

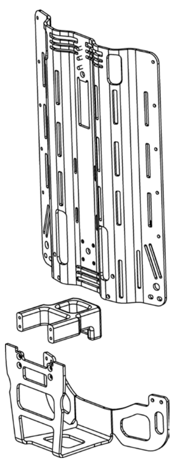
ppO_2 in dive mode[1] (bar; color blind)	1.1	• 1× green flash		• 1× green flash
	1.2	• 2× green flash		• 2× green flash
	1.3	• 3× green flash		• 3× green flash
	1.4	• 4× green flash		• 4× green flash
	1.5	• 5× green flash		• 5× green flash
	1.6	• 6× green flash		• 6× green flash

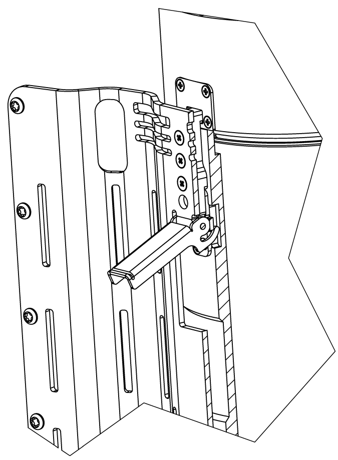
1 Indicated ppO_2 value in the range ±0.05 bar

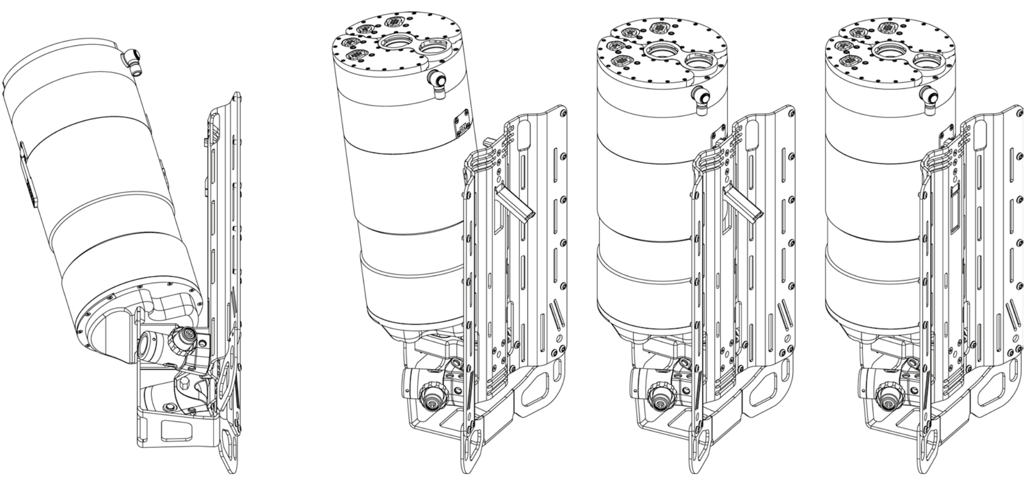
1.11 Backplate and mounting

The method of mounting the CCR Liberty on the diver’s body is based on the backplate and harness common among wing-type buoyancy compensators used in technical diving.

The body of the rebreather, comprised of the scrubber canister and attached head, is attached to the backplate with a cam. The cam lever cannot be released when the diver is wearing the rebreather.







The CCR Liberty's integrated stand, which serves as a lumbar support, is intended for setting the rebreather on a hard, level surface with sufficient rigidity. Always secure the standing rebreather to prevent falling.

If needed, it is possible to remove the CCR Liberty's backplate, together with the buoyancy compensator from the components specific for the rebreather and use it with the harness for open-circuit diving. It enables attachment of a twin-set (two tanks firmly connected with stainless steel bands) using bolts and wing nuts as is common in technical diving, as well as attachment of a single tank with a strap with fastener (not included with the CCR Liberty).

When mounting the CCR Liberty onto the backplate, set the bottom of the scrubber cannister into the protrusion in the rebreather stand.

1.12 Harness

The backplate is equipped with harness that is threaded through in a way that ensures proper system functioning. Do not change the way it is made. If you do try to take the harness out, record or remember exactly how it is threaded through to prevent interference with the functioning of the whole system.

It is necessary to adjust the harness so that it fits properly. Adjust the harness without the mounted scrubber canister, head, corrugated hoses and breathing bags.

Adjust the length of the shoulder straps so that it is possible to insert three fingers under the straps at the collar-bone level without great resistance but not entirely freely.

The chest D-rings should be as low as possible, while still allowing you to cross your arms over your chest comfortably. The D-rings should be high enough for you to reach the left ring with your left thumb, and the right ring with your right thumb. The D-ring on the left side of the waist strap should be roughly on your hip.

Adjust the length of the left part of the belt strap so that it passes through the eye of the crotch strap and there is approximately 5 cm (strap width) between the ring and the eye. Adjust the right part so that the strap is slightly tight. If you shorten a strap, leave sufficient reserve for different suits and possible change of body dimensions. After shortening, it is necessary to deburr the ends of the straps by heat sealing them with a cigarette lighter or candle. Do this carefully so as not to form a hard surface on the strap ends.

Adjust the length of the crotch strap so that it passes closely to the body but does not bind. Set the position of the rear D-ring as low as possible but sufficiently high so that it does not place pressure on the buttocks when swimming. The rear D-ring should be within the diver's reach. Test the exact position of the rear D-ring in the water with the complete apparatus.

1.13 Buoyancy compensator

The CCR Liberty uses a wing-type buoyancy compensator (BCD) with displacement of 200 N. The compensator's design and materials are very durable and even suitable for cave and wreck diving.

The wing has a two-ply design. The internal bladder is made of high-frequency-welded Cordura 560 fabric with PU coating. The wing's external cover is made of Cordura 2000 fabric.

The wing is attached with screws along the edge of the backplate.

To achieve the correct position of the inflator, pass the low-pressure hose through the rubber ring on the corrugated hose, then through the rubber ring on the shoulder strap and finally through the second rubber ring on the corrugated hose. Do not skip either of the rings on the corrugated hose; upon disconnecting the quick-release connector from the inflator, it could recede so far that it would be difficult to find it.

The buoyancy compensator is not a life preserver. It does not maintain the diver in a face-up position. It is not designed to hold the diver's face above the surface should he/she become unconscious or immobile.

1.14 Ballast

The ballast system is composed of two pouches placed on the sides of the scrubber canister and is attached to the tanks. In the lower part of the pouches, there is a loop through which the attachment strap of the rebreather body is passed. The internal pouches, which contain the individual weights, are inserted into the external pouches. The upper flap of the external pouch is intended for inserting weights before a dive and removing them after. For emergency jettisoning of ballast, pull the red strap on the lower part of the pouch. This will open the external pouch and will release the internal pouch containing the ballast.

For common removal of the ballast, do not use the method for emergency jettisoning. This could lead to excessive wear of the Velcro.

A diver in a dry suit typically needs 2×4 kg of ballast. Proper ballast weight and distribution is a subject of the CCR Liberty diver course.

1.15 Weights of individual parts

The listed weights are merely an indication. The weight of the parts of each apparatus may vary.

Backplate with the wing, harness and hoses, without counterlungs	10.68 kg
Weight pockets (without weights)	0.43 kg
Counterlungs incl. all valves	1.86 kg
Tank with valve, empty	5.44 kg
Corrugated hose, complete	1.11 kg
Scrubber body and cartridge, without sorbent	3.76 kg
Head incl. handsets, HUD and BD	4.59 kg
Charger with cable	0.09 kg
Supplied accessories and small parts (without chargers)	1.00 kg
Peli Stormcase iM2975	10.30 kg
Oxygen 3 l at 200 bar	0.84 kg
Diluent (air) 3 l at 300 bar	0.91 kg
Sofnolime	2.50 kg
Energy stored in batteries	4.16×10^{-11} kg

2. Control-unit operation

2.1 Control elements

The control of all electronics in the CCR Liberty is performed via the handsets.

The following inputs and combinations are differentiated:

- Press upper key
- Press lower key
- Press both keys
- Long press upper key
- Long press lower key
- Long press both keys
- Coded key press (press both keys, then release one key and press it again, then release both keys)
- Tilt the HS away from yourself
- Tilt the HS toward yourself
- Tilt the HS to the left
- Tilt the HS to the right
- Tap the display glass
- Shine a light on the display

"Long press" means pressing the key for more than 2.5 seconds. The key-press operation is terminated now the key is released or, when pressing both keys, when the last key is released.

The configuration of the given HS determines the upper/lower keys and directions of tilting, depending on whether it is set up for the left or right hand.

HS tilting can be changed in the configuration to tapping on the HS from any of the four sides.

2.1.1 Meanings of inputs in surface modes

The keys and other inputs are assigned meanings in connection with the current navigation item in the menu. At the same time, however, general rules, which apply wherever possible, are determined for their use.

Press upper key — confirmation of the selected menu item
Press lower key — cycle downward through the menu
Press both keys — exit the menu without performing any action
Long press upper key — page up
Long press lower key — page down
Long press both keys — return to main screen
Coded key press — switch to maintenance mode (this can be done only from the main screen)
Tilt HS away from yourself — increase the entered digit by one or check flag
Tilt HS toward yourself — decrease the entered digit by one or uncheck flag
Tilt HS to the left — move the cursor to the left
Tilt HS to the right — move the cursor to the right

Wherever possible (menu, editing screen), helpful symbols relating to the keys are displayed. A symbol can be either next to a key, indicating the action executed during a short key press, or between the keys, indicating the action executed during a short press of both keys.

The  symbol next to a key means scroll down one row in the menu. Scrolling in the menu is cyclical, so the first row appears again after the last row. The scroll-up function is not available due to two-key control.

The  symbol means return one level without executing any action.

The  symbol represents confirmation of the action or selection.

2.1.2 Meanings of inputs in dive modes

The meanings of inputs are the same as in surface modes. Other possibilities are:

Long press upper key — high setpoint
Long press lower key — low setpoint

Tilting is expanded with movement in decompression games; entry of digits, for which tilting is used in surface modes, is limited during the dive to special cases only.

Tapping on the display glass – switch on (activate) the display if it is switched off (deactivated).

Shining a light on the display – in the dark, illuminating the display with a dive light activates it in the same way as tapping on the glass. In the light, the display can be activated by covering and then uncovering it.

2.1.3 Language

All textual information on the CCR Liberty is in English. Controlling the apparatus requires knowledge of the English language at a level that at least allows the user to thoroughly understand this information.

2.2 Switching on the unit

For it to be possible to switch on the CCR Liberty's control unit, it must be in standby mode, which is indicated on the HUD (slowly flashing blue LED) and the buddy display (slowly flashing green LED).

If the jumpers are removed (or turned so that the pins are not inserted in the connector), the rebreather's control unit cannot be turned on, except with USB power when connected to a computer via an adapter.

2.2.1 Activation

The device is activated by pressing both keys on either handset for three seconds.

Automatic activation occurs in the event of a submersion to a depth greater than 1.5 m with a deactivated rebreather. In such a case, the user cannot continue the dive, but must perform complete pre-dive preparation on the surface as soon as possible.

Using automatic activation, it is also possible to switch on the CCR Liberty in the event of damage or loss of both handsets. **Using this option is risky and should thus be considered only for a rescue attempt, for example for the evacuation of a diver from a siphon of a flooded cave.**

Upon activation, the rebreather switches to surface mode. If submerged to a depth greater than 1.5 m, the rebreather automatically switches to CCR mode (Assuming the jumpers are connected to the batteries). **Due to low depth sampling rate when the unit is switched off, the rebreather will automatically switch on after approximately one minute of submersion, when the diver can be at a depth larger than 1.5 meters.**

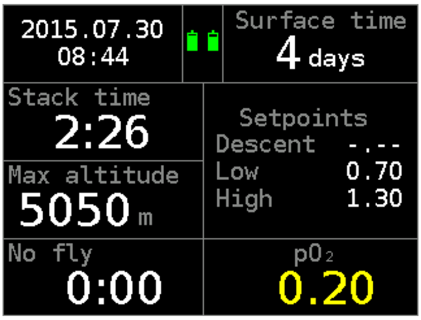
WARNING: NEVER BREATHE FROM A UNIT THAT IS SWITCHED OFF! This can result in serious injury or death.

2.3 Surface mode

2.3.1 Entering surface mode

The CCR Liberty switches to surface mode when switched on and activated by pressing the keys. In the water, surface mode can be selected in the menu if the depth is less than 1.5 m.

2.3.2 Surface mode primary screen



Date and Time

Maintain correct local time setting. It will be used for log recording.

Stack time

The scrubber stack timer runs continuously in dive mode (except OC bailout) regardless of depth, it can be set to run on the surface (more in “Stack timer sfc.”).

If you spend a long time in dive mode while not breathing from the rebreather’s loop, then increase the time for the stack time warning.

Don’t forget to reset the timer when you refill the scrubber (Predive → Stack time reset).

Max altitude

The maximum allowed altitude calculation is based on the ZHL decompression algorithm with an additional safety margin (GF = 0.80). It is a continuation of the decompression calculations and functions in the same manner as a decompression ceiling.

No fly

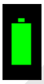
The calculation of the no-fly time is based on the maximum allowed altitude according to the Bühlmann decompression algorithm ZHL.

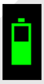
The air pressure in the cabin of a commercial aircraft is maintained at a level corresponding to air pressure at 1800–2400 m (6000–8000 feet) above sea level while cruising altitude falls in the range 11 000–12 200 m (36 000–40 000 feet).

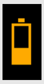
The no-fly time calculation uses the decisive altitude 4464 m (14 646 ft). At this altitude compartments containing the oxygen masks will be opened automatically and the oxygen masks will drop down in front of the aircraft passengers.

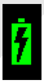
Battery symbol

A graphical indication shows the remaining battery capacity. Two batteries are indicated separately.

 The battery is full

 Bar height is proportional to the remaining battery capacity

 Color is changed at less than half capacity

 Plugged into a charger

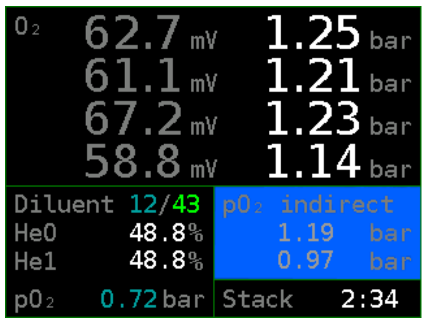
Setpoints

Descent ("-.--" if disabled), low and high setpoints are listed.

ppO_2

Measured partial pressure of oxygen is displayed.

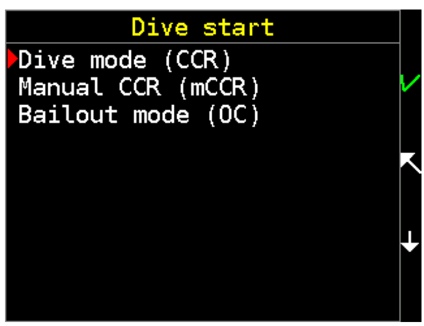
2.3.3 Surface mode O_2 sensors screen



To switch between the different screens in surface mode, press the top button Not only the ppO_2 but also the voltage on the sensors can be read. If the state of a sensor is not in operational mode (not connected, offline, error, excluded, disabled, uncalibrated), the appropriate tag appears instead of the ppO_2 value.

You can find also the local time, the max. sensor's reading difference and the stack time on the O_2 sensors screen.

2.3.4 Switching to other modes



In the menu the user can switch from surface mode to the CCR, manual CCR, bailout and standby modes.

If submerged to a depth greater than 1.5 m, the rebreather automatically switches to CCR mode.

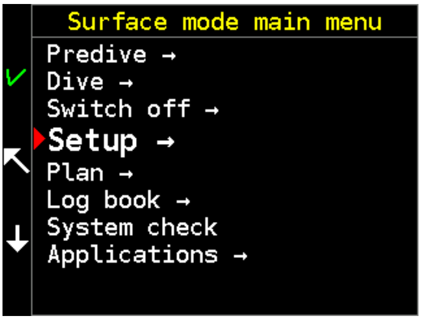
2.3.5 ppO_2 control in surface mode

Simple ppO_2 control is started in surface mode. If the oxygen content in the loop falls below 19% (with respect to the current atmospheric pressure) the solenoid will open to add 0.5 liter of oxygen. This should ensure that the partial pressure of oxygen will climb to a value of at least 0.23bar. Then O_2 is injected in six-second intervals (three seconds after the last closing of a solenoid). This control algorithm is intended to prevent the dangerous decline of ppO_2 and the subsequent loss of consciousness by the user, who could mistakenly breathe from the circuit without activating dive mode.

ppO_2 control is subject to other conditions — the oxygen tank must be full, connected, and open. PpO_2 sensors must be installed and calibrated; and the user may not perform excessive physical activity which causes high consumption of oxygen.

ppO_2 control in surface mode only maintains the oxygen level closely above the hypoxia threshold; therefore, it may not be used routinely for breathing.

2.4 Setup



The CCR Liberty is configured in surface mode. Activate the surface mode main menu with a short press of both keys and select Setup.

Some values can be set during a dive; however, this possibility is reserved for resolving exceptional situations only.

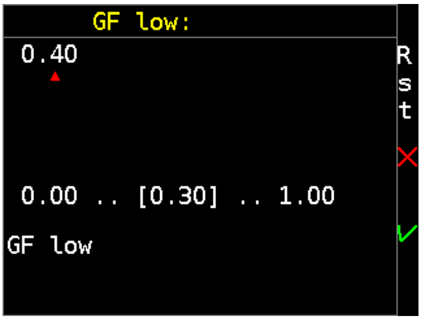
The set values depend primarily on the user's experience, physiology and personal preferences. The fact that the CCR Liberty enables setting a certain value does not mean that such a setting is safe and suitable for you and for your planned dive.

If you are not sure which value to set, leave the values on the default setting.

The manufacturer does not provide a warranty for faulty operation of the CCR Liberty if this faulty operation is the result of improper setup.

The factory default setting value is shown between square brackets in headlines of following text.

2.4.1 Editor use



Most of the variable values are edited in a similar manner.

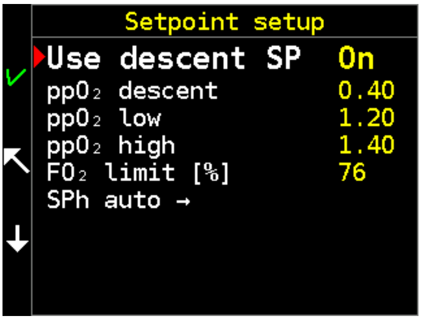
Tilt toward yourself— decrease the entered digit by one or uncheck flag

Tilt to the left — move the cursor to the left
Tilt to the right — move the cursor to the right
Press upper key — discard editing (reset to previous value)
Long press upper key — reset to default value
Press both keys — exit without save
Press lower key — save and exit

Permissible range is indicated by <minimum .. [default] .. maximum> value.

The display shows a brief description below

2.4.2 Setpoints



Use descent SP [Off]
This enables the use of the descent setpoint.

See also 55 Descent setpoint.

ppO$_2$ descent [0.4 bar]
Value of the descent setpoint (range: 0.2—1.0 bar).

See also 55 Descent setpoint.

ppO$_2$ low [0.7 bar]
Value of the low setpoint (range: 0.4—1.3 bars).

See also 55 Setpoint.

ppO_2 high [1.3 bar]

Value of the high setpoint (range: 0.7—1.6 bars).

See also 55 Setpoint.

FO_2 limit [90%]

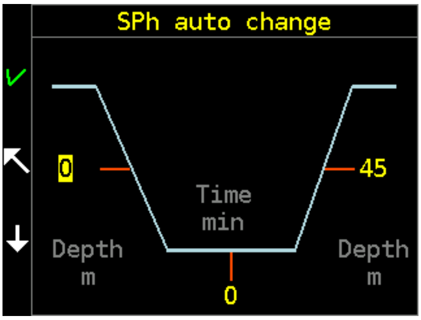
The setpoint is limited to the percentage of ambient pressure (range: 60—96%).

Setting a percentage that is too low reduces the effectiveness of decompression in small depths. Setting a percentage that is too high in small depths increases the intake of oxygen, which makes it necessary to discharge the content of the breathing loop and makes balancing more difficult.

See also 56 Setpoint limitation.

SPh auto

Automatic switching to high setpoint. If values greater than 0 are entered into the chart, the unit will automatically switch to high setpoint according to specified parameters when underwater. You can switch to high setpoint due to exceeding a certain depth during descent, bottom time, or exceeding a certain depth during ascent. The values are entered into the chart of the dive profile schematic. Navigate the chart with the bottom button, select the item with the top button, tilt to edit.

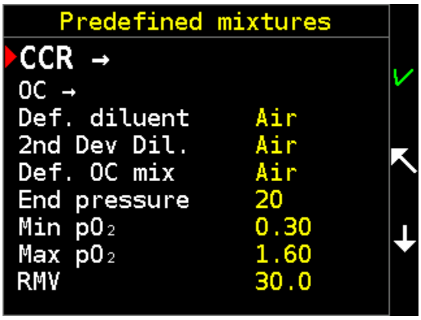


2.4.3 Mixtures

CCR

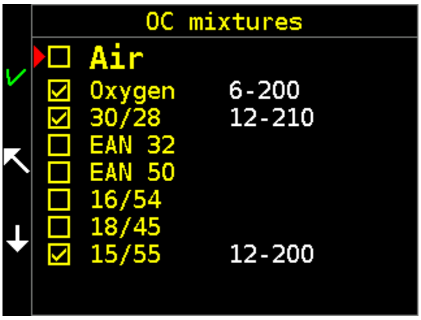
Eight different diluent mixtures with variable fractions of oxygen, nitrogen and helium can be preset.

Select the mixture to edit with the upper key short press, use tilting for changing the values and cursor position.



Each mixture can be enabled (marked checkbox) or disabled (clear checkbox). This can be done in the editing screen or via a shortcut – long press of the upper key in the list of mixtures.

Next to every gas mix MOD and END is displayed. MOD is calculated in a way in which the diluent will always be able to dilute the mixture in the loop. It is calculated from a partial pressure 0.2 bar lower, then the one of the high setpoint.



The mixture that you use as diluent must be among the set mixtures. Setting an incorrect diluent composition will lead to an incorrect calculation of the decompression procedure and can lead to an inaccurate determination of the proportion of oxygen in the mixture if the rebreather switches to indirect measuring using the He sensors.

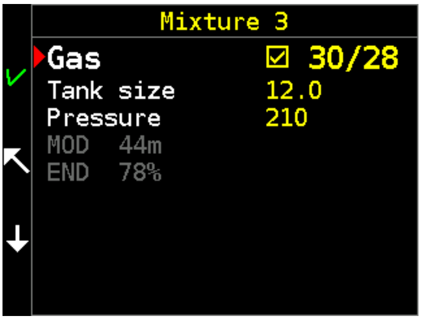
See also 72 Diluent.

OC

Eight different OC bailout mixtures with variable fractions of oxygen, nitrogen and helium can be preset.

Each mixture can be enabled (marked checkbox) or disabled (clear box). Only enabled mixtures can be selected.

Next to every gas mix a pressure (bar or PSI) and cylinder volume (litres or cubic feet) is displayed. During mixture editing we set individual items separately. MOD (maximal operational depth) is displayed in a grey font taking a maximum ppO_2 of 1.6 bar and END (equivalent narcotic depth) into consideration. END is usually expressed through the depth of at which diving with air would have the same narcotic effects as the inert gases used in the current mixture. This fictitious depth is the equivalent of a specific (mostly target) depth. In this case, however, the target depth is not known, therefore the END is expressed as the % narcotic effect of the mixture on the air.



Mixtures that you have prepared for bailout (stage tank) must be entered and enabled.

Unused gas mixes must be disabled. Otherwise the gas management calculations or BO RMT will be distorted

In an emergency, a mixture can be enabled during a dive. Furthermore, a new mixture can be defined during a dive. These possibilities are reserved for emergency situations only.

Def. diluent

A different default diluent can only be selected from mixtures that are enabled.

2nd Dev Dil

If a backup rebreather is used, it defines the composition of the diluent in the backup rebreather for the relevant decompression calculation.

Def. OC mix

A different default OC bailout mixture can be selected only from mixtures that are enabled.

End pressure

Planned end-of-tank pressure balance for planning gas management in the scheduler and BO RMT during the dive.

Min PO2

Determines the usability of OC mixtures with respect to the minimum ppO_2.

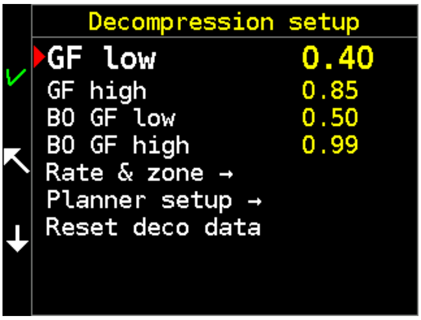
Max PO2

Specifies the usability of OC mixtures with respect to maximum ppO_2.

RMV

Respiration minute volume to calculate gas management in scheduler and BO RMT during dive. We recommend setting a sufficient margin to deal with an emergency situation. RMV during a CO_2 hit situation can significantly exceed 50 l / min.

2.4.4 Decompression



GF low [0.30]

Gradient factor at the start of decompression (range: 0.05—1.00).

GF low determines an additional increase of safety at the depth of the decompression ceiling at the start of decompression. Setting a value of 1.00

corresponds to the Bühlmann decompression algorithm without additional increase of safety using the gradient factors method.

Setting low values leads to deeper and longer stops at the start of decompression.

GF high [0.80]
Gradient factor at the end of decompression (range: 0.10—1.00).

GF high determines an additional increase of safety when ascending to the surface. Setting a value of 1.00 corresponds to the Bühlmann decompression algorithm without additional increase of safety using the gradient factors method.

Setting low values leads to longer shallow decompression stops.

Bailout GF low [0.80]
Gradient factor for bailout at the start of decompression (range: 0.05—1.00).

As a general rule, for bailout GF low, a higher GF value (a lower additional increase of safety) is set than for standard GF low.

Bailout GF high [0.95]
Gradient factor for bailout at the end of decompression (range: 0.10—1.00).

As a general rule, for bailout GF high, a higher GF value (a lower additional increase of safety) is set than for standard GF high.

Rate & zone
This item allows you to set the descent and exit speeds. The input is done in the chart of the schematic dive profile. Navigate the chart with the bottom button, select the item with the top button, tilt to edit. Descent rate is first defined depth from which the descent rate monitored (m or feet). The following value is the descent rate (m / min or ft / min) Ascent speeds are divided into three zones: the maximum depth of the first limit from the first limit to a second limit and finally from the second limit to the surface. These limits can be defined in the graph on the right. The speeds in the individual zones then on the left side of the output part of the graph.

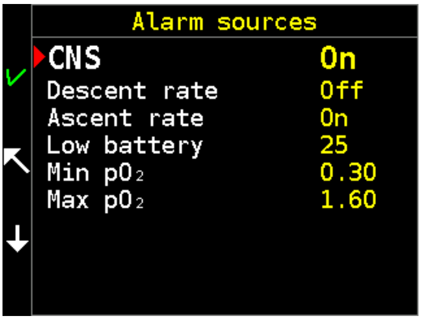
Planner setup
Used to set the decompression and gas management planer. For a detailed description, see planner settings

Reset deco data

This resets the saturation of biologically inert gases and the calculation of oxygen toxicity to a state that corresponds to a very long period after the previous dive.

A diver that uses the CCR Liberty after resetting the decompression data should not dive for 48 hours prior to submersion with the reset apparatus. Do not dive for 24 hours with reset apparatus after a significantly increased altitude above sea level.

2.4.5 Alarms



Alarm sources

CNS [On]

Oxygen toxicity limit has been reached.

ppO_2

Partial pressure of oxygen has exceeded the allowed set range.

Descent rate [Off]

Descent rate has exceeded the set limit.

Ascent rate [On]

Ascent rate has exceeded the set limit, with a tolerance to very short, fast movements.

Low battery [25%]

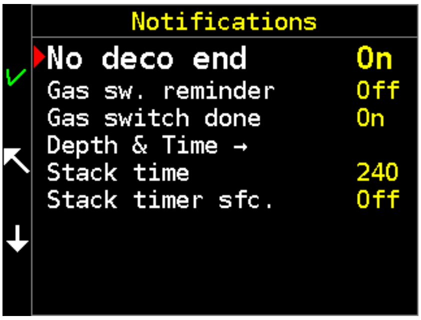
Battery power has dropped below the set limit (range: 0—40%). Setting 0 means deactivation of this alarm.

Min PO2

Specifies the lower limit for ppO_2 alarm in CCR dive mode.

Max PO2

Specifies the upper limit for ppO_2 alarm in CCR dive mode.



Notifications

No deco end [On]

End of the dive in zero time (in the terminology of the Bühlmann decompression model), i.e. notification that it will be necessary to reduce the ascent rate and/or perform decompression stops.

Gas switch reminder [Off]

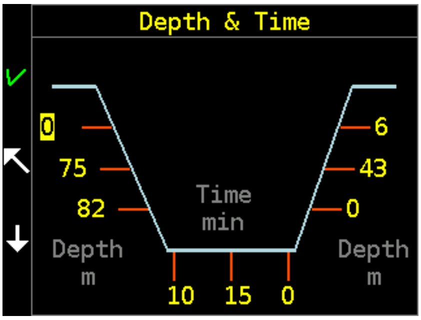
Recommendation to switch to a different mix. This is used only in bailout OC mode.

Gas switch done [On]

Change of mixture (in bailout OC mode) or diluent has been executed.

Depth & Time

Depth and time notifications are set through a dive schematic graph. Navigate the graph using the bottom button, select with the top button and set the values by tilting the computer.



Notification that the set **depth during the descent** has been reached. It is possible to set three separate depths within the range of 0 – 300 m. 0 means deactivation of the notification.

Notification that the **dive time** has been reached. It is possible to set three separate times within the range of 0 – 999 min. 0 means deactivation of the notification.

Notification that the set **depth during the ascent** has been reached. It is possible to set three separate depths within the range of 0 – 300 m. 0 means deactivation of the notification.

Stack time [150 min]

Notification that the cumulative time in any close circuit dive mode has been reached (range: 0 – 360min). 0 means deactivation of the notification.

To reset a timer go to the Predive menu.

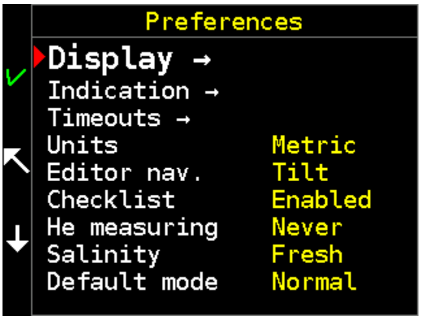
Stack timer sfc.

Can be set to not count stack time when the unit is in dive mode, but is on surface level

On – counted on the surface

Off – not counted on the surface

2.4.6 Preferences



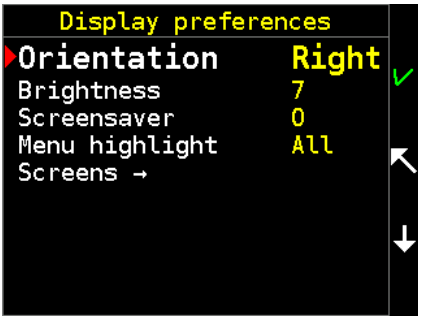
Display

Orientation

Setting for left/right hand.

Screensaver

The display becomes inactive after the set period (range: 0—120 s). 0 means that the display will be constantly active.



Dive mode screens

Any of the five following screens can be enabled or disabled. This can be done during a dive.

Detailed — the primary screen displays all necessary information
Synoptic — the depth value is easy to read; it is accompanied by other important information
Big — the most important information written in really big characters
Graph — Dive profile screen
O_2 sensors — detailed state of the sensors
TTS – Time to surface screen with unique BO RMT value and future TTS

Indication

Auxiliary displays

Setting the position of HUD and buddy display. The default positions are on the right side for HUD and on the left side for BD.

Color blind mode

If you cannot distinguish blue and green LED lights on HUD, switch color blind mode on. See 27 Color Blind mode.

Timeouts

Key press delay [1]

Minimum key press duration (range: 1 — 5, in 100 ms).

Auto switch off

The time period after which the CCR Liberty switches from surface mode to standby mode (range: 0 – 999 min.). 0 deactivates automatic switching to standby mode. If no handset is connected, switch-off will occur after 150 minutes regardless of the setting.

Units [Metric]

Metric and imperial units (or, more precisely, the US traditional systems of weights and measure) can be set for the entire apparatus. All physical calculations are internally executed using the metric system; results are converted for display only.

Editor navig. [Tilt]

The numbers in the editor can be increased or decreased by tilt or by tap. To control with tapping it is necessary to practice a little. Do not change the tilt setting unless you have a strong reason.

Checklist [enabled]

When entering CCR mode from the surface mode menu, a checklist is displayed. This can be disabled.

He measuring [TMX only]

TMX only – He sensors are used only in case that the selected diluent contains helium.

Never – He sensors are permanently deactivated.

Salinity

Sets appropriate water salinity (Fresh/Sea). It has a direct influence to depth measurement.

2.4.7 Calibration

Calibrate He-Air

The He sensors are calibrated with air. The sensor is stable for a long period of time; therefore, perform calibration only after replacing the sensor or in case there are doubts about its accuracy. Sensors must be free of any traces of helium.

Oxygen purity [99.5%]

The oxygen concentration in the calibration gas can be set. If possible, use oxygen with a purity of at least 99.5% for calibration.

Do not use air for calibration. The partial pressure of oxygen in air at atmospheric pressure differs significantly from the partial pressures determined by the setpoints. At the end of its service life, an oxygen sensor can successfully undergo calibration to 21% (air) but will no longer be capable of measuring ppO_2 of 1 bar or higher.

See also 75 Calibration of oxygen sensors and 73 Oxygen.

Recommended [3 days]

Recalibration of the oxygen sensors will be recommended after a set number of days (range: 0–30).

2.4.8 Faulty sensors

Oxygen sensors

Overview of sensor status with the possibility to exclude individual oxygen sensors for ppO_2 calculation.

Normal – no sensor malfunction detected; the sensor is used as a data source.

Uncalibrated – sensor has not been calibrated.

Excluded – sensor excluded automatically by the algorithm. The algorithm can return the sensor to Normal status if it determines that the reason for exclusion has no longer exists.

Disabled – sensor excluded manually.

Error – sensor not present, or bad contact.

Offline – sensor not available (digital communication at the module level is not functioning).

Helium sensors

It is possible to include and exclude helium sensors.

Normal – no sensor malfunction detected; the sensor is used as a data source.

Uncalibrated – sensor has not been calibrated.

Disabled – sensor excluded manually.

Error – sensor not present, or bad contact.

Offline – sensor not available (digital communication at the module level is not functioning).

Pressure sensors

Overview of pressure sensors with the possibility to manually exclude individual sensors. Do not start a dive with more than one malfunctioning pressure sensor.

Normal – no sensor malfunction detected; the sensor is used as a data source.

Disabled – sensor excluded manually.

Error – sensor not present, or bad contact.

Offline – sensor not available (digital communication at the module level is not functioning).

See also 24 Pressure and depth measurement.

Other devices

You can switch off a solenoid that is not functioning properly. If so, the other solenoid overtakes completely and its frequency is corrected from 12 seconds to 6.

pO2 source

Switching the data source for the control of oxygen partial-pressure in the loop

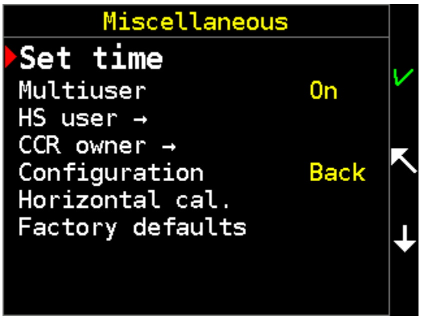
O2 – For measuring and controlling oxygen a chemical oxygen sensor is used

He – For measuring and controlling the oxygen an indirect measurement is done using helium sensors

2.4.9 Miscellaneous

Set time

Date and time setting is done in the format YYYY/MM/DD hh:mm:ss.



Horizontal calibration

The accelerometers are used for control by tilting and tapping. They have to be calibrated.

Place the handset on a level surface (e.g. a table) before starting calibration.

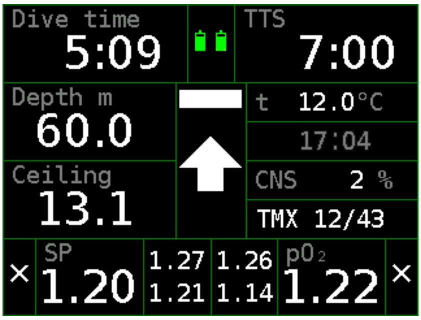
Factory defaults

This resets all settings to the default values.

Following a reset, make sure to change all necessary settings before a dive.

2.5 Dive mode

2.5.1 Detailed screen



The primary screen displays all necessary information during a dive. Most information is provided by clear values and unambiguous symbols.

Dive time

The timer starts after submersion (depth > 1.5 m) and halts after surfacing (depth < 0.5 m). In case of stay on the surface (or at very shallow depth) followed by a second submersion (during a time set in the dive termination timeout) the dive time indicated will be the time from the first submersion including the surface time.

Depth

The depth can be read in the units set in the setup (m or ft). Depth is calculated from measured hydrostatic pressure. Fresh water (default) or seawater density can be set for the depth calculation (units and salinity are set in Setup → Preferences).

Setting fresh/sea water doesn't affect decompression calculations. Decompression is based on ambient pressure and is independent of the displayed depth.

No deco

You can stay for the indicated time at the current depth, breathing the current mixture (current He content and current SP), to avoid a decompression obligation. It is however presumed that the diver will follow the recommended ascent rate.

During the dive, there is a situation where the No Deco indicator already shows a zero value, but the decompression ceiling value is still not displayed. Such a situation can last for tens of seconds. The situation is due to the fact that No deco time has ended and the decompression ceiling is below the surface level, but its value is so low that just ascending at the prescribed speed directly to the surface will suffice, there is no need for step decompression.

Ceiling

The depth of the decompression ceiling decreases continuously up to the surface. The reading is not artificially stopped anywhere during the ascent. Always stay below the depth of the ceiling, even if the ceiling depth is very shallow.

The ceiling indicator in Liberty replaces the indicator of decompression stops. The diver selects the depth at which they do the decompression stop or steadily ascends in accordance to the decompression ceiling. This approach may be more effective in terms of decompression time. Time reference is TTS (Time To Surface). Do not follow the decompression ceiling at low depths if conditions do not permit it. Waves, currents, positive lift of gear at a small depth, absence of visual reference and other factors can cause uncontrolled ascent above the ceiling or completely hinder decompression at this level.

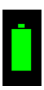
Ascending above the ceiling generates a warning. Further violation, more than 1 m (3 ft), leads to an additional alarm. Both alarms are logged. The decompression calculation will continue without a penalization. The diver is responsible to decide how to minimize the probability of severe consequences.

Decompression is no longer required when the ceiling value disappears. In that case it is possible to surface.

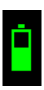
TTS

The time to surface (TTS) includes the complete decompression profile. The rounding of TTS is influenced by the settings in Menu / Setup / Decompression / Planner setup / Rounding. The rounding can be set to 60 s, 30 s, 1 s.

Battery symbols



The battery is full



Bar height is proportional to the remaining battery capacity

Color is changed at less than half capacity

Combined graphic symbol

The combined graphic symbol on the detailed screen is intended for rapid orientation. It tells the diver what must be done. The color of the warning symbols changes from yellow to red according to the degree of importance.

Permitted to ascend to the surface.

Permitted to ascend to the depth of the decompression stop or decompression ceiling.

The depth of the decompression ceiling or decompression stop has been reached; do not change depth.

The depth of the safety stop has been reached; do not change depth.

The ascent rate has been exceeded; slow your ascent.

The current depth is less than the depth of the decompression ceiling; descend.

t (Temperature)

Water temperature is measured inside the HS case. After a water temperature change wait about 1-2 minutes until the temperature reading reaches a stable value. The air temperature is affected by many factors and is only an indication.

CNS

The so called "oxygen clock" is a percentage of consumption of CNS toxicity limit. Calculation is based on NOAA oxygen exposure limits.

See also 85 Breathing high oxygen content gases.

Diluent

Currently used diluent is displayed

Solenoid symbols

In the lower left and right corners, there are symbols indicating the state of the solenoids according to data from the control units.

- **X** – solenoid in closed state
- **=** – solenoid in open state

SP

The setpoint is a required ppO_2 value. The setpoint values is usually displayed in white. The setpoint value will be displayed in yellow when the value is not physically reachable (ex. Setpoint of 1.4 in 2 meters). The evaluation of the ability to reach the setpoint is influenced by setting of FO_2 max. (ex. Setpoint of 1.3 in 3 meters can be reached, but only if there is 100% of oxygen in the loop, but the FO_2 is set to 80%, in this example the setpoint will be displayed in yellow and the solenoid will not add oxygen for as long as the value of ppO_2 does not drop below 1.04bar [1.3×0.8]). The setpoint value will be displayed in red only when the setpoint is changed.

For information on adjusting the setpoint, see 55 Setpoints.

O_2 sensors

ppO_2 as measured by individual O_2 sensors is displayed.

ppO_2

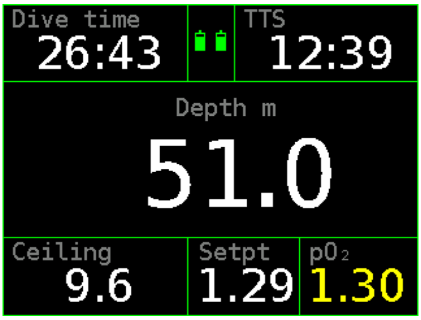
The ppO_2 can be measured directly (using O_2 sensors) or indirectly (using He fraction sensors). **It shows the average value.**

See 22 Direct measurement of ppO_2 and 23 Measurement of He content.

Exclamation mark

If a yellow exclamation mark is displayed next to a value, it means that one or more sensors were excluded. This applies to the measurement off ppO_2, temperature, pressure and helium.

2.5.2 Synoptic screen



The depth value is easy to read. It is accompanied by other important information.

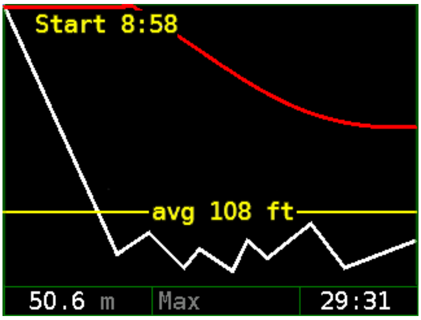
The meaning of all values is identical to the detailed screen.

2.5.3 Big Screen

The most important information is written in big characters.

This screen is useful when visibility is very bad. Many divers can read the numbers even without a mask.

2.5.4 Dive profile screen



Start

The time of submersion is useful for checking compliance with the schedule.

Avg

The average depth is indicated with the yellow horizontal line and with a number displayed in yellow.

Current depth

See lower left corner.

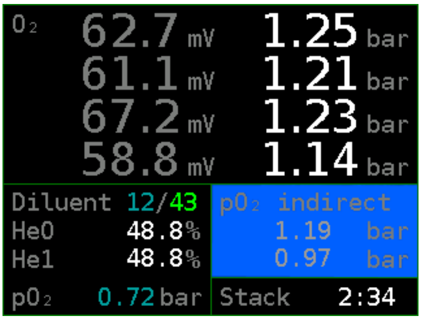
Dive time

Runtime of current dive is placed in lower right corner.

Max

This is the maximum depth reached during the dive. The field with this value is placed in the middle of the bottom line.

2.5.5 Sensors screen



Displays the value of the potential of the sensors and their calibrated ppO_2 values

Diluent

The composition of the current diluent (O_2/He)

He0 / He1

Helium content in the loop as detected by the individual helium sensors. Under ideal conditions the measured value will correspond to the fraction of helium in the diluent.

pO2

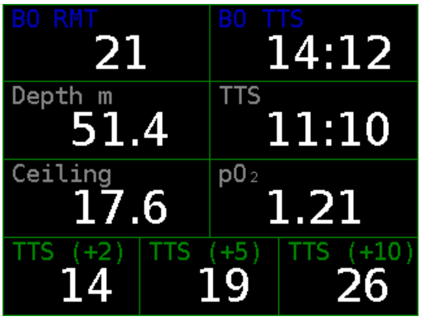
Partial pressure of oxygen in diluent at current depth

pO2 indirect

Indirectly measured ppO_2 using helium sensors. The cell is coloured blue. The same as the ppO_2 cell, when the ppO_2 measurements are switched to indirect measuring through helium sensors.

Stack
Scrubber stack time

2.5.6 TTS Screen



This screen contains useful and unique timeout information

BO RMT
Bailout remaining time is the time that determines the maximum length of stay at the current depth so that the bailout gas supply is sufficient for the entire ascent including decompression. The algorithm counts all the set gases and their amount together with the specified minute consumption (RMV). In order for the calculation to be correct, it is always necessary to accurately enter the volume, pressure and composition of the gas and to have only those gases actually used in the gas list. BO RMT is calculated based on the Bailout GF setting

BO TTS
The time required to surface in the case of OC bail out ascent. The ascent time is calculated according to the Bailout GF setting

TTS (+2) (+5) (+10)
The values of these three items represent future TTS, i.e. the length of ascent if the diver stays at the current depth for the next 2, 5, or 10 minutes. In the saturation phase of the dive, the values increase gradually, in the desaturation phase it is the opposite.

2.6 CCR mode

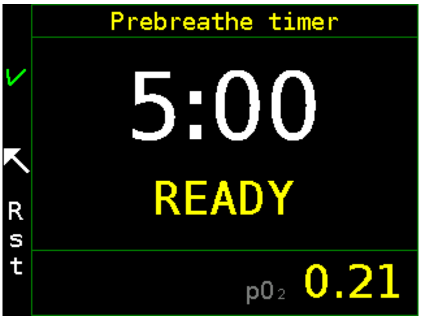
This is the primary dive mode with the CCR Liberty.

2.6.1 Entering CCR mode

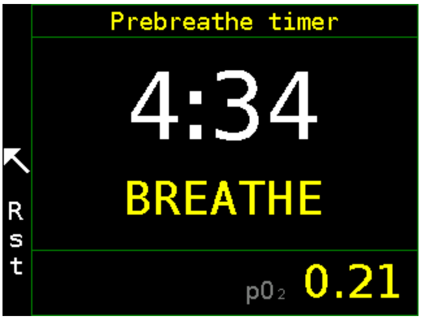
The standard method of switching to CCR mode is by selecting it in the menu from surface mode.

If submersion to a depth greater than 1.5 m occurs in surface mode or standby mode, the rebreather will automatically switch to CCR mode. **Do not intentionally use this switching method; it is intended only for emergency situations.**

The process of switching to dive mode has the following course. By choosing dive mode, oxygen injection is started immediately based on the current partial pressure of oxygen and setpoint settings. At the same time, oxygen sensors are automatically verified and their calibration is checked. If the calibration is older than the set number of calibration days, or the sensor voltages differ by more than 10%, warnings and recommendations for new calibration of oxygen sensors are shown.



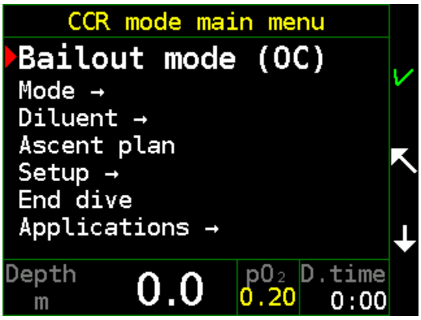
The next step is a pre-dive checklist. The diver should follow this list step by step and personally check all the items marked on it. Move to the next screen using the bottom button.



After checking all the checklist items, the pre-breathe screen appears. Prepare the device for pre-breathing. Press the upper button to count down the set pre-breathing time. The rules and procedure for pre-breathing are described in Chapter 3.2.12

In the lower right corner, the average ppO_2 is displayed. All sensors and other values can be monitored on the second handset, where all dive mode screens are accessible. If pre-breathing is interrupted, the countdown can be reset with the lower key.

The end of pre-breathing is reported by vibration and “FINISHED”. If the diver does not continue by themself, after a few seconds, the basic Dive mode screen will automatically appear.



2.6.2 Switching to other modes

It is possible to switch from CCR mode to the manual CCR and bailout OC modes in the menu.

If the current depth is less than 1.5 m, it is possible to switch to surface mode and standby mode.

2.6.3 ppO_2 regulation

The basic function of the CCR Liberty is to maintain correct partial pressure of oxygen.

A predictive algorithm of ppO_2 control is used. Measured ppO_2 is adjusted according to the mathematical model of the breathing loop. The calculation of O_2 delivery and possible subsequent opening of the solenoid is performed at six-second intervals. Oxygen is added alternately using the solenoids corresponding to both control units.

In the event that it is not possible to determine the actual depth (due to a malfunction or manual exclusion of all pressure sensors), regulation of oxygen delivery switches to a simple algorithm.

Setpoint

The setpoint is a required ppO_2 value; for information on adjusting the setpoint, see 37 Setpoints. Two special values, "low setpoint" and "high setpoint" are set. These can be selected simply by a long press of the upper key (for the high setpoint) or lower key (for the low setpoint).

In the default setting, the low setpoint has the value of 0.7 bar (70 kPa). It is possible to reset it within the range of 0.4 to 1.3 bars.

In the standard setting, the high setpoint has the value of 1.3 bars (130 kPa). It is possible to reset it within the range of 0.7 to 1.6 bars.

Upon starting CCR dive mode, the low setpoint is activated by default.

Descent setpoint

The descent setpoint is designed for situations when it is necessary to rapidly descend to a given depth, for example when diving in a current. The utilized algorithm uses the natural rise of ppO_2 during descent. It is necessary to descend rapidly. The natural rise of ppO_2 has to be faster than the oxygen consumption.

Use of the descent setpoint must be enabled in the configuration.

If it is enabled, the descent setpoint is automatically activated when switching from surface mode to CCR mode. It cannot be activated in another way. The descent setpoint has a variable value. The initial set value gives the ppO_2 on the surface. At depth, the current setpoint increases linearly by 0.2 bar (20 kPa) for every 10 m of depth (i.e. it increases by the same absolute values as when diving with an open circuit with air, only with a different initial value).

The descent setpoint is automatically switched to the low setpoint upon reaching the value of the low setpoint or upon completing or significantly slowing the descent, but no later than after ten minutes.

When using the descent setpoint, the user must continuously check whether he/she has reached or exceeded the maximum physiologically permissible ppO_2 limit and adjust the rate of descent accordingly or take other measures.

Setpoint limitation

Besides the set value, the setpoint limit is defined by the ambient pressure. For example, at a depth of 3 m, where the hydrostatic pressure is 1.3 bars, ppO_2 can reach a maximum of 1.3 bars when using pure oxygen.

For practical reasons (unattainability of a precisely 100% oxygen atmosphere in the breathing loop), the setpoint is set at 90% of the ambient pressure by default. This value can be reset within the range from 60% to 96%.

Emergency ppO2 control

If all chemical sensors are not valid (error, disabled etc.), the depth is < 6m/20ft and the ppO_2 source is O_2 sensors,
an emergency O_2 injection + alarm is done every 6s. In fact, Liberty become an oxygen rebreather (6m / 20ft depth is safe for pure oxygen).

The unit assumes that in a depth lower than six meters the risk of hypoxia is much larger than the risk of hyperoxia and to prevent fatal consequences of dysfunctional or disabled sensors. In this case the diver must not continue submerging until the ppO_2 stabilizes and the diver is sure of the breathing mixture.

Emergency ppO_2 control by indirect measuring with He sensors

If all chemical sensors fail in dive mode, an alarm “pO2 measuring lost” is raised.

Indirect measurement of ppO_2 using helium sensors can only be activated manually, provided the helium measurement setting is switched on (TMX only) and the helium fraction in the diluent is greater than 20%. When using indirect oxygen measurement with helium sensors, always be sure that helium sensors are calibrated and functional.

For indirect oxygen measurements, all fields displayed with ppO_2 are blue.

2.6.4 Decompression

The decompression algorithm takes measured ppO_2 values and inert gases according to the set diluent composition into account.

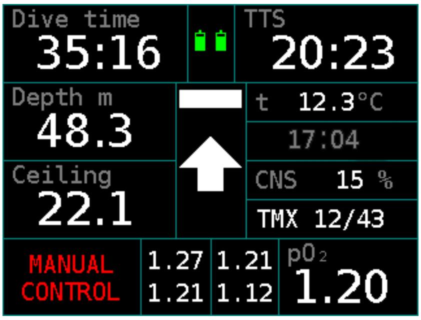
During a dive, the safety level can be set in the menu by switching the set of standard and bailout gradient factors (GFs) without affecting the mode in which the CCR Liberty is operating.

2.6.5 Specific handset control

Long press upper key – high setpoint

Long press lower key – low setpoint

2.7 Manual CCR mode



This mode serves primarily for training

2.7.1 Entering manual CCR mode

It is possible to switch to manual CCR mode from the menu in CCR mode, bailout OC mode or surface mode.

2.7.2 Switching to other modes

In the menu, it is possible to switch from manual CCR mode to CCR mode and bailout OC mode.

If the current depth is less than 1.5 m, it is possible to switch to surface mode and standby mode.

2.7.3 ppO_2 regulation

Manual CCR mode is based on CCR mode. However, automatic replenishment of oxygen is not available and ppO_2 regulation is performed only manually. Measuring and display of ppO_2, decompression calculations and the display of all other data are operational.

It is assumed that the user adds oxygen manually using the manual bypass valve or by manipulating the oxygen-tank valve if any solenoid is locked in the open state.

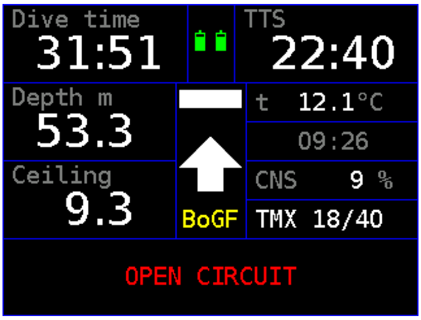
If the ppO_2 falls below 0.3 bar, then oxygen will be added to the breathing loop automatically for security reasons. This is only possible if the solenoids are operational and an oxygen supply is available.

When manually adding oxygen to the breathing loop, anticipate a delay between adding oxygen and the change in measured values. This delay is due to the fact that oxygen is added to the exhalation bag and the mixture must pass through the scrubber before it reaches the sensors.

2.7.4 Decompression

The decompression algorithm takes measured ppO_2 values and inert gases according to the set diluent composition into account.

2.8 Bailout OC mode



This mode serves primarily for resolving emergency situations.

2.8.1 Entering bailout OC mode

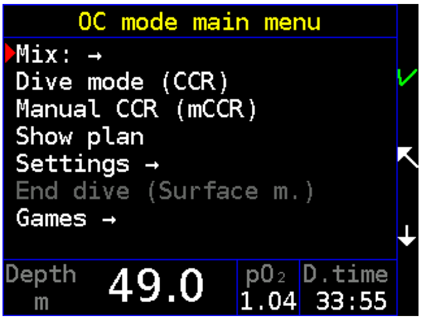
Switching to bailout OC mode is possible from the menu in CCR mode, manual CCR mode or surface mode.

2.8.2 Switching to other modes

In the menu, it is possible to switch from bailout OC mode to CCR mode and manual CCR mode.

If the current depth is less than 1.5 m, it is possible to switch to surface mode and standby mode.

2.8.3 Mixture



It is assumed that the diver will not breathe from the apparatus's breathing loop but will rather use a separate open-circuit apparatus. **Automatic ppO_2 regulation is deactivated in bailout mode**; the apparatus functions only as a decompression computer.

Due to this, you must not breathe from the unit, if it is switched to bailout OC mode

Up to eight preset breathing mixtures are available in this mode. The user can select the currently utilized mixture from the menu or can successively select individual mixtures with a long press of the upper or lower key. After switching to bailout OC mode, the configured default mixture is set.

2.8.4 Decompression

The decompression algorithm takes the partial-pressure values according to depth and the set mixture into account.

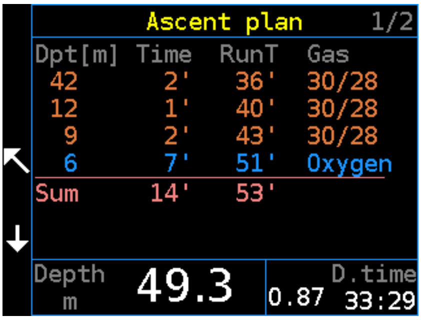
After switching to bailout OC mode, the safety level is automatically set using the bailout gradient factors (GFs). It is possible to switch between the standard and bailout GF sets in the menu without affecting the mode in which the CCR Liberty is operating. If the diver switches back to the CCR mode during the dive, the GF automatically switches back to Standard GF.

2.8.5 Specific handset control

Long press upper key — change of mixture (up according to the list, cyclically)

Long press lower key — change of mixture (down according to the list, cyclically)

2.9 Ascent plan

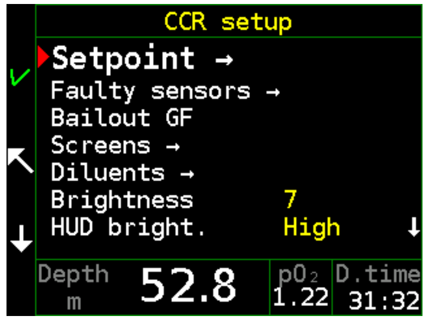


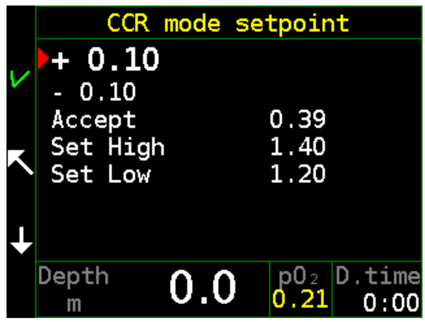
In any diving mode, you can view the current ascent plan with the entire decompression course. Although Decompression is shown on the Liberty using the depth of the decompression ceiling and time to surface, the Ascent plan is displayed in decompression stops at intervals of 3 m. The last column displays the gas with which the decompression stop is calculated.

If a diver is in no-deco time, only “Free ascent” is shown.

Calculating and displaying the Ascent Plan is also affected by the Planner setup setting. In particular, the depth of the last decompression stop, whether the ascent is calculated with all available mixes, or with the current mix only. Details of settings are in Chapter 3.1.1 Schedule settings

2.10 Setup in Dive mode





During the dive, many preconfigured factors can be changed such as setting a new temporary setpoint, adding a new mix, or removing a lost mixture, changing the diluent, adjusting the brightness of the display, or HUD,

Setpoint

You can set a new temporary setpoint by adding or subtracting from the value of the current setpoint.

To increase the current setpoint, press +0.1, until you reach the desired setpoint. Once you have reached the desired value, move the cursor to Accept and confirm the change by pressing the upper button.

To decrease the current setpoint, move the cursor to -0.1 and press the top button repeatedly until you reach your setpoint. Once you have reached the desired value, move the cursor to Accept and confirm the change by pressing the upper button.

These setpoints are only temporary. By switching to low or high setpoint, this temporary setpoint is deleted, and the procedure described above has to be repeated to reset it.

Set high

Switch to high setpoint

Set low

Switch to low setpoint

Faulty sensors

In the event of malfunction of some sensors, it is necessary to exclude faulty sensors from averaging disable the non-functional solenoid or switch the oxygen measurement mode (oxygen or helium sensors). Faulty sensors would cause a poor evaluation of the unit’s condition, which could have fatal consequences. The procedure for excluding and including all sensors is the same as the procedure in the surface mode – see 46 Faulty sensors.

Bailout GF

Switches to the set Bailout Gradient factors to accelerate decompression in an emergency. Once the device is switched to Bailout GF, this item changes to Standard GF, which can be used switch back to standard gradient factors.

Screens

Turns some screens on or off. The procedure is the same as the surface mode setting See Chapter 2.4.6 Display

Diluents

It is used to switch or set a new diluent if another diluent is used from an off-board source. In order for the diluent to be counted correctly with respect to the decompression and the He-N2 ratio, a diluent flush should be performed to replace the original gas.

Mixtures (OC mode only)

Adds a new bailout mixture or can be used for editing the current ones. It is also possible to deselect a lost decompression bottle so it is not counted in the ascent calculation. The setting is the same as setting the blends in surface mode: chapter 2.4.3 Mixtures

Brightness

Adjust the brightness of the display (1-10). The brightness of the display significantly affects the power consumption. To save the battery, lower the brightness of the display to the lowest acceptable level.

HUD brightness

HUD diode brightness can be set to 3 levels. In very dark conditions, the full brightness of the diodes may be irritating, but sunny shallow water the low brightness may be less visible. The intensity is adjusted by pressing the upper button

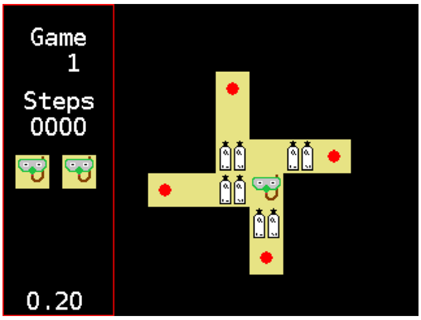
2.11 Games

Do not disable error messages and notifications if the games are played underwater.

Ensure to not accidentally reposition while playing during a dive. Check the pressure gauges and rebreather state on the second handset on a regular basis. Playing a game will reduce your attention. Remember: you want to dive safely, not just achieve a higher level in the game!

The games were tested on children. Nobody was hurt.

2.11.1 Sokoban

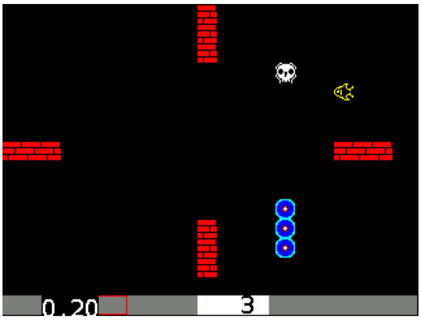


Sokoban is a type of transport puzzle, in which the player (a diving mask with snorkel) pushes tanks or crates around in a warehouse, trying to get them to storage locations (red dots).

The game is played on a board of squares, where each square is either a floor or a wall. Some floor squares contain tanks, and some floor squares are marked as storage locations.

The player is confined to the board and may move horizontally or vertically onto empty squares (never through walls or boxes). The player can also move into a tank, which pushes it into the square beyond. Tanks may not be pushed into other tanks or walls, and they cannot be pulled. The puzzle is solved when all tanks are in the storage locations.

2.11.2 Snake



Snake is a game where the player maneuvers a line which grows in length, with the line itself being a primary obstacle.

The player controls the head of the snake. As it moves forward, it leaves a trail behind, resembling a moving snake. The snake has a specific length. The player loses when the snake runs into the screen border, a trail or another obstacle, or eats poison (skull), or starves to death.

The snake lose its length slowly (every 30 steps), and when it is too short, it dies from starvation.

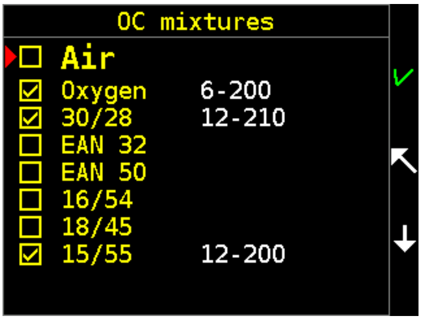
The player attempts to eat fish by running into them with the head of the snake. Each fish eaten makes the snake longer, so maneuvering becomes progressively more difficult.

3. Procedures

3.1 Dive plan

For planning a dive in the strict sense (gas management and decompression) the internal functions of Liberty can be used. The planner calculates a dive plan in CCR mode or with an emergency bailout on open circuit. To compute the decompression, the Bühlmann ZHL-16B algorithm, with adjustable gradient factors, is used as well as on-line decompression calculation.

3.1.1 Planner settings



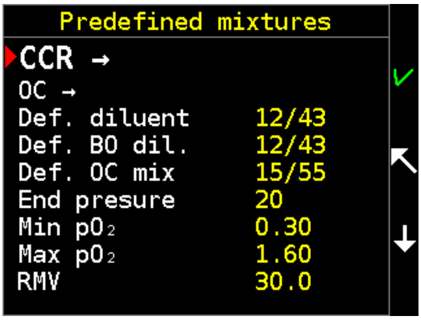
To simplify the planner control, the planner takes all set values as setpoints, breathing mixtures, gradient factors, ascent speed from device settings. For the correct calculation of the plan, it is therefore necessary to set these items exactly as they will be used for the real dive. **Particularly in the case of breathing mixtures for bailout, it is necessary to check only those mixtures which are actually available during the dive and their composition, pressure and cylinder parameters are set correctly.** If any other mixtures are checked or mixtures have a larger gas reserve set, they will be included in the planning and will cause a serious distortion of the dive plan, which may have tragic consequences.

A detailed guide for setting these parameters can be found in the following chapters

2.8.2 Setpoints (see 58)

2.8.3 Mixtures (see 58)

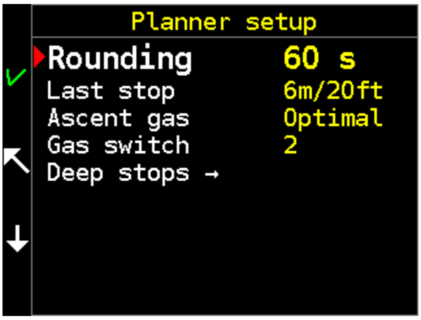
2.8.4 Decompression (see 59)



In mixture settings, note the Respiration minute volume expressed in liters per minute (l / min) or cubic feet per minute (cuft / min). We recommend that you choose a sufficient reserve for a crisis situation. In the CO_2 hit – hypercapnia situation, a diver's ventilation can exceed 50 l / min (1.8 cuft / min). For details on the planner settings, see Menu / Setup / Decompression / Planner setup

Rounding

Here you can set the decompression time rounding to 60 seconds, 30 seconds, 1 second



Last stop

Specify the depth of the last planned stop 3 m (10 ft) or 6 m (20 ft)

Ascent gas

Determine whether you want to plan the bailout ascent using all of the set gases – the Optimal option or only one current gas. The most widely used gas in the planner is the Current option. This setting also influences the TTS calculation during the bailout of the output. It is either planned with all available mixes (optimal) or just current (current).

Gas switch

Select this option to set the minimum switching stop length for open circuit bailout ascent. In this stop the diver tries to use the high ppO_2 and the oxygen window effect when changing the mixture. The stop depth is set automatically according to the ppO_2 mixture. The ascent ppO_2 1.6 is used. If the stop is deeper than the first decompression stop, a separate stop is created and is included in the ascent and gas consumption plan. If the depth is in the step decompression zone, the setting determines the minimum stop length. The numeric value represents the length in minutes. If a zero value is selected, the stop is not counted.

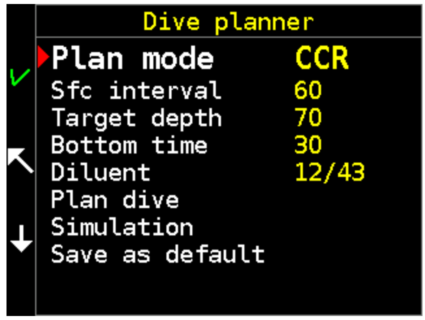
Deep stops

Here you can include extra deep stops to reduce silent bubbles. For the calculation, Richard Pyle's known procedure is used to halve the pressure between the start of the ascent and the depth of the first decompression stop. In this choice, it is necessary to consider setting the gradient factors so that the medium and slow tissues are not saturated.

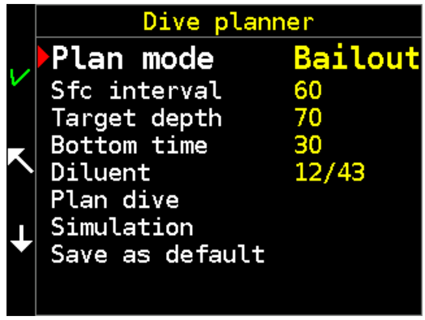
3.1.2 Planning

In the scheduler itself, we choose a mode that we are going to plan (CCR / Bailout).

Liberty allows the plan to be calculated on each handset separately, so the user can simultaneously plan the plan for the entire dive with the rebreather and the emergency plan with the bailout ascent on the second handset. Just set the surface interval, target depth, bottom time. Bottom time includes the descent time.

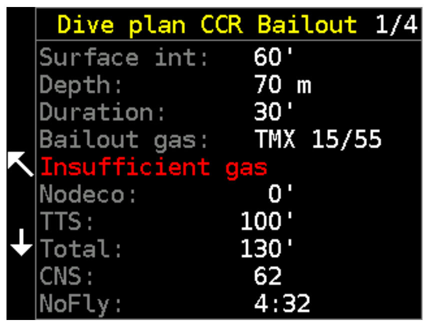


For multiple diluents, select the diluent that is going to be used on the bottom. Surface interval is the time elapsing from the dive plan after the dive. This value is entered to account for the residual tissue saturation from previous dives and the rate of desaturation during the surface interval.



After entering all values, select Plan dive.

In the case of CCR dive planning, a recapitulation (Surface interval, target depth, bottom time, diluent) and summary of planned dive information are displayed.



No deco – Time with no decompression at the bottom with the current mixture

TTS – "Time to surface" total ascent time

Total – total dive time

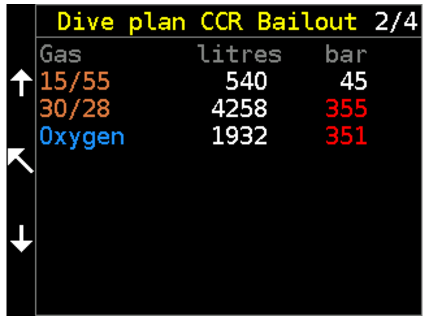
CNS – accumulated exposure of CNS for planned dive

NoFly: – Expected time limit of flying after surfacing

In addition, when planning a bailout mode, an "Insufficient gas" warning may appear if the specified amount of gas is not sufficient to complete the open circuit ascent.

Press the bottom button to go to the next page. Use the top button to return the previous page.

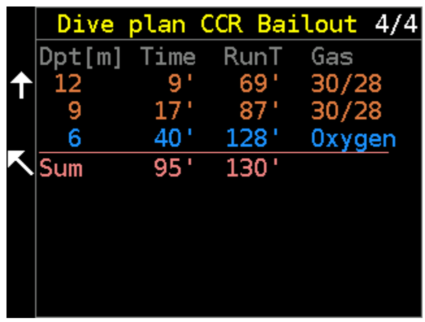
The second Bailout screen – "gas management" shows the individual gases used and their consumption in liters (cuft) and bars (PSI). If the pressure exceeds the limits of the cylinder, it is red. In this case, it is necessary to add another gas to the dive plan. If you do not have additional gas available, shorten the time on the bottom or reduce the target depth. Beware, avoid reducing the value of the RMV, as the dive plan should always be done with possible crisis situations where increased gas consumption is anticipated in mind.



If your gas management is OK, press the bottom button to go to the next page.

V the left column shows the depths of each step, including bottom time (yellow). The second column (Time) determines the time spent at a specific depth. The RunT column (runtime) represents the current dive time at the moment of leaving the given depth. The Gas column determines which gas is to be used at a given depth. Gases are color-coded. Helium blends are labeled brown, nitrox mixtures green (various tints by amount of oxygen), air or diluent white, oxygen blue.

If the plan is longer than 8 steps, the plan is overflow to the next page. The summary is expressed in pink. The first number represents the total time of the ascent, the second number represents the total time of the entire dive.



3.2 Dive preparation

3.2.1 Replacement of CO_2 sorbent

Sorbent service life

Continually keep records of the extent of consumption of the scrubber cartridge. Set a stack time warning and don't forget to reset the stack timer after replacing the sorbent. If ever in doubt, replace the sorbent.

The recommended scrubber filling material is Sofnolime 797 sorbent (producer: Molecular Products). The cartridge holds approximately 2.5 kg of sorbent.

The maximum safe operating period of the sorbent is 168 min, determined by a test in accordance to EN 14143:2013 (Article 6.6.2). During the test 1.6 l/min of CO_2 were added to the breathing loop with ventilation of 40 l/min in water with temperature 4 °C, exhaled gas with temperature 32±4 °C, 40 m depth and limit at $ppCO_2$ 5 mBar (test provided by Life Support Test Facility – LSTF 0916). This is the worst case scenario and it considers a very high level of body exertion. Corresponding oxygen consumption is 1.78 l/min.

Typical oxygen consumption for scuba diving is from 0.4 l/min for a diver in rest using DPV (Smith, 2008) to 1.2 l/min for moderate work.

In normal conditions scrubber duration can be considered to range from 4 h in deep cold water with moderate work to 6 hours for an easy dive.

	O_2 consumption (l/min)	CO_2 production (l/min)	Scrubber duration (hh:mm)
Diver in rest	<0.5	<0.5	>8
Easy dive, experienced diver	0.8	0.7	6
Mild work	1.0	0.9	5
Moderate work	1.2	1.1	4
EN 14143	1.78	1.60	2:48

The physiological limit is not $ppCO_2$ 5 mBar, but ten times higher (Knafelc, 2000). A respiratory quotient 0.9 is too high; a more realistic estimate is 0.8-0.85. Sorbent service life is longer (or safety margin bigger) than previously stated.

In the course of the sorbent's service life, it is allowed to remove the scrubber cartridge maximum two times (see 92 CO_2 scrubber maintenance).

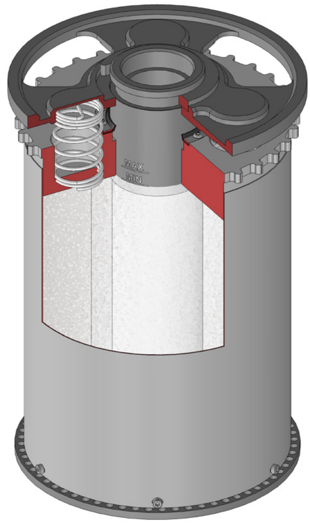
Sorbent replacement procedure

Handle the sorbent in accordance with the manufacturer's instructions. Comply with all safety instructions and use protective gear. Take environmental protection into account when disposing of used sorbent.

Remove all of the old sorbent content from the cartridge.

If you disinfect the rebreather, proceed according to 92 Cleaning and disinfection. However, it is preferable to disinfect after a dive rather than waiting for a longer period.

Place the scrubber cartridge on a clean surface. Handle it with clean, thoroughly washed hands. We recommend using disposable surgical gloves. Dirtying the cartridge can contaminate the breathing circuit and cause infection. A seemingly clean surface can be contaminated with microbes, especially in tropical and subtropical conditions.



If you cannot ensure the cleanliness of a surface, place the cartridge on a clean towel.

Follow these hygienic principles not only when filling the scrubber, but also when handling it in any way.

If you are working outside (recommended) and there is, at least, moderate wind, stand sideways to the wind and pour the sorbent slowly into the cartridge from a height of approximately 20-30 cm (1 ft). Allow the wind to remove the finest dust particles.

If you are working indoors, pour the sorbent into the cartridge from a minimal height. Sorbent dust is aggressive and can cause corrosion. Therefore, we do not recommend working with the scrubber inside of an automobile, for example.

In order to prevent the sorbent from falling into the central tube, place the lid of the sorbent canister on the opening or plug it by other suitable means.

Pour sorbent into the cartridge until it is approximately one-third full. Then gently lift the cartridge and allow it to fall three times from a height of approximately 1 cm (1/2″). Repeat this process when the cartridge is two-thirds full and again when it is completely full. The cartridge is completely full when the sorbent reaches a level between the min and max lines marked on the central tube.

After filling, close the lid and pressure plate with springs and press down. Then remove the pressure plate and lid and verify that the surface of the sorbent is levelled and that no channels have formed in it. Then close the lid and pressure plate with springs again, press down and secure the assembly with the retaining ring. The retaining ring must fit into the slot in the pressure plate.

If the cartridge is not filled sufficiently, a gap of less than 6 mm or no space at all will remain between the edge of the lid and edge of metal mesh. In such a case, add sorbent and then shake and close the cartridge according to the procedure described above.

If the cartridge is overfilled, there will be a gap greater than 17 mm between the edge of the lid and the edge of the metal mesh and it will not be possible to insert the retaining ring without excessive force. In such a case, remove the excess sorbent with a clean teaspoon or any other suitable tool. Shake the cartridge and close the lid again.

Before inserting the cartridge into the scrubber canister, check to ensure that the water trap is dry. If that is not the case, remove the water trap and dry it with a towel.

After each scrubber change, the stack timer Menu / Predive / Stack time reset must be reset

The stack timer measures the use of the scrubber by simply counting the time spent in the dive mode. You can adjust whether stack time is calculated on the surface or not.

Sorbent dust damages textiles, especially polyamide and cotton fabrics. Therefore, after working with the scrubber, immediately rinse the towel on which the cartridge was placed and all clothing that was exposed to sorbent dust.

Do not work with sorbent in the vicinity of load-bearing straps, ropes or even metal mountain climbing or speleological equipment. In the event of possible exposure to sorbent, ropes and load-bearing straps should be discarded immediately, as their load-bearing capacity can deteriorate significantly.

Condition of the scrubber before submersion

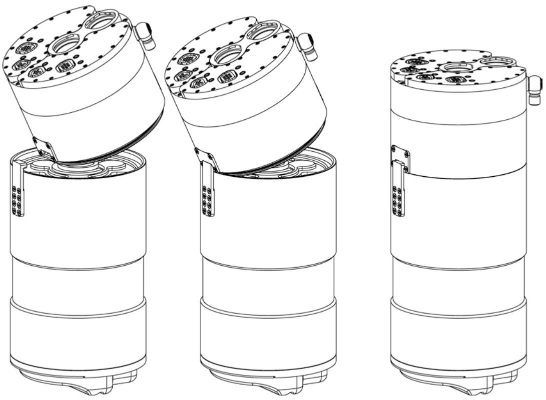
The scrubber must have sufficient absorption capacity for the planned dive.

The sorbent must contain moisture so that chemical reactions that enable the scrubber to remove CO_2 from the breathing mixture can take place. This means that it cannot be completely dry and cannot be frozen.

In freezing weather, stow the rebreather in a warm space prior to the dive. If you are outside with the apparatus and a delay happens, maintain the temperature of the sorbent by breathing from the apparatus.

3.2.2 Assembling the rebreather body

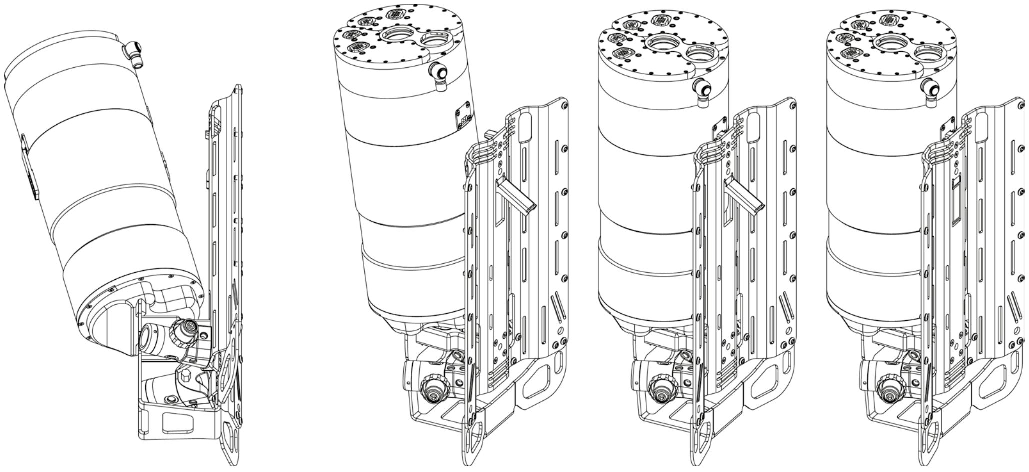
Mount the head on the CO_2 scrubber canister.



When mounting the head, push the scrubber canister pin into the opening on the head and close the head.

Press the head from above so that it is fully seated. If too much force is required to completely close the head, apply a small amount of lubricant to the O-ring on the neck of the head. You can also choose an O-ring with a smaller cross section diameter.

3.2.3 Mounting the rebreather body



Procedure:

1. Mount the body of the apparatus on the frame so that the recesses in the lower part fit into the protrusions on the base.
2. Lift the lever in the center of the backplate.
3. Press the rebreather body against the backplate so that the tongue in the upper part of the backplate fits into the recess in the head of the apparatus. If necessary, forcefully press the top of the head downward.

4. Press down the lever in the middle of the apparatus and check whether the lock is closed.
5. Check whether the apparatus is firmly attached.
6. Secure the body with the securing strap.

3.2.4 Attaching the counterlungs and hoses

The position of the counterlungs in relation to the diver's body determines inhalation and exhalation resistance and work of breathing. Adjust the position by shifting the upper strap on the back side of the counterlung.

Procedure:

1. Attach the counterlungs using the buckles so that the T-piece bulkheads are roughly at shoulder level and the flaps with Velcro are facing the center (toward each other).
2. Connect the manual diluent bypass valve to the lower bulkhead of the left breathing bag.
3. Connect the overpressure valve to the lower bulkhead of the right breathing bag.
4. Connect the manual oxygen bypass valve to the middle bulkhead of the right breathing bag.
5. Attach the inhalation T-piece (without the partition) to the upper bulkhead of the left breathing bag.
6. Attach the exhalation T-piece (with the partition) to the upper bulkhead of the right breathing bag.
7. Attach the terminal elbow of the inhalation (left) corrugated hose to the opening in the center of the head.
8. Attach the terminal elbow of the exhalation (right) corrugated hose to the opening on the edge of the head.
9. Screw the short oxygen hose to the 9/16″ elbow on the side of the head. Tighten the union nut firmly by hand.
10. Route the LP hoses to the ADV and to the manual diluent bypass valve and the HP hose to the diluent pressure gauge, so that they pass together over the shoulder strap from the outside to the inside of the strap.
11. Attach the ADV to the middle bulkhead of the left counterlung.
12. Attach the quick-release connector of the LP hose to the manual diluent bypass valve.
13. Straighten the hoses and secure them under the Velcro flap of the left breathing bag.
14. Route the LP hose to the manual oxygen bypass valve and the HP hose to the oxygen pressure gauge so that they pass together over the shoulder strap from the outside to the inside of the strap.
15. Attach the quick-release connector of the LP hose to the manual oxygen bypass valve.
16. Straighten the hoses and secure them under the Velcro flap of the right breathing bag.
17. Route the LP hose of the buoyancy control device (BCD) under the first rubber band on the corrugated inflator hose of the BCD, then under the rubber band on the left shoulder strap above the D-ring and finally under the second rubber band on the corrugated inflator hose.

18. Connect the quick-release connector to the inflator of the BCD.
19. Adjust the position of the BCD inflator hose so that it is easily accessible when diving.

For attaching devices to the connectors, see also 15 Corrugated hoses, 15 Connection to the breathing bags, 16 Inhalation bag and 17 Exhalation bag.

3.2.5 Tank filling

When filling the tanks with the breathing mixture, follow the procedures and rules with which you were familiarized in the course on blending mixtures for technical diving within your training system (trimix blender, etc.). If you have not successfully completed such a course, leave the blending of mixtures to a qualified person.

When handling oxygen, follow the procedures and rules with which you were familiarized in a course on diving with trimix and subsequently in a course on diving with the CCR Liberty. If you have not successfully completed such a course, do not handle the CCR Liberty.

Diluent

Choose the diluent to be able to flush high oxygen mix from breathing loop. Prepare the diluent so the partial pressure of oxygen will o 0,2 bar lower than the planned setpoint at the greatest depth of your planned dive. Partial pressure of nitrogen should not exceed 4 bars (3.2 bars are recommended).

Regarding to oxygen compatibility and cleanliness for oxygen service of the parts working with diluent, do not exceed the oxygen concentration of 21% (± 1%) in the diluent. Minimum oxygen concentration is 5%.

Contaminant content of the diluent should not exceed the limits given by the standard EN 12021 Section 6.2 for compressed air for a breathing apparatus.

Make sure that the diluent was filled by a compressor with properly maintained filters. Alternatively, you can use an additional personal filter. When using a compressor with a combustion engine, ensure that the exhaust gases from the engine cannot get into the compressor intake.

Mixtures with higher helium content are more advantageous for a number of reasons. A low O_2 mix on the surface and in small depths, with a lack of breathability, significantly increases risks.

After filling, write the mixture composition with a permanent marker on a label (piece of duct tape) and attach it to the tank.

The consumption of diluent depends on the dive profile, frequency and extent of depth changes. Diluent capacity is not limited by time but by the dive profile. This should be taken into account especially when planning dives in caves. Diluent is consumed mainly during the descent. During the ascent there is a zero theoretical consumption and any practical consumption is mainly due to mask clearing.

Based on a practical experience, the typical diluent consumption during a simple dive to a depth of 100 m is approximately 50 to 70 bars. It usually does not increase by staying longer at the same depth.

Always keep a sufficient safety margin (at least 50 bar) to cover unforeseen situations. If the pressure in the diluent tank is lower than 70 bars even a brief dive should not be started.

The standards according to which the CCR Liberty is CE certified and designated do not cover diving to depths greater than 100 m. Therefore CCR Liberty is CE certified to 100 m.

Oxygen

Use oxygen intended for breathing. Contaminant content of the oxygen shall not exceed the limits given by the standard EN 12021 Section 6.2 for compressed air for breathing apparatus

We recommend using oxygen with a purity of at least 99.5%.

Oxygen consumption for gas duration calculations is 1.78 l/min according to the EN 14143. When considering the initial tank pressure of 200 bar and a final pressure of 50 bar in the tank, the oxygen supply suffices for 253 minutes. In this calculation oxygen contained in the diluent is not considered.

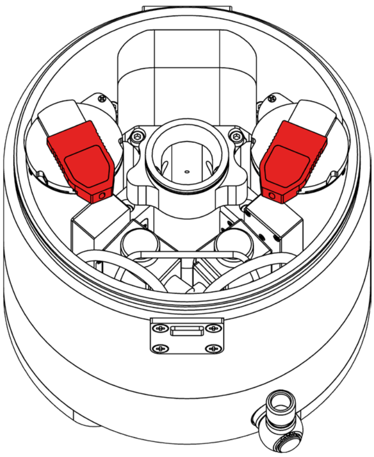
These conditions correspond to high levels of physical effort during a dive. If a diver is calm during a dive, consumption significantly decreases and the quantity of oxygen and the sorbent service life is extended. A dive plan, which relies on the fact that the whole dive will be in a low-effort, is wrong.

In any case an oxygen tank filled to 200 bars is sufficient for a dive which greatly exceeds the duration of the CO_2 scrubber.

If the pressure in the oxygen tank is lower than 70 bars even a brief dive should not be started.

According to the valid technical standards, filling oxygen to operating pressure greater than 200 bars is prohibited.

3.2.6 Battery charging



Before charging the batteries, remove the jumpers from the sockets.

We recommend charging the batteries to full capacity one week or less before diving. Before a brief dive (up to one hour), it is permissible to store fully charged batteries for up to one month.

Do not completely discharge the batteries before charging. The service life of the batteries is extended by frequent charging.

For charging the batteries, use the enclosed charger or any USB charger dimensioned to 2 A (most chargers used with vehicle power outlets are not sufficiently dimensioned). Fully discharged batteries require approximately eight hours of charging with the charger.

Charging from a computer's USB port is possible, though charging is done with a significantly lower current. The time required for charging fully discharged batteries in this manner is approximately 15 hours. Charging from a computer's USB port can be done via an adapter connected to the external connector of the handset.

In you prepare the CCR Liberty for diving no more than one week after charging, insert the jumpers so that their pins are inserted into the connector. The rebreather will thus be switched to standby mode and it will be possible to switch on the control unit using the handset. Otherwise, insert the jumpers in reverse position with the pins outside; in this position, the power supply is completely disconnected and the control unit cannot be switched on.

30 sec switch-off timeout is active during charging. The timeout is prolonged by pressing a button but not by tilting in editor. Don't alter the settings while charging because the unit may switch-off suddenly."

3.2.7 Helium sensor calibration

For proper helium measurement in the loop and indirect oxygen measurement, it is necessary to calibrate the helium sensors before the first use or if the measurement values are inaccurate.

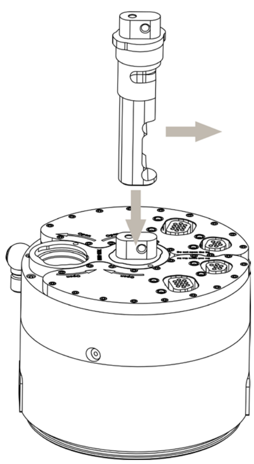
Before calibration, make sure that only the air and no other gas are present at the inlet chamber of the helium sensor (inside the head) and that the helium sensors are not contaminated with moisture.

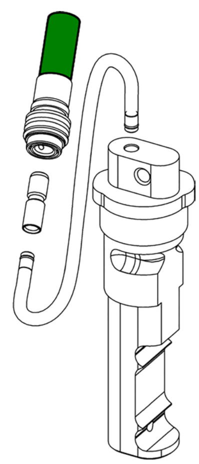
Select Menu / Setup / Calibration / Calibrate He – Air

The measured speed of sound should approximately be around 0.5500 ms. Start the calibration by pressing the start button. After the sensors stabilize, press the upper "Accept" button again

3.2.8 Calibration of the oxygen sensors

Insert the measuring jig into the inhalation opening (in the center of the head). The head can be, but does not have to be, mounted on the scrubber canister. Connect the flow limiter to the oxygen hose quick-release.





A hissing sound that accompanies the flow of oxygen can be barely heard in a quiet environment. The flow also becomes apparent on a moistened finger covering the discharge aperture. Connect the sampling tube between the flow limiter and measuring jig.

Procedure:

1. Start O_2 sensor calibration on HS in Predive → Calibration O_2
2. Wait for mV stabilization (this could take a while)
3. Start calibration
4. Save

Whether or not a sensor is already at the end of its service life is also determined during calibration.

At higher altitudes above sea level, the partial pressure of oxygen in the calibration mixture decreases in proportion to lower atmospheric pressure. The CCR Liberty measures atmospheric pressure and takes it into account during calibration. Therefore, do not perform any corrections at higher altitudes above sea level.

3.2.9 Preparing the bailout apparatus

The bailout apparatus must ensure a reliable return to the surface at any time during a dive.

The standard solution is to use a corresponding number of stage and decompression tanks with mixtures according to depth, distances and the bailout plan. For a deep diving backup it is recommended to use a mixture rich in He, regardless of the financial costs. The mixture will probably not be used for many dives. A higher content of He results in a lower negative buoyancy, which makes transporting the tank under water more convenient.

Preparation of the bailout stage tanks is similar to that of open-circuit diving with trimix. When planning and preparing, proceed according to the rules with which you were familiarized in a course on diving with trimix.

3.2.10 Setting parameters

Set or check the settings of all dive parameters.

For a detailed description, see 36 Setup.

3.2.11 Directional valve check

The purpose of this test is to detect possible leakage of the directional valves of the dive/surface valve (DSV). This kind of leakage could seriously endanger the diver. It is not possible to assemble the complete breathing loop in the wrong direction but the diver has to be sure that this part is not missing or leaking.

Procedure:

1. Put the bayonet socket cover on both T-pieces.
2. Cover the left (inhale) elbow.
3. Place the mouthpiece in your mouth, open DSV and try to inhale. Inhaling shouldn't be possible. The left corrugated hose collapses. Exhaling should be possible.
4. Close the DSV and check for leakage (the corrugated hose should stay collapsed).
5. Open the DSV, unplug the inhale elbow and cover the right (exhale) elbow with bayonet socket cover.

6. Inhale from the mouthpiece and try to exhale. Inhaling should be possible.
7. Pull the exhalation elbow to extend the corrugated hose on the right side. Check for leakage (the corrugated hose stay extended).

If some leakage occurs, change the directional valves or do not dive.

3.2.12 Physical inspection

Check to ensure that the CCR Liberty is complete, correctly assembled and mechanically undamaged.

If the CCR Liberty is operated within an organization where someone other than the diver is responsible for the physical preparation of the apparatus, we recommend the implementation of detailed organizational rules. An assembly checklist in editable form is prepared for download on the CCRLiberty.com website.

3.3 Pre-dive inspection

The pre-dive inspection (PDI) procedure can be started in surface mode. Testing is conducted immediately before the dive, after transport, with a fully assembled rebreather with the control units switched on.

To start the test select Menu/Predive/Predive check

The user confirms the results of the individual inspection steps:

OK — test result is positive top button

FAIL — partial test failure, but the other steps of the PDI will be performed normally bottom button

ABORT — premature termination of the PDI. Both buttons It is also necessary to use the ABORT command when a reparable defect is detected and the full PDI must be carried out again. The ABORT command is carried out automatically if the user does not respond to the prompt within two minutes.

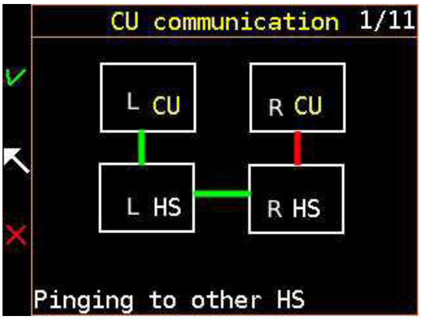
The results of testing are recorded in the log.

During the test, no oxygen is added. The user is warned before the test begins. This must be confirmed for the test to take place.

The result of testing is displayed to the user (the apparatus can/cannot be used for diving), but does not influence the subsequent behavior of the apparatus; in particular, it does not block the functions necessary for undertaking a dive (in accordance with the Responsibility of the CCR Liberty User set forth in the introduction). Ignoring the conclusions of the pre-dive inspection is the diver's choice, for which he/she bears responsibility.

3.3.1 Internal testing of the control units

A test of communication between the control units and the peripheral devices is automatically started at the beginning of the pre-dive inspection.

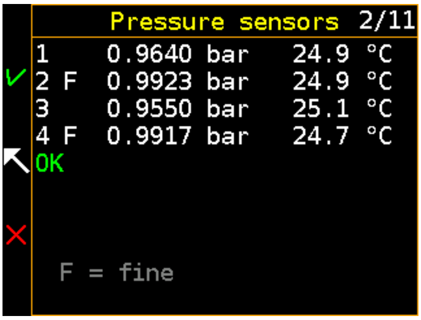


Testing is automatic. Confirmation by the user is required only in the event that the test result is negative.

If the individual elements of the system are connected correctly, a green line appears between them. If the connection has failed for some reason, or if part of the system is missing (for example, a disconnected handset), the line appears red.

3.3.2 Pressure sensor test

The system will display all pressure sensors that are arranged underneath and marked with letters C or F.



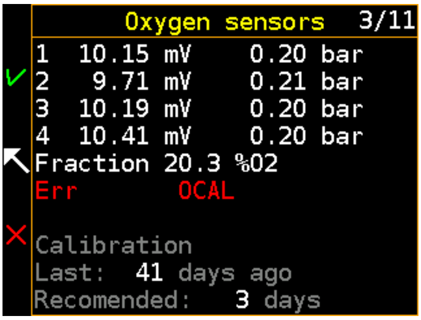
C – coarse. It is a coarse pressure sensor that measures the pressure from the water level to a depth of 300 m.

F – fine. A fine pressure sensor that measures atmospheric pressure and depths up to 10 m.

The purpose of the pressure sensor test is to determine whether the pressure sensor values correspond to the actual pressure (altitude) and do not show any significant deviations from the expected pressure or from each other.

3.3.3 Comparison of oxygen sensors and their calibration

The current values of the individual sensors are shown on the display in millivolts and the ppO_2 values are displayed in bars, using to the most recent calibration.



The purpose of the test is to verify that the oxygen sensors do not exhibit deviant voltage values, whether they are properly calibrated and that the calibration is not too old. During testing, keep in mind that sensors measure the actual value of ppO_2 in the loop. If testing is preceded by oxygen manipulation, this will be reflected in the sensor voltage.

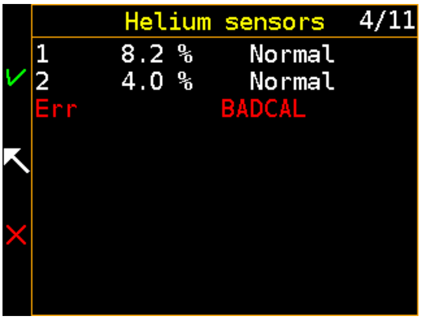
Sensor check

- some sensor is Offline or reports Error
- Online sensors are checked for minimum voltage, at least 5mV must be measured on air at sea level.
- the permitted tolerance between the largest and the smallest is 5%
- the calibration age must be less than the set value in the configuration

Setup / Calibration / Recomm. Days

3.3.4 Helium-sensor test

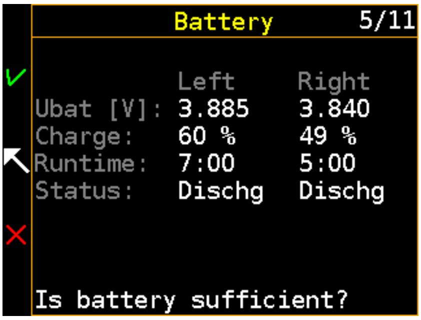
Functionality of the He-concentration sensors is performed. The user is informed of the ongoing test on the HS display.



The purpose of the Helium-sensor test is to detect if the sensors are calibrated or if they don't show wrong values. The picture shows bad or missing calibration detected during the test. The test is automatic. Confirmation by the user is required only in the event that the test result is negative.

3.3.5 Battery testing

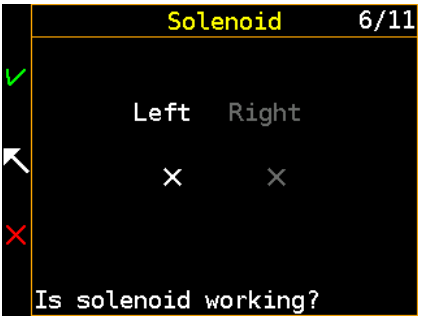
Both batteries are stressed with an artificial load caused by an intentionally increased power consumption by the processors, connected solenoids (without using energy-efficient control), vibration motors and the maximum brightness of the HS display. After completing the test, status of both batteries (%) and the estimated duration of the batteries in dive mode are shown.



The user then decides whether he/she considers the batteries' estimated duration to be sufficient for the planned dive.

3.3.6 Solenoid testing

The left solenoid is opened cyclically three times and closed with an interval of two seconds and with 1:1 duty cycle. The expected state of the solenoid is shown on the HS display. The right solenoid is subsequently tested in the same manner.



The test repeats cyclically if the user does not confirm the result or if automatic termination of the PDI does not occur due to the user's inactivity.

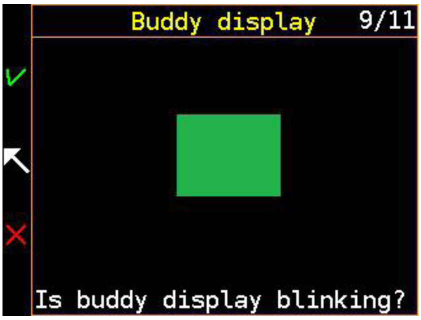
3.3.7 HUD inspection

The diodes light up in blue, red and green successively in three steps. At the same time HS displays which colors should light up on the HUD. Three different color combinations are displayed three times so that each of the three colors of the RGB spectrum is tested.

The test repeats cyclically if the user does not confirm the result or if automatic termination of the PDI does not occur due to the user's inactivity.

3.3.8 BD inspection

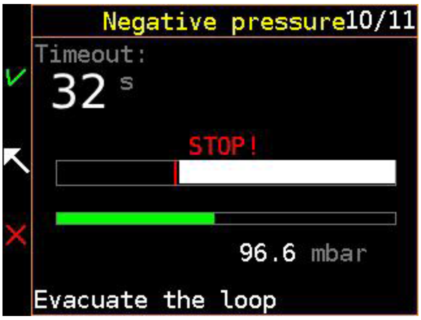
The buddy display successively lights up in green at low, medium and high intensity, then in red at low, medium and high intensity. A symbol with the same color is at the same time displayed on the HS; intensity is indicated by the size of the symbol.



The test repeats cyclically if the user does not confirm the result or if automatic termination of the PDI does not occur due to the user's inactivity.

3.3.9 Negative pressure test

The purpose of this test is to detect possible leakage in the breathing loop, which appears when the pressure in the loop is lower than the ambient pressure.



The test is conducted immediately before diving, after transport, with a fully assembled rebreather.

Procedure:

1. Close the diluent and oxygen tank valves.
2. Open the DSV and create sufficient underpressure with your mouth according to the indication on the HS display. The negative pressure is indicated by a white bar graph. For sufficient leakage testing, it is advisable to develop such a negative pressure that the white bar graph will cross over the green field.
3. Close the DSV and cease all movement with the rebreather; in particular, do not move the bags and breathing hoses. After closing the mouthpiece, place the breathing hose loosely on the device. Movement of the breathing hoses and lungs causes volume changes that are manifested by changes the pressure in the loop and distorting the measurement results.
4. Wait 60 seconds; the countdown runs automatically on the display.
5. The test can be considered successful if the under-pressure loss after 60 seconds is less than 10 mbar (do not count the initial pressure change into this, as it is caused by the change of length of the hoses)

Final evaluation of the test and confirmation of the result are left at the user's discretion.

See also Chapter 103 Detection of leaks.

Note: In spite of the positive result of the under-pressure test, leaks may occur during the dive. This is most often caused by a loose or punctured rubber mouthpiece.

3.3.10 Positive pressure test

The purpose of this test is to detect possible leakage in the breathing loop, which appears when the pressure in the loop is higher than the ambient pressure.

Procedure:

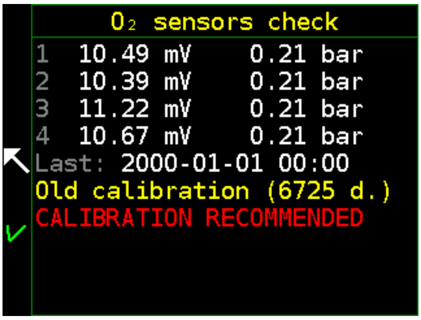
1. Close the oxygen tank valve, open the diluent tank valve.
2. Close the DSV and close the overpressure valve.
3. With the manual diluent valve, create sufficient overpressure according to the indication on the HS display. It is also possible to do this using your mouth if you want to conserve gas in the diluent cylinder. If you want to set the device straight to the higher setpoint, pressurize the loop with oxygen.
4. Cease all movement with the rebreather; in particular, do not move the bags and breathing hoses.
5. Wait 60 seconds; the countdown runs automatically on the display.
6. The result is influenced by the opening of the over-pressure valve, which is set to max. 35 mbar. If you notice a leakage of pressure above this value, verify that it is only the over-pressure valve and the leakage has no other source. Below the set limit of the over-pressure valve, the pressure should no longer fall.

Final evaluation of the test and confirmation of the result are left at the user's discretion.

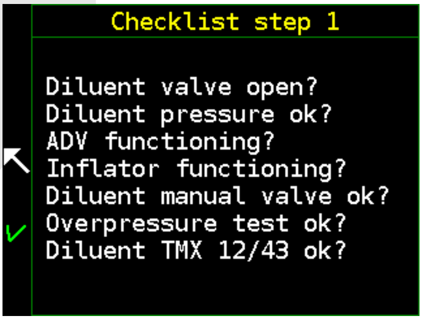
See also Chapter 103 Detection of leaks.

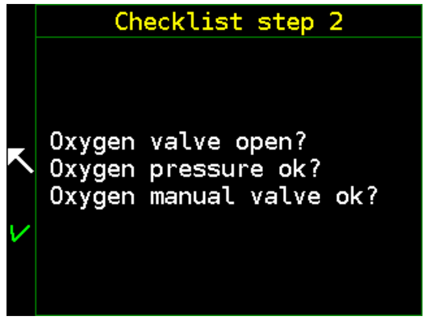
After finding and repairing the leaks, you must repeat all the pressure tests. For this you can use Menu / Predive / Pressure tests which skips all the sensor, battery and solenoid test and starts the pressure tests right away

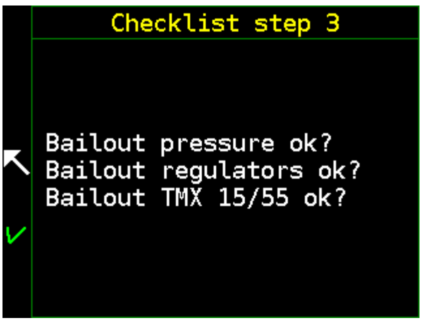
3.3.11 Predive checklist

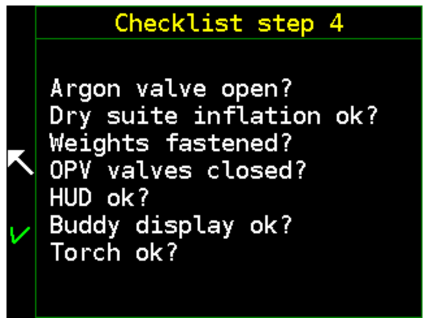


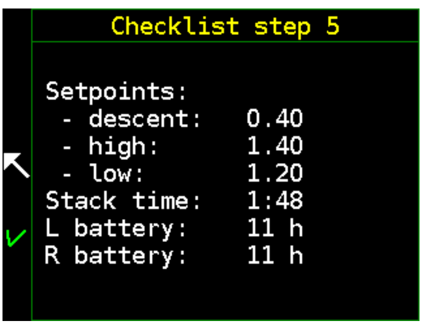
Upon entering the Dive Mode the unit automatically checks the oxygen sensors and their calibration, and in case old calibration or sensor deviations of more than 10%, a warning is issued along with a recommendations for re-calibration. Then follow the checklist. The diver is required to personally verify all the items listed.

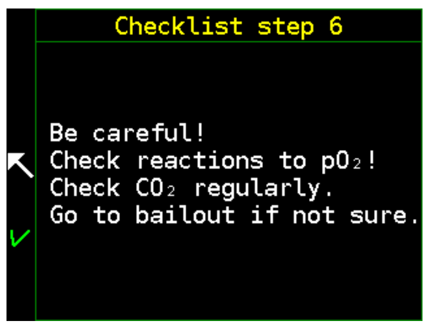








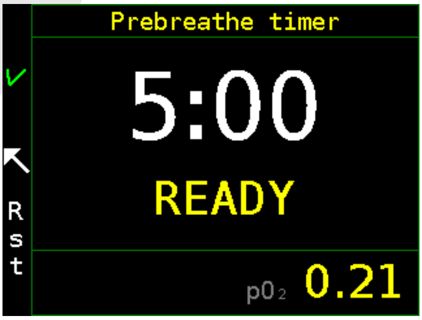


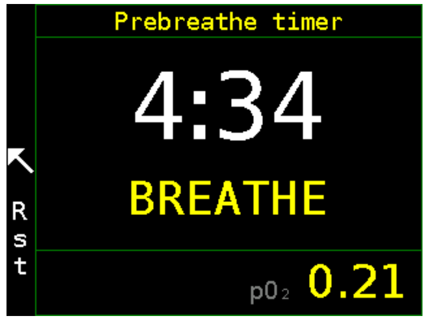


3.3.12 Prebreathe

Pre-breathing of the device has a major impact on the safety of the dive. We strongly recommend performing pre-breathing at least every time you assemble your device (before the first of a series of dives within one day), preferably before each dive. Pre-breathing is not related to the start of the scrubber's chemical reaction but to **the verification of the important functions of the device before the dive, in particular the ability of the device to**

maintain ppO_2 at the setpoint and the function of the absorber. While the first function can be easily verified by observing oxygen sensors during breathing from the instrument, testing the absorber functionality should only be performed under the conditions listed below and follow the reactions of the body. Even after a 5-minute pre-breathing of the instrument, it is not guaranteed that a poorly filled or missing absorber has been detected.





Procedure:

1. Ensure that the setpoints are reached in the loop so that overheating does not lead to excessive oxygen addition that distorts the test result.
2. Before starting the test select a safe place to sit for the duration of the test to avoid injury in case of loss of consciousness.
3. Put the mask on your face and keep it on throughout the entire test period to prevent the intake of ambient air through the nose, thereby compromising the accuracy of the test
4. Start breathing from the device and start the countdown on the handset
5. Monitor the partial pressure on the second handset and the behavior of all oxygen sensors
6. Make sure you breathe comfortably, that your breathing does not stop, and that there are no feelings of breathlessness, nausea, headache, or other unusual conditions
7. After finishing the test with a positive result, you can start the dive.

Warning: If you are pre-breathing in temperatures below freezing point, under no circumstances should you stop breathing from the unit up until full submersion. When you are not breathing from the unit you are risking your scrubbers interstitial space freezing, hindering its functionality.

3.4 Diving

3.4.1 Breathing high oxygen content gases

The mixture in the CCR Liberty circuit usually contains oxygen at much higher partial pressure than the air we breathe on the surface.

Acute (CNS) oxygen poisoning

Exposure to high oxygen partial pressure may under certain circumstances cause acute (CNS) oxygen poisoning. This may cause the affected person to drown.

The so called "oxygen clock" is a percentage of consumption of CNS toxicity limit. Limit the maximum partial pressure and total exposure so that acute oxygen toxicity cannot occur, according to the following NOAA table.

NOAA oxygen exposure limits

ppO_2 (bar)	Maximum Single Exposure (minutes)	Maximum per 24 hr (minutes)
1.60	45	150
1.55	83	165
1.50	120	180
1.45	135	180
1.40	150	180
1.35	165	195
1.30	180	210
1.25	195	225
1.20	210	240
1.10	240	270
1.00	300	300
0.90	360	360
0.80	450	450
0.70	570	570
0.60	720	720

Whole body oxygen toxicity

Long term exposure to oxygen partial pressure higher than 0.5 bar, common when using the CCR Liberty, leads to whole body (also known as pulmonary) oxygen poisoning. At exposures common to amateur technical diving, whole body toxicity symptoms are not significant. During rebreather diving, however, the diver is exposed to a relatively high partial pressure of oxygen throughout the dive, unlike with open circuit, and exceeding the whole body toxicity threshold is real danger.

For very long dives or a series of rebreather dives it is necessary to calculate with long-term exposure limits and to limit the overall exposure.

The main symptom of chronic toxicity is a temporary reduction in vital lung capacity. Another symptom may be nearsightedness (hyperoxic myopia). Symptoms may persist for several months.

When $ppO_2 \geq 1.4$ bar then the CNS toxicity limit is always shorter than the pulmonary toxicity limit.

For calculations related to chronic toxicity use the REPEX method that you know from the nitrox diving course. The CCR Liberty does not perform calculations associated with chronic oxygen toxicity.

3.4.2 Putting on the apparatus

After the pre-dive inspection, set the CCR Liberty on its stand on a hard surface – on the ground, a bench or table, or in a vehicle's cargo space. Properly secure the rebreather so that it cannot fall, for example by having a partner hold it.

Procedure:

1. Flip the breathing bags and corrugated hoses with the DSV to the opposite side of the rebreather's body.
2. Position yourself under the shoulder straps.
3. Put on the shoulder straps, ideally with both arms at the same time.
4. Stand up on both feet. Due to the weight of the CCR Liberty, avoid rotating your spine, which could lead to injury. When standing up from the ground, carefully assume a kneeling position and then stand up.
5. Take the crotch strap up between your legs and pass the belt buckle through the eye of the crotch strap.
6. Gently tighten the belt and fasten the belt buckle.
7. Flip the breathing bags and corrugated hoses with the DSV to the front.
8. Attach the breathing bags to the crotch strap V-straps with the buckles.
9. Make sure that all of the straps are adequately tightened and are not twisted.
10. Secure the handsets to your wrists. Ensure that the HS's cables are wrapped around your arms.
11. Ensure that the HUD is attached to the DSV and its cable is wrapped around the corrugated hose.
12. Check the accessibility of the BCD inflator.

3.4.3 Using the DSV

The DSV must be closed at all times when it is not in your mouth. Close it before taking it out of your mouth; open it after putting it in your mouth and clear the DSV before inhaling.

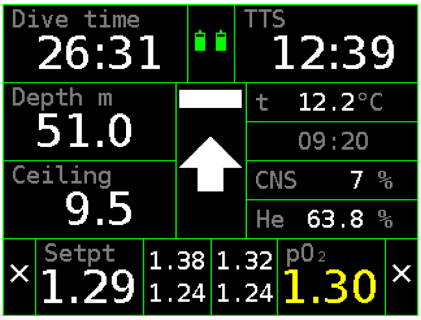
Always exhale into the mouthpiece before inhaling from the mouthpiece under water.

Opening the DSV when it is not in your mouth will cause an immediate loss of buoyancy and could possibly flood the breathing loop.

3.4.4 Monitoring of devices

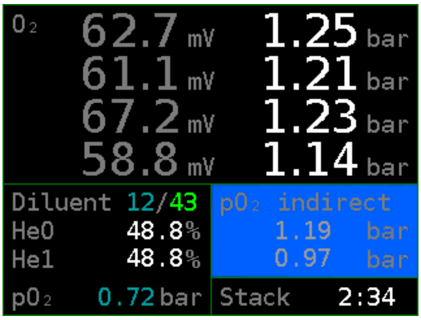
Partial pressure of oxygen

You must know the concentration of oxygen (ppO_2) in the breathing loop at all times. Learn to use the HUD for continuous monitoring as it allows you to concentrate on other tasks.



Always know your ppO_2!

Check the partial pressure of oxygen on the handset display at regular intervals as well. If the values from various sensors differ, check whether any of the sensors is coming to the end of its service life.



Pay extra attention to the ppO_2 reading when significantly changing depth.

Do not rely solely on the alarm indicating reduced partial pressure of oxygen.

Reduced partial pressure of oxygen is also signaled on the buddy display. Familiarize your diving partners with the BD signals so that they will be able to recognize in time that you need help.

For monitoring ppO_2, it is not enough to monitor the average value of all sensors, which is highlighted by a larger font. All sensors must be monitored, either on the main display of the handset or on the screen of all sensors. In case of doubt about the correct measurement of one or more sensors, compare the indirect oxygen measurement values with helium sensors (only if the helium fraction in the diluent is greater than 20% and helium measuring is allowed through the settings). These values can be found on the sensor voltage screen.

Another option is a diluent flush (the correct performance of which is a part of the CCR Liberty Diver course) after which you compare the result with the value in the lower left corner on the sensor voltage screen. This gives the ppO_2 diluent at the current depth. The sensor, which after a diluent flush corresponds to the displayed value, can be considered valid. Pay attention if you are using a hypoxic diluent at a low depth.

The system can automatically disable one or two sensors. Always keep your common sense and make sure the discarded sensors are really the wrong ones and not the other way round.

Oxygen and diluent pressure
We recommend checking the pressure of oxygen and diluent approximately once every five minutes.

Compared to an open-circuit apparatus, the oxygen and diluent tanks have a small volume. Even a minor leak can cause rapid loss of pressure. Therefore, it is necessary to check the oxygen and diluent pressure gauges (SPGs) more frequently than when diving with an open circuit.

3.4.5 Switching to CCR mode

In surface mode, bring up the menu and switch to CCR mode.

Perform an inspection according to the displayed checklist.

3.4.6 Water entry

Do not enter the water without having performed a pre-dive inspection according to Chapter 77 Pre-dive inspection!

We recommend breathing from the rebreather for at least three minutes right before entering the water in order to make certain that the scrubber and the rest of the apparatus are working properly.

In freezing weather, do not allow the scrubber to cool down after transferring the rebreather from a warm environment. Limit the rebreather's exposure to freezing air. If necessary, keep the sorbent warm by breathing from the rebreather.

We recommend gradually entering the water and submerge the rebreather slowly.

If it is necessary to jump into the water, preferably use the “giant stride” method, whereby your legs and buttocks impact the water first, thus protecting the breathing bags and corrugated hoses from direct impact. When entering the water in this manner, have the DSV in your mouth; have it closed at the moment of entry. Sudden entry into the water must be supervised by a person qualified to provide assistance in the event that problems arise.

Perform a bubble check after entering the water. Due to the small volume of the oxygen and diluent tanks, minor leaks in the high-pressure and low-pressure parts, which are tolerable in open-circuit diving, can lead to a rapid decline of pressure in the tanks.

3.4.7 Submersion

For submersion, use the compensator (BCD) to control buoyancy.

Choose the amount of ballast with respect to the possible change of weight during a dive. Do not overload yourself to facilitate submersion. Unlike in open-circuit diving, weight reduction due to consumption of gases is minimal. The possible use of the open-circuit bailout apparatus has a more significant impact on weight reduction. Determination of the correct amount of ballast is one of the skills that you will learn in a course on diving with the CCR Liberty.

3.4.8 In-water check

Verify the ppO_2 control system and adjust buoyancy.

Perform a bubble check with your diving partner. Scan all parts of the breathing loop in the direction of the gas flow. Rotate horizontally using the “helicopter turn”.

Check your bailout source. Take a few breaths from the bailout bottle to see if the regulator is easily and quickly available and functional. Check the pressure in the bailout cylinder.

3.4.9 Descent

During the descent, the ADV adds diluent to the breathing loop; you can also add diluent manually. Diluent is added to the inhalation bag. During a rapid descent, the mixture delivered to the DSV is practically identical to the diluent.

If you use diluent with low oxygen content (e.g. when starting a descent to a great depth), it is necessary to significantly limit the descent rate. Continue this until you reach a depth where the ppO_2 in the diluent exceeds 0.2 bar. It is also possible to isolate the ADV and administer the diluent manually for maximum control over the injected hypoxic diluent.

Do not descend rapidly in order to reach the depth at which the mixture is breathable. Low partial pressure of oxygen in the loop leads to significantly faster loss of consciousness than if you descend while holding your breath. Do not take this risk.

Upon completion of the descent, it is possible to isolate the ADV to accurately maintain the optimum loop volume.

3.4.10 Controlling buoyancy and trim

When diving with a rebreather, buoyancy cannot be controlled by breathing as in open-circuit diving. Since you are breathing within a closed loop, there is no effect on the overall buoyancy.

Buoyancy, including minor corrections is controlled with the compensator.

For a very small, temporary increase of buoyancy (e.g. when swimming over an obstacle), instead of using the compensator, you can add a small amount of diluent into the breathing loop and breathe using the top of your lungs. Though this method is convenient, it also leads to a greater consumption of oxygen and diluent. Remember: swimming around an obstacle is better than swimming over it.

Keep balance corrections to a minimum by using other sources of buoyancy, such as a dry suit. The increased difficulty of controlling several sources of buoyancy would overload the diver with tasks.

The optimum trim of the diver is horizontal, even for descending and ascending. During the course on diving with the CCR Liberty, you will find the optimum ballast position. Do not use a weight belt.

When training to achieve the correct balance and trim while breathing continuously, try to remain motionless and not change depth or body position for several tens of seconds.

A backup source of buoyancy is always needed when diving. This can be a dry suit, disposable ballast or, for example, a lift bag.

3.4.11 Mask clearing

When diving with a rebreather, a significant portion of the mixture consumed during a dive can be lost when clearing the mask. Therefore, keep mask clearing to a minimum.

3.4.12 Increased physical exertion

The CCR Liberty adds oxygen to the breathing loop as needed. Unlike with some mechanical rebreathers, increased physical exertion does not lead to a reduction of the partial pressure of oxygen.

In the case of longer physical exertion, check the pressure in the oxygen tank frequently.

Take increased physical exertion into account for your decompression planning.

Increased effort also causes larger CO_2 production. In addition to shortening the life of the scrubber, increased CO_2 production, along with reduced ventilation, due to gas density, has a significant effect on the increase in arterial CO_2. This phenomenon causes a greater susceptibility to oxygen toxicity, nitrogen narcosis, increased tissue saturation with nitrogen (due to vasodilatation). There is also the risk of acute hypercapnia. Avoid increased strain in depth.

3.4.13 Ascent

Under normal conditions, i.e. when ascending at a rate of less than 15 m/min., with a setpoint at minimally 0.8 bar and a normal functioning apparatus, a decline of the partial pressure of oxygen (ppO_2) below the limit value of 0.16 bar does not occur.

If inadvertent rapid ascent occurs in a small depth, pay greater attention to the ppO_2. It is possible that a short-term decline will happen, but this will be automatically corrected with of two to three inhalations.

Before starting an ascent, check to ensure that the oxygen tank valve is open.

During the ascent, expansion of the mixture in the breathing circuit occurs due to the reduction of ambient pressure. It is necessary to expel the excess breathing mixture. The overpressure valve on the exhalation (right) counterlung is used for this purpose. Open the overpressure valve completely. Some divers consider it more convenient to expel excess breathing mixture via the nose through the mask. Do not expel excess mixture via the mouth around the mouthpiece as doing so increases the risk of water leaking into the breathing circuit.

3.5 Post-dive procedures

3.5.1 Immediately after surfacing

Close the DSV, put the rebreather in a suitable place, close the tank valves and switch off the control units.

If a stable, firm and level surface is available, set the rebreather up on its stand and take measures to prevent it from falling.

If you are in the field, where it is not possible to place the rebreather on its stand, lay it down.

When handling the rebreather, focus particular attention on protecting the corrugated hoses against damage.

As a general rule, it is necessary to dry out the water trap after every dive or at least at the end of the diving day. Detach the head, remove the scrubber cartridge, remove the water trap and dry it with a paper towel. With another paper towel, also dry the exterior surface of the cartridge.

The head should be left to dry to ensure proper functionality of the oxygen and helium sensors. Helium sensors are sensitive to moisture and condensation. The moisture condenses directly inside the sensor as well and therefore is vital to dry out your head properly after diving.

This is important to ensure a long lifetime and functionality of your sensors.

In areas or periods with increased humidity, we strongly recommend using the optional DIVESOFT Head drying fan.

3.5.2 CO_2 scrubber maintenance

If the sorbent capacity is sufficient, with reserve for the next planned dive and it will not be necessary to disinfect the rebreather until the next dive, it is possible to reinsert the scrubber cartridge into the canister and leave it in the rebreather. You can leave the scrubber canister opened for a maximum of 24 hours if stored in a dry place. Mount the dry head and close the breathing loop openings for longer storage. We recommend using the “DIVESOFT scrubber cover with stickers”. It is advisable to write the date of the first filling and the times of the individual dives on which the scrubber was used. After changing the sorbent, change the label. Do not store used and closed scrubber for more than 30 days after first use.

3.5.3 Cleaning and disinfection

When in use, the rebreather's breathing loop is colonized by microorganisms from the diver's respiratory tract and from the external environment. The purpose of regular cleaning and disinfection is to prevent the multiplication of these microbes to an extent that would pose a hazard to the user and to prevent the transmission of infection between various users.

Not more than a week may pass from the first dive after disinfection until the next disinfection if the CCR Liberty is stored in a cool place. When storing the rebreather at a temperature higher than 25 °C, this interval is shortened to four days; the weekly interval can be maintained only for the scrubber cartridge. It does not matter how many dives you undertake during the stated period.

Disinfection is always necessary before changing users of the CCR Liberty. Never lend (or borrow) a rebreather that has not been disinfected! Transmission of infection can happen with a single inhalation. An infected user will not necessarily have any symptoms of infection.

Start cleaning by rinsing the assembled rebreather with clean fresh water. Disassemble the rebreather into its individual parts.

Procedure:

1. remove the ballast.
2. unscrew and detach the oxygen and diluent tanks, insert watertight stoppers in the regulator inlets.
3. remove the HUD from the DSV.
4. remove the breathing bags with corrugated hoses from the head.
5. remove the ADV, manual valves and overpressure valve from the breathing bags.
6. detach the breathing bags from the harness.
7. remove the head with the attached handsets and HUD.
8. remove the CO_2 scrubber from the cartridge and dispose of it safely.
9. remove the scrubber canister from the backplate and remove the water trap.

Put the head with control units in a clean, cool and dry place.

Prepare the antiseptic solution in a suitable vessel. The vessel must be clean and free of all mechanical and chemical impurities. For example, a child's bathtub, a mortar tub (a new, previously unused one) or large Tupperware container is suitable for disinfection.

For ordinary disinfection, use Mikrobac forte antiseptic in 0.5% concentration. Follow the instructions when working with the antiseptic agent.

Rinse with clean fresh water and place the tube, water trap, corrugated hose assembly with open DSV, breathing bags and CO_2 filter in the tub. Manipulate the corrugated hose assembly and the DSV to expel air so that the antiseptic solution fills the entire space (this necessary skill is part of the CCR Liberty training course). Completely fill the breathing bags with the antiseptic solution.

If you have noticed (either visually or by smell) mold growth, it is necessary to perform thorough disinfection and to clean the surfaces also mechanically. Most surfaces can be wiped with a rag soaked in the antiseptic solution; use a bottle brush (reserved specifically for this purpose) to clean the inner surfaces of the corrugated hoses.

Leave the parts in the antiseptic solution for one hour. Then remove them, rinse with clean fresh water and allow to them dry. Do not dry the parts in direct sunlight.

When more intensive disinfection is required, use a more highly concentrated solution (maximum 2%) or leave the parts in the antiseptic solution for a longer time (maximum four hours).

Instead of Mikrobac, it is possible to use a different antiseptic agent based on quaternary ammonium salts that is compatible with the materials from which the CCR Liberty is manufactured. The CCR Liberty's manufacturer does not guarantee the compatibility of antiseptic agents other than Mikrobac forte. In any case do not use chlorine-based agents.

In normal circumstances, the head, ADV, manual bypass valves and overpressure valve does not need to be disinfected.

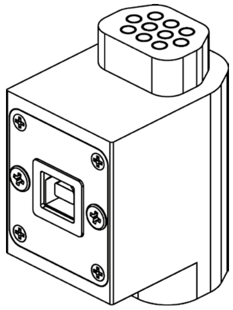
In the event of increased requirements for disinfection, the oxygen sensors can be removed from the head and the remaining parts disinfected by washing them with the antiseptic solution. The ADV, manual bypass valves and overpressure valve can be disinfected by submerging them in the antiseptic solution.

The antiseptic solution is highly toxic to aquatic organisms. Dispose of it in an environmentally friendly manner.

3.5.4 Battery care

Prevent complete discharging of the batteries. If possible, charge the batteries after every diving day.

3.5.5 Dive log download



After disconnecting the handset and attaching a multipurpose USB connector to the handset connector on the head (without the connected handset), the CCR Liberty's dive-record memory is accessible via the USB interface in mass storage mode. This means that for the computer to which the USB cable is connected, it appears as an ordinary flash drive with restriction to read only. Records of individual dives are stored as separate files in the divelog folder.

The control unit (CU) features the possibility to insert a micro SD card. Such card is installed by the manufacturer in CU and a separate dive log, which is not dependent on the CU's memory, is stored on it. The card's capacity is sufficient for storing detailed logs throughout the apparatus's service life, though the diver can delete logs from the card according to his/her needs. The card is generally accessed in the same manner as accessing a mass storage device via a USB cable, though in the case of damage to the CU, the micro SD card can be removed from the connector on the control-unit board and the dive log can be read using an ordinary reader.

Logs are generally worked with in the cloud at www.wetnotes.com.

3.5.6 Long-term storage

Before storing the rebreather for a period longer than one week, proceed according to 92 Cleaning and disinfection.

If the CCR Liberty is stored in a dry and clean environment, do not connect the corrugated-hose assembly with the DSV to the head or to the breathing bags and store the rebreather open. Dust occurs even in an environment with the same level of cleanliness as the home environment. Limit accumulation of dust by, for example, covering the unit with a washed cotton bed sheet. Store the detached corrugated hose assembly in a suitable container that will not prevent complete drying.

If you store the CCR Liberty in an environment with a lower degree of cleanliness, store it assembled and closed (without sorbent). Such an environment with a lower degree of cleanliness may be, for example, a home with pets.

Before putting the closed rebreather in storage, all parts must be thoroughly dried, including all creases in the corrugated hoses and the interior surface of the bags.

Charge the batteries at least once every six months.

If, after storing the unit for more than a month, you find that moisture persisted inside the apparatus or you can smell mustiness or mold from the corrugated hoses, it is necessary to disinfect the apparatus again.

When storing the rebreather, make sure that no rubber parts (hoses, cables) are pinched or compressed.

Ensure that no other objects are leaned against the rebreather. Secure the rebreather against falling.

3.6 Emergency procedures

Prevent the occurrence of emergency situations through high-quality training. Do not exceed the limits of your diving qualification. Carefully adhere to the prescribed procedures before, during and after every dive. In the event that prior to a dive you discover a problem associated with the rebreather and you are not able to resolve it, do not dive with the rebreather, regardless of the severity of the problem.

3.6.1 Emergency ascent (bailout)

Whenever diving with the rebreather is necessary to wear a backup breathing apparatus.
A common type of backup device is a standard stage bottle.

If, during a dive, a malfunction occurs in the CCR Liberty that you are not able to resolve or precisely identify, or if you even have a suspicion that something is wrong with the rebreather, switch to the bailout breathing apparatus:

1. put the bailout breathing apparatus in the standby position,
2. exhale into the circuit and close the DSV, but hold a sufficient amount of the mixture in your lungs for removing water from the mouthpiece of the bailout apparatus,
3. Perform the standard procedure associated with starting breathing from the bailout apparatus, e.g. for stage tanks, check to be sure that you are breathing from the correct stage tank.

If you subsequently resolve the rebreather malfunction or if you determine that the cause of the problem is outside the rebreather, you can resume breathing from the rebreather.

After switching to bailout OC mode, the safety level is automatically set using the bailout gradient factors (BoGF). It is possible to switch between the standard and bailout GF sets in the menu without affecting the mode in which the CCR Liberty is operating.

Knowledge and skills related to the use of the stage bottles are among the entry requirements necessary for everyone interested in diving with CCR Liberty. In the CCR Liberty diving course, accredited by manufacturer, the use of stage bottle in the role of backup breathing apparatus is thoroughly practiced.

3.6.2 Oxygen-source malfunction

Low pressure in the oxygen tank

In this case it is necessary to terminate the dive.

It is necessary to switch to the bailout breathing apparatus no later than when the partial pressure of oxygen in the circuit falls below 0.3 bar.

If this situation arises due to a lack of thoroughness when preparing for the dive or due to failure to regularly check the pressure during the dive, please consider whether diving with a rebreather represents too great a risk for you.

Solenoids have stopped delivering oxygen

If the partial pressure falls significantly below the setpoint but there is still sufficient pressure in the oxygen tank, use the manual bypass valve to add oxygen.

Add oxygen gradually, with short presses. Breathe regularly. Oxygen is delivered to the exhalation bag. It takes several inhalations before the oxygen in the scrubber blends with the breathing mixture and reaches the sensors on the inhalation side.

If the situation persists, control the delivery of oxygen manually. In a stabilized state, invariable depth and with a low level of exertion (slow swimming), it is necessary to add oxygen approximately once or twice per minute.

This malfunction does not pose an immediate threat to the diver. However, do not continue in your descent or penetration. Start your return and ascent.

Manual O_2 bypass valve free-flow

Disconnect the quick-release. Disengaging the quick-release connector causes a disruption of the oxygen delivery via the manual bypass valve.

This malfunction does not pose an immediate threat to the diver. However, do not continue in your descent or penetration. Start your return and ascent.

Manual bypass valve does not function, oxygen is not added after pressing
This malfunction does not pose an immediate threat to the diver. However, do not continue in your descent or penetration. Start your return and ascent.

Oxygen delivery does not function by means of either the solenoids or manual bypass valve
In this case it is necessary to terminate the dive.

It is necessary to switch to the bailout breathing apparatus no later than when the partial pressure of oxygen in the circuit falls below 0.3 bar.

3.6.3 Diluent-source malfunction

Low pressure in the diluent tank
In this case it is necessary to terminate the dive. During the ascent, the diluent in the circuit expands and thus replenishes its volume in the circuit. If possible, do not increase depth during your return.

As long as the volume of diluent in the circuit is sufficient, it is possible to breathe from the rebreather. If it is not sufficient, it is necessary to switch to the bailout breathing apparatus.

Bear in mind that in this case it is not possible to perform the standard procedure for high ppO_2 (flushing out the loop, adding diluent) and that such a situation can be resolved only by immediately switching to the bailout breathing apparatus, which you should therefore have in standby position.

ADV free-flow
Close the ADV by sliding the collar. This causes a disruption of the diluent delivery via the ADV.

This malfunction does not pose an immediate threat to the user. The dive can continue with manual addition of diluent to the circuit.

Manual bypass valve free-flow
Disconnect the quick-release. Disengaging the quick-release connector causes a disruption of the diluent delivery via the MBV.

This malfunction does not pose an immediate threat to the user. The dive can continue with automatic delivery of diluent into the circuit using the ADV. Manual delivery of diluent can be accomplished by pressing the ADV.

Manual bypass valve does not function, diluent is not added after pressing
This malfunction does not pose an immediate threat to the user. The dive can continue with automatic delivery of diluent into the circuit using the ADV. Manual delivery of diluent can be accomplished by pressing the ADV.

Neither the ADV nor the manual bypass valve functions
If the diluent pressure gauge indicates sufficient pressure, a malfunction in the first stage of the diluent regulator has likely occurred and it is no longer possible to add diluent to the circuit.

In this case it is necessary to terminate the dive. During the ascent, the diluent in the circuit expands and thus replenishes its volume in the circuit. If possible, do not increase depth during your return.

If the volume of diluent in the circuit is sufficient, it is possible to breathe from the rebreather. If it is not sufficient, it is necessary to switch to the bailout breathing apparatus.

Bear in mind that in this case it is not possible to perform the standard procedure for high ppO_2 (flushing out the loop, adding diluent) and that such a situation can be resolved only by immediately switching to the bailout breathing apparatus, which you should therefore have in standby position.

3.6.4 Scrubber malfunction

If you need to breathe rapidly, with excessive frequency that does not correspond to your level of exertion, this is a possible cause of an increased concentration of carbon dioxide in the circuit due to a scrubber malfunction. You may also be afflicted with nausea, a headache and confusion.

On the contrary, another possible cause of similar symptoms is psychosomatic hyperventilation and reduced content of carbon dioxide in the blood and other bodily tissues. This usually occurs due to increased mental stress, such as when the diver is confronted with task overload.

If the symptoms are severe, immediately switch to the bailout breathing apparatus, as there is a risk of loss of consciousness. As soon as possible, take several slow, deep breaths from the backup apparatus. Of course, you should never allow such a situation to progress to the stage of severe symptoms.

If you experience discomfort when breathing but the symptoms are not so severe as to pose a risk of unconsciousness, test the concentration of carbon dioxide in your blood. Stay where you are without moving; do not in any case change depth significantly. Try to hold your breath for ten seconds.

If you are unable to hold your breath or you can do so only with great difficulty and with a tremendous, intense urge to inhale, it is apparent that the scrubber is not functioning (premature depletion of the sorbent, occurrence of channels in the sorbent by which air circumvents the scrubber) or there is a mechanical malfunction that has caused air to not pass through or to only partially pass through the scrubber (malfunction of the directional valve on the mouthpiece, joining of the inhalation and exhalation sides outside the scrubber). Switch to bailout and terminate the dive.

If holding your breath does not cause problems, the scrubber is working properly. Over the next several minutes, limit all other activity and concentrate on slow breathing.

3.6.5 Inadvertent release of the mouthpiece

When the mouthpiece falls out of the diver's mouth, the DSV has a tendency to float. However, its connection to the breathing bag prevents it from floating beyond the diver's reach.

If it falls out, it is necessary to immediately return the mouthpiece to your mouth. If the mouthpiece is returned quick enough, a significant amount of water will not have entered the breathing loop.

If this problem is not solved quickly, then the loop would flood. In this case proceed according to the following chapter 3.6.6 Flooding.

There may be a strap (bungee cord) holding the DSV which prevents the mouthpiece from accidentally falling out. Adjust the length of the bungee by shifting the knots.

3.6.6 Flooding

The probability of significant flooding of the breathing circuit is very low. After carefully assembling the apparatus and performing the prescribed pre-dive procedures, flooding can be ruled out unless there is a major disruption of the breathing loop's integrity due to mechanical damage. In the event of significant flooding, it is necessary to immediately switch to the bailout breathing apparatus and to use the compensator (BCD) to prevent loss of buoyancy.

Do not inhale if the mixture from the rebreather's DSV contains fluid. In extreme cases, this could contain a so-called caustic cocktail, i.e. a caustic mixture with dissolved lye from the sorbent.

A smaller amount of water can enter the circuit through the open DSV when the mouthpiece falls out of the diver's mouth. In such a case, water gets into the exhalation bag. Though this does not represent an immediate danger, it is advisable to expel water from the exhalation bag with the overpressure valve as soon as the opportunity arises. Open the overpressure valve completely. In order to avoid a significant change of buoyancy, deflate the buoyancy compensator. Add diluent to the circuit with the manual bypass valve. Assume a position that brings the overpressure valve to the lowest point of the exhalation bag. Expel the water from the bag by exhaling and pressing on the bag with your hand.

3.6.7 Loss of buoyancy

The compensator (i.e. buoyancy control device or BCD) is the basic tool for controlling buoyancy. If the compensator is not functional, use other means of attaining buoyancy.

If the compensator's capacity does not suffice or if it is not possible after a malfunction to fill it with an inflator or orally, use your dry suit to attain buoyancy. The CCR Liberty user must have sufficient knowledge and skill to safely use a dry suit as a backup source of buoyancy.

If it is not possible to attain sufficient buoyancy by using the compensator and dry suit and if, at the same time, there is no other appropriate option, jettison the ballast. If it is not necessary to completely jettison the ballast, try to attain buoyancy by first jettisoning the ballast on the left side and then, if necessary, on the right side. Jettisoning ballast on the left side helps to bring the dry-suit release valve and the compensator's inflator in a position suitable for deflation.

Jettisoning ballast is a skill that, in addition to agility and mobility, requires training under the supervision of an instructor in a CCR Liberty diving course.

3.6.8 Rescue on the surface

When assisting an injured CCR Liberty user on the surface, it is possible to increase buoyancy by jettisoning the ballast.

Even if the diver's life is in serious danger and it would be necessary to jettison all equipment during the rescue buoyancy should be ensured by closing the DSV, inflating the compensator wings and jettisoning the ballast. Complete removal of the CCR Liberty and any other equipment attached to the harness can be time consuming. Sufficient buoyancy provided by CCR Liberty can aid the ongoing rescue procedure.

3.6.9 Malfunction of oxygen-concentration measuring

If the chemical oxygen sensors are not functional (in excluded, disabled, error or offline state, see 60 Faulty sensors) and a trimix is used as the diluent and the helium sensors are functional, then the CCR Liberty can be switched to indirectly determining the ppO_2 using the measurement of the helium content. See 23 Measurement of He content.

Consider this as an emergency procedure only. Use it only when it is not possible to proceed according to 96 Emergency ascent (bailout).

3.7 Maintenance

Maintenance operations, including necessary technical information, are described in the maintenance manual. In the user manual, only basic maintenance operations that every CCR Liberty user should master are described.

Use only oxygen-compatible lubricant for the maintenance of parts that come into contact with oxygen under pressure.

3.7.1 Tools and replacement parts

Your toolbox for resolving problems in the field should contain:

- Surgical gloves
- Roll of paper towels
- PE bag for storing the scrubber cartridge
- DSV mushroom valves (2 pcs)
- Mouthpiece
- Tightening straps
- Oxygen-compatible lubricant
- 2.5 mm and 3 mm hex keys
- #1 Phillips screwdriver
- Tool for removing O-rings (O-ring pick, plectrum, bamboo toothpick)

- Adjustable wrench
- Duct tape
- Permanent waterproof marker for writing on duct tape
- Set of O-rings

3.7.2 Detection of leaks

If the source of a leak is not apparent, we recommend using overpressure to the find the leak.

Leakage can generally be found by submerging the entire rebreather or a part in water while exerting pressure in the breathing loop. It is also possible to find leaks by applying a soapy solution on a certain area.

After eliminating the problem, negative and positive pressure tests must be repeated.

3.7.3 Regular service inspection

The CCR Liberty requires yearly service inspections (maximum 12 months) or after 150 hours of usage, whichever occurs first.

Service inspections must be performed by a service technician certified by Liberty Systems or performed by the manufacturer. The replacement of components and the inspection process are determined by the manufacturer's guidelines valid at the time of inspection.

3.7.4 Long-term maintenance

Oxygen sensors

When the oxygen sensors are calibrated, their degree of wear is checked. Of course, sensors can suddenly reach the end of their service life even during a dive, especially in an environment with high partial pressure of oxygen. Therefore, we recommend replacing the sensors no later than one year after putting them into operation or maximally 18 months after their date of manufacture.

However, the sensors may, despite good handling, exhibit deviations or be limited even during their recommended life. For this reason, we recommend using the DIVESOFT Oxygen sensor tester kit regularly to test the linearity of the sensors. It's the only accurate and safe way to detect a faulty or current limited sensor.

It is not necessary to discard replaced sensors. Even though a sensor's degree of wear prevents it from reliably measuring higher partial pressures of oxygen in the rebreather, it will often suffice for reliable measuring of lower partial pressures of oxygen when preparing mixtures.

Hoses

If any hose shows signs of excessive wear or if damage is detected during a bubble check (see 89 In-water check), replace it. If mechanical damage does not occur as a result of careless handling, hoses should be replaced during a regular service inspection.

The service life of hoses is maximally five years from the date of putting them into operation and maximally seven years from the date of production.

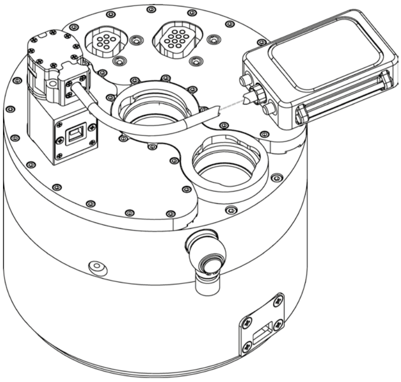
Straps

Harness straps are highly durable. A strap that has been damaged on the edge should only be replaced in case that it was cut to more than one-third of its width.

Straps are generally replaced for aesthetic reasons. You can order a replacement when ordering a regular service inspection.

3.7.5 Firmware update

The CCR Liberty's electronics have two different types of firmware (FW): one for the control unit, the other for the handset. It is possible to download the current version from the support page at www.CCRLiberty.com. Perform FW updates with respect to maintaining CE certification according to the description on the support page. Perform updates with the head removed from the rebreather's body.

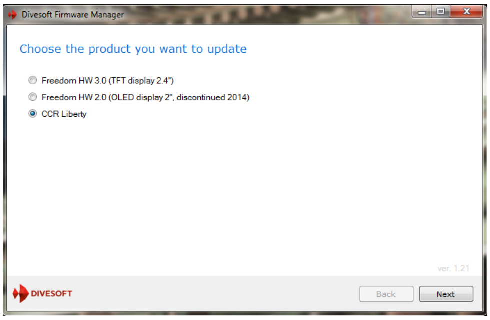


To upgrade your new firmware, use the dektop software "Firmware manager", which you can download at https://ccrliberty.com/support/firmware. The firmware manager takes you step by step through the complete firmware upgrade process. Firmware manager is compatible with Mac OS and Windows 7 or higher.

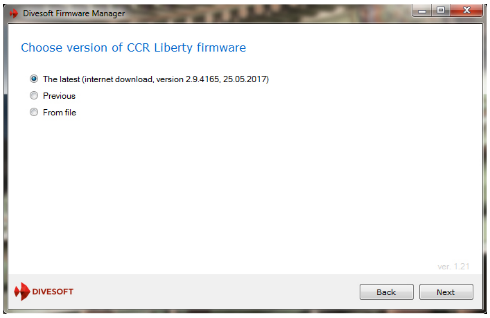
You will need:

Liberty head, both handsets, 3mm allen key, multi-purpose USB connector and a USB AB cable (same as the cable used for printers).

Open the Firmware manager on your personal computer and select CCR Liberty and press Next. If you have your Liberty already connected, the system moves automatically to the next step.

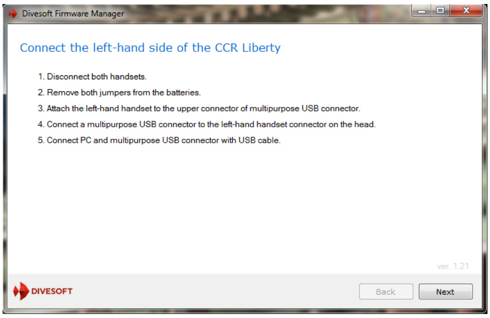


Select the desired firmware version. If you choose the latest firmware version available, the program downloads the firmware version itself. You can also, in exceptional cases, upload one of the older development versions of the firmware (not recommended). If you are not connected to the Internet and have a firmware file on your hard drive, you can choose the latest “From file” option and locate the file on your computer.



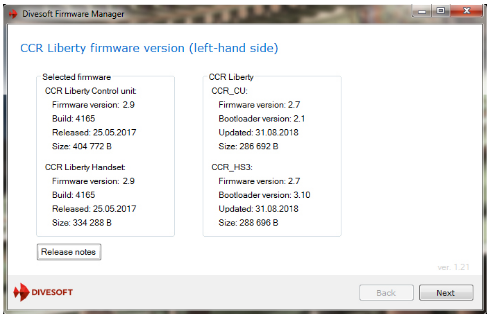
Follow the instructions on your computer screen.

1. Disconnect both handsets
2. Remove both jumpers from the batteries
3. Attach the left handsetu to the upper connector of multipurpose USB connector
4. Connect a multipurpose USB connector to the left handsetu connector on the head



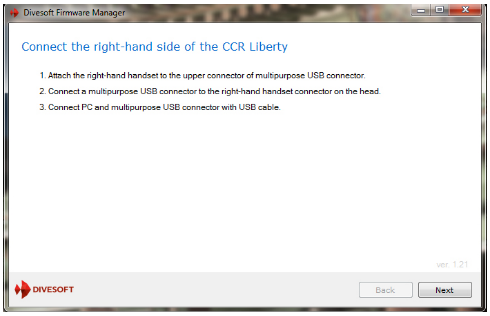
Connect PC and multipurpose USB connector with USB cable.

Check the firmware version you are going to upload to your device. In the left column you can see the selected firmware, in the right column the current firmware build in the control unit and in the handset is displayed.



Once the left side is successfully uploaded, follow the instructions on your computer screen again.

1. Attach the right handset to the upper connector of multipurpose USB connector
2. Connect a multipurpose USB connector to the right handsetu connector on the head
3. Connect PC and multipurpose USB connector with USB cable.



Next, press "Next".

Once the firmware is successfully uploaded, reconnect both handsets

After performing an update, pay close attention to the correct functioning of the CCR Liberty, especially when diving. Do not perform an update immediately before an extreme dive. If you update the FW before embarking on an expedition-type event, we recommend that you také with you a multipurpose USB connector, a USB cable and a notebook with an installed and setup DSLoader and that you have an older version of the firmware available.

3.8 Transport

3.8.1 By car

Transport the CCR Liberty in the case in which it was delivered. Secure the case against unrestricted movement in the vehicle's cargo space.

The dustiness of the sorbent increases when transported in its loose state in the distribution canister. It is better to transport sorbent in the scrubber cartridge.

3.8.2 By boat

On a dive boat, it is usually possible to fasten the apparatus to a bench.

For securing the rebreather, use a line of approximately 1.5-2 m with secure knots. Tie the apparatus to a suitable structure.

Secure the ready-to-dive CCR Liberty by passing the line over the tanks and backplate, with the scrubber canister pressed to the back of the bench.

If you need to prepare the CCR Liberty for diving while onboard a boat, secure it using the holes in the upper part of the backplate to the back part of a bench. This will give you full access to the tanks for filling and you can easily remove the head and scrubber canister.

3.8.3 By plane

Pressure tanks

Airline regulations generally require that all transported pressure tanks should be empty with valves dismounted. Place the valves in clean PE bags (Ziploc) and place duct tape over the neck to prevent contamination. It is possible that security personnel will want to look inside the tanks; therefore, it is not appropriate to use tight plugs that cannot be removed without tools.

When checking your luggage at the airport, notify the airport personnel that you have empty pressure tanks in your luggage. Depending on local regulations, it is possible that you will have to take the tanks to a special counter.

Consider whether it might be better to rent pressure tanks at your destination. Dive centers equipped for closed-circuit diving usually have available tanks that can be used with the CCR Liberty. If you want to pre-arrange tank rental, which is highly recommended, refer to the size specifications available at www.CCRLiberty.com.

When traveling by plane, it is advisable to separate the head of the device and transport it in the hand luggage. You will significantly reduce the weight of your luggage and you will have the most expensive and sensitive part of your device under constant vigil. Be prepared to explain to airport staff that this is a vital part of a modern diving gear and that you have this manual with you.

Sorbent

The sorbent canister should be empty. If you are also transporting a supply of sorbent, it must be in the original packaging or in an appropriately sturdy and airtight container. Familiarize yourself with the valid regulations concerning the air transport of sorbent. Consider the possibility of purchasing sorbent at your destination.

Head

For the purposes of air transport, the batteries must be disconnected by removing or turning the battery jumpers. Do not transport the CCR Liberty in standby mode.

SGS

Certificate GB14/92281, continued

Liberty systems, s.r.o.

EC Directive 89/686/EEC

EC Type-examination

Issue 1

PPE Product

CCR Liberty - a closed circuit electronically controlled rebreather with a maximum operating depth 100 m. The device incorporates over the shoulder mounted counterlungs, a radial scrubber, two controller/handsets, head up display, automatic diluent valve with an inline isolation valve, manual 02 addition, manual diluent addition and an intergrated wing style buoyancy control device. The device is required to be used with an autonomous bailout system in accordance with the manufacturers user information notice

It is certified that the manufacturer's technical file and the above mentioned PPE have been assessed and found to be in accordance with the requirements of Council Directive 89/686/EEC. When examined the PPE satisfied the relevant requirements in the harmonized standard,

EN 14143:2013

The manufacturer's information notice (CCR Liberty Dated 27 November 2014), in English, has been inspected and found to have addressed all of the relevant requirements of the standard. However, the detailed content of the information notice is the responsibility of the manufacturer, as are translations into other languages.

This certificate is issued on the strict condition that appropriate checks on manufactured PPE, as detailed in Article 11 of the directive, are implemented and maintained while the model is in production.

Certification is based on technical file reference: CCR Liberty Technical file dated 8th September 2014,& supplemental Documents..

SGS Reference Number GB/PP 233262

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SGS

Certificate GB14/92282

The management system of

Liberty systems, s.r.o.

K Haltýři 756/14, Praha 8, 180 00, Czech Republic

has been assessed and certified as meeting the requirements of

Directive 89/686/EEC

Article 11B

For the following activities

Manufacture of self-contained re-breathing diving apparatus.

Note: All products marked CE0120 must have a valid EC Type Examination Certificate issued under Article 10.

This certificate is valid from 09 December 2017 until 21 April 2019 and remains valid subject to satisfactory surveillance audits. Issue 3. Certified since 28 November 2014

Authorised by

SGS United Kingdom, Notified Body 0120
United 202B Worle Parkway, Weston-super-mare, BS22 6WA, UK
t +44 (0) 1934 522917 f +44(0) 1934 522137 www.sgs.com

SGS CE 11B 1215

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SGS

Certificate GB14/92281

Liberty systems, s.r.o.

K Haltýři 756/14,
Praha 8,
180 00,
Czech Republic.

It is certified that the manufacturer's technical file and the PPE product detailed on page 2 have been assessed and found to be in accordance with

EC Directive 89/686/EEC

EC Type-examination

This certificate is valid from 28 November 2014
Issue 1. Certified since 28 November 2014

Authorised by

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SGS EC 03 1011

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Liberty User Manual

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www.CCRLiberty.com

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Use of this manual approved by

Lucie Šmejkalová, CEO

EC Type-examination for Directive 89/686/EEC by

Notified bodyNo.0120,

SGS United Kingdom Ltd.

Unit 202b, Worle Parkway, Weston-super-Mare, BS22 6WA, UK.

Product manufactured by

Divesoft, s.r.o.

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LIBERTY USER MANUAL

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