



Rebreather Safe Diving Practices

The collective experience of the members of the Rebreather Working Group has led them to feel it necessary to highlight to BSAC members that: -

- Although all divers are interested in developing technology it must be clearly understood that a meticulous approach to both diving equipment and diving practices must be taken when diving with any form of rebreather.
- Open circuit experience is not a replacement for experience using rebreathers. A new rebreather diver effectively becomes a diver under training and must again build and practise skills progressively and be fully aware of the inherent dangers in going beyond the limitations of their rebreather training and experience.
- The diving, training and general rebreather experience and diving enjoyment gained by using a semi-closed rebreather can also become a safe progressive route into the use of closed circuit rebreather diving.
- Although some rebreathers, particularly closed circuit rebreathers, can be used to dive deeper and longer than the BSAC recommended limits we emphasise that this requires training over and above that of entry level rebreather training and is outside BSAC's current recommendations as a sports diving organisation.
- All diving carries an element of risk and the use of rebreathers increases that risk if the guidelines laid down by the manufacturers and BS-AC are not adhered to rigidly when preparing and diving a rebreather

In order to promote the safe integration of rebreathers within recreational branch diving, this BSAC publication Rebreather Safe Diving has been produced and represents the BSAC recommended practices for safe rebreather diving. This publication is available from BSAC HQ or on the BSAC Web site.

Alternative Air Source

It is recommended that all rebreather Divers should carry an Alternative Air Source (AAS).

An open circuit regulator should not be connected to the Oxygen cylinder of a closed circuit rebreather.

The BSAC strongly recommends a separate air or Nitrox supply (with an appropriate MOD that allows use at any stage of the dive) and with its own regulator assembly, is carried by a rebreather diver to support an unplanned assisted ascent. This cylinder should have sufficient capacity to provide adequate gas to allow bailout at any stage of the dive. In the case of a CCR this bailout should be carried off-board in addition to the diluent cylinder of the standard CCR. Should further advice regarding equipment configuration / training be necessary, please contact the BSAC Rebreather Chief Instructor.

Note: The diluent cylinder of a CCR could be depleted by changes in depth, mask clearing or having been used for previous dives. A fully redundant (off-board) system should ensure that

there is sufficient gas available if the rebreather diver or buddy has a problem with insufficient gas or a faulty first stage on the (inboard) diluent cylinder.

Ascent

A rebreather diver should ascend slowly to allow proper venting of the breathing loop and to avoid becoming positively buoyant.

A slow controlled ascent is also important to avoid a drop in the Partial Pressure of Oxygen (PPO₂) in the breathing loop to hypoxic levels when diving a closed circuit rebreather (CCR). Therefore, it is recommended to return to a shotline / fixed datum for ascent whenever possible.

A SCR diver should flush the breathing loop before commencing an ascent, to ensure the PPO₂ is at a maximum.

Bailout

A bailout cylinder is required to provide an open circuit back-up should a failure occur with the rebreather. The gas carried in the bailout cylinder should be breathable at all stages of the dive i.e. air or Nitrox with an appropriate MOD. The capacity of this supply should suit the depth of the dive being undertaken; neither a 3 litre inboard diluent cylinder nor a 3L pony cylinder are considered an adequate bailout for dives greater than 20 metres. In the case of a CCR this bailout should be carried off-board in addition to the inboard diluent cylinder of the standard CCR. This bailout source could also be used for AAS ascents.

For any dive plan incorporating limited decompression, in accordance with the diver's qualifications, the rebreather diver should have an adequate bailout plan and carry the necessary independent bailout gas to be able to carry out the bailout plan.

Batteries

Any batteries in a rebreather should be changed or charged at the recommended intervals.

Boats

Increased care must be taken when manoeuvring a boat in the vicinity of rebreather divers as they produce no or very few obvious bubbles.

Be aware that a rebreather diver may surface unexpectedly especially just after the initial descent. The boathandler should therefore patrol the dive site at a safe distance to enable an unplanned ascent by the rebreather diver.

The rebreather diver should deploy a delayed SMB before surfacing unless they are returning up a fixed buoyed line.

The suitability of a boat as a diving platform and also the stowage possibilities for the rebreather to ensure adequate protection of rebreather units (e.g. hoses and cylinder valves) should be considered

Breathing

It is recommended that rebreather divers make a conscious effort to breathe freely and normally. Many open circuit divers skip breathe, whether consciously or unconsciously. This practise will lead to CO₂ retention and is highly dangerous when applied to rebreathers.

Pre-dive breathing checks should occur prior to entering the water.

Bubble Check

As early in the descent as possible but no deeper than 6m, a bubble check shall be performed to identify potential leakage.

Buddy Diving

It is important to ensure the rebreather diver is partnered with a buddy who can assist them in the event of a problem. Therefore, the BSAC recommends that the;

- The buddy should be preferably another rebreather diver diving the same rebreather,

If the buddy will be an open circuit diver then;

- Buddy of a rebreather diver (whether SCR or CCR) should be, as a minimum, an experienced Sports Diver with their DO's consent
- The DO (or DM acting on behalf of DO) should ensure that the Sports Diver who will buddy a rebreather diver is;
 - experienced under the current diving conditions (i.e. site and weather)
 - capable of recognising the conditions of hyperoxia, hypoxia and hypercapnia
 - capable of performing a rescue (CBL and surface support) on the rebreather diver in the case of an emergency
- The buddy of any rebreather diver should wear a redundant configuration if diving deeper than 20 m. The capacity of this redundant supply should suit the depth of the dive being undertaken.
- The buddy should carry a D-SMB (or SMB as appropriate) and at least one other surface detection aid
- The buddy check procedure must be modified to accommodate the rebreather layout especially the shutdown operation of the mouthpiece.
- Buddies should have preferably attended a BSAC Rebreather Awareness Course,
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Buoyancy

Rebreather divers should ensure they have sufficient buoyancy to be supported on the surface with a flooded breathing loop.

Checklist

The BSAC recommends that the rebreather diver prepare their equipment by using a checklist.

CO₂ absorbent material

It is imperative that the manufacturer's recommendation regarding the type of absorbent material(s) to be used is followed.

It is imperative that the manufacturer's recommendation regarding duration is followed.

Absorbent shall be stored and disposed of according to the manufacturer's instructions.

Cylinder Pressures

The dive shall commence with sufficient gas to conduct the planned dive in all cylinders directly connected to the rebreather and the divers shall return to the surface with not less than 50 bar reserve in any cylinder.

Cylinder pressures should be regularly monitored throughout the dive.

Decompression

The training currently performed by the Technical Agencies incorporates minimal decompression diving in the entry level courses, which teach the use of nitrox as the breathing gas in rebreathers to a maximum depth of 40metres. Subsequently,

BSAC recommends that when diving a rebreather for dives involving decompression, the maximum planned decompression requirement should not exceed 10 minutes and involve a stop depth not deeper than 6 metres. In all cases, the planned decompression should not exceed that permitted by the unit manufacturer and/or the Training Agency Certification held by the Rebreather diver.

In addition BSAC recommend that;

- The decompression shall be planned and conducted using an appropriate decompression tool;
- A rebreather diver planning a decompression dive must have a bailout plan & carry adequate independent bailout to carry out the bailout plan;
- The decompression planned shall be conducted in accordance with BSAC publication Safe Diving and the rebreather diver's Training Agency recommendations
- The decompression plan should represent the worst case decompression requirement of the buddy pair

The addition of a safety stop is considered good diving practise, if allowed for in the dive plan. Bailout to open circuit occurring near the No Decompression Limits (NDL) can cause the diver to require some decompression. Ensure that the bailout plan caters for this eventuality.

Delayed Surface Marker Buoy (D-SMB)

A D-SMB (or fixed SMB when appropriate) is an essential piece of safety equipment to be carried by a rebreather diver to indicate their intent to surface in open water when not ascending a fixed buoyed line.

Furthermore D-SMBs can be used effectively as a surface detection aid.

The D-SMB should preferably have an independent means of inflation.

Depth

All rebreather diving in BSAC branches shall be conducted to a maximum depth of 40 metres.

Descent

When diving a closed circuit rebreather, ensure a slow descent so that diluent addition, buoyancy control and the control of the Partial Pressure of Oxygen (PPO₂) in the breathing loop can all be managed without task loading.

Diluent

The diluent gas in a closed circuit rebreather should be air.

The use of a Helium mixture as a diluent is not recommended.

Diluent addition

The BSAC firmly believes that all rebreathers should be designed and manufactured as standard with an automatic diluent valve (ADV) to minimise the task loading to the rebreather diver during descent. Examples of such CE approved rebreathers with an ADV are the Dräger Dolphin.

The subsequent retrofit or addition of an ADV to a rebreather must be a manufacturer approved (or performed) modification that does not invalidate the CE approval of the manufactured rebreather.

Dive Marshal

The dive marshal or deputy dive marshal should have:

- Minimum qualification of Nitrox Diver / Advanced Diver
- Preferably attended BSAC Rebreather Awareness Course

Must know the following information:

- Dive plan (i.e. time and direction)
- Max ppO₂ setting and planned MOD
- Surface detection aids carried
- Size and content of all tanks (diluent, oxygen and additional bailout)
- Remaining duration of scrubber material
- Maximum duration of Nitrox tank (excluding 50 bar reserve)

Dive Pairing	CCR + CCR	CCR + SCR	CCR + Nitrox or Air	SCR + Nitrox or Air
Max depth	current experience of user to a max of 40 m or 35m max if SD user	MOD of SCR mix to a max of 40 m or 35m max if SD user	MOD of Nitrox mix to a max of 40 m or 35m max if SD user or buddy	MOD of Nitrox mix to a max of 40 m or 35 m max if Sports Diver user or buddy
Max ppO₂	1.3 bar	CCR: 1.3 bar & SCR: 1.4 bar	CCR: 1.3 bar or open circuit: 1.4 bar	1.4 bar
Dive Time	Limited by any of the following; remaining scrubber duration, CNS toxicity, maximum of 10 minutes planned decompression time per buddy pair, or cylinder size			

Dive Planning and Organisation

In addition to the normal considerations the dive plan should consider:

- The qualification and experience of the chosen dive buddy
- The 40 metre depth limitation for rebreather divers
- The maximum operating depth (MOD) of the Nitrox mix for the semi-closed rebreather or open circuit buddy
- Maximum decompression time of 10 minutes according to qualification of rebreather diver – this limit will be the worst case plan for the buddy pair
- Avoidance of moving water due to increased task loading and possible unexpected depth changes.

Dive planning shall be based upon an appropriate dive planning tool such as the BSAC Nitrox tables, appropriate Nitrox computers or dive planning software.

Discuss your intended dive plan with your buddy and inform the Dive Marshal of your intentions.

Diving Conditions

Any situation liable to cause increased stress on the diver (and equipment) should be avoided. Examples are heavy seas or strong tidal conditions.

First Aid

Always consider the role of the rebreather in First Aid following a DCI incident within the diving party. A rebreather allows prolonged oxygen enriched air to be made available to the conscious casualty.

However, the use of the rebreather should be considered a back-up measure. The first preference would be dedicated oxygen administration equipment (oro-nasal mask); then the

rebreather (high oxygen content but via a mouthpiece) and finally using nitrox (lower oxygen content and via a mouthpiece). The only time oxygen should not be given is when the casualty is showing symptoms of hyperoxia.

Flow Rate

When using a Semi-Closed Rebreather (SCR) the flow rate and Nitrox mix recommended by the manufacturer for the planned dive should always be used.

The flow rate should be tested prior to every dive to ensure it is within the manufacturer's prescribed limits.

Gas Mixtures

BSAC only recommends the use of an air diluent (as per Entry Level CCR training) so consequently BSAC branch diving using trimix in rebreathers is not approved.

Although pure oxygen is carried implicitly within the CCR rebreather, BSAC does not support the use of 100% oxygen in the breathing loop or for open circuit bailout. The majority of diving incidents reported annually still relate to poor buoyancy control and if using 100% oxygen the margin for error in buoyancy control at a 6m stop (the recommended stop depth for BSAC Tables) is minimal. European sea conditions often providing a 2 –3 m swell can also further complicate the situation.

BSAC recommends that the Buddy Inspiration rebreather diver should change to a low set point (default of 0.7 bar) prior to ascending shallower than 6m to avoid use of higher oxygen mixes in the breathing loop and to simplify buoyancy control in the shallows.

Gas Reserve

The rebreather diver should carry enough gas reserve to return to the surface at any point of the dive following a problem to themselves or their buddy, this should cover the eventuality of open circuit bailout. Divers should plan their gas consumption in order to surface with a minimum of 50 bar reserve in each cylinder connected directly to the rebreather.

Hygiene

Always aim to disinfect the breathing loop in accordance with the manufacturer's recommendations.

Logbook

The BSAC recommends that a rebreather diver keep a logbook for their rebreather detailing any routine checks or maintenance or any other relevant information.

Multiple Dives

Rebreather divers should always track their oxygen uptake. When completing multi-day rebreather diving, it is essential to ensure that the NOAA oxygen exposure table recommendations are followed.

Oxygen Cells

The oxygen cells should be changed at the interval recommended by the manufacturer. It is recommended that all O₂ cells be replaced when an individual cell fails. It is probable that if one cell has failed then other cells are near the end of their life.

Partial Pressure of Oxygen (PPO₂)

The BSAC encourage the use of an independent monitoring of inspired O₂ in a semi-closed circuit rebreather. The ppO₂ reading should be checked regularly and appropriate action taken if it is not at the expected value.

Pre-dive checks

Pre-dive checks should be conducted in accordance with unit specific training - including pre-breathing the unit prior to entry the water. (See Checklists)

Rebreather Diver Rescue

Ensure that your buddy understands the operation of your rebreather. Emphasise the shutdown operation of the mouthpiece to maintain gas in the breathing loop in the event of a rescue.

Rebreather Divers

Rebreather divers wishing to dive as part of BSAC branch diving activities must have completed a training course recognised by the manufacturer of the rebreather and by a recognised Technical Training Agency. The qualified rebreather diver should register a copy of their qualification with BSAC Headquarters, recognition will be sent in the form of a BSAC Qualification Record Book certificate.

A CCR rebreather diver should be at least a BSAC Sports Diver with an Advanced Nitrox qualification.

An SCR rebreather diver should be at least a BSAC Sports Diver with a Nitrox qualification.

Rebreather Equipment

Always prepare and use the rebreather following the recommendations produced by the manufacturer, skills taught on the training course and any BSAC recommendations for branch use. (See checklists)

The rebreather units that are approved for use on BSAC organised dives are those that are recognised and fully evaluated, carry the CE marking or other governmental approval.

Those rebreathers meeting international and national standards will be reviewed on an individual basis but a tested pedigree must be proven on such review.

Safe Diving

Current BSAC safe diving guidelines are equally applicable to diving with a rebreather. Rebreather divers should also follow the guidelines for diving with rebreathers published by the BSAC.

Set-Point

It is recommended that the maximum set-point to be used with a closed circuit rebreather should be 1.3 bar.

Skills Practice

A rebreather diver should regularly practice the skills taught on their rebreather-training course.

Surface detection aids

It is recommended that each rebreather diver should carry a D-SMB (or a fixed SMB when appropriate) and at least one additional surface detection aid. This could be a signalling flag, personal flares, torch, strobe, Emergency Position Indicating Radio Beacon (EPIRB), whistle or audible signalling device.

Surface Swims

If a semi-closed circuit rebreather diver has to make a surface swim BSAC strongly recommends that, in order to avoid the potential of hypoxia, the swim is completed using an open circuit regulator. If the gas within the bailout cylinder is planned to be used for a surface swim, then the pre-dive gas planning should take this into account when selecting the bailout cylinder.

Training Agencies

Rebreather Training Agencies recognised by the BSAC:

ANDI	American Nitrox Divers International
IANTD	International Association of Nitrox & Technical Divers
PADI	Professional Association of Diving Instructors (SCR only)
RAB	Rebreather Advisory Board
TDI	Technical Diving International

Wreck diving

Additional care should be taken if considering the penetration of a wreck to ensure that the rebreather hoses are not snagged in confined spaces or damaged by sharp edges.