



Edited by
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Bail out with
Inspiration
rebreather,
Tahiti

Text by Pascal Bernabe
Photos by François Brun

Rebreather diving is currently one of the fastest growing activities in the diving universe. Divers' motivations for getting a rebreather vary. Some derive enjoyment from "piloting" a sophisticated machine like a cosmonaut journeying through (inner) space. Others find pleasure in possessing a powerful tool for exploring caves, wrecks, canyons and reef walls, and being able to silently approach and photograph marine life without any bubbles.

However, despite their increased capabilities, rebreathers can be subject to serious failures. Accordingly, one of the primary objectives of good rebreather training is to learn how to react correctly and quickly to a problem and perform the emergency procedure appropriate to the situation or the failure.

There are a number of rebreather failure modes that require the diver to get off the breathing loop immediately and switch to a reliable back-up system, typically open circuit scuba, which is currently the most reliable and inexpensive form of back-up. Rebreather divers refer to this

as switching to "bailout"—in other words, an alternate gas source appropriate for the dive in the event of problems with the rebreather. The general rule taught in rebreather classes is, "If you are in doubt, switch to bailout."

There are a number of situations that would prompt a diver to bailout. These include:

- A completely flooded loop that has become un-breathable, for example, due to a rupture in the breathing hose or counterlung.
- An excessively high partial pressure of oxygen (PO₂) in the breathing loop creating an immediate risk of hyperoxia particularly at deep depths and where the PO₂ exceeds 1.6 bar. (Note: the solenoid is

an electric valve that injects oxygen into the breathing loop in order to maintain a constant oxygen partial pressure, usually between 0.7 and 1.3 bar.)

- A low PO₂ below 0.16 bar in the breathing loop, resulting in the immediate risk of hypoxia.
- Shortness of breath and/or a carbon dioxide (CO₂) hit caused by strenuous

effort for example swimming against a strong current, panic or the failure of the CO₂ scrubber system to remove carbon dioxide from the breathing loop. This can occur if the diver exceeds the scrubber duration, there's an error in assembling the unit, particularly the absorbent canister, or there's a failure in the mushroom valve.



The Art of Bailing Out





Bail out and BOV with Inspiration rebreather

Bail out with rebreather, Tunisia

- A complete failure of the electronics (PO₂ display and heads up display) making it impossible for the diver to know the PO₂ in the loop.
- Running out of onboard oxygen and/or diluent.
- The failure of two or more oxygen sensors. In this case, the diver can no longer be sure of his or her PO₂ (when three cell voting logic is used).

The general rule for bail-out is that there should be enough of the appropriate gas to ascend to the surface while allowing for a safety margin. For example, the rule used in cave rebreather diving, that is also applicable for decompression diving, is to calculate one's consumption rate based on 30 l/minute (1.1 ft³/min) multiplied by 1.5 for a safety margin or 45 l/min. (1.6 ft³/min). Experience shows that in the case of getting short of breath or CO₂ intoxication, the gas consumption may rise to as much as 70 l/min (2.5 ft³/min) during the first minute and to lower to some 25 l/min (0.9 ft³/min.) during the following minutes.

Bailout options and configurations

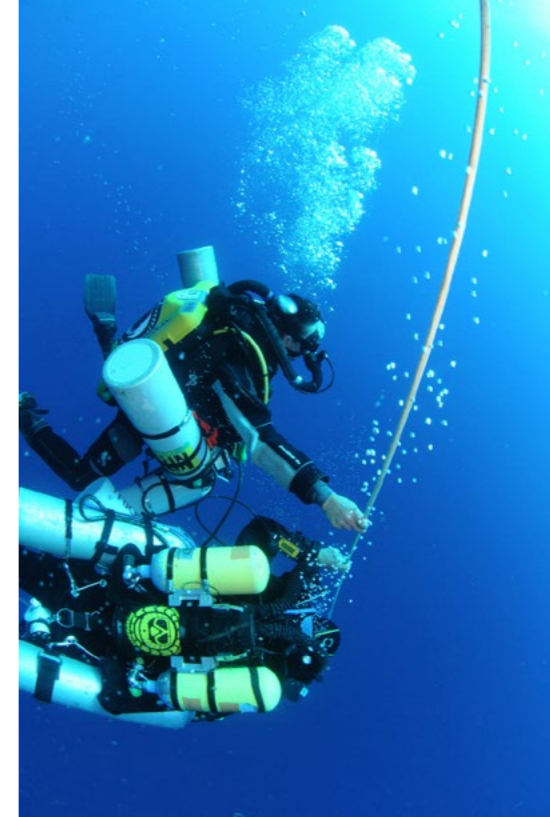
A. Open circuit bailout (tanks)

The first question divers have to ask is whether to have an integrated bail-out valve (BOV) on their

rig or not. A BOV is a regulator integrated into the rebreather's mouthpiece that allows the diver to immediately switch from the closed circuit to the open circuit by moving or turning (depending on the design) a special lever.

Ideally the BOV should be connected via a quick-release and waterproof Swage Lock type fitting to a tank with gas breathable at the maximum dive depth, and

provide means of reconnecting it to other tanks according to the depth during the ascent, for example, to manage the



Bail out and BOV with Inspiration rebreather, Tahiti

Bailing Out

A SHORT GLOSSARY FOR REBREATHER NOVICES

PO₂: Oxygen partial pressure, which should ideally lie between 0.7 and 1.3 bar according to the dive phase: 0.7 during the descent and at shallow depths and 1.2-1.3 bar at the bottom. PO₂s are sometimes boosted to 1.4 during decompression.

Diluent: An air, nitrox, or trimix/heliox, which is contained in the left tank of the rebreather and is blended with oxygen to give the diver the best mix for a given depth.

Solenoid: An electric valve that adds oxygen at the right time to maintain a constant PO₂.

Onboard Gas: Gas inside the rebreather system.

Off Board Gas: A gas source outside the rebreather system (stage/bailout tanks).

HUD: A heads-up display that shows the PO₂ and is positioned on the loop next to the mouthpiece and is very easy to see.

mCCR: A closed-circuit rebreather with manual controls (if the diver needs more oxygen he or she injects oxygen, if the diver wants to lower oxygen he or she adds diluent, simple, no electronics).

eCCR: closed-circuit rebreather with electronic controls. Constant PO₂ is maintained with the help of solenoid.



decompression.

It is not recommended that divers connect the BOV to the small onboard diluent tank that often has only 3-liter (15-21 ft³) capacity tank, which offers too little gas in the case of emergency.

The arguments for a BOV? It is the quickest means of switching from the closed to the open circuit, which is essential in case of emergency.

The arguments against a BOV? It is a fragile and also a costly piece that requires regular maintenance and may free flow on occasion. Moreover, it may represent a risk for a diver if a



Bail out with lateral rebreather (below)

the arms with the help of a rubber band to get them close to the body, and the bottom is attached at the sides or to the butt-plate fixed beneath the rebreather at the buttocks level. This is much more hydrodynamic!

3. In any case, the golden rule is to not connect the Automatic Diluent Valve (ADV), a regulator system that adds diluent to the loop on demand to compensate for ambi-

ent pressure to the same tank as the BOV, wings, dry suit, and or hose for the manual diluent supply to the same tank!

Connecting the rebreather and buoyancy devices to the same small onboard 3-liter tank is a receipt for disaster. If the tank is empty there will be no gas for the rebreather or for maintaining buoyancy!

Instead these connections are typically evenly allocated among different tanks. For example:

- Connect the ADV and the wing to the rebreather's onboard diluent tank if the dive is not deep.
- Connect the wing to one of the stages if the dive is deep or it is a



Bail out with Megaladon rebreather, Tahiti

hypoxic mix is connected to the BOV at the time of switching to the open circuit, for example near the surface.

Some other things to note:

1. Bailout tanks can be carried as stages, or may be attached at the back of a rebreather at both sides with or without manifold, as in some DIR configurations. Such configura-

tions are typically used by divers equipped with semi-closed passive rebreathers such as the RB80, but are becoming more common with closed-circuit rebreathers with manual (mCCR) or electronic (eCCR) controls. Typically the cylinder on the right has a regulator with a long hose of 2m (7ft) in order to share gas with a buddy in the event of an emergency. The cylinder on the left side has a regulator with a short hose that goes under the neck attached by a neck ring in addition to a pressure gauge or manometer. This configuration is an adapted deviation of the Hogarthian configuration, so dear to the heart of DIR divers. It allows them to carry huge amounts of bailout gas.

2. Usually bailout tanks are carried as stages, and are attached with the spring hooks at the sides of a diver. Sometimes they can be carried in sidemount configuration where the neck of the stage cylinder is attached under



Bailing Out



Bailout with semi-closed rebreather, Lot, France

shortness of breath. Finally, the diver does not necessarily know whether the bailout rebreather, which was not breathed during the descent, is full of water or has an appropriate PO₂ when the diver is in urgent need of it (This problem has already happened!) In that case, you completely lose your operational capacity!

The real benefit to a bailout rebreather system is the huge run time (3 to 5 hours) it affords in the event of an emergency. Hence, it's the option of choice for the divers engaged in exploration who want to achieve the best balance between the run time and bulk important in Alpine technique. □

cave dive with a saw-tooth profile.

□ Connect the back-up manually injected diluent to one of the off board bailout tanks and the dry suit to another tank, if there is one, containing air or nitrox (helium mixes create thermal problems) or to a small suit inflation bottle mounted on the side of the rig.

B. Rebreather bailout

A bailout rebreather can be carried on the back creating a double back-mounted rebreather. Two rebreathers are heavy and their buoyancy is hard to manage. The drysuit, wing and two full loops make at least four gas spaces to manage and vent during the ascent. No easy task! A back-up rebreather can also be mounted at the side (like a stage cylinder) or in front of the body—for example, an M3S Triton a White Arrow Sweet Deco.

In general, using a secondary rebreather for bailout is much more expensive and difficult to manage

in comparison with an open circuit back-up.

Moreover, a bailout rebreather does not allow the diver to recover as quickly in the case of a CO₂ hit i.e.

Pascal Bernabé of France holds the world record depth on a deep dive using self-contained breathing apparatus. He dived to 330m on trimix in 2005 off Propriano, Corsica. See: Pascalbenabe.com



Pascal Bernabé with semi-closed rebreather

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