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# Cave Diving & CCR Training
## —The Issue of Bailout Gas

*What to do when things go pear-shaped...*

Text and photos
courtesy of Steve Lewis

**Remember the first rule of scuba diving that you were taught in your basic open-water class? I believe it goes something like: "Keep breathing!" Simple advice and unarguably the best advice possible for *any* diver, not just those entering the sport for the first time.**

For example, the same first rule is true for technical diving. Gas management 101 starts off by stating something like: "Always have a sufficient volume of appropriate gas to breathe throughout the whole dive!" More wordy—and there are other nuances to a gas plan such as having gas to share with your buddy—but the message to the tech crowd is essentially the same as it is to the new diver. And unless I've missed a memo somehow, that message applies to all technical divers without exception.

Given all that, what's difficult to understand, is why some folks seem to lose the plot when they strap on a rebreather… even more baffling is when they strap on a rebreather and then swim into a cave while seeming to ignore the primary directive… always have something to breathe.

You may already know about rebreathers, and you may also be a cave diver. But for those of you who are only one or the other—or neither—here is the Coles Notes version of your CCR cave class. A rebreather offers divers the ability to get a long, long way from fresh air without much effort. Unlike an open-circuit cave diver who generally has to carry many stage bottles of gas to extend her foray into the deepest regions of a cave, way back from the exit, a CCR diver *can* push many hundreds even thousands of meters without making any allowances at all.

Here's one reason why. On a rebreather, the exhaled gas is recycled and the carbon dioxide is removed by a little chemistry set carried in the unit's scrubber. Apart from a few litres of diluent gas used up now and again, all the gas that needs to be added regularly to "the loop" (the breathing gas going round and round in the unit) is the oxygen metabolized by the diver as she swims. A working average for this is about 1.5 litres per minute, and this does not significantly change with depth. In other words, a three-litre bottle charged to 200 bar with oxygen can last for up to 400 minutes.

What that means is that if we were to say that the average cave diver on an easy outing swims at a speed of between 15 to 20 meters a minute, that volume of oxygen could translate into more than 6,000 metres of distance round-trip!

Now here's the problem. Everything on that six kilo-meter journey might be fine as long as the diver's CCR continued to function as it should. But what if it did not?

### Sense-check

OK, sense-check time. I have more than a few dives in caves on a rebreather and have yet to have my unit fail on me. I *have* run out of diluent during a dive—operator error because I was playing silly buggers—and I have had a couple of incidents that required me to take the initiative and fix something on the fly—operator error or intentional skills testing—but

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the truth is that I have not had to bailout in earnest in a cave while diving a CCR. Put it down to luck or using a checklist before every dive, but my CCR cave dives have gone remarkably smoothly… thus far. I have probably jinxed myself now.

## Bailout

Beginning CCR divers doing entry-level CCR programs are often taught that if *anything* goes wrong with their unit, they should bailout. In other words, switch to open-circuit and get the heck back to the surface and sort things out there. One might argue that with all the various options that a rebreather gives its operator, bailing out is not always the best option, and teaching users to react this way as a default does not take full advantage of a CCR's strong points. *But* for the sake of brevity here, let's assume that bailing out to an independent open-circuit gas is "best-practice" for a cave diver with a problem. It follows then that to be ready for a dive where things fall off the rails, a CCR cave diver needs to carry some bailout gas so that she always has a sufficient volume of appropriate gas to breathe throughout the whole dive. So far so good.

I have heard CCR divers talk about a technique called "Buddy Bailout" or "Team Bailout". This essentially means that each diver does not bother to carry the gas he or she would need to swim out of the cave from the furthest penetration point to the exit. They would perhaps carry half of the volume required, and will "get the rest" from their buddy. I am not sure how you feel about this, but it gives me the willies.

Here's an outline of another technique, which doesn't have an official name, but let's call it "sufficient volume bailout" for the time-being.

## Dive buddies

When things go pear-shaped underwater and stuff hits the fan, the simple solutions are generally the most effective and safest. On occasion a solution involves or requires the help of a dive buddy. Technical diving is a team-oriented sport and when things go wrong on a technical dive—and everything is aligned perfectly—we have one or two buddies to help out. All this aside, we are also taught that a diver should be capable of finishing her dive on her own and that the safest team is built around individual members who are perfectly capable of self-rescue should the need arise. This becomes particularly true in an overhead environment, and in the vast majority of cases, self-rescue (perhaps under the watchful eye of a companion ready to help out if needed), is the simplest, most effective and safest solution in a cave.

While it's fine to believe in the tooth fairy, Santa and the Easter bunny, my advice is to be very skeptical that the gas pixie will show up when you are in desperate need of a lung-full of something nice to breathe—especially in a cave. Even though we teach air-sharing in open-circuit cave programs, there is little in the skill as practiced by most divers that will help out in a real OOA event fuelled by panic and desperation. Added to this, and informed by experience, is a pretty solid opinion that operations such as handing a bottle off to a companion, while in a small passage with silt for a floor, and with one of the party fighting for air, will not end well.

Taking all this into consideration, the best practice would seem to be for every CCR cave diver to carry enough gas to get themselves out solo. It would be nice to think that when a CCR diver is an hour's swim from the cave's exit, and they discover that they have no option but to bailout, that their dive buddy is within arm's reach and not swimming away blissfully unaware of the problem.

It's wonderful to have a buddy's gas as a backup, but primacy dictates that you have sufficient gas to exit without their help if possible. Which brings us to a word about how to calculate how much gas is enough.

## SAC to RMV

The process of converting a personal SAC rate (Surface Air Consumption) to a RMV (Required Minute Volume) is as straightforward in CCR cave diving as it is in open-water open-circuit diving… with one added step.

SAC (the volume of gas a diver breathes each minute) is a constant and is influenced during a dive by several other factors such as depth, workload, stressors such as water temperature and visibility. The simple conversion for SAC to RMV is to multiply SAC by depth, and then multiply that number by a dive factor to account for the workload, etc, for the dive.

Here's a simple example. Let's use a SAC of 15 litres per minute and a cave dive on which the average depth is 25 metres. Let's also say this cave is familiar to the diver, has light current (out-flow) and the water is relatively warm and clear (21 degrees and more than 30 metres of vis). For this dive, we might use a dive factor of 1.50.

So here's the arithmetic: 15 X 3.5 (25 metres expressed in absolute pressure) X 1.50. The result is an RMV of approximately 80 litres per minute (78.75 l/m).

ABOVE The author using his AP rebreather at Jackson Blue Springs, Florida, USA

So far so good. If we are planning a dive to swim into the cave for 40 minutes before we turn, we will need approximately 40 minutes-worth of gas if our unit fails us at maximum penetration. That equals 3200 litres… or a 16 litre cylinder pumped to 200 bar… or one and a half 11 litre tanks filled to 200 bar.

Now this assumes something critical, and something that is different for a CCR diver compared to an open-circuit diver. The critical difference—the additional step that separates this type of calculation for a CCR diver as opposed to an open-circuit diver—is hidden in the nature of the possible events that would cause a CCR diver to bailout in earnest and completely from her rebreather's loop. One of these events could be carbon dioxide break-through, and this might influence the respiration rate of the diver… dramatically, and for several minutes. In other words, the 3,200 litres that we calculated to get a diver from maximum penetration to the surface might not be quite enough. We might need to revisit the Dive Factor and change it from 1.5 to an even greater number.

Of course, back-of-a-napkin calculations such as these are fine discussion points while chatting with friends someplace warm and dry with a plate of olives and a glass of wine on the table in front of you. However, the only truly safe numbers come from what is euphemistically called "field-tested data". And these you need to collect yourself.

If the first rule of technical diving is: "Always have a sufficient volume of appropriate gas to breathe throughout the whole dive!" then perhaps the first rule of CCR cave diving should be: "Never take a CCR into a cave that you have not swum out of using open-circuit."

Final word: take notes… read them often! ■

*Steve Lewis regards himself as a cave diver, primarily. He is a technical instructor-trainer with ratings from TDI and PSAI, and among other foibles, teaches divers to have fun and stay safe on two very different CCR units, neither of which lends itself, in his opinion, to team bailout.*