Are You H.A.P.P.Y. with your CCR at the Water's Edge?

Edit 02.2010

This is one of a series of informational articles and technical papers collated by Ocean Opportunity on topics in the field of advanced manned diving technologies and techniques. These are being made available via OO's 'Exploration Technologies Group'.

All content is subject to continual updating and editing based on community review and input. Should you wish to contribute to this work, we welcome information and input, and will credit sources properly. It is our recommendation that only the most current versions of these documents are used as reference.

These documents are well suited as training guides or references. It should be noted that they represent the opinions and experiences of the authors, and are not always regarded as widely accepted standards. Adoption of the techniques and technologies referenced is done at your own risk.

We welcome parties that seek to publish these articles. Parties interested in publishing any of these articles in other formats, be it web or print, are encouraged to contact us at explore@oceanopportunity.com to discuss licensing and rights to publication.

Author: Michael Lombardi

Are you H.A.P.P.Y. with your CCR at the water's edge?

Introduction

Over the past decade (1995-2005), there has been an undeniable shift towards using closed-circuit rebreathers almost exclusively for expedition-caliber diving as opposed to open-circuit techniques. This is with good reason, as the advantages of this technology are all clearly beneficial in carrying out expedition objectives. The ability to have longer no decompression times at depth, shorter overall decompression due to a constantly optimized PO2, breathing warm/moist gas, and unparalleled gas efficiency are all the convincing one needs to begin using rebreather technology for exploration.

While closed-circuit rebreathers are not a new technology, nor are they necessarily complex despite this perception from industry; with their utility value being realized in such a small niche population, the technology is slow to change, as is the evolution of related safety, training, and operational procedures. However, we are at a pivotal time in the industry. The last ten years has slowly but surely served to popularize this powerful tool, and a recreational market, while still small, is emerging.

Pre-dive checklist

The perceived complexity of rebreathers has stemmed from three areas:

1) maintenance procedures
2)'re-thinking' how one dives as opposed to open-circuit
3) assembly and pre-dive mechanics

Today's mainstream systems have been designed with #3 above in focus. You don't have to be a rocket scientist or mechanical engineer to use a rebreather system.

During pre-dive, a strict checklist should be followed to ensure the unit is assembled and functioning properly. While the mechanics of this checklist can vary slightly from system to system, here I propose a general cross-brand pre-dive that is simple and covers all the bases before you get into the water.

Quite simply, if you can answer the question 'Are you H.A.P.P.Y.?' at the water's edge, then you are good to go. This pre-dive was adopted from Mr. Dan Wible, one the early authorities on rebreather development with his work on the CCR2000. The list has been modified to be more readily applicable to a majority of the systems in use today. This list is not intended as a replacement for manufacturer specific pre-dive checklists.

Each section of the acronym H.A.P.P.Y. is described below.

H - Hydrophobic Loop
A hydrophobic loop is critical to rebreather diving. This ensures that no water is leaking in, causing a flood, and no gas is leaking out, which is a waste, and could also cause fluctuations in your PO2. To check for a hydrophobic loop, both positive and negative leak tests should be performed. With all cylinders off, exhale into the rig to fill the counterlungs until the OPV purges slightly. Close the mouthpiece, and let the unit stand for two minutes. Providing the counterlungs remain inflated, the system has passed a positive pressure test. Next, inhale from the unit, and exhale through your nose to remove all gas from the system. Do this until the bags are collapsed entirely, and a vacuum is produced, then close the dive surface valve. Let the rig stand for two

minutes. Turn on the diluent cylinder - a 'whoosh' sound indicates that the ADV has fired and was activated by the collapsed counterlungs against the ADV device. The system has now passed the negative pressure test. Passing both the positive and negative pressure tests indicates that you have a ***hydrophobic loop***.

A - Active Oxygen & Diluent Addition
In referring to 'active' actions, I am describing actions required to be taken by the diver; something the diver has to 'actively' do. In this case, we want to confirm that the diver has the ability to manually add both oxygen and diluent gasses to the breathing loop. During the course of a dive, this ability ensures that the diver can maintain a breathable volume of gas within the counterlung(s), and is able to manually maintain the chosen oxygen setpoint should any passive oxygen addition methods fail. To check for active oxygen and diluent addition capabilities, verify that all gasses are on and plugged into the unit and that there is adequate gas to complete the dive. At this point you should also verify that your electronics are turned on and power levels are suitable for the dive. Upon completing your above negative pressure check, you should check for the ability to actively add oxygen. Manually inflate your counterlungs and then circulate the gas to ensure that you have 100% oxygen in the loop. This is an opportune time to calibrate your electronics. After calibration, actively add a few short bursts of your diluent gas to test for active diluent addition. This will also verify that your sensors are responsive to the change in gas. Assuming that you can manually/actively add both gasses, you can proceed to the next step.

P - Passive Oxygen Addition
In referring to 'passive', again from the perspective of the diver, this means that oxygen is added without the diver doing anything, so the unit is in control. Today's rebreathers may have one of several passive oxygen addition mechanisms. This includes a computer or electronically controlled solenoid valve, a needle valve, or an orifice or 'leaky valve', sometimes referred to as the 'KISS' valve. Ensure that this mechanism has oxygen flowing to it, and that it is delivering properly. Check the flow in the case of a needle or orifice configuration using a flowmeter. In the case of a solenoid, breathe the loop down to drop the PO2, and listen for solenoid actuation. In some (rare) instances, units may be completely manually controlled. Should this be the case, this step should be skipped.

P - Prebreathe
Prebreathing the unit at the surface prior to the dive serves several functions. First, it ensures that the entire system is performing and the ability to maintain an adequate loop volume and target setpoint for a brief period of time. Second, it is the time necessary to jumpstart the scrubber's reaction. In warmwater, 2 minutes are recommended. In cold water, 5 minutes are recommended. This time may be used to program your computer for the PO2 and gasses you have on board, and to check repetitive NDL's if this is a repetitive dive. Prebreathe time should also be used to confirm that all systems are double and triple checked on your unit, and any mechanical components are within reach.

Y - Yourself
Lastly, check yourself. Make a final check head to toe of you and your dive partner. Discuss a final review of your dive plan. If you feel comfortable, it's time to go diving!

One of the complexities in the rebreather community is the variability between systems. Adopting a simple, yet all consuming, pre-dive checklist such as this one will ensure that you do not overlook any critical items when diving any rebreather. This is true whether it be your tried and true unit, or a unit you are diving for the first time.

The key is to go slow, remember that complacency kills, and take the time to do things right.

References

An earlier version of this article was published by the Summit Journal. Citation:

Lombardi, MR. (2007) Are you 'H.A.P.P.Y.' with your closed-circuit rebreather at the water's edge? The Summit Journal. Released December 17, 2007.