

Near fatality with a Rebreather

a post regarding "Annemarie"'s near fatal mishap

<http://www.rebreatherworld.com/rebreather-accidents-incidents/21938-critical-near-fatal-mishap-sept-2-a.html#post212853>

Re: CRITICAL: Near Fatal Misshape Sept 2 / PART 1

Just got this from Annemarie: She nearly lost her life today, and feels it's imperative to pass this on. The potential is for a bad batch of cells. Please use this forum to discuss the near accident.

Dave Sutton

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Today I almost lost my life while diving on a Vision. I will explain the details exactly as they happened.

This morning in Egypt, I prepared the rebreather as usual, new scrubber, freshly filled and analysed cylinders, new batteries. Please note that I installed new sensors labelled F8 earlier this week and they have been working perfectly on all dives.

On the boat, I conducted my pre-dive checks including the full pressure tests, calibration and pre-breathe. Whilst calibrating the unit, I input my oxygen percentage and millibar pressure in accordance with my gas analysis and VR3 millibar check. I noticed while calibrating, that cell 1 did not quite reach 1 bar, but did go into the .90 range, however the unit calibrated as it normally would. It is important to note that I perform an oxygen flush on my sensors on every dive, in addition to the supplementary regular checking of millivolt output. Once a week I leave the unit switched on for 1 hour at 1.0 bar PPO2 and check that there is no drift. In addition, on every dive, I perform regular diluent flushes just to check that the PPO2 values I am seeing displayed, are consistent with the expected PPO2 values for the diluent gas and depth. I cannot stress enough how careful and stringent I am about verifying sensor linearity.

Today I planned an easy diving day as I am here until November and need to be mindful of residual N2 loading as we have some very deep diving coming up. Our first dive of the day was planned to be a simple reef dive on air, to 40m max, as we ended up on a boat full of open circuit divers and were therefore restricted to only 1 hour dive time maximum, even though diving separately from the group.

During the descent, I noticed a variance of .30 between cell 1 and cell 3. In addition, cell 2 did not match either cell 1 or cell 3.

There were no cell errors, despite the significant variance between all 3 cells. I performed an immediate diluent flush, after which the cell values then aligned. At approx. 30m, I felt some very fine trembling in my left leg, only barely perceptible. Once again, I

flushed the loop with diluent and noted 1.3 on all cells. Within only a few seconds, my legs started some strong shaking, that I could not control, followed immediately by my hands, which were shaking hard and uncontrollably. I knew instantly that there was something seriously wrong. I also knew instantly that I was breathing a significantly elevated PPO2 despite what the displays were telling me. I have felt this fine toxing before during trials, I know immediately, from experience of breathing elevated PPO2 that these fine tremors underwater are my first impending symptom and signalled to my buddy that I was aborting the dive, he could carry on as he wished. He elected to ascend with me. I made a slow, controlled ascent to the surface whilst continuously flushing diluent through the loop. My buddy, Mick Perks, an experienced Inspiration and Evolution diver, says he could see my hands shaking like jellies at around 30m and knew immediately there was an oxygen problem, even before I had signalled that I was ascending immediately.

I ascended on the loop, whilst flushing air diluent for the full ascent to slowly lower my inspired PPO2. The reason for this choice and not an immediate open circuit air bailout, is that in the event of breathing elevated oxygen levels, a switch to a gas with a much lower PPO2, can trigger full CNS oxygen toxicity, with resulting convulsions, followed by unconsciousness. This is a phenomenon called the "off effect" and is documented in Kenneth Donald's book and some NEDU studies, both of which I am now glad I have read.

Back on the boat, Mick and I together, stripped the unit. We checked firstly all sensor connections and found them to be fine. We then checked millivolt output, which was in acceptable range, though all 3 cells had slightly different outputs, respectively increasing from cell 1 to cell 3, an exact replication of the cell behaviour with displayed PPO2 values.

We then checked the voltage of the batteries, both were perfect and as expected for brand new batteries. I also re analysed my gases and checked once again the millibar pressure, all was as expected in accordance with my previous checks.

This appears to be a case of current limited cells. I dived yesterday and flushed these cells and they returned a perfect 1.6 at 6m with an oxygen flush. Therefore, if the problem is indeed current limited cells, they basically failed completely during my dive today.

In context, I only changed my cells this week because they were 18 months old, and recommended protocol is to change them at this interval or sooner. The old cells were still working but I am trying to take a professional approach to my safety and diving so I changed them.

However, I am extremely concerned that the Vision software did not manifest a cell error despite a large variance between the cells.

Furthermore Mick and I, after leaving the unit for an hour, flushed the unit with O2 and noted that all three cells can hardly get past .80 on the displays. When the display is left on, the cell readings then drop rapidly. Upon now calibrating the unit, I am seeing a variance between all three cells. There is a difference of .40 between cell 1 and cell 3. Cell 1 will not go past .80. Yet the unit

still calibrates.

Both Mick and I agree that in light of this overall unusual manifestation, it is impossible to determine whether this problem is indeed current limited cells or a software/electronics issue. I could put 3 working cells in tomorrow and if the problem is software related, the same thing could happen again.

Martin, please, revisit the software on the Vision in respect of the calibration element. The software is coded to know the expected oxygen percentage via user input at calibration yet when a flush does not return the expected value, the unit still calibrates. It could potentially save someone's life if this aspect of the software is altered. I have been one of the biggest proponents of improving safety in this sport and indeed in promoting linearity checking yet today I almost died, despite doing everything correctly and safely. Regardless of the underlying cause of the problem, I want to elucidate some important learning points. Today, I have done everything by the book and according to the manufacturer recommendations. I am an extremely careful, disciplined, qualified and experienced rebreather diver with a professional approach to learning and safety. There is nothing that I could have done differently today to prevent this situation except not dive. If I had bailed out today, in all likelihood, I would have immediately sustained full convulsions due to the off effect and become unconscious. If we had done a deeper, mixed gas dive today to for example 80m or I had gone a bit deeper than 30m, I would have toxed and lost consciousness and my buddy would have been left with the choice to either risk his own life and ascend from depth to save my life, or to simply abandon me to my fate. I was actually planning to dive the Maiden in 130+ metres on this unit. That dive would have killed me, through no fault of my own. A perfectly prepared rebreather can and will go wrong sometime in your diving career. Ten rebreather divers have died in the last three months. It is not an infeasible proposition that there is a batch of faulty cells.

Irrespective of that possibility, new cells can fail. They can pass all surface checks and pass a 6m linearity check yet still fail spectacularly on a dive. The only way to be sure that you really know what you are breathing is correct and appropriate for the depth is to regularly perform diluent checks while diving and perform a 6m oxygen flush on every dive. But something must be done regarding the problems with bad batches of cells. Certainly an alteration to the software to block calibration of low versus expected PP02 would facilitate a massive safety improvement to mitigate against faulty cells. They really are the weakest element of any rebreather dive.

I am lucky that I recognised what was happening today and lucky that I have conducted such extensive physiological research and knew not to bail out. A new rebreather diver would have probably died today. I am lucky that I did not die today.

Martin, I therefore think the only sensible and appropriate course of action is to stop diving on the unit immediately as of today and return the head and cells to you for examination. Please, irrespective of your findings, also consult with Teledyne and revisit

their and your quality control procedures and advise of the outcome. I am planning to use a different unit for some planned deeper cave diving later, but in the meantime this leaves me in Egypt for the next five weeks without the guarantee of a rebreather being available for me to dive.

Please respond to my comments with your proposed course of action regarding the cell quality control issue and the software calibration improvement recommendation. In the interim while considering the appropriate resolution to those matters, please advise how you wish me to proceed in respect of returning the head and cells and the resulting predicament of being in the Middle East for five weeks without a working rebreather. I am grateful for any advice and assistance that you can offer.

I would like to thank Mick Perks for his advice and assistance today.

AnneMarie

Re: CRITICAL: Near Fatal Misshape Sept 2 / PART 2

Additional data

<http://www.rebreatherworld.com/rebreather-accidents-incidents/21938-critical-near-fatal-mishap-sept-2-a-2.html#post212978>

Hi

I am really struggling for internet access right now so please be patient for my replies.

The dive lasted for approx. 9 minutes and on the bottom the solenoid was absolutely blasting oxygen in. I had a long swim underwater at the start to get from the boat to the reef and then a perfect descent in the blue. I was probably breathing 4.0 bar PPO2 on the bottom so it did not take long to feel the twitching starting, I'd estimate around five or six minutes into the dive when I first started feeling the little twitches in my legs. I thought the solenoid was stuck open at one point when I could hear big whooshing injections on the bottom, but when I ascended and put the setpoint down, it decreased. Don't forget, by this point just leaving the bottom, I was confused and very shockd because I was into uncontrollable twitching and shaking yet a flush showed my PPO2 going down then the solenoid brought it back up to 1.3 (not really 1.3 though!). A lot of text of my post to the inspiration list seem to be missing and the post never made it onto the list. I sent it from a mobile phone on the boat.

On the ascent, I knocked my setpoint down but my hands were shaking very fast so it took a few attempts to hold my finger onto the handset to knock it down. I had to use both hands on the wing deflate button to dump gas. I was still shaking all the way to the surface.

I have no modifications, I dived a stock rebreather from the factory, out of the box, no changes. APD do not approve 4th cell, third party monitoring equipment and I have had a 4th cell interface made of delrin and glue come apart before on an Inspiration. I do not agree with adding non-manufacturer approved equipment to a CE rated rebreather, which fundamentally changes the architecture of the head and loop. In any case, a 4th cell could still fail. Correct deployment of flushing and appropriate PPO2 verification protocols is a better mitigation than adding extra equipment, in substitution for life-saving checks.

When cells need to be changed, they need to be changed. Faulty batches are a fact of life. The underlying issues need to be fixed, that fix is not the reliance on add ons which can still fail, or protocols which don't mitigate the risk.

I have had a HSE medical this year and the Doctor said my fitness was absolutely excellent and lung and heart function well above average. I have done over 12 weeks of gas diving this year all over the world, not counting weekends, and worked hard on cardiovascular conditioning. I am fit. I can carry more than my own bodyweight in equipment. I have no problems getting up a ladder on a pitching boat in crazy seas. I regularly work out in the optimum cardiovascular heart rate zone for my age. My VO2 max is excellent.

My post is not copyrighted, I wrote on the inspiration list that it can be cross posted anywhere, in the interest of helping my rebreather colleagues. Neither have I made any agreement as to whom will test the cells. That is MY decision. There will NOT be an independent investigation. I and I alone, will manage how matters proceed. I have notified the equipment manufacturer of events and await advice.

That's all for now, I will try and get back on tomorrow. I have a beer waiting, I think it is much deserved! Thank you to everyone for the emails and texts that have been pouring in, life is learning.

Many regards

AnneMarie