Rebreather Blunders and Malfunctions

By Howard Hall


Howard & Thurlow with High Def system ©Michele Hall

The introduction of the ElectroLung during the late 1960s seemed to herald a revolution within the sport diving industry. But after a few short years and several deaths, this revolution came to a crashing halt. The promise of silent, bubble-free diving was replaced by a consensus that rebreathers promise only death and multi-million dollar lawsuits.

Despite the grim history and the prospect of certain death guaranteed by many friends and colleagues, I found the dream of silent diving almost overwhelming. Finally, in the late 1980s, opportunity presented itself. I received a contract to make a film about the Sea of Cortez. The film provided the funds and the justification for pursuing rebreather technology. So in the spring of 1989, Bob Cranston and I travelled to Philadelphia to train on a pair of Biomarine 15.5 rebreathers.

The Biomarine 15.5 was a prototype rebreather designed to replace the US Navy's Mark 15. Fortunately for Bob and I, Biomarine failed to acquire the Navy contract and this failure left a couple dozen of these closed-circuit, mixed-gas rebreathers drifting aimlessly in the civilian community. Biomarine had two of these units at their Philadelphia factory and was willing to loan them to us, assuming we were willing to pay a considerable lease fee and, of course, sign a waiver that detailed the various and likely ways we would almost certainly die using the gear. A few months later, Bob and I donned our leased rebreathers and made our first open water dive in the Sea of Cortez. We were, at once, excited and terrified. We descended to just over fifteen feet and made it back alive.

After surviving the making of our Sea of Cortez film (Shadows in a Desert Sea, WNET Nature), I acquired and highly modified my own Biomarine 15.5 rebreather. My underwater crew and I have been using rebreathers extensively ever since. And today as I write this, floating on the Undersea Hunter above a beautiful Fijian reef, I celebrated logging my 1,000th closed-circuit hour. That was the only event worth celebrating today, however. During today's dive my trimix computer screen went blank soon after beginning a descent to 270 feet where Bob and I planned to use two underwater IMAX® systems to film Richard Pyle collecting rare fish. Bob's camera jammed after running for only ten seconds. My camera failed to run at all. Our reward for total underwater cinematic failure was to spend three hours decompressing. Our rebreathers, however, worked great! And rebreather reliability is not something to be taken for granted.

During my 1000 hours of rebreather diving, the rather high frequency of equipment malfunction has only been exceeded by the much higher frequency of stupid diver mistakes. The editors of Oceans Illustrated believe this magazine's readers may benefit from a chronicle of these dangerous blunders, despite the humiliation such recounting may cause members of my crew and me. My hesitation at humiliating myself by admitting numerous stupid, life-threatening errors while diving closed-circuit is, however, well off-set by the pleasure I take in recounting the stupid mistakes my friends have made.

Always assume your rebreather is going to malfunction at any moment.

Always assuming that your rebreather is going to malfunction is a life extending mind-set. The two rebreathers that I leased for my Sea of Cortez film were only 50% reliable. That is to say that the unit Bob used seemed to work just fine most of the time and the one I used almost never worked properly. Since I was paying the lease fees, this seemed completely unfair to me. But Bob never seemed inclined to trade units with me. During our second open water dive (the first having been the intrepid descent to fifteen feet) my rebreather showed an alarm light just after we reached the bottom in sixty feet of water. Seeing the alarm light, I suddenly felt my worst fears had come true. In a moment I was sure to die of oxygen toxicity! I stopped on the top of a rock, grabbed my open circuit bailout regulator (which at the time was attached to a 15 cf tank that hung from my BC harness) and hoped I could get the regulator clear before the inevitable convulsion. The seizure didn't come. After checking my

secondary display (which shows the oxygen pressure readings on each of three oxygen sensors), I realized that death was not so imminent.

Few things actually happen fast when using a rebreather. I had plenty of time to realize that my on-board computer (which controls the rebreather's gas mixtures) had failed and that I would have to add oxygen manually. In fact, I would have had ten minutes or more to sort the problem out even after the rebreather had quite working. Checking my instruments had easily averted a problem.

The rebreather I used in the Sea of Cortez helped train me to regularly check my instruments. The rebreather encouraged regular instrument checks by failing to function properly on 80% of my dives. An argument can be made for owning a rebreather that almost never works right, since frequent failures encourage good instrument monitoring habits and familiarity with emergency procedures. Personally, however, I wouldn't go so far as purposely seeking out unreliable rebreather designs. However, there is inherent danger in rebreathers that work flawlessly almost all the time. Richard Pyle, an ichthyologist famous for discovering new fish species while diving his Cis-Lunar rebreather to over 400 feet, calls this the "Richard Pyle rebreather paradox." The paradox states that, while everyone desires a rebreather that is reliable, reliability begets complacency.

Check your instruments

The importance of frequent rebreather instrument checks cannot be over emphasized. Since Bob Cranston's rebreather worked pretty well in the Sea of Cortez, he developed less disciplined instrument checking skills than I did. A flawlessly working rebreather is almost as dangerous as a completely unreliable unit since reliability encourages instrument complacency. Bob discovered the wisdom of this during a dive in Grand Cayman.

We were filming yellow-head jawfish in fifty feet of water below the boat early one morning. Bob had not had his second cup of coffee. After about fifteen minutes lying quietly on the bottom, Bob was suddenly stricken with dizziness and tunnel vision. Had he failed to act immediately, he would have been unconscious in less than six seconds. Bob's self- training saved him. In the event of dizziness, one should assume low oxygen and inject gas immediately, any gas. In fact, it is wise to inject both diluent and oxygen simultaneously since six seconds is seldom enough time to do more than one thing. If Bob's oxygen tank had not been turned on, attempting to inject oxygen would have failed to solve the problem. Bob injected gas then, for the first time that morning, he checked his primary display. The lights were out. The problem was immediately apparent; he had failed to turn on his rebreather.

Bob turned on his rebreather and continued to assist me as I filmed the jawfish. Not wanting to admit to suffering from almost fatal stupidity, he didn't tell me he'd had a problem for over two years.

Almost every closed-circuit diver I know has failed to turn on his rebreather or oxygen tank at least once. In the last two weeks while filming here in Fiji, both Richard Pyle and Mark Thurlow have admitted to this error.

Be aware of the consequences of high oxygen partial pressures. But fear, with all your heart, the consequences of low oxygen levels

Not wanting to admit such stupidity, Bob told me of his near black-out while in Grand Cayman two years after the incident, and only after he heard me relate my low-oxygen story to a group of aspiring rebreather divers. Unlike Bob, who was too dumb to turn his rig on in the morning, I had turned mine off on purpose. I was using an IMAX® camera to film kelp at an island near San Diego, California. I wanted to do a shot looking up the kelp plant as I swam the camera up to just beneath the kelp canopy. I didn't want any bubbles in the shot. So to minimize bubbles, I exhaled most of the gas out of my counterlung and turned my rebreather off so it wouldn't inject more gas (even if that gas was rather important). I figured there was plenty of oxygen left to keep me alive during that one short shot. I was wrong. And yes, I admit the idea was completely stupid.

As I swam just beneath the kelp canopy and only about two feet below the surface, with the camera running, I suddenly saw stars, felt dizzy, and then was plunged into a dark visual tunnel that was narrowing at alarming speed. I checked my oxygen level. It read .06 ppO2. Not enough to support life! I barely had time to lift my head above the surface and take a breath.

Checking my instruments at the onset of hypoxia was dumb. A hypoxic diver seldom has time to do more than one thing. I should have immediately lifted my head or injected gas.


Howard and Thurlow at 340 feet ©Bob Cranston

Divers unfamiliar with rebreathers often fear them because they may supply too much oxygen and cause oxygen toxicity and convulsions, followed by drowning. While this is certainly possible, oxygen convulsions are not a major danger when diving rebreathers. Most divers use their rebreathers set at 1.3 or 1.4 pp02. Oxygen convulsions become possible at 1.6. However, you would have to be extremely unlucky to get a convulsion while diving a malfunctioning rebreather at 1.6 for a few minutes. In fact, most divers will get lucky and not be struck with oxygen toxicity even at levels as high as 2.0 or even 3.0. Even the most complacent dullard is likely to check his instruments before high 02 cause's central nervous system toxicity.

Several months ago I was descending past 200 feet in the La Jolla submarine canyon with Mark Thurlow. Suddenly I turned and he was gone. I looked up and saw Mark ascending rapidly while blowing gas out through his nose. A moment later he resumed his descent. When I asked Mark about it later, he sheepishly admitted that he had accidentally injected oxygen during his descent, rather than diluent. He noticed he had a problem when he checked his oxygen readings and found the needle pegged off the oxygen pressure scale. High oxygen levels do not necessarily result in dire consequences.

Low oxygen levels, however, should be feared absolutely. Low oxygen levels can creep up on a diver quickly and are more likely to happen near or at the surface than at depth. Hypoxia is the cause of most rebreather fatalities.

Once Bob Cranston began relating dumb rebreather mistakes, he seemed unable to stop. He once jumped in and began a dive with all of his electrical cables disconnected (the cables that connect the rebreather computer to the mechanics of the system). But a quick check of his instruments easily identified a problem, and he had no trouble returning to the boat while injecting gases manually.

Once Bob jumped in with the cover of his rebreather unsecured and, at the same time, the cover of his CO2 scrubber unlatched. He didn't know he had a problem until the end of his dive when, as he ascended with our underwater IMAX® system, his cover popped off followed by the lid to his scrubber. Essentially, his rebreather completely disassembled underwater. Bob might not have mentioned this accident except that most of his buddies were watching him at the time, and he could think of no way to disguise his error.

Never underestimate your capacity for doing something really stupid

My best advice to an aspiring rebreather diver is to never underestimate your capacity for doing something really stupid. Although Bob's mistakes seem dumb (and certainly were), they are typical experiences for most rebreather divers. I admit to making an equal number of blunders. Actually, I make a few dumb mistakes on every trip. Those that know me can easily understand my predisposition for error. Smarter divers would seem less likely to screw up.

Richard Pyle is a smart guy, most of the time. But, like Bob, he too has had problems with flooding his counterlung. He once jumped overboard with his breathing hoses disconnected. This mistake immediately resulted in a mouthful of water and flooded rebreather. Richard went to the surface, adjusted his full-face mask, and jumped back in assuming his full-face mask had leaked. Since his hoses were still disconnected, his rebreather flooded again.

Of course, making that kind of mistake near the surface seems far less frightening than having a complete failure 300 feet below the surface. But Richard has done that too. Richard told me that he once forgot to insert the drain plug in his rebreather prior to a deep dive. When he looked under a rock at 300 feet, turning his rebreather upside down, all the gas flowed out the hole and his counterlung immediately filled with water. Richard's next breath was entirely saline. Fortunately, Richard always carries plenty of bailout gas. He switched to open-circuit, one of his buddies noticed the open orifice and reinserted the plug. Richard then completed his dive.

Carry sufficient open-circuit bailout, and be prepared to use it

Switching to open-circuit is the last resort when things go wrong on a rebreather. Most problems can be solved by monitoring instruments and adding gases manually. But when everything melts down you need enough open circuit gas to get you to the surface. In over just over 1,000 hours of rebreather diving, I've been forced to switch to open circuit less than a half dozen times. Twice I had oxygen o-rings blow out leaving the rig with no oxygen supply. In both cases, I had plenty of oxygen in the counterlung for ten minutes or more on the bottom before switching to open circuit and ascending. In other instances, I lost the loop.

Failure of the counterlung to hold breathable gas is called "losing the loop." This has happened to me several times due to perforated breathing hoses or torn mouthpieces. It doesn't take much of a hole before the loop becomes unbreathable.

While diving at Cocos Island, I developed a tear in my mouthpiece. The hole was small, but the small amount of salt water that entered the loop reacted chemically with the carbon dioxide scrubber materials. The foam rubber water-absorbers inside my counterlung melted, and the gas became very unpleasant to breath. Back on the surface, I fixed the torn mouthpiece by installing a new one. I should have secured the new mouthpiece with a mouthpiece tie. Oops!

An hour into my next dive I turned my head to get Bob's attention and the mouthpiece popped off. Bob and Mark thought I looked pretty stupid with the mouthpiece sticking out of my mouth and the hoses floating high above my head. Of course, the counterlung immediately flooded. I switched to open-circuit.

Pushing the envelope

During our current film production, Coral Reef Adventure, my crew and I have logged more than twenty deep trimix dives, many of which were well below 300 feet. Our purpose for making these dives was to film, in the IMAX® format, Richard Pyle capturing undescribed fish species on the deep reef. On some of these dives we descended to below 300 feet with two underwater IMAX® cameras. Planning this film sequence seemed like a good idea at the time.

One characteristic of closed-circuit mixed-gas rebreathers that make them seductive is their ability to support dives to over 500 feet and theoretically to over 1500 feet. Unfortunately, the normal tendency of divers like myself to lapse into casual stupidity is not so benignly tolerated on deep trimix dives.

Trimix rebreather dives require multiple gas switches, computer manipulation, huge amounts of bailout gas of various mixtures, and hours of decompression. The degree of complication provides an enormous increase in the number of ways a diver can screw up.

Of course, I take trimix dives very seriously. Unfortunately, that hasn't prevented me from making serious mistakes. My most serious error was forgetting to make a gas switch on a dive to below 350 feet. The result was a visit to the Fiji Recompression Facility and hours of recompression therapy.

In the weeks that followed, I decided that forgetting to make the gas switch was understandable, considering the complexity of the dive and the demands on my attention when attempting to film at that depth with a 300-pound camera system. To remember the various gas switches and computer adjustments, I needed a checklist. This is the solution pilots have discovered for minimizing embarrassments such as finding oneself stuck at the end of the runway after skidding to a halt with the landing gear up.

During the trimix dives that followed my bends incident, my crew and I have found the checklist invaluable. Now, if only I can remember to look at it.

It now seems inevitable that rebreathers will become increasingly commonplace with sport divers around the world. Certainly there will be accidents as, through trial and error, divers develop the protocols for using these complicated machines. But for those divers who are willing to accept the risks and train themselves accordingly, rebreathers will open a new world of opportunity for underwater exploration.