

Feasibility review of “Triton”

Use of the “re-breather” term

Triton inventors initially used the term “rebreather” to describe their device, while the technical description of the “Triton”¹ does not match the definition of a rebreather². A “rebreather” recycles the air in a closed loop - carbon dioxide is being removed from the exhaled air, while oxygen is added to it. Rebreathers typically do not release any gas. The CO₂ could theoretically be released, but it would be a small amount at each breath - approximately 5% of the exhaled volume. The second demonstration video³ with a diver using the Triton gills while sitting in a swimming pool, clearly shows the person exhaling air in volumes corresponding to normal breathing rhythm at rest. This behaviour does not match a rebreather device, and instead follows the operation of an open loop self contained underwater breathing apparatus - or “SCUBA” device. On a much later date, Triton has removed the use of the word “rebreather” from its promotional materials, without a corresponding announcement explaining the sudden change.

For the remainder of this document it is assumed that the “rebreather” term was a mistake of nomenclature, and the “Triton” is an open loop breathing device, that releases all of the exhaled gas into the environment.

Artificial gills

The main principal of operation claimed by the “Triton” team is a “microporous hollow fiber” based filter system, that extracts oxygen dissolved in water, from the surrounding water to provide the user with breathable air. According to the description of the device, the filter is assisted by a small electric pump, powered from a battery. The Triton is claimed to operate at depths of up to 15ft, for periods of 45 minutes before the battery needs to be recharged.

The key issue with this principal of operation is the scarcity of air dissolved in water. The physical properties of air and water dictate the maximum amount of air that can exist dissolved in water. From these physical limitations we may find that in the best case within the operating range of the device, only 0.029L⁴ of air can be dissolved in every 1L of water. Considering that a human diver uses a minimum of 10L of air per minute⁵, the Triton device would have to filter all the oxygen out of a volume of 345L of water per minute to provide that much air. Note that despite the air dissolved in water is richer in oxygen than atmospheric air, this has no benefit to the operation of the device, as a certain volume of air is needed to properly ventilate carbon dioxide out of the divers lungs, and for the oxygen to be properly absorbed into the body, regardless of the specific proportions of gases. That quantity

¹ <https://www.indiegogo.com/projects/world-s-first-artificial-gills-oxygen-respirator--2#/>

² <https://en.wikipedia.org/wiki/Rebreather>

³ https://www.youtube.com/watch?v=QrT_KtdGFa8&ab_channel=SaeedKhademi

⁴ http://www.engineeringtoolbox.com/air-solubility-water-d_639.html, quoted value was linearly interpolated between available data points, with a twofold margin of error to the benefit of the Triton

⁵ <http://www.scubaboard.com/community/threads/what-is-your-average-air-consumption.37301/>

of filtered water - and absolute minimum of 345 L/min or nearly 6 L/second is an unreasonably large flow of water for a device in the proposed form factor. Not only is it extremely unlikely to produce a battery powered pump of such capacity and of that size, but also this would produce jets of expelled water strong enough to significantly propel the user. No such water jets can be observed in Triton's first demonstration video⁶ where we can see a diver floating freely in a body of water.

Supplemental air from a container of liquid oxygen.

As doubts of the feasibility of the Triton emerged on popular internet services^{7 8 9}, the team behind Triton disclosed a new technical specification of the device¹⁰. The creators agreed with the popular opinion voiced by experts that an artificial gill system is unfeasible for supporting human breathing. The revised principal of operation includes a canister of liquid oxygen supplying additional air, so that in combination with the two systems provides, in total, sufficient air for the user to breathe. Two replaceable, liquid oxygen canisters fit into the body of the device, each pair providing a total of 4 sessions of use, each session being 45 minutes long¹¹.

The revised specification is also not achievable, due to the small form factor of the device, and therefore the small volume of the supplemental tanks of oxygen. To estimate the required volume to meet these specifications, we must first assume that the original "Artificial gills" claim is somewhat true. While the previously calculated absolute minimum water flow of 345 L/min is clearly unachievable, we should assume that part of the device operates at a different - more realistic level. Observing the free movement of the diver in the demonstration video⁶ and comparing to existing water pumps of similar size one can assume a flow of 4L/min to be reasonable. However, due to scarcity of information on the Triton, a tenfold margin of error is taken on this estimate, in the benefit of the Triton. Thus a flow of 40L / minute is assumed. That would supply a diver with 11% of the required amount of breathable air, with there remaining 8.9L/min needing to be delivered by the liquid oxygen system.

Therefore, for a total use time of $4 \times 45 = 180$ min, the liquid oxygen tanks would need to store a total of 1600 L of atmospheric pressure air. The volumetric compression ratio between atmospheric pressure oxygen and liquid oxygen is a known physical constant equal to 861¹². Therefore, the pair of liquid oxygen tanks would need to have a total internal volume of 1.86 L, or a volume of 0.93 L each. The proposed form factor of the device would not fit that volume, by far.

⁶ https://www.youtube.com/watch?v=obqxzmmv7uM&ab_channel=SaeedKhademi

⁷ https://www.reddit.com/r/shittykickstarters/comments/4av9xw/triton_allows_you_to_breathe_underwater_100k_in/

⁸ <http://www.iflscience.com/technology/artificial-gills-underwater-breathing-device-has-820000-funding-despite-being>

⁹ <http://www.techinsider.io/can-triton-device-indiegogo-pull-oxygen-water-2016-3>

¹⁰ <https://www.indiegogo.com/projects/world-s-first-artificial-gills-oxygen-respirator--2#/updates> (retrieved 18.04.2016, copy: <http://imgur.com/15kfOv4>)

¹¹ <https://www.indiegogo.com/projects/world-s-first-artificial-gills-oxygen-respirator--2#/comments> (retrieved 18.04.2016, copy: <http://imgur.com/pr3TU3W>)

¹² https://en.wikipedia.org/wiki/Liquid_oxygen

Storage and transport of liquid oxygen canisters

The proposed liquid oxygen tanks are claimed by the Triton team to have a shelf life of 3 months¹¹. This is an extremely unlikely scenario considering that liquid oxygen needs to remain at temperatures below -120°C . Existing liquid oxygen storage tanks, called “dewars”, operate by being very well thermally insulated. The thermal energy that surpasses the insulation makes the content slowly evaporate at a rate called the “evaporation rate” (ER) of a dewar. Contemporary small and portable dewars have a ER of between 0.15 L and 2 L per day. To ensure the shelf life claimed by the Triton team, the canister would require an unheard of level of thermal insulation - at least 30 times better than devices available on the market.

Furthermore, liquid oxygen is considered a hazardous material and there are many restrictions in place limiting the possibility of shipping, handling and even privately transporting liquid oxygen. For example: no liquid oxygen containers can be posted by the USPS, or taken onboard any commercial airline flight. The Triton team claims to be cooperating with third party suppliers and stores to establish a chain of service points offering their liquid oxygen tanks. Although this is a legislative and not physical limitation, in the opinion of the reviewer this claim is extremely unlikely to be followed up by successful action.

It is also worth pointing out, that the replaceable containers, offered at \$17.99 a pair, were announced after the widespread discussion about the feasibility of the device. Before that moment, the Triton crowdfunding campaign collected nearly \$900,000 from supporters, while specifically claiming that the device will only require the battery to be charged after every 45 minutes of use. The only maintenance procedure discussed was the required rinsing with fresh water after use in saltwater.

Claims of working prototypes

Despite the limitations described above, the creators of Triton are repeatedly^{1 13} claiming to have a working prototype of the device. Since it can be proven that a device following this description is not possible to make, the claims of an existing prototype are likely false. Note that the limitation is not related to the technology, or manufacturing processes but is strictly based on well known and well documented physical constants that can not be avoided.

The published video demonstrations of the device have certain characteristics that make them easy to produce without having a working device like the Triton. The first video⁶ consists of three edited shots, each lasting less than a minute. Each shot could have been recorded separately, with the diver surfacing for air in between. Additionally, only a very small volume of air can be observed to be exhaled by the presenter thought out each of the shots - a volume that corresponds to the capacity of the lungs of a healthy person. One may also notice the change of buoyancy of the presenter, most significantly in the last shot - where at the beginning the diver tends to surface, and at the end of the video, tends to sink. This would correspond to the volume of his lungs decreasing as air is being slowly exhaled during filming and no new air is being inhaled. Such a video can be reproduced by simply asking the actor to hold his breath, and exhale in a couple of small portions through out the short scene.

¹³ <https://www.indiegogo.com/projects/world-s-first-artificial-gills-oxygen-respirator--2#/comments> (retrieved 18.04.2016, copy <http://imgur.com/WPp3Stl>)

The second published demonstration³ is substantially different from the first clip. While the recording appears to be an unedited 12 minute clip, in this video one may observe plenty of exhaled air, indicating a working air supply - much in contrast to the previous clip. However, the position of both the presenter and the camera is fixed throughout the entirety of the video. This leaves plenty of opportunity to place external devices and hoses hidden from the view of a person watching the recording. An unnamed internet forum user published a video showing how this a demonstration could have been forged by using off the shelf scuba equipment¹⁴. In this parodic demonstration the triton device was replaced by what appears to be a rubber chicken.

Conclusions

The Triton device, as described by its creators, was proven to be unfeasible due to unavoidable physical restrictions. The demonstration videos published by the Triton team were shown to be easily forgeable, and yet they remain the only evidence supporting the teams claim of having a working prototype. At this point the reviewer would wish to reiterate that all calculations done here were under the assumption of the best possible conditions for such a device to exist, and at any points of uncertainty margins of error were taken in favour of the device existing.

In the opinion of the reviewer, the claims of the Triton team are an act of deliberate misinformation, created for monetary gain. As of writing, the Triton team is collecting substantial sums of money through the crowdfunding portal Indiegogo. All attempts to present such calculations to the Triton team are either deleted by them from the campaign website, or meet with a verbal aggressive response. Attempts to communicate these concerns to Indiegogo are repeatedly met with silence.



Stockholm, 18.04.2016, Marek Bączyński.

¹⁴ https://www.youtube.com/watch?v=IXv_AohVUcQ&ab_channel=TriChicken