OPEN SAFETY

APOCALYPSE TYPE IV

LATIN FROM APO-KALUPTEIN: THE UNVEILER, REVEALER

FEATURES

- Created by the 200 man year rebreather safety project: Open Revolution™
- Full and open compliance with EN14143, NEDU 2007 WOB Objectives, NORSOK U-101, U100 and all other applicable standards
- Optional O2 + CO2 monitor provides safety to EN61508 SIL 3 to 4: a billion hours between safety critical failures
- Lowest Work of Breathing (WOB): 1.44J/L CE conditions of 40msw, RMV of 75 lpm and 0.44 at an RMV of 40lpm.
- WOB depth limits beyond 100msw using air, and 510msw using heliox: far beyond narcotic and non-saturation diving depth limits (30msw and 80msw respectively).
- Rugged with low maintenance
- Clean front and shoulders: internal back-mounted counterlungs
- Quick fit EAC scrubber cartridges
- Profile above diver of just 170.5mm, less than a single 10 litre cylinder
- Light: as low as 17kg ready to dive, depending on configuration
- Full and short case options available
- Designed and manufactured under ISO 9000 Q.A. system, to EN61508 standards.

SAFE and COMPLIANT

A truly unique product, developed out of the 200 man-year Open Revolution ™ rebreather safety initiative led by Deep Life Ltd, the Apocalypse Type IV mCCR is believed to be the safest SCUBA rebreather that can be engineered today for sports divers. Accident studies have found mCCRs are safer than eCCRs with a 250,000:1 level of confidence. The Apocalypse takes this a stage further with the highest performance breathing loop, monitoring safety nets and audited safety certification.

Full compliance with all applicable safety standards, with open publication of the safety documentation, is a cornerstone of the design: the formal verification, test results, failure analysis, performance measurements and compliance matrices are audited and published – an openness that is truly revolutionary in rebreather safety.

VERSATILE

The Apocalypse Type IV mCCR is a multi-role life support system that covers the whole spectrum of operating depths, from very shallow to the most extreme. Interchangeable cases in black carbon fibre pattern, or safety yellow, as well as a choice of wings and harnesses, add further to the versatility of the unit. This versatility enables the Apocalypse Type IV mCCR to meet your diving needs throughout your career: from basic CCR diver to extreme diving, cave diving to wreck diving, photography to hard swimming.

PRINCIPLES

A rebreather removes carbon dioxide exhaled by the diver and adds oxygen into a closed loop, so there are no bubbles and optimal control of oxygen levels. This results in reduced decompression time, no bubbles, low noise, constant buoyancy and dive durations typically five times longer than for an equivalent weight of Open Circuit equipment. Fish almost touch the diver, as they are not scared off by bubble noise. Gas consumption is independent of depth.
Due to the optimum level of oxygen in the breathing loop, the rebreather offers an 18msw “no decompression depth” using air as the makeup gas – dive as long as you like without needing to decompress. Deeper than this, the rebreather provides large reductions in deco time compared to Open Circuit or semi-closed rebreathers.
In a mCCR, there is a constant bleed of oxygen to support the diver’s rest level of metabolism, with periodic injection of gas by the diver. Accident studies and statistical analysis has shown that this is a much safer method of controlling a rebreather for a sports diver than entrusting electronics.

APPLICATIONS

The Apocalypse mCCR can adapt to your needs throughout your diving career. The versatility of the unit can be seen from these photos taken during a few of the Apocalypse test dives: they are just glimpses into the new world that is ready to unfold before you.

Foremost, the Apocalypse mCCR allows you to explore, to unveil some of the wonders of creation. We have chosen the name for the rebreather out of respect for this: the word *Apocalypse* is the Latin word to unveil, or to reveal, from roots Ancient Greek.

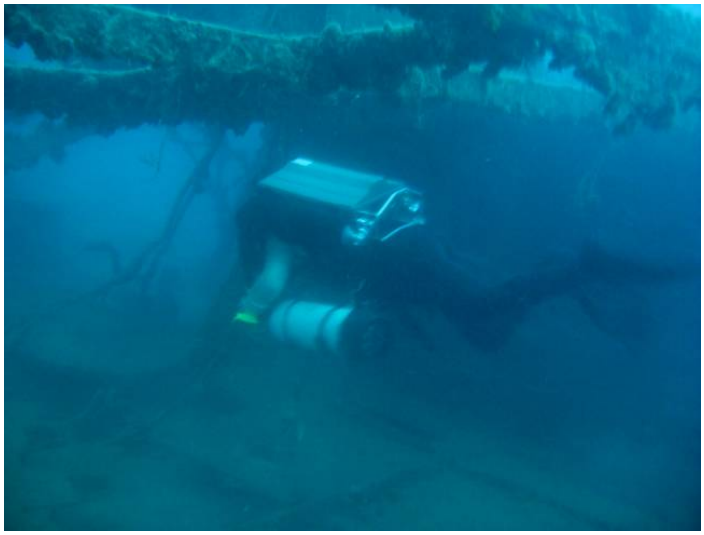
Whether you want to get this close to a 500kg Blue Fin Tuna or photograph the most exquisite sea life such as this nudibranch below, the silence of the Apocalypse mCCR grants you intimate closeness with the marine world.

Cave exploration

The simplicity and robustness of the Apocalypse provides the reliability needed for extended cave dives. The Apocalypse can be ordered with full or partial Hogarthian harness, complete with scooter straps and rings.

Wreck diving

The reliability, low profile and low work of breathing makes the Apocalypse the ideal tool for serious wreck diving. It is offered with two types of technical diving harness, with and without integrated weights. The Apocalypse was developed by well-known wreck divers.



OPERATING LIMITS

- Advised safe depth limit: 30msw using air due to narcosis, and 80msw using 16% heliox or trimix
- Depth limit from sonic flow from preset intermediate pressure: 80msw
- Maximum depths: work of breathing limit of beyond 100msw using air – well beyond narcotic limits, 510msw using Heliox – well beyond non-saturation diving limits.
- Operating temperature in air: -40C to +50C,
- Sea temperature operation -4C to +37..
- Fresh water temperature operation 1C to 37C.
- Counterlung heating below 4C in all cases

O.R. Apocalypse Type IV mCCR comprising as standard:

1. Swedish ergonomics in the case: light, contoured to rest on the hips, with carry handle.
2. Breathing Hose assembly with Auto Loop Volume, Bail out and Auto loop shut off valve
3. Micropore EAC Scrubber, the safest and easiest to use scrubber technology in existence
4. Internal Oxygen cylinder US 2 litre or CE 1.72 litre: oxygen will outlast the scrubber
5. High quality regulators for oxygen & make-up-gas, each with fill point and button contents gauges.
6. Self cleaning gas injector with 0.7 lpm constant bleed, and manual inject with tactile feedback
7. Two biased counterlungs, heavy duty welded construction with port reinforcing rings, stainless steel springs and 36mm dual button P-Ports
8. Water Dumps fitted to both counterlungs allowing recovery from a full flood underwater
9. Automatic Over-Pressure-Valve
10. Hose and scrubber insulating wraps, mouthpiece retainer
11. Side rail tank mounts that fit bio-clamp type cylinder attachment or cam bands
12. Oxygen decanting whip for integrated cylinder valve
13. Webbing harness (50mm webbing with shoulder quick releases, D-Rings, 50mm crotch strap)
14. 25kg lift non-bungeed Wing
15. Manual on CD, with copy of safety certifications and key safety data
16. 80L Shipping box
17. Short case option fitted with external tanks, with no provision for onboard O2. Otherwise the short case configuration is the same as for the full case.

Rebreather Monitor option

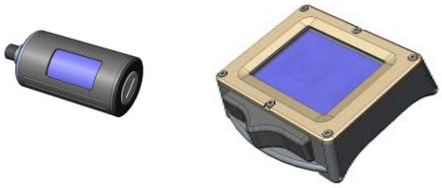
Provides auto-shut-off to the breathing loop, CO2 monitoring, PPO2 monitoring, flood monitoring, respiratory monitoring, dive logging at 1 second intervals with 10cm depth resolution, two full colour buddy OLED displays, a Peripheral Field Display to the diver, as well as voice annunciation for status and alarm conditions.

Web shop options include:

1. A Hogarthian webbing harness with crotch strap is available as a zero cost option for DIR divers
2. Tech Harness providing a comfortable and reliable platform
3. Military grade integrated weight harness, with high tech ceramic fabric
4. High lift (45kg) bungeed tech wing for diving with steel stages
5. Quick harness and cylinder attach: Metalsub
6. Storage pockets for self inflating SMBs, and selection of clips
7. Side Slung Bailout rigging kit
8. Long breathing loop hoses for tall divers
9. T piece for dry suit and Wing/BCD, with hoses for both (when using bail out cylinders >7L)
10. Short case and stand option for the most space constrained traveller
11. Pure oxygen rebreather conversion kit
12. Counterlung heating kit for ice diving
13. All individual mCCR components and spares kits
14. Micropore ExtendAir scrubber cartridges, packs of four
15. Virkon tablets for cleaning (pk10)
16. O2 cells PSR-11-39-DL
17. Annual Service
18. Cylinder Contents Labels stating unrestricted air transport is permitted when empty

Scheduled for release in 2009:

1. Wrist display for CO2+PPO2 monitor, with AMOLED full colour display and wireless link
2. Wireless tank contents senders linking to PPO2 monitor and wrist display
3. Environmental protection: Breathable dry suits
4. Dive planning and logging software



TURN-AROUND-TIME AS LOW AS TWO MINUTES

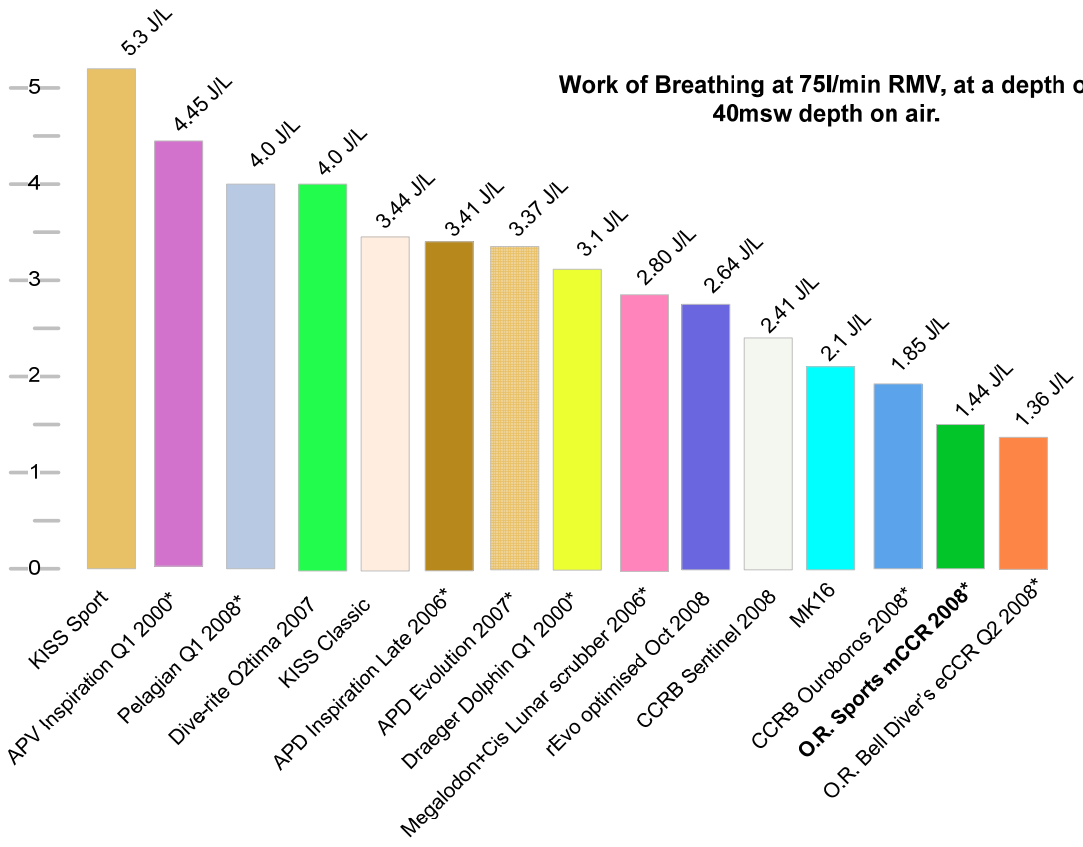
The Apocalypse takes as little as two minutes to remove the old scrubber, wash the breathing loop, unpack and fit a new scrubber, then pressurise as the positive pressure test that starts the pre-dive checks. This fast turnaround time is a reflection of the unique two button connectors allowing fast disassembly and reassembly, the ease of scrubber and counterlung access, and the use of EAC scrubber cartridges.

EASY TO LIVE WITH!

In the words of one of the independent test divers:

> I especially liked the weight/trim of the unit. You can wear it (with weights), on land for a long time and not suffer. I had to walk some distance with it to reach a cave on some hills and it was easy. I cannot say the same thing about the 10L steel bailout. In water the trim feels nice. Not much need to fiddle around with the weights.
>
> *T. Naskali, CMAS Dive Instructor and Test Diver. August 2008*

Work of Breathing has been identified by the US Navy's NEDU as a primary factor affecting the diver's safety[1]. Low work of breathing is important to minimise retained CO2, with its associated cardiac risks and diver well being. The Open Revolution rebreathers achieve the lowest confirmed work of breathing that is reported for any SCUBA rebreather.



(*) are units measured by Deep Life Ltd. All others are units measured and reported by CCRB Ltd, ANSTI Ltd, NEDU or Micropore Ltd. Deep Life Ltd sweep the loop volume and take the average of ten breathing cycles with the lowest WOB, all other results are a single loop volume, and in some cases a single cycle with the lowest WOB, which tends to produce a better looking result (typically 0.2 J/L to 0.3J/L lower than that reported by Deep Life or NEDU). Deep Life Ltd use an approximately 50% exhausted scrubber for the test, measured in elapsed time to scrubber exhaustion, other results generally use a fresh scrubber.

The meaning of this extremely low WOB in words of one of the independent test divers:

> I must say the unit dives very nicely and is extremely easy to breathe. I have been down to 40m with the twin scrubber unit and did not notice any increase with the breathing effort. With the single scrubber version I have been to 35-ish meters and compared WOB with my Poseidon Xstream. I must say that the rebreather was nicer to breathe. I also tried swimming around fast and did not notice any extra effort required while breathing. *T. Naskali, CMAS Dive Instructor*

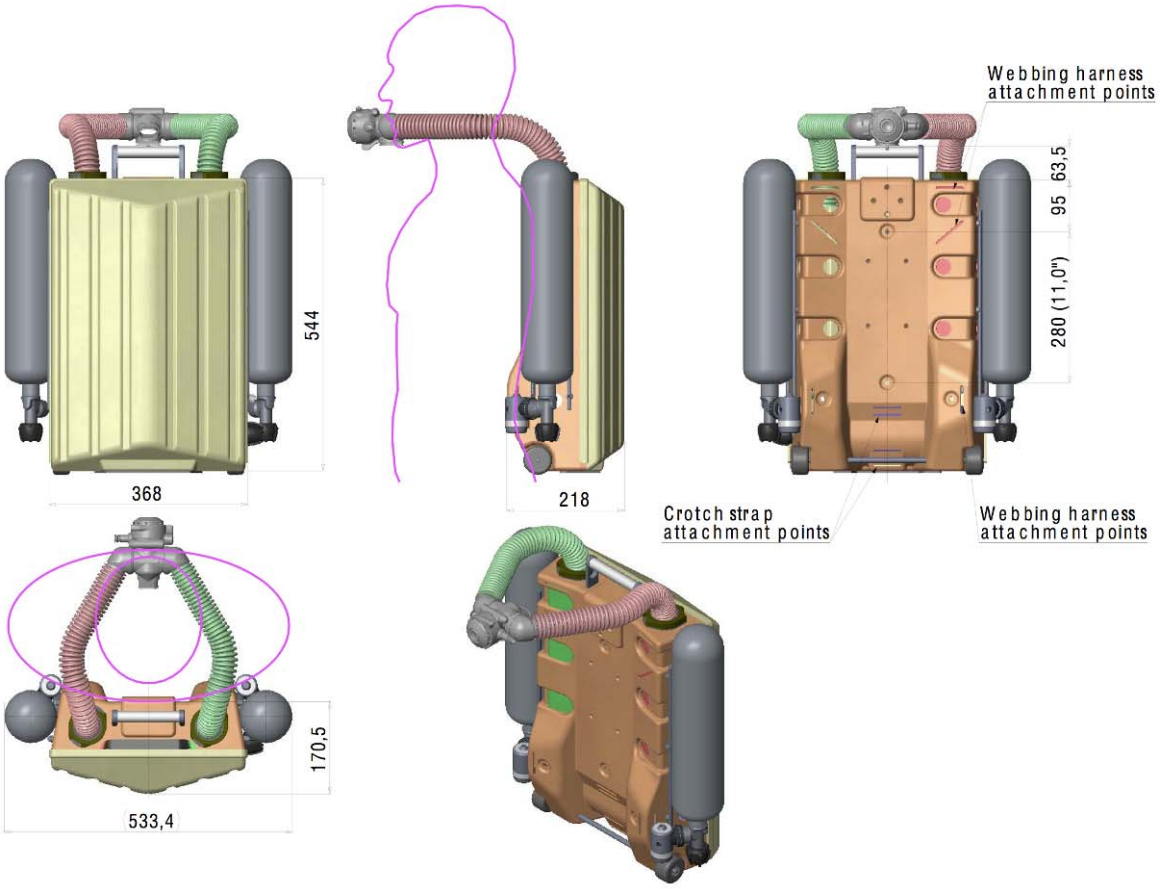
[1] D. Warkander, "Comprehensive Performance Limits for Diver's Underwater Breathing Gear: Consequences of adopting diver focused limits", U.S. Navy Experimental Dive Unit TR07-02, 2007

Apocalypse mCCR Description

Dimensions

Two case options are provided: a short case and a full case. Both stand just 170mm off the diver's back, and their width is matched to the diver's body, the Apocalypse mCCR provides a very low cross-section, which translates to low drag in the water. The length is optimised to allow the diver to sit on a bench with the rebreather, without having to support the weight.

The image below shows both bail out and make-up-gas tanks attached to the full case: these are 3 litre tanks in the image below, but anything from 1 litre to 12 litre tanks can be fitted.



A lot of attention has been paid to the ergonomics, from reducing weight, the body sculpted form, the case latches that are secure but work even in the dark, the secure harness attachment, providing ease of access to all parts.

Weight

The total weight ready to dive, with standard harness, a 2L light weight make-up-gas cylinder, 4kg trim weight, gas & EAC is ~17kg.

Scrubber Endurance

The endurance to the 2.0 kPa CO2 limit in NORSOK U-101:1999 is 2 hours 45 minutes, at an ambient water temperature of 4C and a CO2 injection rate of 1.6 lpm, which equates to an oxygen metabolism of 1.78 lpm. This metabolism covers 99% of divers swimming at a moderate rate.
The scrubber endurance is not affected by breaks of up to one week, subject to the scrubber remaining in the rebreather.
It is recommended that for the second dive, that the diver rotate the scrubber 180 degrees (but not reverse it: top stays as top, bottom as bottom).

Perfect trim straight out of the box

The trim for most divers should be pretty well perfect straight out of the box. There is a weight pouch inside the unit fitted with a 4kg dive weight to enable the trim to be adjusted.

For a diver in a shortie, no extra weight should be needed: for thick wet suits and dry suits, the diver should weight themselves the same as if snorkelling.

Oxygen Injector

The oxygen injector is a unique self-cleaning design, opening up as the manual inject valve is pressed.

Should the gas be off, there is a strong tactile feedback so the diver knows immediately he touches the injector.

The O2 injector has a single hose attached to it with a HP hose inside it. The HP hose has a 0.8mm internal diameter so should it burst, the breathing loop is not filled with O2 quickly but gives a burst of oxygen before blowing the over-pressure valve, to give the diver more time deal with the loss of oxygen supply.

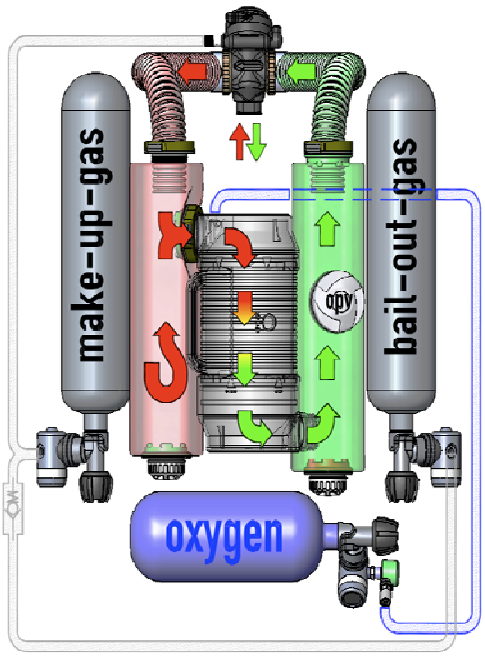
The pressure needed to operate the button is set at 1kg, to avoid cramp in the fingers in cold water.

Professional Right to Left Loop

Professional rebreathers use right to left because hoses or ports are marked in red and green for dirty and clean gas respectively, which is visible when looking at the diver. The normal maritime convention uses Red and Green for Port and Starboard, so this leads naturally to Green on the right.
Another reason fro Right to Left flow is that as a general principle any oxygen rich gas should come from the right, so the oxygen cylinder is on the right side, which tends to lead the diver to think that his oxygen rich gas comes from the right.

There is one further reason for right to left: most divers' right hands are slightly stronger and more adept than an their left hand, so the right hand can inject oxygen better.

The image on the right shows the BOV and ALV connections, as well as gas flow (right to left, as it is on professional rebreathers), water dumps at the bottom of the counterlungs, and the one-way valve between the cylinders. The diagram shows the tanks fitted with the Apeks regulator option.



Gas Regulators

The highest quality regulators have been chosen for the Apocalypse, each fitted with a button type contents gauge. The full case is fitted with a 2 litre[2] internal oxygen cylinder, with integrated regulator. Short case is fitted with an external 2 litre oxygen cylinder.

The diver must check their gas before the dive, but should not need to look at the gauges during the dive: the oxygen tank will last between four and twelve hours, depending on the size of the diver and the amount of work being carried out – well beyond the scrubber duration. The oxygen injector has a tactile feedback so the diver can tell immediately if the oxygen is off, or when the oxygen tank is empty.

The oxygen regulator is specially designed for the Apocalypse. The oxygen regulator is combined with the tank valve to save weight, and ensure oxygen filling rates are safe. The valve handle cannot turn the tank on or off accidentally: it has a safety mechanism that has to be pressed in before it can be turned, similar to that used by firemen to prevent tanks turning off when they are rubbed against stair rails. The handle is made from metal, not elastomers that tend to catch lines and turn.

The oxygen regulator has just one hose port to avoid it being used accidentally to fill the wing or a dry suit. A tee-piece is available to use the Apocalypse as a pure oxygen rebreather for shallow diving.

The integrated oxygen regulator has an over-pressure valve and a male HP decanting connection: the same as for a HP contents gauge hose. A 300 bar decanting whip is supplied with the rebreather to allow the Make-Up-Gas and oxygen to be filled from a normal DIN SCUBA cylinder.

[2] All territories outside Europe are supplied with a 2 litre tank. Due to regulatory requirements to use specific threads, the CE tank may be 0.28 litres smaller.

The Make-Up-Gas is either air or 16% trimix. An Apollo make-up-gas regulator is provided – Apollo is a Japanese company that has been producing high quality regulators for decades. These have a European 25mm x 2mm DIN thread: other threads available as options.

The rebreather can be supplied with DS1 + DS4 Apeks regulators as an option.

The Make-Up-Gas is there for a purpose, and it is not bail out. A good diver would not use Make-Up-Gas as bail out: a 2 litre cylinder is not sufficient for bail out, nor is a 5 litre. It needs to be 7 litre or more. If the diver is carrying bail out, then running a BCD from that is easy and safer.

Buoyancy control

There are three wing/BCD options:

1. The standard wing supplied with the unit is a 22kg/55lb lift wing with gas cross-over space top and bottom.
2. An optional tech wing with 45kg/110lb of lift, bungeed, for divers with steel stages.
3. The Incursion integrated weight and BCD, developed originally for military diving.

Buoyancy swing when the Apocalypse is fully flooded is 8.5kg, assuming that both counterlungs are flooded, hoses are completely flooded and scrubber is flooded. The wings provide enough buoyancy in the event of a total loop flood, if the diver is weighted properly.

The Counterlungs provide 5.9 litres of volume: two normal breaths. This Work of Breathing - loop volume curve is so flat that buoyancy can be controlled by adjusting loop volume in the event of BCD failure.

Harness

Four harness options are provided:

1. Basic webbing harness supplied with the unit: a 50mm webbing harness without a crotch strap, with clip on the shoulders.
2. Hogarthian DIR Harness, for those who are dive with a DIR group.
3. Tech harness providing a comfortable platform for both the rebreather and accessories
4. Integrated weight harness with integrated wing and using ceramic fabrics (standard on the Open Revolution Clearance Diver's eCCR, the Incursion).

Dual Button 36mm P-Ports

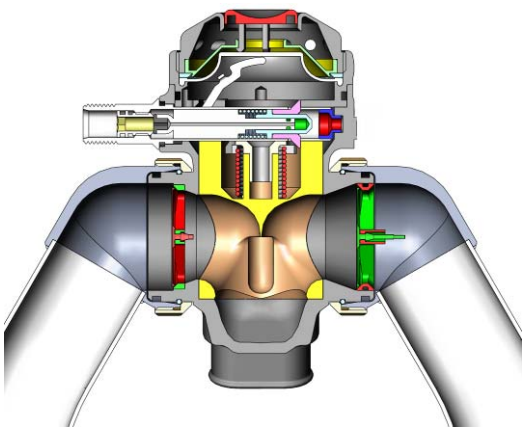
The P-ports provide a simple connector, but again loaded with safety features:

- Two buttons that have to be pressed at the same time to disengage, to prevent accidental loop failure.
- Use of double piston EPDM O-rings to avoid dives being lost from a single O-ring failure
- Colour indicators to show that they are engaged properly, as well as a positive click
- Large 36mm internal bore provides a low resistance to gas flow
- Custom plastics formulated to prevent off-gassing
- Main parts are screwed together for reliability
- Tested for 100kg pulls, four times the CE requirement, as are the breathing hoses

Combined Auto-Shut-Off, Auto-Loop-Volume and Bail-out-valve

The combined valve is hardly larger than many Open Circuit demand valves, but is packed with novel safety features[3], including:

- The lowest claimed work of breathing of any rebreather mouthpiece at just 5.2 J/L at 40msw with a 75 lpm RMV – the standard CE test conditions due to the flow contouring that can be seen in the cross-section opposite.
- The valve is bi-polar: it cannot be set half open, or half closed.
- It avoids the question of whether the bail-out-valve works, by using the same valve for automatic-loop-volume and bail-out. The cracking pressure of the valve is adjusted automatically as it switches between closed and open circuit.
- The diaphragm is protected from free-flow using vortex balancing: in the presence of a strong current it creates a



[3] Patents pending in PCT countries in respect of multiple features

vortex of water under the purge button to counterbalance the force from the oncoming water – whether this is direct or at an angle.

- The valve has stainless steel hose attachments for robustness, and for neutral buoyancy in salt water.
- The valve is clad with neoprene to avoid injury should it drop on the diver, and for insulation.
- Flapper valves cannot be swapped
- The valve is below the diver's mouth to optimise WOB and visibility: gas leaving the mouth does not exit in a straight line, but in a downwards arc
- Removing the valve from the mouth, and mouthpiece retainer, causes the breathing loop to shut automatically
- It has a provision for a power drive from the Open Safety rebreather monitor, such that the diver is bailed out and the loop is shut automatically, when the loop cannot sustain life.

The valve uses an Apeks second stage, so annual servicing can be carried out by any qualified service technician.

Counterlungs

Back mounted counterlungs are strongly preferred by divers over the more common Over-The-Shoulder (OTS) design, because they do not block the diver's vision. The reason OTS designs are more common is that they can meet the hydrostatic imbalance limits in Europe easily; but the Apocalypse has a better solution: biased counterlungs.

The bias makes the counterlungs act like bellows that want to expand outwards, so there are a few millibars of breathing assistance when the diver is on his back. This counteracts the hydrostatic pressure in that position, and gives more range for adjusting the loop in other positions.

The counterlungs have a total capacity of 5.9 litres to allow two full breaths from an above average sized diver. This allows the diver to adjust their buoyancy to perfection by controlling the loop volume.

The counterlungs are made from a single layer of ultra-flexible material, that proved to be more resistant to knife attack than 1100 grade Cordura: it simply flows around the knife. The lungs are protected from the environment by their location inside the rebreather housing, but the abrasion resistance and ease of cleaning of the material allow the unit to be dived with the covers off if required.

A 36mm I.D. stainless steel spring prevents the counterlungs trapping gas, and compared to the 8mm I.D. coils normally fitted, they provide a lower resistance gas path under the worst operating conditions.

Apocalypse Type IV rebreather in standard case, fitted with a 3 litre make-up-gas cylinder.

Over-Pressure-Valve (OPV)

The OPV is on the inhale counterlung: this is the only correct place for it.

There is a safety hazard on all rebreathers with OPVs on the exhale side: in a fast ascent the gas expands in the inhale CL and goes back through the scrubber to the exhale CL and then is exhausted. As it does so, it carries with it the injected oxygen. The result is that the PPO2 breathed by the diver plummets. The solution is to put the OPV on the inhale counterlung as it is on the Open Revolution rebreathers such as the Apocalypse.

Water Dumps

Water dumps are provided on the bottom of each counterlung similar to a BCD or a wing. To dump water, the diver fully inflates the loop and pulls the toggles. A one-way valve prevents water ingress to the counterlungs while the dump is open in normal diving attitudes.

The breathing hoses are spiral, so shed water more easily than normal hoses, and avoid trapping water and bacteria.

The combination of these features allows the rebreather to be completely flooded and then recovered underwater. Even the scrubber is flood tolerant for up to five minutes.

Work of Breathing at different depths and work rates, using air

Diver Vertical

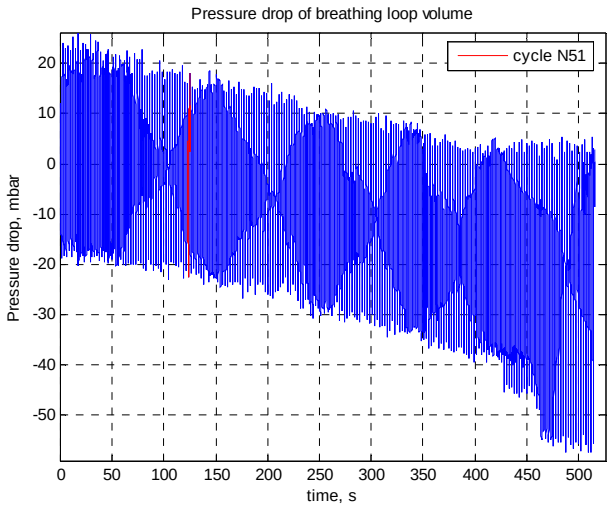
RMV	Depth, msw	WOB, J/l Typical and (best case)	Inhale / exhale peak pressure, mbar
10	0	0.14	8.5 / 15.9
	40	0.18	-3.4 / 4.8
	60	0.2	-10.1 / -2.5
	100	0.23	-8.8 / -1.4
40	0	0.40	4.8 / 18.0
	40	0.41	6.4 / 19.4
	60	0.56	-7.5 / 5.6
	100	0.74	-11.0 / 2.6
75	0	0.64 (0.58)	-1.2 / 18.1
	40	**1.44 (1.39)**	**-7.1 / 17.8**
	60	1.85	-16.2 / 12.9
	80	2.2	-17.9 / 15.3
	100	2.66	-22.7 / 18.0
90	0	0.73 (0.67)	3.0 / 20.7
	40	1.96 (1.93)	-10.9 / 19.2
	60	2.46	-19.1 / 14.6
	80	2.95	-23.5 / 18.1
	100	3.55	-27.9 / 24.2

Diver Horizontal

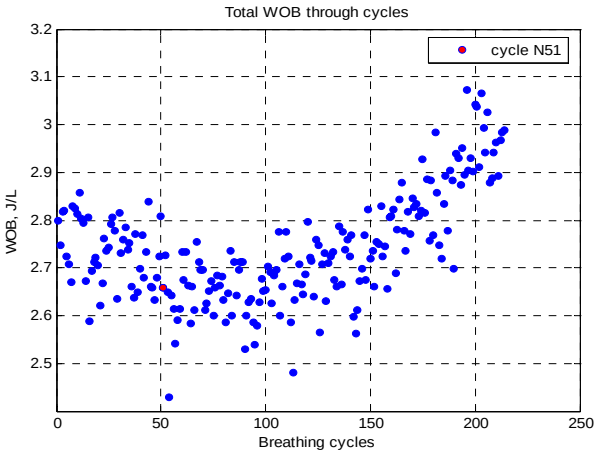
RMV	Depth, msw	WOB, J/l Typical and (best case)	Inhale / exhale peak pressure, mbar
40	0	0.20	6.0 / 11.1
	40	0.43	3.8 / 12.1
	53	0.49	2.8 / 11.0

The role of Work of Breathing (WOB) on diver's comfort is obvious but its critical role in diver's safety has only been understood recently.

The attention given to achieving the lowest WOB in the Open Revolution rebreathers, is no different to the attention to each of the other safety issues. Some of these are immediately apparent, others are more subtle. The result is that the Apocalypse is leap ahead in safe rebreather diving.



Example at 100msw, 75 lpm RMV:
In each case, the loop volume is swept from maximum loop volume to empty loop, and the breathing resistance curve for every breathing cycle is stored: see plot above. The WOB for every breathing cycle is then plotted, and an average figure is taken for the most comfortable breathing cycles. The WOB curve against loop volume is checked to ensure there are no sudden changes that could cause a diver difficulty.
Even at 100msw, the Apocalypse passes European WOB requirements of < 2.75 J/L.



Open Safety Equipment Ltd
Zetland Road, Hillington, Glasgow, Scotland

Online shop and further data:
www.opensafety.eu

Contact
sales@opensafety.eu