

## Glossary of Rebreather Diving by Jill Heinerth

### A

Absolute pressure – The total pressure imposed by the depth of water plus the atmospheric pressure at the surface.

Absorbent pads – Absorbent material placed in a breathing loop; used to soak up moisture caused by condensation and metabolism.

Accumulator – A small chamber that provides a collection vessel to ensure proper gas flow of oxygen to a solenoid valve.

Active-addition – A rebreather gas-addition system that actively injects gas into the breathing loop (such as a constant-mass flow valve in certain kinds of semiclosed rebreathers).

Atmospheres absolute (ata) – The absolute pressure as measured in atmospheres.

Atmosphere (atm) – A unit of pressure equivalent to the mean pressure exerted by the Earth's atmosphere at sea level, or by 33 fsw, or by 10 msw (equal to 1.0 bar or 14.7 psi).

Automatic diluent valve (ADV) – A mechanically-activated valve that adds diluent gas when increasing pressure associated with descent or lowered volume triggers the device.

Axial scrubber – A type of CO<sub>2</sub> absorbent canister design. In this design, the gas flows through the canister in a linear fashion from one end of the canister to the other.

### B

Backplate – A plate made of stainless steel, aluminum or acrylonitrile butadiene styrene (ABS) plastic which attaches to a rebreather and allows for the use of a webbed or soft harness system.

Bailout – A failure requiring a dive to be terminated, usually using open-circuit gas.

Bailout gas – Tanks carried by the diver to allow for escape from a serious situation, often conducted with open-circuit technique.

Bailout valve (BOV) – An open-circuit regulator built into the mouthpiece assembly that allows a diver to switch from closed-circuit mode to open-circuit without removing the mouthpiece from their mouth. When the loop is closed, the BOV activates, supplying open-circuit gas directly from the onboard diluent tank (in a closed-circuit rebreather) or supply gas cylinder (in a semiclosed-circuit rebreather).

Bar – A unit measure of pressure, roughly equivalent to 1 atm.

Barotrauma – A pressure related injury.

Bottom-out (counterlung) – A term used to refer to the situation when a rebreather counterlung becomes completely collapsed after a full inhalation.

Boom scenario – An explosion or implosion of a hose or other component usually resulting in rapid gas loss or catastrophic loop failure.

Boyle's Law – The volume occupied by a given number of gas molecules is inversely proportional the pressure of the gas.

Breakthrough – The point at which a scrubber allows CO<sub>2</sub> to bypass the scrubbing process to be re-inspired. The fraction of inspired CO<sub>2</sub> normally rises extremely quickly once breakthrough is reached.

Breathing hose – Large bore hoses in a rebreather breathing loop, through which the breathing gas travels.

Breathing loop – The portion of a rebreather through which gas circulates, usually consisting of a mouthpiece, breathing hose(s), counterlungs, non-return valves and a CO<sub>2</sub> absorbent canister.

Buddy lights – Warning lights that indicates system status including life-threatening oxygen levels; usually monitored by the buddy diver.

Buoyancy control device (BCD) – An inflatable bladder which allows a diver to precisely adjust buoyancy.

C

Calibration gas – A gas of a known composition used to calibrate gas sensors, particularly PO<sub>2</sub> and PCO<sub>2</sub> sensors.

Carbon dioxide (CO<sub>2</sub>) – Waste gas generated by the process of metabolism and exhaled by the diver into the breathing loop.

Carbon dioxide retention – Condition in which arterial CO<sub>2</sub> is seen to increase in divers due to insufficient ventilation, excessive dead space in the breathing loop, or ineffective CO<sub>2</sub> scrubber filtration.

Catastrophic loop failure – A complete failure of the breathing loop of a rebreather such that it cannot be recovered in closed-circuit mode; usually occurring from a ripping or tearing and subsequent flooding of a unit or a carbon dioxide emergency.

Central nervous system (CNS) – The human brain, spinal cord, and associated major neurological pathways that are critical for basic life-support processes, muscular and sensory systems.

Central nervous system oxygen toxicity – A serious form of oxygen toxicity, usually caused by exposure to breathing mixtures with an oxygen partial pressure in excess of 1.6 ata. Symptoms may include visual disturbances, hearing anomalies, nausea, twitching, dizziness and severe convulsions.

Chain of custody – Refers to the chronological documentation that captures the seizure, custody, control, transfer, analysis, and disposition of physical or electronic evidence, typically for legal purposes.

Channeling (of scrubber canister) – Condition in which improper packing or excessive settling forms channels that allow some CO<sub>2</sub> to pass through the scrubber without being absorbed.

Check valve – A one-way, non-return valve that directs gas to move in only one direction through the breathing loop.

Closed-circuit rebreather (CCR) – A type of rebreather that usually includes some form of oxygen control system and generally only vents gas upon ascent.

CO<sub>2</sub> absorbent – A material that chemically binds with CO<sub>2</sub> molecules (Sodasorb, Drägerorb®, lithium hydroxide, Sofnolime®, Micropore ExtendAir, etc.).

CO<sub>2</sub> absorbent canister – A canister in the breathing loop containing CO<sub>2</sub> absorbent.

Condensation – Water that forms when water vapor cools and forms liquid droplets. In a rebreather, heat conduction through the breathing hoses and other components of the breathing loop lead to condensation. This process may be exacerbated by materials with greater heat conductivity and lessened with insulation of the breathing loop components.

Conduction (thermal) – Heat flow between objects in physical contact; the inverse of insulation.

Constant mass flow valve – A type of valve that allows a constant mass of gas molecules to flow at a fixed rate.

Constant volume flow – A type of valve that delivers a constant volume, independent of ambient pressure, thus a flexible number of gas molecules.

Convection (thermal) – Heat flow through circulating currents in liquid or gas environment.

Counterlung – A collapsible bag connected to a rebreather breathing loop, which expands as a diver exhales and collapses as a diver inhales.

Cubic feet (ft<sup>3</sup>) – A unit measure of volume, defined as the space occupied by a cube one foot on each side; 1 ft<sup>3</sup> = 28.3 L.

Current limited (oxygen sensor) – A condition in which a change in the load applied to a sensor is not met with a change in the current supplied by the sensor.

D

Dalton's law (of partial pressures) – States that the total pressure exerted by the mixture of gases is equal to the sum of the partial pressures of individual gases.

dcCCR – Diver-controlled closed-circuit rebreather. A manually operated rebreather which requires the diver to monitor oxygen levels and manually inject oxygen as needed to maintain an appropriate setpoint. Also known as a manual CCR (mCCR).

Decompression dive – Any dive that requires staged stops during ascent (determined by the decompression algorithm used).

Decompression model/algorithm – Mathematical algorithm used to compute decompression procedures. A variety of computational models and derivatives are available in tabular or dive computer form.

Decompression illness (DCI) – Injury that includes arterial gas embolism (AGE) and decompression sickness (DCS).

Decompression sickness (DCS) – Injury seen especially in divers, caused by the formation of inert gas bubbles in the blood and tissues following a sudden drop in the surrounding pressure, as when ascending rapidly from a dive, and characterized by severe pains in the joints, skin irritation, paralysis, and other symptoms.

Demand regulator – A valve that delivers gas from a pressurized source at or near ambient atmospheric pressure when the diver inhales.

Diffusion – The process in which molecules move from a region of high concentration to a region of low concentration.

Diluent – A cylinder in a closed-circuit rebreather that contains a supply of gas which is used to make up the substantial volume within the breathing loop; a mixture capable of diluting pure oxygen.

Diluent purge valve/diluent addition valve – A manual valve used to add diluent gas to a breathing loop, usually through the counterlung or a gas block assembly.

Display integrated vibrating alarm (DIVA) – A light-emitting diode (LED) heads-up display module mounted close to the diver's mask, offering information about various states of the rebreather such as PO<sub>2</sub>; this style includes a vibrating warning alarm when oxygen levels are unsafe.

Downstream – A relative direction with respect to the flow of gas through the breathing loop of a rebreather; the direction of travel of the diver's exhaled gas.

Downstream check-valve – A one-way, non-return valve that directs exhaled gas to flow in one direction only, for a rebreather. This would typically be the mushroom-type valves that prevent subsequent re-inhalation of used gas and directs exhaled gas towards the CO<sub>2</sub> scrubber canister.

Dynamic setpoint – Also referred to as a floating setpoint, it is a setpoint that changes to optimize gas use, no stop time and other consumables and dive variables. The floating setpoint can be determined by an electronic system or modified manually by a diver using a mCCR.

E

Equivalent air depth (EAD) – A formula used to help approximate the decompression requirements of nitrox. The depth is expressed relative to the partial pressure of nitrogen in a normal breathing air.

eCCR – An electronically controlled closed-circuit rebreather in which an electronics package is used to monitor oxygen levels, add oxygen as needed and warn the diver of developing problems through a series of audible, visual and/or tactile alarm systems.

Elastic load – A load on the respiratory muscles originating from the rebreather and/or diving suit. Materials in the suit and rebreathing bag may restrict breathing. As the diver breathes, the volume of rebreathing bag(s) changes making the depth of the bag(s) change. This depth change means a change in pressure. Since the pressure change varies with bag volume it is, by definition, an elastic load.

Electronically-monitored mSCR – A mechanical SCR with electronic monitoring. Electronics are used to inform the diver of PO<sub>2</sub> as well as provide warnings and status updates, however the gas control is manually controlled by the diver.

Endurance (of scrubber) – The time for which a CO<sub>2</sub> scrubber operates effectively. The duration varies with individual size, work rate, scrubbing material, depth, and ambient temperature.

Equivalent narcotic depth (END) – A formula used as a way of estimating the narcotic effect of a breathing mixture such as heliox or trimix.

eSCR – An electronic semiclosed-circuit rebreather where an electronics package monitors the PO<sub>2</sub> and adds gas to maintain a floating setpoint that optimizes gas use and compensates for changing levels of diver exertion.

Enriched air nitrox (EAN) – A gas mixture consisting of nitrogen and oxygen; with more than 21% oxygen.

Evaporation (thermal) – The heat energy expended to convert liquid water to gaseous state. Evaporative heat loss results from humidifying inspired gases and the evaporation of sweat on the skin.

Exhalation counterlung – The counterlung downstream of the diver's mouthpiece.

F

Failure mode, effect, and criticality analysis (FMECA) – Summarizes the study of all components that could fail, and identifies the type of failure, the probability, and severity as well as possible causes of the failure and mitigation and emergency procedures.

ffw – Water depth as measured in feet of freshwater.

Floating setpoint (dynamic setpoint) – A setpoint that changes to optimize gas use, no stop time and other consumables and dive variables. The floating setpoint can be determined by an electronic system or modified manually by a diver using a mCCR.

Flush (as in flushing the loop) – Replacing the gas within the breathing loop by injecting gas and venting bubbles around the edge of the mouthpiece or through a vent valve.

FHe – The fraction of helium in a gas mixture.

FN<sub>2</sub> – The fraction of nitrogen in a gas mixture.

FO<sub>2</sub> – The fraction of oxygen in a gas mixture.

Fraction of gas – The percent of a particular gas in a gas mix.

Fraction of inspired gas – The fraction of gas actually inspired by the diver.

Fraction of inspired oxygen (F<sub>I</sub>O<sub>2</sub>) – The fraction of oxygen inspired by the diver. In SCR operation, this figure is calculated using a formula that takes into account the diver's workload.

fsw – Water depth as measured in feet of seawater.

Full face mask – Mask system that encompasses the entire face, in contrast with a typical regulator held in the mouth alone.

## G

Galvanic fuel cell sensor – An electrochemical transducer which generates a current signal output that is both proportional and linear to the partial pressure of oxygen in the sample gas. Oxygen diffuses through a sensing membrane and reaches the cathode where it is reduced by electrons furnished by simultaneous oxidation of the anode.

Gas narcosis – A form of mental incapacity experienced by people while breathing an elevated partial pressure of a gas.

## H

Harness – The straps and/or soft pack that secures the rebreather to the diver.

Heads-up display (HUD) – A light-emitting diode (LED) display module mounted close to the diver's mask offering information about various conditions within rebreathers, such as PO<sub>2</sub>.

Heat exchange – Divers experience four primary avenues of heat exchange important in the diving environment - radiation, conduction, evaporation and convection.

Heliox – A binary gas mixture consisting of helium and oxygen.

Helium (He) – An inert gas used as a component of breathing gas mixtures for deep dives because of its very low density and lack of narcotic potency.

Henry's law – The amount of gas that will dissolve in a liquid is proportional to the partial pressure of the gas over the liquid.

Hydrophobic membrane – A special membrane that allows gas to flow through it, but serves as a barrier to water.

Hydrostatic imbalance – See static lung load.

Hyperbaric chamber – A rigid pressure vessel used in hyperbaric medicine. Such chambers can be run at absolute pressures up to six atmospheres (more for some research chambers) and may be used to treat divers suffering from decompression illness.

Hyperbaric medicine – Also known as hyperbaric oxygen therapy, is the medical use of oxygen at a higher than atmospheric pressure.

**Hypercapnia/Hypercarbia** – Elevated levels of CO<sub>2</sub> in the body due to inadequate breathing, generally induced by elevated respiratory loads and/or inspired CO<sub>2</sub>. The level of CO<sub>2</sub> maintained varies from person to person (e.g., CO<sub>2</sub> retainers maintain relatively high levels). Effects of hypercapnia may include shortness of breath, headaches, migraines, confusion, impaired judgment, augmented narcosis, panic attacks, and loss of consciousness. Dangerous levels can be reached while the diver remains unaware. Recovery may take many minutes under optimal conditions.

**Hyperoxia** – A concentration of oxygen in the breathing mixture that is not tolerated by the human body, generally occurring when the inspired PO<sub>2</sub> rises above about 1.6 ata. Symptoms include visual and auditory disturbances, nausea, irritability, twitching, and dizziness; hyperoxia may result in convulsions and drowning without warning.

**Hyperoxic linearity** – The condition that a PO<sub>2</sub> sensor is linear at partial pressures of oxygen above the highest calibration point.

**Hypothermia** – Condition of low body temperature, defined by a core temperature falling below 35°C (95°F), substantially below the normal core temperature range of 36.5-37.5°C (97.7-99.5°F). Reaching a state of frank hypothermia is very unlikely in normal operational diving.

**Hypoxia** – A concentration of oxygen in the breathing mixture that is insufficient to support human life, generally occurring when the inspired PO<sub>2</sub> drops below about 0.16 ata.

## I

**Inhalation counterlung** – The counterlung upstream from the diver's mouthpiece block.

**Insulation (thermal)** – The resistance in heat flow between objects in physical contact; the inverse of conduction. The standard unit of insulation is the 'clo,' with 1.0 clo (1 clo = 0.18°C·m<sup>2</sup>·h·kcal<sup>-1</sup> = 0.155°C·m<sup>2</sup>·W<sup>-1</sup> = 5.55 kcal·m<sup>2</sup>·h<sup>-1</sup>).

**Integrated open-circuit regulator** – A second-stage, open-circuit regulator which is built-in to a mouthpiece block; also known as a bailout valve (BOV).

## L

**Layering (thermal protection)** – Base layer (hydrophobic) to wick water away from the skin and reduce conductive heat flow; mid-layer with high insulation value to reduce conductive heat flow; shell layer barrier to reduce convective heat flow.

**Liquid crystal display (LCD)** – An energy efficient display that relies on the light modulating properties of liquid crystals.

**Light-emitting diode (LED)** – A small, low power light source used for warning lights on rebreathers.

**Lithium hydroxide (LiOH)** – A type of CO<sub>2</sub> absorbent material.

**Loop vent valve** – The adjustable overpressure-relief valve attached to the bottom of the exhalation counterlung, which allows excess gas and accumulated water in the breathing loop to be vented. Also known as an OPV.

## M

**Manual bypass valve** – A valve on a rebreather that allows the diver to manually inject gas into the breathing loop.

**Manual diluent addition valve** – The valve on a rebreather that allows diluent gas to be manually injected into the breathing loop.

**Manual oxygen addition valve** – The valve on a rebreather that allows oxygen to be manually injected into the breathing loop.

Maximum operating depth (MOD) - The maximum operating depth of a breathing gas before reaching a predetermined PO<sub>2</sub>, usually 1.4 ata or higher. This depth is determined to safeguard the diver from oxygen toxicity.

mCCR – A manually operated closed-circuit rebreather which requires the diver to monitor oxygen levels and manually inject oxygen as needed to maintain an appropriate setpoint. Also known as dcCCR or diver-controlled CCR.

Metabolism – The physiological process where nutrients are broken down to provide energy. This process involves the consumption of oxygen and the production of CO<sub>2</sub>.

mfw – Water depth as measures in meters of freshwater.

msw – Water depth as measured in meters of seawater.

Mixed-gas rebreather – A rebreather that contains a gas mixture other than pure oxygen in the breathing loop.

Mouthpiece (of CCR) – The portion of a rebreather breathing loop through which the diver breathes. This usually includes a way to prevent water from entering the breathing loop and sometimes includes an integrated open-circuit regulator (BOV).

msw – Water depth as measured in meters of seawater.

N

Narcosis – A form of mental incapacity experienced by people while breathing an elevated partial pressure of a gas such as nitrogen or CO<sub>2</sub>.

Near eye rebreather display (NERD) – A heads-up display that duplicates the wrist unit or primary controller.

Nitrox – See enriched air nitrox.

No-decompression dive – Any dive that allows a diver to ascend directly to the surface, without the need for staged decompression stops. Also referred to as a no-stop dive.

Normoxic – A mixture of gas containing 0.21 ata oxygen.

Notified body – Agent that acts as the certifying authority and verifies that equipment testing was conducted properly in compliance with all applicable requirements.

O

Offboard diluent – A diluent gas tank that is clipped externally to a rebreather.

Offboard oxygen – An oxygen tank that is clipped externally to a rebreather.

Organic light-emitting diode (OLED) - A display type that does not use a backlight and is able to display rich blacks that offer greater contrast in low light applications such as diving.

Onboard diluent – A diluent tank that is integrally mounted on a rebreather.

Onboard diluent regulator – A first-stage regulator which attaches to the onboard diluent tank of a rebreather.

Onboard oxygen – An oxygen tank that is integrally mounted on a rebreather.

Onboard oxygen regulator – A first-stage regulator which attaches to the onboard oxygen tank.

Overpressure relief valve (OPV) – the adjustable valve attached to the bottom of the exhalation counterlung, which allows excess gas and accumulated water in the breathing loop to be vented; also known as a loop vent valve.

Open-circuit scuba (OC) – Self-contained underwater breathing apparatus where the inhaled breathing gas is supplied from a high-pressure cylinder to the diver via a two-stage pressure reduction demand regulator, and the exhaled gas is vented into the surrounding water and discarded in the form of bubbles.

Optode – An optical sensor device that measures a specific substance usually with the aid of a chemical transducer.

Oxygen consumption ( $VO_2$ ) – A measure of the work intensity. Resting  $VO_2$  is usually assumed to be  $3.5 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  (1 metabolic equivalent [MET]). Aerobic capacity ( $VO_{2 \text{ max}}$ ) can be described as multiples of 1.0 MET. Recommendations for minimum  $VO_{2 \text{ max}}$  to be maintained by divers range from a low of  $>6.0$  MET to  $>13$  MET.

Oxygen ( $O_2$ ) control system – The components of a rebreather which manage the concentration of oxygen in the breathing loop. The system usually includes sensors, electronics and a solenoid valve that injects oxygen.

Oxygen rebreather – A type of closed-circuit rebreather that incorporates only oxygen as a gas supply. The earliest form of closed-circuit rebreather, designed for covert military operations, submarine escape and mine rescue operations.

Oxygen ( $O_2$ ) sensor – Any sensor that produces a signal related to  $O_2$  pressure or concentration. In diving, the most common type is a galvanic cell that generates an electrical voltage that is proportional in strength to the partial pressure of oxygen exposed to the sensor.

Oxygen toxicity – Symptoms experienced by individuals suffering exposures to oxygen that are above normal ranges tolerated by human physiology. See pulmonary oxygen toxicity and central nervous system oxygen toxicity.

## P

Partial pressure – The portion of the total gas pressure exerted by a single constituent of a gas mixture calculated by multiplying the fraction of the gas by the absolute pressure of the gas.

Passive addition – Gas addition systems utilized by some semiclosed-circuit rebreathers to passively inject gas into the breathing loop; usually achieved by a mechanical valve that opens in response to a collapsed bellow or drop in breathing loop gas pressure.

$PN_2$  – The partial pressure of nitrogen in a gas mixture, usually referring specifically to the breathing gas mixture inhaled by a diver.

$PCO_2$  – The partial pressure of carbon dioxide in a gas mixture, usually referring specifically to the breathing gas mixture inhaled by a diver.

$PO_2$  – The partial pressure of oxygen in a gas mixture, usually referring specifically to the breathing gas mixture inhaled by a diver.

$PO_2$  setpoint – The  $PO_2$  set by the diver, used to determine when a solenoid valve injects oxygen into the breathing loop.

psi – Unit of pressure measured in pound per square inch (1 psi = 55 mm Hg = 6.9 kPa).

Pulmonary oxygen toxicity – Pulmonary irritation typically caused by prolonged exposure to breathing mixtures with oxygen partial pressures in excess of 0.5 ata. This form of oxygen toxicity primarily affects the lungs and causes pain on deep inhalation as well as other symptoms.



## Q

Quality assurance (QA) – Methods to prevent mistakes or defects in manufactured products. QA can be applied to physical products in pre-production and post-production to verify that specifications are met.

## R

Radial CO<sub>2</sub> absorbent canister (radial scrubber) – A cylindrical CO<sub>2</sub> absorbent canister design wherein the gas flows laterally from the outside to the inside of a hollow tube (or vice-versa), like a donut.

Radiation (thermal) - The flow of electromagnetic energy from any object to any cooler object separated by space (air or vacuum).

Rebreather – Any form of life-support system where the user's exhaled breath is partially or entirely re-circulated for subsequent inhalation.

Redundancy – The duplication of critical components or functions in a system with the intention of increasing reliability, usually in the form of a backup in case of primary system failure.

Respiratory load – Any load or breathing impediment that makes it harder to breathe. Respiratory loads include breathing resistance, elastic loads and static lung load (hydrostatic imbalance). Elevated inspired CO<sub>2</sub> will make a person breathe more which increases the effects of other respiratory loads.

Respiratory minute volume (RMV) – The volume of gas inhaled and exhaled during one minute of breathing.

## S

Safety stops – Stops carried out during ascent not required by the decompression model being followed for the dive.

Scrubber – See CO<sub>2</sub> absorbent.

Semiclosed-circuit rebreather (SCR) – A type of rebreather that injects a mixture of nitrox or mixed gas into a breathing loop to replace that which is used by the diver for metabolism; excess gas is periodically vented into the surrounding water in the form of bubbles.

Sensor validation – Methods to confirm the appropriate function of sensors, typically oxygen sensors.

Setpoint – See PO<sub>2</sub> setpoint.

Shoulder port – The plastic shoulder connectors in a breathing loop which connect the breathing hoses to the counterlungs, sometimes serving as water traps to divert condensation and leaked water into the counterlungs and down to the overpressure relief valve (OPV).

Skip breathing - The practice of inhaling, holding the breath and then exhaling slowly in order to attempt to extend the time underwater by using less air. This practice can lead to buildup of CO<sub>2</sub> (hypercapnia).

Sodalime – A general term referring to a chemical agent which reacts and bonds with CO<sub>2</sub> and is commonly used in the scrubbers of rebreathers.

Solenoid valve – A valve that opens when electricity is applied to an electromagnetic solenoid coil; usually the type of valve used to inject oxygen into the breathing loop of a closed-circuit rebreather.

Solid state sensor – A sensor with no mobile parts that detects or measures a physical property.

Stack – Slang terminology referring to the CO<sub>2</sub> absorbent canister.

Stack time – A term used to describe the predicted time that a canister of CO<sub>2</sub> absorbent will last before it needs to be replaced.

Static lung load (SLL; hydrostatic imbalance) – The pressure gradient between the outside and inside of the chest imposed by underwater breathing apparatus. Comfort and performance can be adversely affected, especially during exertion. The lungs can be thought of as having a center (lung centroid) located approximately 17 cm below and 7 cm behind the suprasternal notch on the chest. SLL represents the difference between the pressure delivered by the breathing apparatus (at the start of an inspiration) and the pressure at the lung centroid. If gas is delivered to the diver at a pressure equal to the depth of the lung centroid then no SLL is imposed. A person immersed to the neck has pressure inside the chest at atmospheric and outside the chest at the elevated water pressure. This represents negative SLL and can be measured as the depth of the lung centroid. A negative SLL will make a person breathe at smaller lung volumes, while a positive SLL makes a person breathe at larger lung volumes. For scuba diving, the placement of the regulator determines the SLL. A regulator in the mouth of an upright diver imposes a negative SLL. If the vertical diver is head down then the SLL would be positive. A prone diver may have a slightly positive SLL. A diver swimming shoulder down will not have an SLL imposed. With rebreathers, the placement of rebreathing bags and the amount of gas therein determines SLL. Since gas collects at the top of the bags, the orientation of the diver also matters. The pressure delivered by the breathing apparatus is determined by the depth of the bottom of the gas bubble. The SLL is then equal to the difference between this pressure and the pressure at the lung centroid. A back-mounted bag will impose a negative SLL. A chest-mounted bag will impose a positive SLL. Over-the-shoulder bags with the right amount of gas in them may have a neutral SLL, but the actual SLL varies with gas volume and can be positive or negative. If a diver with an over-the-shoulder bag rebreather swims with a shoulder down then the SLL may be negative since the gas will collect in the upper bag; should the gas volume be large enough that all breathing is in the lower bag then the SLL will be positive. Should the gas volume in the upper bag be such that an exhalation forces some gas into the lower bag, then a sudden large pressure increase is required by the respiratory muscles.

Statistical dependence – A condition in which two variables are not independent.

## T

Technical diving – A form of scuba diving that exceeds conventional limits, generally including dives that are deeper than 130 ft (40 m), using mixed gas, requiring multiple cylinders or decompression, or taking place within overhead environments.

Temperature stick – An array of thermal sensors aligned in the scrubber canister to monitor the thermal activity of the scrubber (measuring the advance of the thermal front) to provide information on scrubber depletion. Also known to as a Temstick or Thermal profile monitor (TPM).

Trimix – A gas mixture containing three constituents; usually oxygen, nitrogen, and helium.

## U

Upstream – A relative direction with respect to the flow of gas through the breathing loop of a rebreather; the opposite of downstream.

Upstream check-valve – A one-way valve system that permits inhaled gas to flow from the inhalation breathing hose to the mouthpiece, but prevents exhaled gas from flowing backwards. This valve is part of the breathing loop system that enables circular flow of gas.

## V

Venting breath – A type of breathing pattern used to purge gas from a breathing loop; accomplished by inhaling through the mouth and exhaling through the nose into the mask or around the edge of the mouthpiece, thus creating bubbles.

Volume-averaged pressure (aka resistive effort) – Terminology used by US Navy Experimental Diving Unit (NEDU) to describe work of breathing (WOB) in correct physical units and physiological terms. It is equivalent to the difference between inhalation and exhalation pressures averaged across a diver's breath, and is sensitive to flow resistance.

Voting algorithm/logic – The procedure in which rebreather electronics rely upon output from multiple sensors to determine when oxygen needs to be added and when sensors are faulty and signals need to be ignored. This approach assumes statistical independence of sensors, which may not be valid since the sensors are exposed to the same conditions for part of their history, possibly all of it if they are from the same manufacturing lot, and they are monitored by the same measurement system.

W

Whole-body oxygen toxicity – See pulmonary oxygen toxicity.

Work of breathing (WOB) – The effort required to complete an inspiration and expiration cycle of breathing. For a breathing apparatus, the work of breathing can be affected by breathing hose diameters, check valve design, scrubber design, depth, absorbent material, and other factors. The placement of counterlungs does not affect the WOB, but is a respiratory load by itself.

Workload – A representation of the level of physical exertion; often measured through oxygen consumption in a laboratory setting.

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