HOLLIS®

PRISM™ 2

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Hollis Prism 2 eCCR User Manual
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General Safety Statements and WARNINGS:

No person should breathe from, or attempt to use in any way, a Hollis Prism 2 rebreather, or any component part thereof, without first completing an appropriate Hollis Certified user-training course.

Further, no Prism 2 diver should use a Hollis Prism 2 without direct Hollis instructor supervision unless they have mastered the proper set-up and operation of the Hollis Prism 2. This includes new Prism 2 divers as well as Prism 2 certified divers who have been away from diving for 6 months and would benefit from an instructor-led refresher course to regain skills mastery of the Hollis Prism 2. Failure to do so can lead to serious injury or death.

The Prism 2 rebreather can, as with any closed breathing loop, circulate breathing gas that may not contain a sufficient quantity of oxygen to support human life. The breathing gas within the Hollis Prism 2 loop must be closely monitored and manually maintained with a safe oxygen content by you (a properly trained and alert user) at all times.

The computer-controlled addition of oxygen to the breathing loop is intended only as a fail-safe back-up system to you, the primary controller. If you (either knowingly or by inattention) allow the computer to control oxygen addition to the breathing loop at any time, you are diving outside the principals of your training. By abdicating user responsibility and system control to a machine, whether intentionally or not, you assume all risk to life and limb that may result.

WARNING
High Pressure Oxygen

The Prism 2 uses cylinders, gas feed lines, pressure gauges and other devices which will contain pure oxygen at high pressure when in operation. Oxygen by itself is non-flammable, however it supports combustion. It is highly oxidizing and will react vigorously with combustible materials. Oxygen at elevated pressure will enhance a fire or explosion and generate a large amount of energy in a short time.

The user must maintain all parts of the Prism 2 that can come into contact with high-pressure oxygen as oxygen-clean components. This includes scheduled servicing by a Hollis service professional, and using approved oxygen-compatible lubricants on any part of the pneumatic systems that will come into contact with high-pressure oxygen.

If any part of the oxygen-clean system comes into contact with contaminants or is accidentally flooded with any substance (including fresh water), you MUST have the entire high-pressure oxygen system serviced by an authorized Prism 2 service professional prior to use. Failure to do so can cause fire or explosion and lead to serious injury or death.

WARNING
Design and Testing

The Hollis Prism 2 has been designed and tested, both in materials and function to operate safely and consistently under a wide range of diving environments. You must not alter, add, remove or re-shape any functional item of the Hollis Prism 2 or substitute any part of the Hollis Prism 2 with third-party items that have not been tested and approved by Hollis for use with the Prism 2.

This includes, but is not limited to, hoses, breathing assemblies, electronics, pneumatics assemblies and their constituent parts, sealing rings, valves and their constituent parts and sealing surfaces, latches, buoyancy devices, inflation and deflation mechanisms and on-board alternate breathing devices.

Altering, adding, removing, re-shaping or substituting any part of the Hollis Prism 2 with non-approved parts can adversely alter the breathing, gas delivery or CO_2 absorption characteristics of the Hollis Prism 2 and may create a very unpredictable and dangerous breathing device, possibly leading to serious injury or death.

Non-approved alterations to functional parts will automatically void all factory warranties, and no repairs or service work will be performed by any Hollis service professional until the altered Prism 2 unit is brought back into factory specifications by a Hollis service professional at the owner's expense.

WARNING
Computer/controller-specific warnings

This computer is capable of calculating deco stop requirements. These calculations are predictions of physiological decompression requirements. Dives requiring staged decompression are substantially more risky than dives that stay well within no-stop limits.

Diving with rebreathers and/or diving mixed gases and/or performing staged decompression dives and/or diving in overhead environments greatly increases the risks associated with scuba diving.

WARNING
Computer Software

Never risk your life on only one source of information. Use a second computer or tables. If you choose to make riskier dives, obtain the proper training and work up to them slowly to gain experience.

Always have a plan on how to handle failures. Automatic systems are no substitute for knowledge and training. No technology will keep you alive. Knowledge, skill, and practiced procedures are your best defense.

WARNING
User-packed radial scrubber

As of this writing, the Hollis Prism 2 design does not include any technology or other device which can detect or warn of potentially dangerous levels of carbon dioxide (CO_2) within the breathing loop.

The Hollis Prism 2 utilizes a user-packed, radial design CO_2 scrubber. Only Hollis tested and approved CO_2 absorbents should be used, and factory-stated maximum scrubber durations **must never** be exceeded. Exceeding factory stated scrubber durations for a particular material will eventually lead to serious injury or death.

It is entirely possible that, for any number of reasons including but not limited to: channeling, ambient temperature, exhausted, damaged, inappropriately stored, or (for whatever reason), inert scrubber material, the chemical and thermodynamic reaction required to sequester gaseous CO_2 will not occur as expected, and a toxic, and possibly fatal level of gaseous CO_2 within the breathing loop can result.

You must carefully follow all instructor and manufacturer recommendations for use and handling of CO_2 absorbent, never use a CO_2 absorbent if you cannot verify that it is able to sustain CO_2 absorption and carefully pack the radial scrubber and complete a system pre-breathe prior to each immersion, as you were taught in your training course.

Further, you must carefully monitor yourself for any symptoms of possible CO_2 poisoning whenever you are breathing from the Hollis Prism 2, and bail-out to open circuit should any physical or mental symptom lead you to suspect elevated CO_2 levels in your breathing loop. Failure to bailout at the first sign of trouble can lead to serious injury or death.

WARNING
Weighting of the Hollis Prism 2

Unlike open circuit scuba gear, it is possible for the Hollis Prism 2 breathing loop to flood, causing the rebreather to quickly become 17 pounds negatively buoyant (not including any user-added weight or offsetting buoyancy inflation). It is the responsibility of the diver to insure that the Hollis Prism 2 is never weighted in such a way that it is not possible for the installed buoyancy device to overcome the flooded weight of the unit plus any diver-added non-detachable weights, and still provide enough positive buoyancy at the surface to keep the divers head well above water.

Consult your instructor, dealer, or call the Hollis factory directly with any questions or concerns. Failure to maintain positive buoyancy at the surface with the Hollis Prism 2 in a fully flooded state can lead to serious injury or death.

Caution

Batteries tested in the Prism 2

It is strongly recommended that only name-brand batteries (such as "Duracell" or "Eveready") are used to power the Prism 2. Off-brand / Discount batteries have been found to vary greatly in quality of materials from batch to batch (and even piece to piece!) and therefore may not perform as expected, or be capable of consistently delivering the power required to drive the components, despite battery voltage levels reported by a battery voltage meter.

WHILE OFF-BRAND / DISCOUNT BATTERIES ARE PERFECTLY ACCEPTABLE FOR USE IN TOYS AND FLASHLIGHTS, THEY HAVE NO PLACE IN LIFE SUPPORT GEAR AND MUST NEVER BE USED TO POWER ANY COMPONENT OF YOUR PRISM 2.

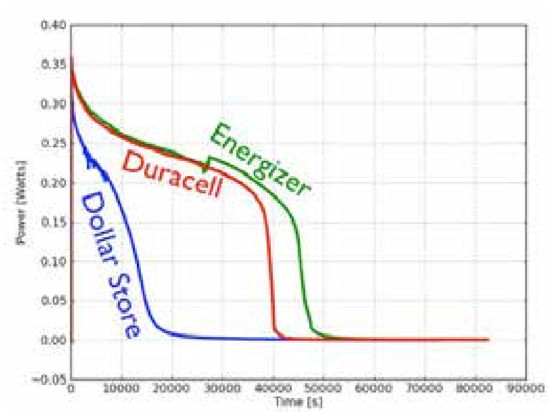


Diagram showing rapid discharge of non-branded batteries, which in life support gear can result in unnecessary hazards. Image courtesy of Rhett Allain, Wired

The full article, "Are-expensive-batteries-worth-the-extra-cost" is available at www.wired.com

Rechargeable Batteries

Because of the potential rapid drop-off of charge from rechargeable batteries, rechargeable batteries are not recommended for use with your PRISM 2 rebreather and must not be used.

Note

Use of the Prism 2 User Manual

This user manual **does not, nor is it intended to** contain any information needed to safely dive with any type of SCUBA apparatus. It is designed as a guide for the proper setup, operation, maintenance, and field service of the Hollis Prism 2 CCR only. It does NOT take the place of a recognized training agency instructor-led diver-training course or its associated training manual(s) and materials. This user manual is intended to be used only as a type specific addition to such training and materials, and as a user reference. This manual cannot be used as a substitute guide for any other type of Self Contained Underwater Breathing Apparatus (SCUBA).

Table of Contents

Part 3 – Setting Up Your Prism 2 eCCR

Part 4 – In-Water Skills

This page reserved for Hollis welcome message

Foreword

By Sharon Readey

Peter Readey
Photo: Dan Burton

This foreword is my attempt to condense nearly 20 years of CCR development history into a few paragraphs whilst making sure everyone who deserves it gets the credit they're due. I'll do my best.

When Peter Readey first got involved in diving back in the late 1980's he realized that cold European waters although teaming with life and wrecks, were not conducive to fighting off narcosis and getting the best bottom times. So he did what any qualified engineer would do and looked at ways to improve his hobby. His helium habit (quite expensive in the UK back then) was disguised with his welding products, but even then it was sizeable enough he realized there had to be a better way. More research put him together with Stuart Clough of Carmellan Research. He purchased a highly modified Rexnold 15.5 and discovered what most rebreather divers were facing back then – a distinct lack of water-proof-ness, delicate technology and dated performance.

Pete in Kraken (Sept 27-Oct 1, 1992). Project to video a sunken vessel in the Baltic Sea with Rob Palmer, utilizing Pete's Marine Engineer qualifications. Video evidence indicated deliberate scuttling.

But engineers are a resourceful group and they like nothing better than to design a better mousetrap, or in this case redesign a rebreather. Working with Stuart throughout the early to mid 1990's, refining and redesigning, they did everything they could to bring rebreathers to the sport market, or as Michael Menduno put it "the second coming" (because CCRs had made a brief foray into the "professional diver" market in the late 1960's- early 1970's). These were heady start-up days, when people started to come out of hiding and confess to their accomplishments, mixed gas, technical diving, computer generated decompression software and AquaCorps/Tek Shows. Much hard work done then by those pioneers did not always result in the rewards that they may have been due, but their efforts grew the market and we have all profited from the fruits of their labours.

Pete and Dr Brad Carte in Drager SMS2000 (Dec 1992-Jan 1993), Discovery Bay Marine Lab, Jamaica, during testing. SmithKline Beecham contracted PRISM to dive the "Twilight Zone" in remote locations looking for organisms which could help in cancer cures etc.

Peter has continued to work and develop his design, taking it from a variable mass flow controlled SCR, to simple analogue electronic controlled CCR and then onto the multi-mode digital PRISM Topaz. As a result, he has worked with some of the brightest and best in the industry, from Stuart Clough at Carmellan Research, Iain Middlebrook/HSM Engineering, Dr Bill Hamilton/Hamilton Research, Rob Palmer, Dragerwerks, Fullerton Sherwood, Carlton Technologies, Billy Deans/ Key West Diver, Wings Stocks/Ocean Odyssey, Hal Watts, Barb Lander, Dick Long/DUI, John & Jean Lamb/Vandergraph, DDRC, AII, Michael Menduno/AquaCorps, Steven Stuart/Mid-Atlantic Research, and many others. Entwined through all that time was the work right at the start with Bob Hollis and Oceanic.

Pete in PRISM SCR (June 19994) at Diving Diseases Research Center, Ft Bovisands, UK. Getting ready for manned testing, scrubber durations, WOB tests and chamber runs to 300ft with independent test subjects.

The teaming of Pete and Oceanic started in 1992 when he worked as a sub-contractor to Carmellan on Oceanic's early Phibian CCS system, through it's initial chamber tests in 1993 alongside the PRISM SCR, subsequent Phibian dealer training and DEMA/Tek Shows. More recently between 2008 and 2011, Peter and Bob worked together on Oceanic's US Navy project, the ATUBA (Advanced Tactical Underwater Breathing Apparatus). It is somewhat ironic that nearly 20 years after they first worked together, these two innovative principles, Bob Hollis and Peter Readey should work together again on a recreational/technical CCR and bring that product to market. It has a long pedigree, based on one of the first recreational rebreathers available that is still here today, made by a company with over 40 years in the scuba industry.

We hope you will enjoy your transition into the world of CCR Diving.

Welcome and Enjoy.

Sharon Readey
March, 2012

Pete in Phibian CCS (1993-4) Cornwall, UK. After chamber tests in Nov 1993 of the PRISM SCR and Phibian at DDRC, this prototype was put together for the DEMA/Tek shows.

Prism Topaz photographs

All Photos courtesy of Steam Machines, Inc.

Sharon Readey modeling an early Prism nicknamed “Kermit”.
Front view.
Photo: Matt Elder

Kermit. Back view.

Photo: Matt Elder

Above: Pete and his son Christian on a dive in La Paz, Mexico.
Photo: Kenny Schneider
Below: Manned testing of the Prism Invader at NEDU, 2002.

Pre-breathing the rig. Manned Testing of the Prism Invader at NEDU, 2002.

Pete hanging in the green of Gold-diggers Quarry, Cornwall wearing a Prism semi-closed RB.
Photo: Dan Burton

Kenny Schneider wearing a Prism Invader, a militarized Topaz.

Photo: Peter Readey

Top: American Diving’s Prisms.
Bottom: Kevin Rottner with analog meter
Photo: Robert Landreth

Peter diving an early Cochran Electronic Prism in 1995

Photo: Wes Skiles

Peter taking Dr. Neil Polack and Dr. Dick Vann for their final certification dive.

Part 1

System Overview


Matthew Addison

Indo Steps

Design Philosophy

The Prism family of rebreathers has a long and illustrious history, and it is considered one of the foundation platforms of the modern day electronically controlled “sport” rebreather.

The Prism 2, like its forerunner the Prism Topaz, is a digitally controlled electronic closed circuit rebreather with split front-mounted over the shoulder counterlungs. It incorporates a radial design scrubber for the best possible duration and work-of-breathing. All gas delivery systems on the Prism 2 have both automatic and manual function, as well as an option for a Constant Mass Flow orifice, classing it as a hybrid type rebreather (hCCR).

Manual Control or Computer Control?

One of the ongoing debates when discussing rebreather safety is whether manually controlled or electronically controlled rebreathers are safer. From the day in 1995 when Prism Topaz class #1 was held in Hermosa Beach, CA, students were taught to “fly” their rebreathers manually by watching their secondary analog displays and manually injecting oxygen and diluent as needed.

From day one, Prism students were taught that the primary control system was always the divers brain. It wasn’t until the last dive of the last day of class that students were told, “OK, you can turn on your electronics and experience a computer controlled dive”.

Diving with the computer monitoring the oxygen and the user keeping an eye on everything with (at that time) a wrist-mounted primary display and analog secondary sure kept us busy, but we quickly realized that the computer was a LOT better at closely maintaining a set point! We also realized that our instructor had trained us to be manually controlled rebreather divers with the *safety* of computer over-watch.

Why two independent monitoring systems in one rebreather? Simply put, electronics, batteries and wiring combined with salt water (or even fresh water) do not work well together. While we can seal circuit boards and wiring interfaces against water intrusion, rebreathers should have a diver accessible compartment to change batteries, and because of this need for accessibility, flooding can occur.

This is the Achilles heel of rebreathers with on-board electronics. Any time an O-ring sealed Compartment is unsealed, the potential for debris to get on the O-ring and cause the compartment to flood during the next dive is increased.

So, with two separate systems onboard with separate battery compartments, if one battery compartment floods and destroys the battery, we simply switch to the other monitoring system to safely end the dive. When our dive is over, we dispose of the wiring harness and battery, clean the compartment and put in a fresh battery and new O-ring(s).

Getting to know your Prism - Schematics & Design

The Gas Path
The Prism 2 incorporates an over-the-shoulder split counterlung design. The gas flows through the loop from left to right shoulder as has become a standard in the recreational rebreather market **(Fig. 1)**.

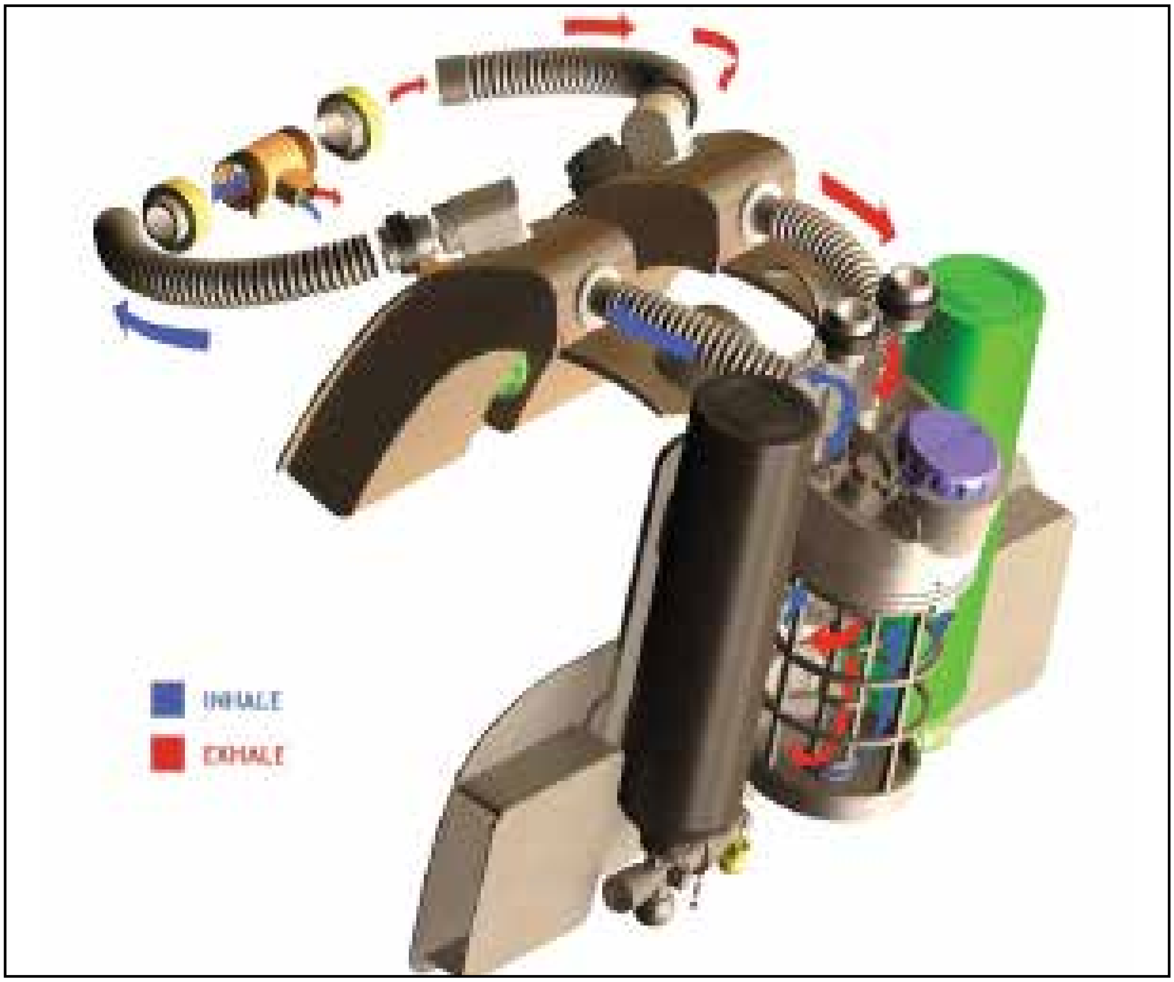


Fig. 1

Oxygen and the exhalation side of the loop
Pure oxygen injection into the system, whether manually or electronically, is injected into the exhalation side of the breathing loop **(Fig. 2)**. This design insures that a diver can never inadvertently get a high PO_2 dose of oxygen while diving, and that oxygen has plenty of time to properly mix with the loop gas and thereby avoid potentially dangerous O_2 spikes.


Fig. 2

The Over Pressure Valve (OPV) (Fig. 3) The OPV acts automatically to protect the user from lung injuries caused by excessive pressure in the breathing loop. Being placed on the exhalation counterlung along with the manual oxygen addition valve also insures that, should the manual oxygen addition valve **(Fig. 4)** ever experience a free flow, the free flowing oxygen will exit the system through the OPV before traveling through the loop and significantly raising loop PO_2. This gives the diver time to take corrective action. Exhaled gas, and any solenoid-injected oxygen enter the head at the exhaust plenum just prior to the scrubber basket. ***(See O2 addition valve (Fig. 6) exploded diagram on the following page).***


Fig. 3


Fig. 4


Fig. 5

Exhaust Plenum (Fig. 5)
Once the exhaled gas enters the head, it travels into the exhaust plenum, which is also where O_2 injected by the solenoid enters the breathing loop. The exhaust plenum sealing gasket sits in a groove at the end of the exhaust plenum facing the scrubber basket. The Red CO_2 sealing gasket must be in place at all times!

WARNING
Breathing from the Prism 2 without the Red CO_2 Seal in place will result in 100% gas bypass of the scrubber.

Fig. 6A

Fig. 6

The Scrubber

The gas leaves the exhaust plenum and enters the radial scrubber basket through its center tube **(Fig. 7)**. As the gas radiates outwards through the CO_2 absorbent and towards the bucket walls, exhaled CO_2 is chemically removed in an exothermic reaction and any added oxygen is mixed with the loop gas as it travels through the scrubber granules. Upon exiting the scrubber, the heated gas enters the thermal air jacket area between the basket and bucket.


Fig. 7

The air jacket serves two purposes: First, it insulates the scrubber material from colder external temperatures, which helps increase the efficiency of the scrubber. Secondly, the moisture in the heated gas exiting the scrubber condenses along the bucket walls as the gas cools, dropping the overall humidity of the gas entering the oxygen sensors' area.


Fig. 8

From the thermal jacket, the gas flows up through the scrubber basket flow vanes **(Fig. 8)**. This restriction creates higher gas velocities in the sensor area, further dropping the dew point of the gas prior to reaching the oxygen sensor faces. By using natural condensation along the surface of the bucket wall and manipulating gas velocities in the area around the O_2 sensors, we are able to keep the sensors as dry as possible.

The inhalation side counterlung

The inhalation counterlung **(Fig. 9)** houses the automatic diluent addition valve (ADV). Having the ADV on the inhalation side of the loop makes sense for several reasons. Should the loop contents ever become questionable or the diver begins feeling "abnormal", flushing the loop with a known normoxic gas is always recommended while switching to bailout*. Therefore, having the diluent as close to the mouthpiece as possible is the best way to insure that fresh breathing gas of known and safe oxygen content is only a breath away.
*(Not applicable if the diluent is a hypoxic mix)


Fig. 9

The hose attaching hardware for both the head and DSV/BOV assembly attaching points **(Fig. 10)** are welded into place, so they cannot come loose and cause an unintended loop flood. The DSV hose attaching hardware is a “keyed” part **(Fig. 11)** and will only accept the correct hose assembly elbow, thereby avoiding incorrect assembly of the loop.

Fig. 10

Fig. 11

Behind each lung, under the Fastex Buckle panel are weight pockets **(Fig. 12)** which will accept up to 5 lbs/2.3kg of hard or soft weight. The weight pouch flap is held in place by Velcro. There are 2 D-rings on the counterlung, one on the side and one at the bottom.

Fig. 12

Each Counterlung has a water drain at the bottom of the lung **(Fig. 13)** to drain fluids as they accumulate during a dive. The Faxtex clip panel on the back of the counterlung contains 2 fastex clips for clipping the counterlungs to the harness and one chest strap with clip.

Fig. 13

Fig. 14

The exhalation side counterlung

The Exhalation side counterlung is of similar build to the Inhalation side counterlung in all respects excepting it houses the manual oxygen addition valve and the automatic, adjustable loop over-pressure valve (OPV) **(Fig. 14)**

Inhalation Hose and hardware (Fig 15)

The Inhalation hose is a 15” X $1^{1/2}$” fixed-length rubber breathing hose. The Inhalation hose hardware which connects the hose to the DSV/BOV and counterlung, also houses the inhalation mushroom valve on the DSV/BOV side of the hose. The mounting hardware is held in place by 2 Oeteker clamps on each side.

Fig. 15

DSV (Dive Surface Valve)
The Dive Surface Valve **(Fig. 16)** is a neutrally buoyant one-way loop "shut down" valve with a water purge. The rotating barrel is made of stainless steel. The exhalation mushroom valve is seated on the right side of the valve housing.
(See exploded diagram (Fig 18) on facing page)

Fig. 16

BOV (Bail-Out Valve)
The bail out valve **(Fig. 17)** is a unique 3-position neutrally buoyant loop shutdown valve with an in-line second stage for single action bail out to open circuit. When the lever is in the top position, the valve is fully closed to avoid free flows of air from the diluent supply. The second position is closed circuit, and the third position is open circuit. ***(See exploded diagram (Fig 19) on facing page)***

Fig. 17

Exhalation Hose and hardware
The Exhalation hose is a 15" X 1$^{1/2}$" fixed-length rubber breathing hose. The mounting hardware on each end are held in place by 2 Oeteker clamps. There is no mushroom valve in the exhalation hose.

Fig. 18

Fig. 19

Battery Compartment cover

The battery compartment cover **(Fig. 20)** is made of glass reinforced ABS. The cap utilizes two O-rings for redundant water tightness, a radial seal on the lip of the cap and a compression seal on the top of the battery compartment housing.

There is a pressure relief valve built into the top of the cover to vent excess pressure should the battery compartment flood. If the pressure release valve (red) were ever to actuate, you would need to replace it prior to immersing the unit (see maintenance section).

Fig. 20

Battery compartment

The battery compartment **(Fig. 21)** holds two sets of batteries: two 9V alkaline batteries wired in parallel which powers the solenoid, and one SAFT 3.6 volt LiON (Lithium Ion) that powers the LED Primary Display. The sealed bulkhead power connector at the bottom of the compartment is a female molex connector. A foam insert holds the batteries in place.

Fig. 21

O_2 sensors, sensor holders, connector, pins

The 3 O_2 sensors are located in a chamber above the scrubber basket **(Fig. 22)**.

This insures a low condensation area and consequently drier O_2 sensors. The sensors are Analytical Industries PSR-11-39-MD which have an operating range of 8.5mV-14mV in air and 40.6mV-67mV at 100% O_2 at 1 atm pressure. The holders are removable to give users better access to the O_2 sensors, wiring harness and connector pins. The holders are manufactured from a soft silicone material to help protect the O_2 sensors from vibration and minor impact forces.

Fig. 22

See "Taking Care of your Oxygen Sensors" on page 21 for more information.

Solenoid (Fig. 23)

The Prism 2 solenoid is a low power (0.65 watt) normally closed electromagnetic valve mounted in an isolated compartment in the head. The normally closed solenoid will only allow gas to flow when an electrical current is applied and the valve is momentarily opened. Operational failure or loss of adequate voltage to open the solenoid valve will keep oxygen from flowing into the system. Oxygen flows from the solenoid body directly into a channel that leads from the solenoid into the exhaust plenum in the head.

Fig. 23

All electrical components of the solenoid are external to, and isolated from the breathing loop.


Fig. 24

The solenoid chamber has an overpressure valve that, should the solenoid ever loose gas containment, vents to the outside environment **(Fig 24.)**. There are no user serviceable parts in the solenoid compartment, and only factory authorized repair technicians should replace the solenoid.

Field Notes
Because the oxygen solenoid is a safety-critical part, should it malfunction, it must be replaced by a factory authorized service center, never repaired.


Fig. 25

Solenoid Electrical connections
The Molex electrical connector for the solenoid is found in the electronics module and connects through a bulkhead into the sealed solenoid compartment **(Fig. 25)**. There are no user serviceable parts inside either compartment, and these compartments should only be opened by an authorized service center.


Fig. 26

Solenoid O-rings
The solenoid is sealed by two O-rings **(Fig. 26)**. The outer O-ring seals out water, and the inner O-ring keeps the oxygen contained within the solenoid. The O-rings are replaced during routine annual service by an authorized Prism 2 service center and are therefore not considered user-serviceable parts.


Fig. 27

Bucket sealing O-rings
There are two bucket sealing O-rings **(Fig. 27)** for redundant sealing of the breathing loop. Standard user maintenance during system set-up and tear-down are required.

The Solenoid and the PID controller

The Prism 2 Solenoid is controlled by state-of-the-art PID Control loop feedback circuitry (The Controller). The PID Controller makes calculations based on an error value which is calculated as the difference between a measured process variable (how much oxygen is in your loop) and a desired setpoint (the O_2 setpoint). It also considers the history of what has occurred previously, and makes predictions about what may occur in the future, constantly making adjustments to it's algorithms accordingly. Sometimes called a “Three Term Controller”, the P, I and D stands for Proportional - Integral - Derivative.

A familiar example of a control loop is the action taken when adjusting hot and cold faucets (valves) to maintain the water at a desired temperature. This typically involves the mixing of two process streams, the hot and cold water. The person touches the water to sense or measure its temperature. Based on this feedback they perform a control action to adjust the hot and cold water valves until the process temperature stabilizes at the desired value.

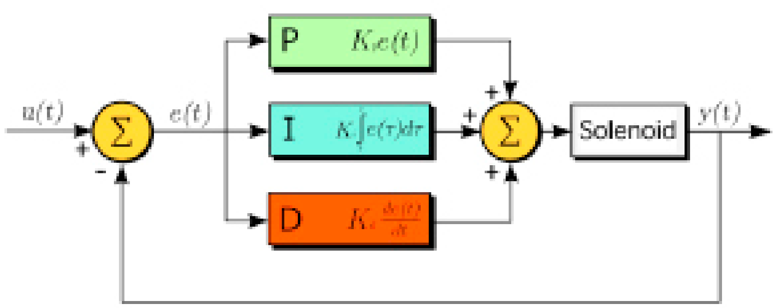
The sensed water temperature is the process variable or process value. The desired temperature is called the setpoint. The input to the process (the water valve position) is called the manipulated variable. The difference between the temperature measurement and the set point is the error and quantifies whether the water is too hot or too cold and by how much.

After measuring the temperature, and then calculating the error, the controller decides when to change the tap position and by how much. When the controller first turns the valve on, it may turn the hot valve only slightly if warm water is desired, or it may open the valve all the way if very hot water is desired. This is an example of a simple proportional control. In the event that hot water does not arrive quickly, the controller may try to speed-up the process by opening up the hot water valve more-and-more as time goes by. This is an example of an integral control.
Making a change that is too large when the error is small is equivalent to a high gain controller and will lead to overshoot. If the controller were to repeatedly make changes that were too large and repeatedly overshoot the target, the output would oscillate around the setpoint in either a constant, growing, or decaying sinusoid. If the oscillations increase with time then the system is unstable, whereas if they decrease the system is stable. If the oscillations remain at a constant magnitude the system is marginally stable.

In the interest of achieving a gradual convergence at the desired temperature, the controller may wish to damp the anticipated future oscillations. So in order to compensate for this effect, the controller may elect to temper its adjustments. This can be thought of as a derivative control method.

If a controller starts from a stable state at zero error, then further changes by the controller will be in response to changes in other measured or unmeasured inputs to the process that impact on the process, and hence on the process variable. Variables that impact on the process other than the manipulated variable are known as disturbances. Generally controllers are used to reject disturbances and/or implement setpoint changes. Changes in feed water temperature constitute a disturbance to the faucet temperature control process.

In theory, a PID controller can be used to control any process which has a measurable output, a known ideal value for that output and an input to the process that will affect the relevant process value. PID controllers are used in industry to regulate temperature, pressure, flow rate, chemical composition, speed and practically every other variable for which a measurement exists.



A Typical Solenoid Loop Feedback Circuit*

*Source: Wikipedia

Bucket latches

There are 4 Nielson Sessions 300 series Stainless Steel locking latches mounted on a stainless steel band **(Fig. 28)** that hold the bucket securely onto the head assembly. While two latches will hold the bucket securely, it was felt that redundancy here was critical.

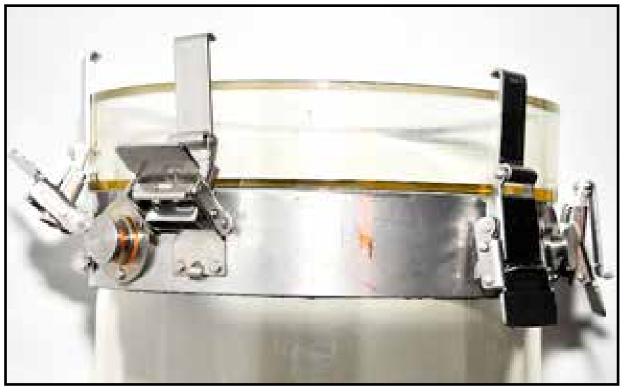


Fig. 28

Basket spring on bucket

The absorbent basket is pressure-sealed onto the Red CO2 Seal under the head by the bucket spring assembly **(Fig. 29)** at the bottom of the bucket. The spring creates the seal between the basket and Red CO2 Seal and also reduces vibration on the basket during transit.

Fig. 29

Absorbent basket assembly

The absorbent basket is comprised of five main pieces **(Fig. 30)**. The basket outer cage that supports the nylon absorbent-retaining mesh, a screw-in center tube, which also supports the nylon mesh and a screw-on cover. Two foam pads must be installed top and bottom prior to filling the absorbent basket. The bottom pad has a larger center diameter hole than the top pad. The foam pads impede the flow of gas against the smooth surfaces of the basket top and bottom, hindering any potential gas channeling in these areas.

Fig. 30

The gas flow vanes built into the top of the scrubber basket create an area of increased gas velocity within the O_2 sensor area of the head, reducing the dew point of the gas around the O_2 sensors. The reduction in condensing humidity in this critical area helps reduce the potential for water to condense on the surface of the hydrophobic membrane of the O_2 sensor.

Backplate

The Hollis Prism 2 can be outfitted with an industry standard technical style backplate. The user can specify either a stainless steel **(Fig. 31)** or anodized aluminum backplate when ordering their rebreather. The style of threading the webbing for the backplate is left to user preference.

Fig. 31

O_2 and Diluent first stages

All Prism 2 first stages **(Fig. 32)** have been oxygen cleaned and assembled in a clean room environment with specially designed materials, halocarbon-based lubricants and color-coded for easy identification on and off the Prism 2 chassis (green=O_2, Black=Dil). In non-CE countries, they come outfitted with 300 BAR/4500 PSI DIN connections and custom designed port blocks with 4 low pressure and 1 high pressure ports. This custom design does away with the need to add in fail points such as hose swivels. The working Intermediate pressure of both first stages is 130 to 150psi / 8.96 to 10.34 bar.

Fig. 32

All First stages are equipped with pressure relief valves **(Fig. 33).** The valves reduce the likelihood of an uncontrolled increase in intermediate pressure causing a free-flow of gas into the breathing loop. The first stage pressure relief valve is not a user serviceable part.

The oxygen feed lines to the solenoid and manual O_2 addition valve incorporate in-line flow restrictors to meter the flow of oxygen into the breathing loop. The restrictors must not be removed.

Fig. 33

Gas Cylinders

The Hollis Prism 2 will accommodate all sizes of cylinders commonly used on rebreathers.

Fitting your Prism 2

Your Prism 2 rebreather should be fitted to you with the same attention as you would any other fine (and very expensive) custom-made piece of clothing. A properly fitted rebreather will perform more consistently with better all around breathing characteristics, have less hydrostatic imbalances in all diving positions, less strain and fatigue on spinal musculature and better diver trim while diving.

The fitting process begins before you even set-up the Prism 2. First you must assess your body type, as that will give you a starting place for making close approximations to what will be the final, best fit.

The standard counterlung yoke fits a wide range of body types, and generally anyone between 5ft to 6ft tall with a standard torso will find a best fit using the standard counterlung yoke. At the upper ranges of that measurement, a person with a long torso, or anyone taller than 6' will probably find that the Long yoke works best for them. If you have any questions, or need help finding which set-up works best for you, ask a Prism 2 Instructor, or go into your local Hollis dealer. They will be more than happy to help you get your rebreather properly fitted.

Once you have decided which yoke should work best, you will begin testing out the different variables such as backplate position (2 available), Wing position (2 available) and three positions on the yoke, which will dictate where the counterlungs sit on your chest.

First look at the backplate. The harness webbing should be adjusted so the top of the backplate plate sits about 1 inch or so below your shoulders. Next, put the counterlungs on the yoke. Take the assembly and put it on so the yoke hangs over the backplate while holding the counterlungs on your chest. The DSV/BOV assembly breathing hose holes should be level with your collar bones.

Proper fit is the first element in a rather complex dance with physics. These few pointers should give you a good starting place in custom fitting the Hollis Prism 2 for best fit. Don’t be afraid to experiment with placement as the ultimate goal is diver comfort. Once you have a fit that you feel will work for you in the water, we need to examine how and where to distribute any weight you will require to get you the best in-water “stability” possible.

Stability

by Gerard Newman

What is stability? Briefly, it's the ability to choose and maintain your position in the water column. When we have a stable platform for diving we are more comfortable, in better control and better able to observe our underwater surroundings. Diving with a CCR adds some additional considerations for stability. Ideally, we should be stable when swimming (*dynamic stability)* and when hovering *(static stability*)*.* We have better control over our stability when we assume prone (horizontal) trim in the water with our fins flat. This increases our vertical drag (helping to maintain our vertical position in the water column) and decreases our horizontal drag (as when swimming) (fig S1).

Fig. S1

Stability is affected by weighting and buoyancy. Our weighting components include the cylinders we choose to dive with, lights, fins, backplates and lead ballast that we carry with us. These components may be distributed from side to side and head to toe. Improper distribution will result in non-horizontal trim. Too much lead at our waist will tend to drag our hips down resulting in a head-up position in the water (fig S2). Fins that are too light will result in a feet-up position. Divers often instinctively compensate for weight placement problems by arching their backs to maintain trim. The objective is to allow proper trim with a relaxed posture in the harness. Of course proper weighting is key – we should be able to maintain a 10 foot stop with no gas in the wing and a comfortable amount of gas in our exposure suit. With the CCR we have to account for the gas volume in our breathing loop. I typically recommend starting with an extra 4 lbs over what the diver would normally wear with a single tank open circuit rig as a starting point. Divers with larger or smaller tidal volumes will need to adjust accordingly.

Our buoyancy components include our exposure suit, our wing, and our counterlungs. Minimizing the gas volumes in each will go a long way towards minimizing the effects of Boyle's Law. The larger the gas bubble, the harder it is to control. The shallower you are, the more pronounced the effects of Boyle's Law – careful attention to controlling the gas volumes in our counterlungs, wing and our exposure suit on ascent is critical. Adding or removing small amounts of gas and allowing time for the change to take effect is the key to controlling our buoyancy (Fig. S2, S3).

Fig. S2

Fig. S3

Counterlung position should be such that they are as close to your lungs as possible, both in the vertical and horizontal planes (Fig. S4). This will minimize *static lung loading* and decrease the work of breathing. The bottoms of the counterlungs should be secured to the waist strap to hold them in place when they are inflated and become buoyant. For most divers the elbows on the counterlungs should be positioned at the collarbones, with the chest strap tightened to control their horizontal position. Gas volume in the counterlungs will affect both your buoyancy and trim. Too much gas in the counterlungs will result in head-up trim; too little will result in head-down trim (and difficulty taking a full breath). With practice one can become proficient at adding and removing gas from the breathing loop to maintain horizontal trim and neutral buoyancy.

Fig. S4

The wing may be positioned to increase buoyancy towards our head or our feet if needed to adjust our trim. Weights can be placed near the shoulders to provide a counterbalance to the counterlungs and help keep us prone in the water with minimal effort.

The backplate should be positioned such that the top of the plate is easily reachable with the tips of your fingers if you swing your arms back with your elbows next to your ears. On most people this will position the backplate at the top of the scapulas. Straps should be loose enough to allow full range of movement of your arms across the chest and allow you to "chicken wing" into and out of the harness. The crotch strap should be adjusted to keep the rig stable – tight, but not too tight. If the crotch strap is pulling the waist strap down then it is too tight and needs to be lengthened (Fig. S5).

Fig. S5

A very helpful technique is to have someone shoot some video of you while hovering and while swimming. Reviewing this video can help identify where your buoyancy or trim needs adjusting. A good Intro to Tech instructor can also be very helpful.

Taking Care of your Oxygen Sensors

The best way to care for an exotic animal is to first acquire some knowledge about it's likes and dislikes, and environments that will help the animal thrive. Likewise, having a working knowledge of what is and is not good for the health of your oxygen sensors will help you take the best care possible of them, and hopefully avoid unnecessary mid-season damage replacement. Here are some important questions, and their answers.

What is a galvanic O_2 sensor?
An oxygen sensor is a very small electrochemical generator. Some people equate them to a battery, but that comparison is largely incorrect since a battery does not produce electricity as the O_2 sensor does, and the O_2 sensor does not store electrical energy as a battery does. Understanding that the O_2 sensor is more like a delicate power-generating machine than a robust Duracell D battery is your first clue in understanding how they should be handled.

What materials are used to manufacture the Analytical Industries PSR-11-39-MD sensors?
The body of the sensor is made of High-Density Polyethylene (HDPE). The membrane on the front of the sensor is a thin Teflon gas permeable membrane. The internal components are comprised of a lead anode, a precious metals-plated cathode, a base pH electrolyte consisting of mostly water and a bit of Potassium Hydroxide. A printed circuit board (PCB) with resistor-thermistor temperature compensation circuitry is heat sealed to the outside back of the sensor.

What environmental conditions are best and worst for the O_2 sensor?
Your "PSR" series O_2 sensors are happiest between 32°F/0°C and 122°F/50°C. Operating or storing the O_2 sensor above 122°F/50°C will prematurely dry out the electrolytic fluid and destroy the sensor. Operating or storing the O_2 sensor below 32°F/0°C will freeze the electrolytic fluid causing expansion damage to the Teflon membrane and possibly leakage of the electrolyte upon thawing, thereby destroying the sensor.

How does changes in ambient temperature influence the O_2 sensor's performance?
Temperature influences the signal output at a rate of 2.54% per °C. Gradual ambient changes in temperature can be maintained within +-2% accuracy by processing the signal output through the resistor - thermistor temperature compensation network. Rapid changes of

59°F/15°C require 45-60 minutes for the compensated signal output to equilibrate, e.g. the electronic thermistor reacts immediately to offset the change in the sensor, but the sensing membrane and electrolyte reacts at a much slower rate.

Because of the exothermic (heat generating) reaction of CO_2 scrubbing taking place next to the sensor housing during diving operations, it is important that you calibrate the sensors close to “room temperatures” (60°F/16°C – 80°F/27°C) so you are not temporarily outside of the 59°F/15°C “rapid compensation” range while diving.

How does pressure influence the oxygen sensor’s performance?
Pressure influences the signal output on a proportional basis. The sensor is accurate at any constant pressure up to 30 ATM provided the sensor (front and rear membranes) is pressurized and decompressed gradually (similar to human lungs). The membranes, especially the front sensing membrane, do not tolerate rapid change in back pressure or vacuum. Normal diving operations will not generate pressures excessive to which the sensor is designed to operate.

If you use a pressure vessel to check voltage limiting, it is important that you slowly bleed off the accrued pressure in the vessel after the checks are completed. The optimal analysis pressures range is 5-30 PSIG, up to 100PSIG, with a flow rate of 1-2SCFH. The longer you keep the cells pressurized, the slower you need to bleed off pressure. This procedure may sound familiar to divers.

What is the maximum altitude the oxygen sensor can be exposed and still function?
The oxygen sensors have been tested up to 20,000 Ft / 6096M with no error.

Does moisture or water affect the oxygen measurement?
If moisture or water is present in the gas stream it will not damage the oxygen sensor or analyzer, but it can collect on the sensor’s sensing membrane, thus blocking the flow of gas.

What happens when the O_2 sensor has been exposed to water.
The collection of condensation on the sensing surface of the sensor (standing water) reduces the signal output. Once either drying or gravity removes the standing water, the signal output will return to normal within 30 seconds. For example, a thin layer of water over the sensing surface will reduce the signal output of a sensor from 11.8mV to 10.1mV within 20 minutes;

remove the standing water and the signal output returns to 11.8mV in 30 seconds. The design of the Prism 2 makes condensation collecting on the face of the sensor such that the signal can be degraded in a normal diving position very unlikely. Note: Salt water can corrode or bridge electrical connections resulting in erratic oxygen readings.

Can a sensor be contaminated by carbon dioxide ($C0_2$) gas, reducing the sensor life?
Exposure of the sensor with its base electrolyte to carbon dioxide (CO_2) gas or acid gases will produce crystal-like deposits on the cathode, which reduces the surface area of the cathode and the corresponding signal outputs. This effect is cumulative, cannot be reversed and can dramatically reduce the expected sensor life. This means that attempting to "Push the Scrubber" beyond its factory-stated duration, or breathing into a loop without active scrubber material installed will shorten the life of your O_2 sensor.

Can the oxygen sensor be damaged if dropped or if the rebreather is dropped?
Absolutely! Sensors are fragile and can be damaged in a number of ways. Dropping a sensor by itself or while mounted in the rebreather can result in: (a) broken wires; (b) broken electrical connections; (c) dislodging the anode and either breaking a connection or creating an internal short as the loose anode comes in contact with the cathode connection. If the motion stop-force is applied onto the sensor face, the liquid electrolyte can be forced onto the Teflon membrane, stretching the material and destroying the sensor. Testing has shown that dropping a sensor one time from 3ft/1m onto a carpeted concrete slab can result in an immediate 25-100% reduction in signal output.

Types of forces known to cause sensor damage while housed in a rebreather include, (but are not limited) to transportation shock (baggage handler throwing distance competitions, driving over rough terrain, jolts during heavy seas and extreme motor vibrations). It is always recommended that you remove the sensors from the rebreather if it may be subject to any of the above conditions.

Can I touch the Teflon membrane with my finger? How do I clean the sensor and contacts?
No, you must not touch the sensor face with anything, especially your fingers. Fingers have oils on them even when freshly washed, and the oil permanently clogs the membrane, destroying the sensor. If salt has dried on the sensor face, you can gently pour a bit of distilled water on the membrane and allow it to air dry. Never use any cleaning solutions on the sensor face. You may use an electronics contact cleaner such as DeOxIt Gold on the contact pins, but use it sparingly and wipe off all residual cleaner before use.

What is the expected oxygen sensor life?

The operational life of the PSR-11-39-MD sensors are calculated as one year from the date they are put in service. The warranty is one year from the date they were shipped from the factory. Do not attempt to extend the life of the sensors past one year from the date they were put in service. Doing so can result in incorrect or no signal output which can lead to serious injury or death.

What is the recommended storage temperature?

During a "diving season" (if one exists for you) the oxygen sensors, when stored, should be kept in a cool, ambient, unsealed environment to insure they are immediately operational. If you will be storing the sensors for a month or more, you can place them in an airtight container in a refrigerated environment that is kept above 34°F/0.1C to insure that the electrolyte does not freeze (see "Environmental Conditions" above). While this will not extend the operational life of the sensor, it may reduce response time degradation during the latter part of its 16-month service life.

After storage, you will need to acclimate the sensors by placing them in air at room temperature for 24 hours prior to putting the sensors back in service. Failure to acclimate the sensors after storage can cause the sensors to read incorrectly and possibly lead to injury or death.

Are the O_2 sensors date coded?

Oxygen sensors have a finite life. Understanding the date code is vital to getting the benefit of the warranty period. As an example, the serial number 10734789 breaks down as follow: Digit #1 a (1) denotes the year of manufacture as 2011; digits #2, #3 (07) indicate July as the month of manufacture; the remaining digits are sequential for uniqueness. As the result of a number of issues related to the use of aged sensors, Analyitical Industries has added a "DO NOT SELL AFTER: (date)" to the sensor's labeling which is 4 months from the date of manufacture along with a requirement that the cells service life must not exceed 16 months from the date of manufacture.

You must NEVER use oxygen cells past beyond their expiration date, no matter if the output is still within the sensor's stated operational parameters.

Part 2

Displays and Electronics Operation

Matthew Addison

PRIMARY DISPLAY WIRING

WARNING

Do not attempt to unscrew the Primary Display wiring from the head.

THIS IS NOT A THREADED PART!

Attempting to unscrew or remove the wiring from the head will destroy the wiring and quite possibly the hardware sealing surface in the head.

SECONDARY DISPLAY WIRING

WARNING

Do not attempt to unscrew or remove the Secondary Display wiring from either the head or the Secondary Display.

THESE ARE NOT THREADED PARTS!

Attempting to unscrew or remove the wiring from the head or the Secondary Display will destroy the wiring and quite possibly the hardware sealing surface in the head or Secondary Display housing.

Displays and Controller

There are two separate diver display systems in the Prism 2. The LED Primary Display and the wrist mounted Secondary Display.

LED Primary Display

The LED Primary Display **(Fig 34)** consists of 3 bi-color (red/green) LEDs (light Emitting Diodes) mounted on either the right or left side of the DSV/BOV mouthpiece just below eye level.

Fig. 34

Each of the three bicolored LEDs corresponds to one of the three O_2 sensors mounted in the head and reports the oxygen reading by numbered and colored flashes of red, green and orange. LED number 1 (L to R) reports the readings from O_2 sensor number 1, and so forth as reported on the secondary display**(Fig 35).**

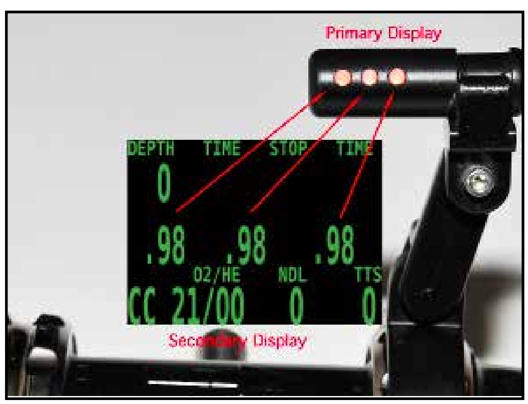


Fig. 35

The Primary Display light sequences for reporting loop PPO_2 to the user is called “Smithers Code” and are the same for each LED. Each LED reports only on the O_2 sensor it represents, so the user will see a different flash sequence of an LED if its corresponding sensor drifts out of range of the others. While this may seem confusing at first, having one of the three lights flash more or less often than the others is far more obvious than a single alarm. The Smithers Code sequences are run in 5-second cycles throughout a dive.

The PO_2 light states encountered on the LED Primary Display shown in the table below and are as follows: While in dive mode reporting loop PO_2, 1.0 ATM O_2 is considered the mid-line for the LED Primary Display. When the PO_2 is between 0.95 and 1.05 PPO_2, you will see one orange flash every five seconds (the orange color is created by both the red and green colors of the LED flashing simultaneously {see field note, pg 29}). When the PO_2 in the loop is below the mid-line of 1.0 PO_2, you will get one red flash for every 0.1 atm O_2 below, and one green flash for every 0.1 atm O_2 above the centerline of 1.0 PO_2 **(Fig. 36)**.

PO_2	Color	# Flash / 5 Sec	Cycle
1.6	Green	6	5 sec
1.5	Green	5	5 sec
1.4	Green	4	5 sec
1.3	Green	3	5 sec
1.2	Green	2	5 sec
1.1	Green	1	5 sec
0.95 - 1.05	Orange	1	5 sec
0.9	Red	1	5 sec
0.8	Red	2	5 sec
0.7	Red	3	5 sec
0.6	Red	4	5 sec
0.5	Red	5	5 sec
0.4	Red	6	5 sec
Accept Cal	Red	Solid - 5 Sec	Once after calibration
Lost Signal	Green\Red	Continious	Continious
LEDs Check	Green/Red	Once only	Once at turn-on
Battery Low	Orange	Solid - 30 sec.	Once at turn-on

Fig. 36

LEDs check at turn on

When you first turn on the Primary Display, the green and red LEDs will each flash once. This is a test to insure that all LEDs are working correctly. Once this test has competed, the system will check the battery voltage and if it is low, will flash a battery warning (see Low battery warning). If the battery is operational, the electronics will begin displaying the appropriate O_2 cell information.

WARNING

USE ONLY NAME-BRAND BATTERIES (DURACELL, EVEREADY, etc)

OFF-BRAND / DISCOUNT BATTERIES ARE ACCEPTABLE TO POWER TOYS AND FLASHLIGHTS BUT HAVE NO PLACE IN LIFE SUPPORT GEAR AND MUST NEVER BE USED TO POWER ANY COMPONENT OF YOUR PRISM 2.

(Refer to full battery warnings on page V)

Low Battery Warning

The Primary Display is powered by a SAFT LiON 3.6V AA battery mounted in the battery compartment in the head. After the LED check, the Primary Display, it will check its battery state. If the battery charge is low, the display will flash all three LEDs orange (combined red and green) for 30 seconds **(Fig. 37)** and then go into operational mode if enough battery charge remains for it to do so. Low battery warnings will only occur once at power-on and will not be repeated until the LED Primary Display power is cycled off and on again.

Fig. 37

WARNING

You must change the Primary Display battery when you receive a low battery warning. Failure to change the battery when the Primary Display indicates a low battery during power-on could result in the LED Primary Display shutting down unexpectedly mid-dive.

Cell Calibration Accepted

If calibration of all three cells have been accepted, the Primary Display will illuminate the 3 LEDs in red for 5 seconds without blinking. If any cell has failed calibration, the LED corresponding to the failed cell will oscillate green/red continiously until a successful calibration of that cell has been achieved.

Cell Calibration Failed

Any cell that fails calibration will flash green/red continiously until a valid calibration for that cell is accepted by the controller. If all 3 sensors fail calibration, all LEDs will flash green/red continiously. It is rare that all three cells would fail calibration at the same time if they are within their expected service life, not damaged by mishandling and the loop is fully flushed with oxygen. Ususally, an accidental calibration in air or an incomplete loop flush with pure O2 will cause all three sensors to fail calibration concurrently.

Lost Signal

If the Primary Display were to lose cell signal for any reason, the LED corresponding to the lost signal will oscillate green/red continiously until signal output is restored. Some of the more common conditions which could cause this would be broken or shorted wiring in the cell or wiring harness or a completely dead (aged) cell. An operating cell which has gotten its permeable membrane wet will rarely lose signal completely.

Field Notes: Bi-Colored LEDs

"Bi-color LEDs are actually two different LEDs in one case. They consist of two dies connected to the same two leads antiparallel to each other. Current flow in one direction emits one color, and current in the opposite direction emits the other color. Alternating the two colors with sufficient frequency causes the appearance of a blended third color. For example, a red/green LED operated in this fashion will color blend to emit a yellow or orange appearance"

Secondary Display

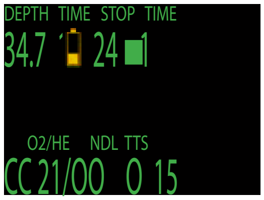


Fig 37

The display has five areas. There are three title areas and three data display areas **(Fig 37)**.

Across the top line is the title for the first row of information. This area only changes during the display of the dive log. The first data area shows depth, battery warning, dive time, ascent rate, first stop depth, and first stop time. Fig 37 is showing a depth of 34.7 meters, a low battery alarm, 15 minute dive time, a 3 meter per minute ascent rate, and a stop at 24 meters for 1 minute.

The low battery indicator glows yellow after the battery is less than 3.28V for 30 seconds. Below 3.15V the battery indicator will flash red. You will need to change your battery immediately. It is recommended to change your battery when the battery indicator steadily glows yellow.

The ascent rate indicator shows 6 levels of ascent rate. Each block represents either 10 fpm or 3 mpm. 1, 2 and 3 bars will be green, 4 and 5 bars will be yellow, 6 bars will be red. When the ascent rate is greater than 6 bars, the whole block will be filled in red, and it will flash.

If you are above the indicated stop depth, the stop depth will flash red.

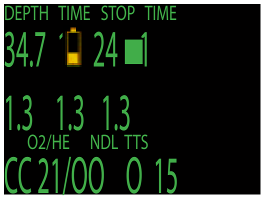


Fig 38

The second data line shows the three O_2 sensor readings **(Fig. 38)**. If a sensor is voted out, it will display the current value, but it will flash yellow and the value will not be considered in the average PPO_2. This area will also display fixed PPO_2.

The next area is the title for the bottom line. This title changes frequently in the menu system to provide additional information about the bottom line. The last line shows that the computer is in closed circuit (CC) mode with a gas containing 21% oxygen and 0% helium.

If there is a gas programmed in the current mode (OC or CC) that would normally be used at the current depth, the system will flash the gas contents in red to remind you to either switch gases, or remove the gas if you aren't using it.
In addition, there is a context sensitive area at the bottom which is implemented when cycling through menus.

The no decompression limit (NDL) is zero since we are in decompression, and the time to surface (TTS) is 15 minutes.

The computer works in both metric and imperial for depths and temperatures. The depth shows a decimal point when the depth is between 0 and 99 meters. It shows no decimal point if the display is set to feet.

To turn the computer on, press both the MENU and the SELECT buttons at the same time.

Buttons

MENU (Left)

- From the default display, pressing MENU brings up the menu.
- Once in the menu system, MENU moves to the next menu item.
- If the current function is an edit, pressing MENU increments the current display.

SELECT (Right)

- In the menu system, the select button saves the current value or executes the command.
- Out of the menu system, the select button brings up information displays.

BOTH BUTTONS

- When the computer is off, pressing MENU and SELECT at the same time will turn the computer on.

The left button (MENU) can be used to scroll through the menu. When the “Switch Setpoint” menu item is displayed, MENU will move to the “Select Gas” menu item **(Fig 39)**.

Fig 39

The right button (SELECT) is used to accept the current choice.

Pressing SELECT with this screen displayed will enter the Select Gas function **(Fig 40)**.

Fig 40

In the “Select Gas” function, MENU increments the gas number **(Fig. 41)**.

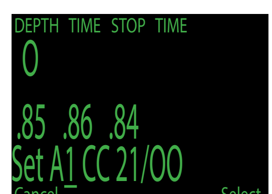


Fig 41

SELECT would select closed circuit gas 2 **(Fig. 42)**.

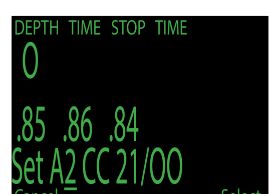


Fig 42

When the system is not in a menu, pushing SELECT will bring up information displays with various dive status information. This is the first information display showing the diluent PPO_2 amount, the current CNS loading, the setpoint (if applicable), and the average PPO_2 being used for decompression calculation **(Fig. 43)**.

Fig 43

Menu

The system is designed to make the selection of the common operational functions while diving easy. The menu selections are separated into two sets. The “Operation” menu is to provide easy access to commonly used functions. The “Setup” menu is to change system settings.

The system will continue to read the sensors and update the sensor display while you are in the menu system.

If no buttons are pushed for a minute, the menu system will time-out. Anything that had been previously saved will be retained. Anything that was in the middle of editing will be discarded.

A key characteristic of the menu system is that it is adaptive. It uses the information that it knows about its current state to only ask questions or offer menu items that make sense given the current situation.

For example, on the surface, the first menu item you will see is Turn Off. During a dive, the Turn Off menu item doesn’t appear.

The second menu item is Calibrate. That item only shows on the surface. External PPO2 monitoring must be left “ON” (the System Default) or the secondary will not report the output of the O_2 cells.

The full menu structure is below:

- **Turn Off**
- **Calibrate**
- **Switch Setpoint**
- **Select Gas**
- **Switch Open Circuit / Closed Circuit (Open Circuit / Semi-Closed Circuit)**
- **Dive Setup**
  - **Edit Low Setpoint**
  - **Edit High Setpoint**
  - **Define Gases**
  - **Dive Planner**
  - **NDL Display**
  - **External PPO2 Monitoring**
  - **Brightness**
- **Dive Log**
  - **Display Log**
  - **Upload Log**
  - **Edit Log Number**
  - **Clear Log**
- **Setpoint -> .19**
- **System Setup**
  - **Dive Setup**
  - **OC Gases**
  - **CC Gases**
  - **O_2 Setup**
  - **Auto SP Switch**
  - **Display Setup**
  - **System Setup**
- **Advanced Configuration**
  - **Salinity**
  - **Title Color**
  - **OC Show PPO_2**
  - **End Dive Delay**
  - **CC Min PPO_2**
  - **CC Max PPO_2**

The Turn Off, Calibrate, Dive Log, Setpoint -> .19, and System Setup menus are only available on the surface. This is the menu during a dive:

- **Switch Setpoint**
- **Select Gas**
- **Switch Open Circuit / Closed Circuit (Open Circuit / Semi-Closed Circuit)**

- **Dive Setup**
  - **Edit Low Setpoint**
  - **Edit High Setpoint**
  - **Define Gases**
  - **NDL Display**
  - **Brightness**

The status screens are:

- **Gases, no-decompression limit and time to surface**
- **Diluent PPO_2, CNS, and average PPO_2**
- **Oxygen sensor millivolts**
- **Max depth, average depth, average atmospheres**
- **Water temperature, current Gradient Factor, current fixed Oxygen**
- **GF99, decompression ceiling, time-to-surface in 5 minutes and time-to-surface**
- **Battery voltage**
- **Pressure**
- **Date and time**
- **Surface interval**
- **Serial number and version number**

Basic Setup

Before using the computer there are several things that need to be configured. This is not an exhaustive list of the prerequisites for diving the system, but a suggestion of key tasks.

Calibrate the oxygen sensors.

In the System Setup menu set the units to metric or imperial, also set the date and time.

Enter the gases that you will use for the closed circuit portion of your dive, and/or enter the gases for you will use for open circuit.

The system will use the gases that are available in the order of oxygen content during the Time To Surface (TTS) prediction. The system will use the next available gas that has a PPO_2 of less than 1.0 for closed circuit diving.

If the computer is switched to open circuit during a dive, the system will calculate the TTS based on the configured open circuit gases that are available. It will use the next available gas that has a PPO_2 of less than 1.6 for open circuit diving.

NOTE: These gases are used automatically only for TTS predictions. The gas used to calculate the current tissue load and the current ceiling is always the gas actually selected by the diver.

Display Elements Descriptions:

Closed-Circuit Partial Pressure of O_2 ($PP0_2$):

The Secondary will Flash Red PPO_2 when less than 0.4 or greater than 1.6.

Shows internal sensor PPO_2 (will show three values).

Shows the current setpoint, which is the PPO_2 at which the Secondary assumes the breathing loop is being maintained. Displays 3 sensors.

Displays PPO_2 in Yellow when sensor is voted out.

Displays FAIL when calibration is not valid.

When in OC mode, the sensor values continue to display.

This shows the state of the breathing loop, but not what is currently being breathed.

Fraction Inspired O_2 (FiO_2) (Fig. 44):

The fraction of the breathing gas composed of O_2. This value is independent of pressure.

Fig 44

Ascent Bar graph (Fig. 45-47):

Imperial: Shows 1 bar for every 10 feet per minute (fpm) of ascent rate.

Metric: Shows 1 bar for every 3 meters per minute (mpm) of ascent rate.

Green when 1 to 3 bars, Yellow when 4 to 5 bars, and Flashes Red when 6 bars or more.

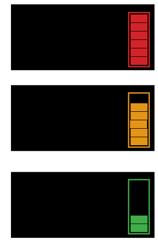


Fig 45-47

Battery Symbol (Fig. 48-49):

When the battery is good, the battery symbol does not display.

Displays Yellow when the battery needs to be changed.

Flashes Red when the battery is dangerously low and must be replaced immediately.

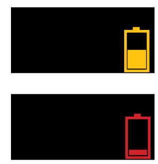


Fig48-49

Depth (Fig. 50):

Shows the depth in the currently selected units (feet or meters). Meters are displayed with 1 decimal place up to 99.9 meters. Feet are never displayed with a decimal place.

Fig 50

Note: If the depth shows a Flashing Red zero, then the depth sensor needs service **(Fig. 51).**

Fig 51

Dive Time (Fig. 52):

The length of the current dive in minutes. Does not display when not diving.

Fig 52

Stop Depth and Time (Fig. 53):

Stop – the next stop depth in the currently selected units (feet or meters).

Time – the time in minutes to hold the stop.

Fig 53

Will Flash Red when you ascend shallower than the current stop **(Fig. 54)**.

Fig 54

Note on 10ft/3m last stops: The Secondary uses 10ft/3m last stops. You may perform 20ft/6m stops with no penalty, since the Secondary Display is always calculating tissue loading at your actual depth. The only difference is that the predicted time-to-surface will be shorter than the actual TTS since off-gasing is occurring slower than expected.

Average Depth (Fig. 55):
Displays the average depth of the current dive, updated once per second.

Fig 55

When not diving, shows the average depth of the last dive.

Average Depth in Atmospheres (AvgATM) (Fig. 56):
The average depth of the current dive, measured in absolute atmospheres (i.e. a value of 1.0 at sea level).

Fig 56

When not diving, shows the average depth of the last dive.

Circuit Mode (Fig. 57-59):
The current breathing configuration. One of:
OC = Open circuit
CC = Closed circuit
SC = Semi-closed circuit

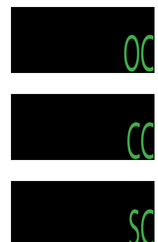


Fig 57-59

Current Gas (O_2/He) (Fig. 60):
The current gas shown as a percentage of Oxygen and Helium. The remainder of the gas is assumed to be Nitrogen.

Fig 60

In closed circuit mode, this gas is the diluent. In open circuit mode this is the breathing gas.

Flashes Red when there is another programmed gas that is more appropriate at the current depth than the current gas **(Fig. 61)**.

Fig 61

No Decompression Limit (NDL) (Fig. 62):
The time remaining, in minutes, at the current depth until decompression stops will be necessary.

Fig62

Displays in Yellow when the NDL is less than 5 minutes **(Fig. 63).**

Fig 63

Once the NDL limit has been exceeded, this value can be set to optionally display other information. These options are:
CEIL: The current ceiling in the currently selected units (feet or meters). Flashes Red if you ascend shallower than the current ceiling **(Fig. 64)**.

Fig 64

GF99: The raw percentage of the Buhlmann allowable supersaturation at the current depth **(Fig. 65)**.
@+5: The time-to-surface (TTS) if you were to stay at the current depth for 5 more minutes **(Fig. 66)**.

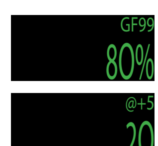


Fig 65-66

Time-to-Surface (TTS) (Fig. 67):

The time-to-surface in minutes in the current circuit mode. Assumes an ascent rate of 30 feet per minute (10 meters per minute), that stops will be followed and programmed gases will be used as appropriate.

Fig 67

Maximum Depth (Fig. 68):

The maximum depth of the current dive.
When not diving, displays the maximum depth of the last dive.

Fig 68

CNS Toxicity Percentage (Fig. 69):

Central Nervous System oxygen toxicity loading percentage.

Flashes Red when 100 or greater **(Fig. 70)**.

The CNS percentage is calculated continuously, even when on the surface and turned off. Removing the battery will reset the CNS percentage.

Fig 69-70

Setpoint:

The current PPO_2 setpoint. Displays in Yellow when the setpoint is 0.19 **(Fig. 71)**.

Fig 71

Average PPO_2:

The average PPO_2 of the current breathing gas **(Fig. 72)**.

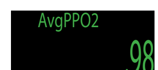


Fig 72

In OC mode, displays in Flashing Red when less than 0.19 or greater than 1.65 **(Fig. 73)**.

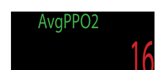


Fig 73

In CC mode, displays in Flashing Red when less than 0.40 or greater than 1.6. In CC mode, averages all sensors that are not voted out **(Fig. 74)**.

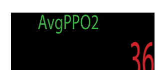


Fig 74

Diluent PPO_2 (Fig. 75):

Only displayed in CC mode. Displays in Flashing Red when the partial pressure of the diluent is less than 0.19 or greater than 1.65.

Fig 75

Gas PPO_2 (Fig. 76):

Only displayed in OC mode. Displays in Flashing Red when less than 0.19 or greater than 1.65.

Fig 76

Gradient Factor (Fig. 77):

Fig 77

Decompression and Gradient Factors

The basic decompression algorithm used for the computer is Buhlmann ZHL-16C. It has been modified by the use of Gradient Factors that were developed by Erik Baker. We have used his ideas to create our own code to implement it. We would like to give credit to Erik for his work in education about decompression algorithms, but he is in no way responsible for the code we have written.

The computer implements Gradient Factors by using levels of conservatism. The levels of conservatism are pairs of number like 30/85.

The default of the system is 30/85. The system provides several settings that are more aggressive than the default.

Don’t use the system until you understand how it works.

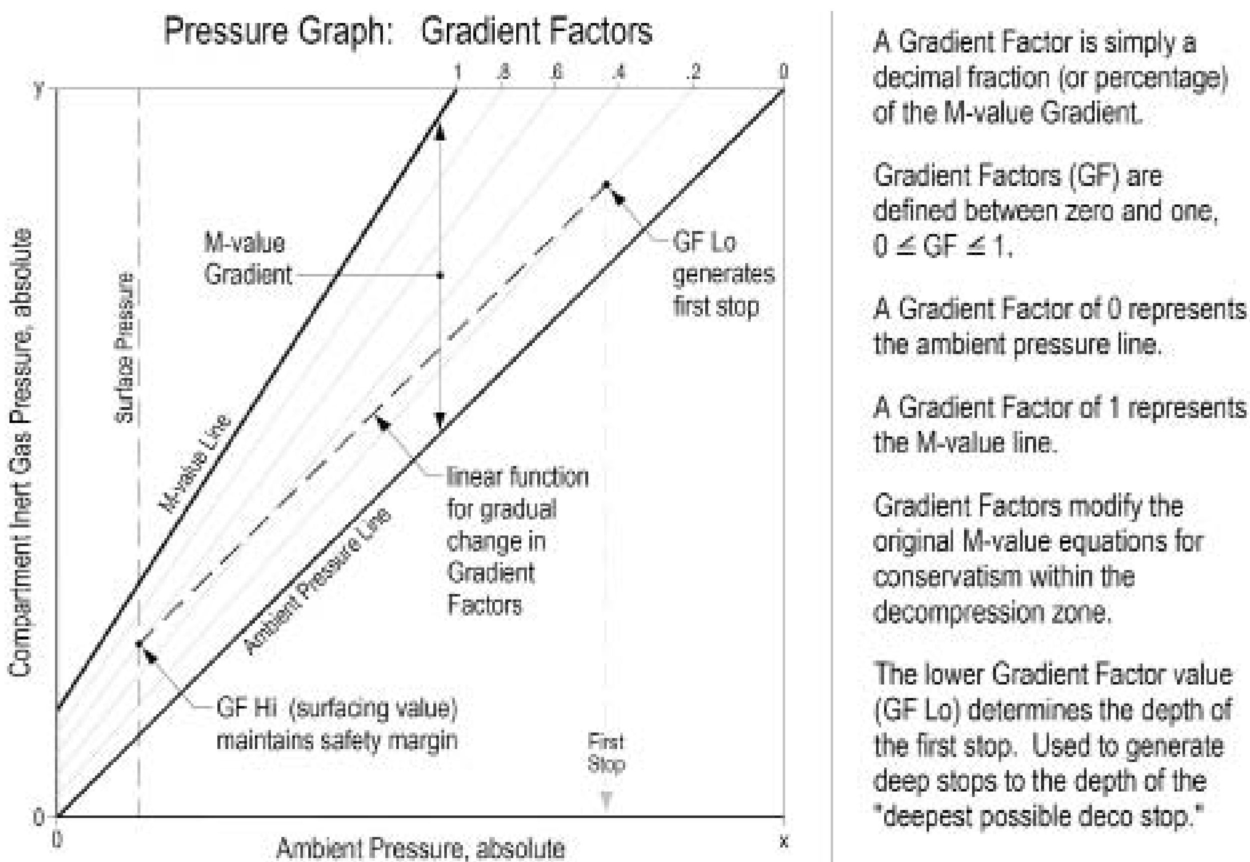


Fig 78

Graph from Erik Baker’s “Clearing Up The Confusion About Deep Stops”

Gradient Factors Explained

By Kevin Watts

This primer attempts to provide a user's view of gradient factors, an Erik Baker derived method of calculating decompression schedules.

Back to Bühlmann

Everything in the gradient factor decompression algorithm revolves around Dr. Albert A. Bühlmann's tissue model. Currently this means 16 hypothetical tissue compartments that are constantly tracked during a dive in order to determine each tissue compartment's inert gas pressure.

As you ascend, all those tissue compartments start to release pressure (off- gas). The question is "How fast can you let those tissue compartments off-gas?"
Bühlmann answered that question by coming up with an "M-value". Basically, an M-value is a maximum pressure value (different for each depth and tissue compartment) that tells you, if you exceed that value, your chances of getting decompression sickness are greatly increased.

A natural ascent strategy then would be to move up in the water column until the pressure in your tissue compartments just reaches Bühlmann's M-value and then let your tissue compartments off-gas a bit, rise to the next level, etc. In this strategy, you would keep going up in such a way that you never let your tissue compartments exceed Bühlmann's M-value.

Unfortunately, decompression illness does not exactly track Bühlmann's M-values. A greater potential for decompression illness occurs at and above the pressures represented by M-values and the potential lessens when divers never reach Bühlmann's M-values.

Enter Gradient Factors

Gradient factors (GFs) were invented to let the diver choose how fast, and how close their tissue compartments get to Bühlmann's M values.
Gradient factors are calculated as follows:

$$\text{Gradient Factor} = \frac{\text{Tissue Compartment Pressure} - \text{Ambient Pressure}}{\text{MValue} - \text{Ambient Pressure}}$$

What does this formula tell us?

First, the gradient factor formula tells us that at a Gradient Factors of 1.0 (GF=1.0), you are at Bühlmann's M-value. Therefore, staying at or below GF=1.0 seems important. Second, it tells us that when our tissue compartment pressure just reaches ambient pressure, then the GF=0.0.

Another ascent strategy, then, might be to shoot up to a GF=0.8 and ascend in such a way as to not exceed that value. In this way you know that your tissue compartments are never over 80% of the distance between ambient pressure and Bühlmann's M-value. In essence, you have a 20% safety margin on Bühlmann's M-value. Dive computers implementing gradient factors usually let you set two gradient factor parameters. Moving straight to GF=0.8 would be equivalent to setting your dive computer to 80/80.

Erik Baker's Strategy

Erik baker didn't like the idea of ascending directly to a GF close to Bühlmann's M-value. Instead, he said, "let's all ascend first to a lower GF, then slowly move to higher GFs". So, let's say you want to first ascend to a GF=0.30, and then slowly move to reach GF=0.85 as you surface. This setting on your gradient factor computer is 30/85. The Prism 2 secondary uses 30/85 as its default setting.

So what is happening when you use a GF setting of 30/85?

First, your dive computer allows you to ascend until the pressure in your tissue compartments first reaches a GF-0.30. This means your tissue compartment pressure is 30% of the way between ambient pressure and Bühlmann's M-value. Then you sit there until your tissue compartments drop enough pressure, so that you can ascend to your next stop.

How much pressure must leave your tissue compartments before you can ascend?

Assume you hit your first stop (GF=0.30) at 110ft. We now have two known points. Point 1 is (110,0.30), that is, at 110ft we are at GF of 0.30. Point 2 is (0, 0.85) that is, at the surface, we want to be at GF=0.85. A natural way to ascend (and this is what Baker did) is to create a line from those two known points and ascend in such a way that you never exceed the GF generated by that line.

Once you determine your two points, the formula for the maximum GF at any depth is:

$$\text{MaxGF} = \text{HighGF} + \frac{\text{HighGF - LowGF}}{\text{HighGFDepth - LowGFDeptrh}}\ \text{Current Depth}$$

But since the high gradient factor is reached at the surface, HiGFDepth=0. So,

$$\text{MaxGF} = \text{HighGF} + \frac{\text{HighGF - LowGF}}{\text{LowGFDepth}}\ \text{Current Depth}$$

Therefore, if you hit your first GF=0.30 at 110ft, then your LowGFDepth=110. Before you can ascend to 100ft you must let off enough tissue compartment pressure so that when you arrive at 100ft the GF of your tissue compartments does not exceed 0.35 calculated as:

$$MaxGF = 0.85 + \frac{0.85 - 0.30}{110} 100$$

You can ascend to 90ft when your tissue compartments let off enough pressure at your 100ft stop so that when you reach 90ft your tissue compartments does not exceed 0.40 calculated as

$$MaxGF = 0.85 + \frac{0.85 - 0.30}{110} 90$$

The GF method allows you to ascend by walking that line all the way to the surface.

Summary

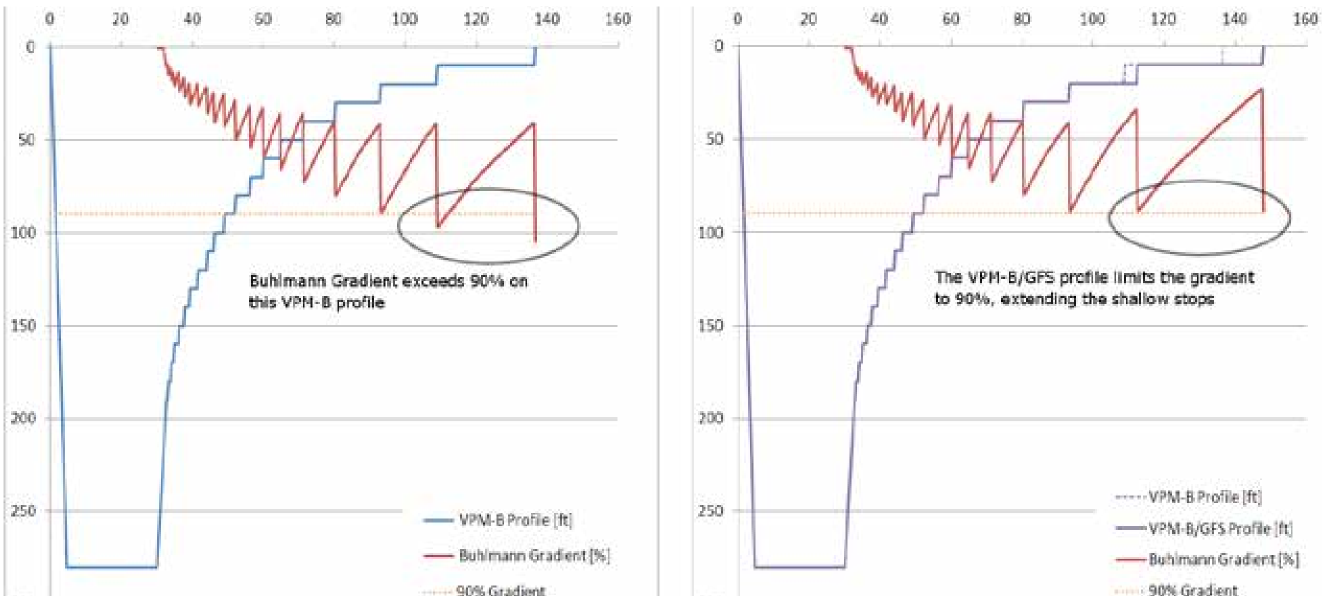
If you understood the above explanation, then you see why divers say that setting your GF parameters to 10/90 or 10/80 etc. helps generate deep stops. The low GF of 10 means a stop must be generated when your tissue compartments are only 10% of the way between ambient pressure and Bühlmann's M-value, rather than 30% if you were to set the low GF to 30. Simply, the GF line just starts deeper.

The gradient factor method is a natural extension of Bühlmann's tissue compartment model. Divers using computers implementing the gradient factor method should understand how modifying their GF parameters would alter the decompression profiles. You must consider altering your GF parameters based on dive characteristics, your physical condition, and your general attitude toward the risk of decompression illness. The gradient factor method provides the diver substantial flexibility in controlling their decompression profiles. Your responsibility is to choose the factors appropriate for you.

For more information on gradient factors and M-values, please refer to Erik Baker's excellent articles, "Clearing up the confusion about deep stops" and "Understanding M-values", available on the web.

The VPM-B algorithm requires an activation code which cen be purchased at additional expense. To activate the VPM-B decompression algorithm, contact your Hollis Dealer.

VPM-B/GFS EXPLAINED



a) VPM-B Profile **b) VPM-B/GFS Profile**

- Gradient Factor Surfacing (GFS) adds conservatism to the shallow stops of a VPM-B profile.
- In the pure VPM-B profile the Buhlmann (ZHL-16C) Gradient exceeds 90%.
- On the VPM-B/GFS profile, the shallow stops have been lengthened because the gradient is limited to 90%.
- GFS adds more time to dives that require more decompression. Dives with deco times under 45 minutes are typically not affected.
- The GFS gradient factor can be adjusted from 70% to 99%. The default is 90%.

NOTE:

For VPM-B, higher conservatism values are <u>more</u> conservative. The most aggressive settings is 0, and the most conservative is +5. The default is +3.

For the GFS value, higher values are <u>less</u> conservative. The most aggressive setting is 99%, and the most conservative is 70%. The default is 90%.

Pressure (Fig. 79):

The pressure in millibars. Two values are shown, the surface (surf) pressure and the current (now) pressure.

Fig 79

The current pressure is only shown on the surface (i.e. when not diving).

The surface pressure is set when the Secondary Display is turned on. If the Altitude setting is set to SeaLvl, then surface pressure is always 1013 millibars.

Temperature (Fig. 80):

The current temperature in degrees Fahrenheit (when depth in feet) or degrees Celsius (when depth in meters).

Fig 80

External Voltage (Fig. 81):

The external voltage of the solenoid battery.

Fig 81

Internal Voltage (Fig. 82):

The Secondary Display's internal battery voltage. Displays in Yellow when the battery is low and needs replacement. Displays in Flashing Red when the battery is critically low and must be replaced as soon as possible.

Fig 82

Millivolts (Fig. 83):

The raw millivolt readings from the O_2 sensors.

Fig 83

Date and Time (Fig. 84):

In the format mm/dd/yy

24-hour clock time.

Fig 84

Serial Number (Fig. 85):

Unique serial number identifier for every Secondary Display.

Fig 85

Version (Fig. 86):

The version number indicates the features available on the Secondary Display.

Fig 86

The last two numbers are the firmware version.

Surface Interval (Fig. 87):

The time in days, hours and minutes since the last dive ended. Reset when the battery is removed.

Fig 87

Example Dive

This is an example of the displays that might be seen on a dive. This example shows a complicated dive with multiple Closed Circuit (CC) gases and multiple Open Circuit (OC) bail-out gases. A normal, single gas CC or OC dive wouldn't have any button pushes at all, so there isn't much to show.

The first step is to calibrate **(Fig. 88)**. Since we are on the surface and not diving, MENU will bring up "Turn Off", then "Calibrate." Once the loop is flushed with oxygen, SELECT will bring up the confirmation display **(Fig. 89)**, and another SELECT will calibrate **(Fig. 90)**.

Fig 88

Fig 89

Fig 90

Next, we check the closed circuit gases that we have programmed. Entering the gas selection function by pressing SELECT with the "Select Gas" menu item showing **(Fig. 91)** will display the first CC gas that is available **(Fig. 92)**. MENU will increment to the next gas available. Another MENU takes us back to the "Select Gas" menu item. Those are the only two gases configured. We SELECT gas number 2, Trimix 10/50 **(Fig. 93)**.

The system will use both of these gases for our dive when calculating the TTS. It assumes a diluent switch at a PPO_2 of 1.0. That means that it will assume that you have switched to an air diluent at 124 feet. This is only for TTS. The computer will always use the currently selected gas for tissue loading calculations.

Then we switch to open circuit to look at our bail-out gases. Flipping through the gases with MENU shows that we have three gases available **(Fig. 91-93)**. (Whether they are appropriate gases is a subject for one of the web forums.)

Fig 91

Fig 92

Fig 93

These are the gases that will be used to estimate TTS in the event that you switch to open circuit during a dive. The computer will assume that you will switch gases when the PPO_2 of the next available gas is less than 1.61.

Automatic decisions of when to switch gases for the TTS calculation means that it is very easy to set up your CC and OC gases. There is no need to enter a depth or a PPO_2 to switch gas. There is no need to keep track of which gases are turned on and off in which mode.

If a gas is available in the CC gas list it will be used in CC, and it will be used at an appropriate depth. The same is true for OC. It is always configured correctly if you actually have the gases you have created.

If it is necessary to switch to OC while diving, 3 button pushes will do it **(Fig. 94)**. You will be switched to OC and will be using the gas that has the highest PPO_2 less than 1.61. Your OC gas list is likely very different from your diluent gas list, but all of the OC gases are automatically selected and available.

Now switch back to closed circuit and start the dive **(Fig. 95)**.

Fig 94

Fig 95

We have reached a depth now that will incur decompression soon **(Fig. 96)**. The NDL is 8 minutes, and the TTS is 4 minutes. The TTS just reflects the ascent time at 30 fpm.

The computer has automatically switched to the high setpoint. This can be disabled if automatic setpoint switching isn't required.

Fig 96

We are now at our maximum depth. Our first stop is at 90 feet **(Fig. 97)**.

Fig 97

The diver is ascending to the 90 foot stop. Note the ascent rate indicator showing a 30 fpm / 10 mpm ascent rate. Although the ascent rate is 30 fpm now, during the 7 minute ascent, the diver ascended slower than was predicted, and now there is a 100 foot stop **(Fig. 98)**.

Fig 98

But the diver missed the stop, and has ascended to 95 feet. At this point, the stop depth and time is flashing red to show that the depth is above the recommended stop **(Fig. 99)**.

Fig 99

The diver switches to the other programmed CC gas, air. Note that if you change the diluent on the computer you must flush the loop to change the diluent in the loop. At the same time the 100 foot stop clears. It is common for the first stops to clear in less than a minute. They mainly just slow down the ascent **(Fig. 100)**.

Fig 100

At 60 feet a problem develops that causes the diver to bail out to open circuit. The first push (#1) on MENU brings up Select Gas **(Fig. 101)**.

Fig 101

The second push (#2) brings up Switch CC -> OC **(Fig. 102)**.

Fig 102

A push on SELECT does the switch (#3). The system has switched the gas set from the closed circuit gas set to the open circuit gas set, picked the gas with the highest PPO_2 less than 1.6, and recalculated the decompression based on the new profile **(Fig. 103)**.

Fig 103

At 20 feet, one push on MENU brings up select gas **(Fig. 104)**.

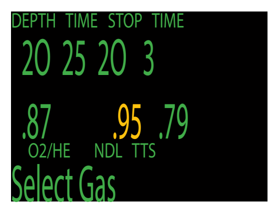


Fig 104

A push on SELECT enters the select gas menu, and another SELECT picks the O_2. Since the gases are sorted by oxygen content, O_2 is the first gas offered **(Fig. 105)**.

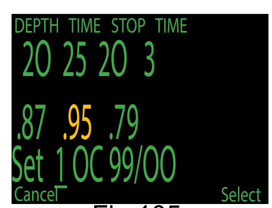


Fig 105

Menu Reference

Turn Off (Fig. 106)

The “Turn Off” item puts the computer to sleep. This menu item will only appear if the water contacts are dry on controllers. While sleeping, the screen is blank, but the tissue contents are maintained for repetitive diving. The “Turn Off” menu item will not appear during a dive. Turn off time is user selectable in the Advanced Configuration menu.

Fig 106

Calibrate (Fig. 107)

This will calibrate the sensor displays to oxygen. Flood the breathing loop with pure oxygen, SELECT with “Calibrate” in the display, and the confirmation message will display. On the top line, the millivolt reading will show. Good sensors should be in the range of 35 - 60 mV at sea level in 100% oxygen. The allowable millivolt range for calibration in the computer programming is 30 - 70 mV. This scales with percentage of oxygen and barometric pressure.

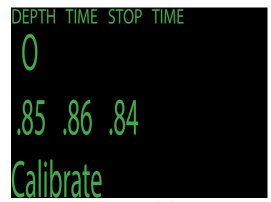


Fig 107

Pressing the MENU button will prevent the calibration. Pressing SELECT will calibrate the sensor displays. The displays should now all read .98. If any display shows FAIL, the calibration has failed because the mV reading is out of range. **(Fig. 108-109)**

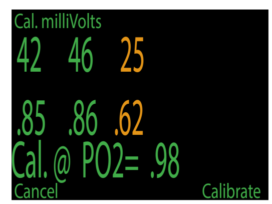


Fig 108

The system defaults to a calibration gas of 98% oxygen. This is to compensate for the difficulty in completely filling the loop with 100% oxygen and also to allow for water vapour. If you are using a calibration kit with no water vapour and 100% O_2, you can set the calibration gas to 100. It can also be set to other values if pure oxygen is not available.

Fig 109

The calibration takes into account the altitude at which the computer was turned on. For example, if the altitude was 885 mBar or .87 ATA, then with a 98% calibration gas, the sensors would calibrate to .85.

The “Calibrate” menu item will not display during a dive.

Calibration Problems

Here are some common calibration problems. In this display, one sensor is flashing yellow. This shows that the sensor is voted out. If it comes back within range, it will be voted back in, stop flashing yellow and return to green **(Fig. 110)**.

Fig 110

A failed sensor is a different situation. In this case, the sensor failed calibration. Changing the sensor won't make it register again. Once a sensor has failed calibration, the only way to bring it back is to successfully calibrate. If the computer were to display a value with a new sensor, it would be a meaningless value without calibration **(Fig. 111)**.

Fig 111

If this was the display, it would indicate a faulty sensor. It is not within the expected range for a sensor in oxygen. Most sensors are designed to output 10 mV +/- 3 mV in air. If the output is linear, then that translates to a range of 30 to 70 as valid mV readings in 98% oxygen. The computer will refuse to calibrate outside that range **(Fig. 112)**.

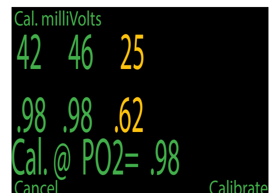


Fig 112

Three sensors all showing FAIL is usually caused by an accidental calibration in air. A failed calibration can only be fixed by performing a successful calibration **(Fig. 113)**.

Fig 113

External Battery (Solenoid Battery) Alerts

The two 9 volt batteries located in the battery compartment in the head drive the Watt Miser 0.65 watt solenoid. The operating range of the solenoid is from 9 volt to 7 volt, at which time the user will get a “low battery” alert on the Secondary Display. The battery is measured by the computer while the battery is under load. Failure to change the battery after a “Low Battery” alert will result in the solenoid eventually discontiniung operation.

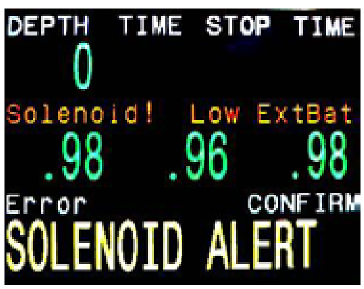
1

“Low Ext Battery” when battery falls below operating threshold (7V).

2

After user confirms, the small red text persists as long as the low battery condition remains.

3



If the battery falls so low that the solenoid does not fire (or current falls out of range), a “Solenoid Alert” occurs.

4

After user confirms, the small red text persists as long as the solenoid alert condition remains.

5

If “Ext V” is viewed, it appears in red.

USE ONLY NAME-BRAND BATTERIES (DURACELL, EVEREADY, etc)
OFF-BRAND / DISCOUNT BATERIES HAVE NO PLACE IN LIFE SUPPORT GEAR
AND MUST NEVER BE USED TO POWER ANY COMPONENT OF YOUR PRISM 2.
(See full battery warnings on page V)

Switch Setpoint

When SELECT is pushed with either of these displays, the displayed setpoint on the right will be selected.

Fig 114

During a dive, the “Switch Setpoint” menu item will be the first item displayed. The “Turn Off” and “Calibrate” displays are disabled **(Fig. 114 - 115)**.

Fig 115

Select Gas (Fig. 116)

This menu item allows you to pick a gas from the gases you have created. The selected gas will be used either as the diluent in closed circuit mode, or the breathing gas in open circuit mode.

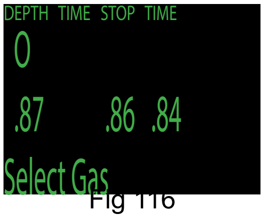


Fig 116

Gases are always sorted from most to least oxygen content.

Press the SELECT button when "Select Gas" is displayed, and the first available diluent/gas will be displayed **(Fig. 117)**.

Fig 117

Use the MENU button to increment the diluent/gas to the one you want, then press the SELECT button to select that diluent/gas **(Fig. 118)**.

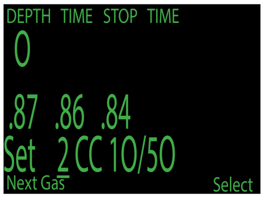


Fig 118

If you increment past the number of gases available, the display will fall back out of the "Select Gas" display without changing the selected gas.

The current gas will flash YELLOW when a more appropriate gas is defined. Use the "Confirm" button to select a gas. The bottom line of the display shows the selected gas. An 'A' will appear next to the currently active gas.

Radio Station Gases

The system maintains two sets of gases - one for open circuit and one for closed circuit.

The way they operate is very similar to the way car radios work with AM and FM stations.

When you are listening to an FM station and you push a station selection button, it will take you to another FM station. If you add a new station, it will be an FM station.

Similarly, if you are in the AM mode, adding or deleting a station would add or delete an AM station.

With radio station gases, when you are in open circuit, adding, deleting or selecting a gas will refer to an open circuit gas. Just like the FM stations are selected when your radio is in FM mode, the closed circuit gases are available in the closed circuit mode. When you switch to open circuit, the gases available will be open circuit gases.

Switch to OC/CC

Depending on the current computer setting, this selection will show as either “Switch CC -> OC” or “Switch OC -> CC” **(Fig. 119-121)**.

Pressing SELECT will select the displayed mode for decompression calculations. When switching to open circuit while diving, the most appropriate open circuit gas will become the breathing gas for calculations.

At this point, the diver may want to switch to a different gas, but since the diver may have other things to deal with, the computer will make a “best guess” of which gas the diver would choose.

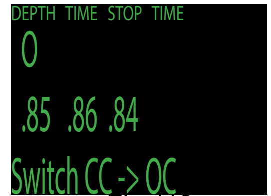


Fig 119

Fig 120

There is also an option to set the computer to calculate decompression predictions using semi-closed circuit. This is enabled in the System Setup menu **(Fig. 122)**.

When switching the computer from CC mode to OC mode, the computer will continue to maintain the active O_2 setpoint. You can manually adjust setpoint after switching the computer to OC mode to as low as 0.4ata O_2.

Fig 121

Fig 122

Dive Setup+ (Fig. 123)

These screens are showing controller displays.

Pressing SELECT will enter the Dive Setup sub-menu.

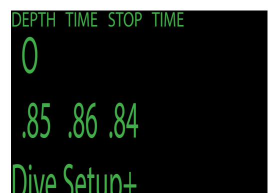


Fig 123

Low Setpoint (Fig. 124)

This item allows you to set the low setpoint value. It will display the currently selected value. Values from 0.4 to 1.5 are allowed.
A press of MENU will increment the setpoint.

Fig 124

Press the SELECT button when “Edit Low SP” is displayed and the edit display will be shown. It is set at the lowest valid value for setpoint, 0.4 **(Fig. 125)**.

Fig 125

Another press of MENU will increment it again **(Fig. 126)**.

Fig 126

If SELECT is pushed, the currently displayed setpoint will be selected, and the display will return to the “Low SP” menu item **(Fig. 127)**.

If the highest allowable value 1.5 has been passed, the value will return to 0.4.

Fig 127

High Setpoint **(Fig. 128)**

The high setpoint function works exactly like the low setpoint function.

Fig 128

Define Gas **(Fig. 129)**

The function allows you to set up 5 gases in Closed Circuit and 5 gases in Open Circuit. You must be in Open Circuit to edit open circuit gases, and you must be in Closed Circuit to edit closed circuit diluents. For each gas you can select the percentage of oxygen and helium in the gas.

Fig 129

Pushing SELECT when "Define Gas" is displayed presents the function to define gas number 1 **(Fig. 130)**.

Fig 130

Pushing the MENU button will display the next gas **(Fig. 131)**.

Fig 131

Pushing SELECT will allow you to edit the current gas. The gas contents are edited one digit at a time. The underline will show you the digit being edited **(Fig. 132)**.

Fig 132

Each push of the MENU button will increment the digit being edited. When the digit reaches 9 it will roll over to 0 **(Fig. 133)**.

Fig 133

Pushing SELECT will lock in the current digit and move on to the next digit **(Fig. 134)**.

Fig 134

Pushing SELECT on the last digit will finish editing that gas and bring you back to the gas number **(Fig. 135)**.
Any gases that have both oxygen and helium set to 00 will not be displayed in the "Select Gas" function.

Fig 135

Pushing MENU will continue to increment the gas number **(Fig. 136)**.

Fig 136

Note: The “A” denotes the active gas. You cannot delete the active gas. If you try it will generate an error. You can edit it, but cannot set both the O_2 and He to 00 (Fig. 137).

Fig 137

The computer will display all 5 gas entries available to allow you to enter new gases.

Pressing MENU one more time when the fifth gas is displayed will return you to the “Define Gas” menu item **(Fig. 138)**.

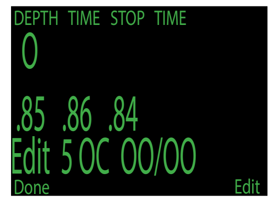


Fig 138

Only enter the gases you are actually carrying on the dive. With radio station gases, the computer has a full picture of the OC and CC gases you are carrying and can make informed predictions about decompression times. There is no need to turn gases off and on when you switch from CC to OC, because the computer already knows what the gas sets are. You can still add or remove a gas during the dive if needed.

Dive Planner+ (Fig. 139)

INTRODUCTION:

- Calculates decompression profiles for simple dives.
- In closed-circuit (CC) mode, also calculates open-circuit (OC) bail-out (BO).

SETUP:

Uses the current gases programmed into the Secondary Display, as well as the current GF low/high settings.
Deco profile is computed for the current circuit mode (CC or OC).

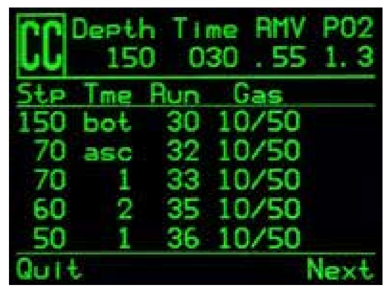
ON THE SURFACE:

Enter the dive bottom depth, bottom time, respiratory minute volume and PPO_2.

Note: Residual tissue loading (and CNS%) from recent dives will be used in calculating the profile.

DURING A DIVE:

Computes the decompression profile assuming the ascent will begin immediately. There are no settings to enter. (RMV is last used value)



Dive Plan Setup
Fig 139

LIMITATIONS:

The Secondary Display Dive Planner is intended for simple dives. Multi-level dives are not supported.

The Secondary Display Dive Planner makes the following assumptions:

- Ascent and descent rates are 33ft/min (10m/min).
- For OC, the gas in use will be the gas with the highest PPO_2 less than 1.61.
- For CC, the gas in use will be the gas with the highest PPO_2 less than 1.05.
- Last stop is 10ft (3m).
- For CC, the PPO_2 is constant for the entire dive.
- The RMV is the same while diving as during deco.

The Dive Planner does not provide any validation of the profile. It does not check for nitrogen narcosis limitations, gas usage limitations, CNS percentage violations, or isobaric counter-diffusion violations due to sudden helium switches. The user is responsible for ensuring a safe profile is followed.

RESULT SCREENS (Fig. 140-141):

The results are given in tables showing:

- Stp: Stop Depth — In feet (or meters)
- Tme: Stop Time — In minutes
- Run: Run Time — In minutes
- Qty: Gas Quantity — in CuFt (or liters). OC and BO only

The first two rows are special, the first row showing the bottom time and the second showing the ascent to the first stop. When diving, these two rows are not displayed.

Fig 140

Fig 141

Example Results Table for Closed-Circuit and Bailout.

If more than 5 stops are needed, the results will be split onto on several screens. Use the right button to step through the screens.

For OC or BO profiles, a total gas consumption report is given.

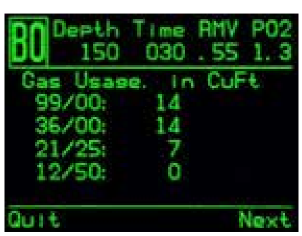
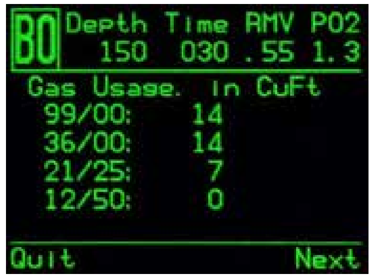


Fig 142

Gas Usage Report

The final result screen shows the total dive time, the time spent on deco and final CNS%.



Results Summary Screen

Fig 143

If no decompression is required, no table will be shown. Instead, the total No-Decompression-Limit (NDL) time in minutes, at the given bottom depth will be reported. Also, the gas quantity required to surface (bailout in CC) will be reported.

No Decompression Results Screen

Fig 144

NDL Display **(Fig. 145)**

The NDL Display option allows you to display four different values during the dive. The display can be changed during the dive to provide different information.

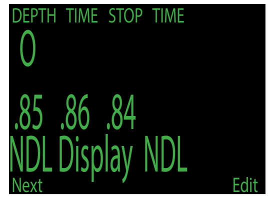


Fig 145

Pushing SELECT will make the NDL display editable. The first choice available will be **NDL**. If you select NDL the NDL will always be displayed during the dive whether or not you have a decompression ceiling. **(Fig. 146)**

Fig 146

The next selection is **CEIL**. With this setting, as long as the NDL time is 0 (you have a decompression ceiling), the raw ceiling will be displayed instead of the NDL. This is the equivalent of the 'Man on a rope.' It will show your ceiling without it being rounded up to the next even 10 foot or 3 meter stop. Please note that there is very limited information on the effects of following a continuous ceiling instead of stopping at stops and only moving up to the next stop when the stop has cleared **(Fig. 147)**.

Fig 147

It is the author's opinion that all stops should be honored. It seems intuitive that if you have bubbles and you stop you give the bubbles an opportunity to be re-absorbed. If you continuously ascend, the ambient pressure is continuously reduced which prevents bubbles from shrinking. Because of this belief, the computer will give one MISSED DECO STOP message during the dive and one after the dive, and will flash the stop depth and time in red as long as you are above the stop depth. It will use the increased gradient though, and your calculated off-gassing will be faster than staying at the stops.

The next option is to display the actual supersaturation gradient for a pure Buhlmann (99/99) profile **(Fig. 148)**.

Fig 148

The selection is **GF99**. With this setting, as long as the NDL time is 0 (you have a decompression ceiling), the gradient will be displayed instead of the NDL.
The number shown is the percentage of supersaturation. The number is calculated by reference to the Ambient Pressure Line and the M-Value line. It can be thought of as the current GF, but it is different in a couple of ways. First, the current GF generates stops rounded to the nearest 10 feet or 3 meters. So a gradient of 40 may reflect a ceiling of 15 feet, but the computer will show a rounded-up 20 foot stop **(Fig. 149)**.

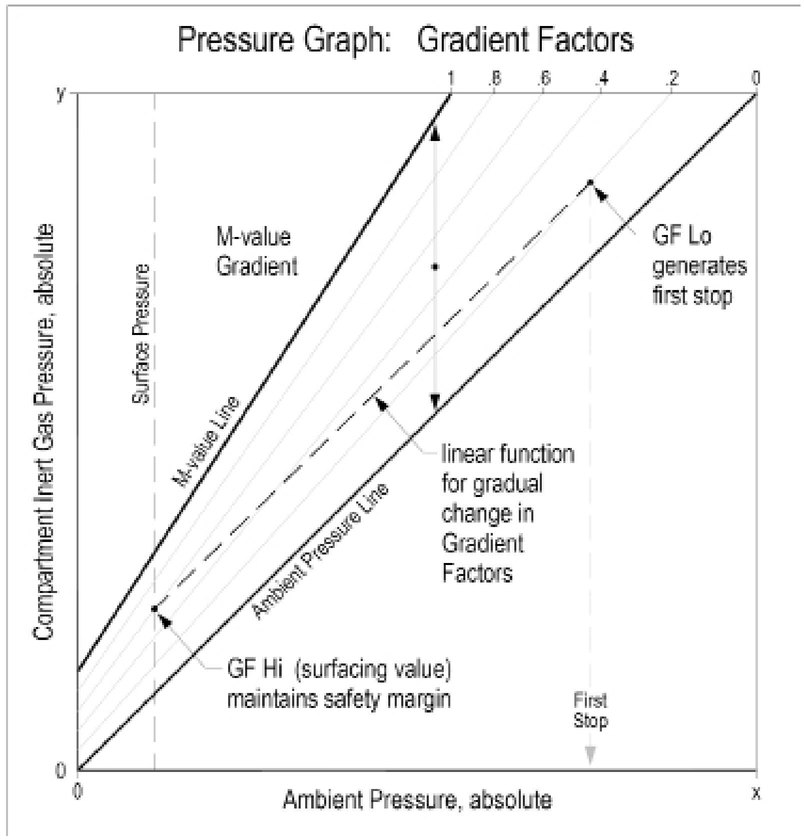
Fig 149

This number can be used in several ways. First, it can be used to calculate an aggressive ascent that still has some justification in decompression science. For example, if a diver were to lose a significant portion of their gas and needed to get shallow fast, they could ascend until they reached a gradient of 90, then stop until it dropped to 80, then ascend to 90 again, etc. That would produce a Buhlmann-like profile with very little conservatism. In an emergency, that may be an acceptable risk.

Another use might be to do a slower ascent on a dive to sightsee, but to stay in the decompression zone by keeping the gradient above 0.

Another use would be to observe the rapidly increasing gradient in the last 1O feet to the surface and slow that ascent.

All of this is based on gradient theory that may be completely false. There is significant disagreement in the decompression research community about the nature and practice of decompression. Any techniques described here should be considered experimental, but the concepts may be useful to the advanced diver.



The last selection is **@+5**. This feature has been borrowed from Dan Wible's CCR2000 computer. It is the time-to-surface (TTS) if you were to stay at the current depth for five more minutes.
This can be used as a measure of how much you are on-gassing or off-gassing **(Fig. 150)**.

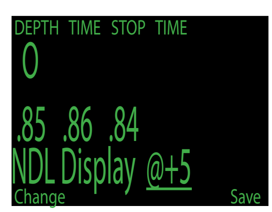


Fig 150

External PPO_2 Monitoring

The next menu item is used to turn external PPO_2 monitoring on and off **(Fig. 151)**. By default, external monitoring is turned on and reads "Ext." for External. To turn external monitoring off (Int.), press the MENU button to change from External to Internal, then press the SELECT button on this menu item.

Fig 151

Now the PPO_2 of the three sensors is displayed. In the displayed screens we have three sensors and they have been calibrated at some point **(Fig. 152)**.

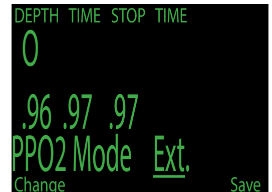


Fig 152

This system is plugged into three sensors and is the primary display for the system **(Fig. 153)**.

Fig 153

Note that since we are in Closed Circuit mode, that the PPO_2 used to calculate decompression is the average of the three sensors after voting. In this case, sensor three has been voted out, and the decompression calculation will use the average of sensor 1 and 2.

Sensor 3 will be flashing yellow. **(Fig. 154)**

Fig 154

Switching to Open Circuit mode **(Fig. 155)**.

Fig 155

The PPO_2 used for calculation is now is the PPO_2 of the selected gas at the current depth **(Fig. 156)**.

Fig 156

If we now unplug sensor 1 and sensor 3, the computer will use voting logic to pick the two readings that agree and will think the PPO_2 is 0. Sensor 2 will be voted out and flashing yellow. **This is one of those times that the user will have to determine which sensors are correct (Fig. 157).**

Fig 157

With sensors one and three unplugged, we simulate the situation with fourth sensor monitoring. If we calibrate in this situation, the system will assume that this computer is only attached to one sensor, and will re-configure for fourth sensor monitoring **(Fig. 158)**.

Fig 158

It will no longer average the sensors or vote on them. Now the single sensor is the only one considered and the PPO_2 used for calculations is the PPO_2 of the single sensor **(Fig. 159)**.

Fig 159

Setpoint -> .19 **(Fig. 160)**

It allows the solenoid to be turned off while on the surface when the loop is exposed to air. This prevents the solenoid from firing continuously. It is mainly used while uploading logs or other maintenance functions.

Fig 160

To switch back to normal low setpoint, select the Switch Setpoint menu item. The setpoint will also switch to normal low setpoint if a dive is started with the .19 setpoint selected. **(Fig. 161)**

Fig 161

Dive Log Menu

Display Log:

At the “Dive Log” prompt, press SELECT to view the most recent dive **(Fig. 162, 163)**.

The profile of the dive is plotted in blue, with decompression stops plotted in red. The following information is displayed **(Fig. 164)**:

- Maximum and Average depth
- Dive number
- Date (mm/dd/yy) and time (24 hr clock) of dive start
- Length of dive in minutes

Press MENU to see the next dive, or SELECT to quit viewing logs.

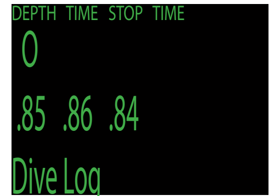


Fig 162

Fig 163

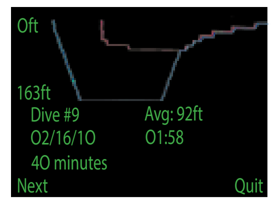


Fig 164

Upload Log:

See “Firmware Upload and Dive Log Download Instructions.”

Edit Log Number (Fig. 165):

The dive log number can be edited. This is useful if you need to clear the dive log, but want the numbering to continue from where you left off.

At the “Edit Log Number” prompt, press SELECT to begin editing. While editing, use MENU to change the value of the currently underlined digit, and SELECT to move to the next digit **(Fig. 166)**.

The next dive number will be +1 from the value entered here. For example, if you enter 0015, then the next dive will be dive number 16.

Fig 165

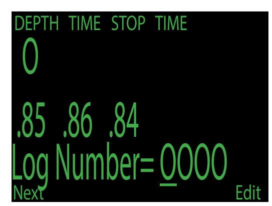


Fig 166

Clear Log (Fig. 167, 168):

At the “Clear Log” prompt, press SELECT. You will be asked to SELECT again. Press SELECT to begin clearing the log, or press MENU to cancel.

It will take about 1 minute to clear the log. Do not remove the battery during this time.

Clearing the log will not clear the dive number.

Note: The Secondary Display has a 20 hour dive log memory. If this limit is exceeded, the oldest dive logs will be overwritten by the newer dives.

Fig 167

Fig 168

Firmware Upload and Dive Log Download Instructions

Plug the Bluetooth dongle into your PC if bluetooth support is not built in.
Place the Secondary within 6 inches of the Bluetooth dongle.

Go to http://www.hollisgear.com/Prism2/library and download the most recent version of ‘Prism 2 Desktop with Air’ and the latest firmware update. Uninstall any old versions and install the new Desktop **(Fig. 169)**.

If “Dive Computer” menu item is greyed out, the PC cannot find a Bluetooth device plugged into it. **(Fig. 170)**

If you cannot connect to either “update firmware” or “download dive log” then you need to ensure that Bluetooth is working on your PC or laptop. **(Fig. 172)**

Once you can access “dive computer” run the program and select “Update Firmware” from the “Dive Computer Menu” **(Fig. 171)**.

Fig 169

Select the Prism2 .AES file that is with the document.

Fig 170

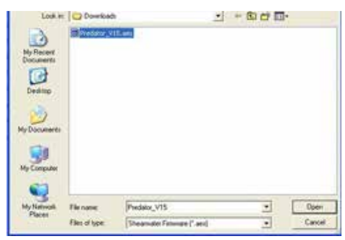


Fig 171

Fig 172

Now on the Secondary, go to the “Dive Log” menu and select “Upload Log” **(Fig. 173, 174)**.

Fig 173

Fig 174

The Secondary Display screen will switch from ”Initializing” **(Fig. 175)** to “Wait PC” **(Fig. 176)** which will have a countdown.

Fig 175

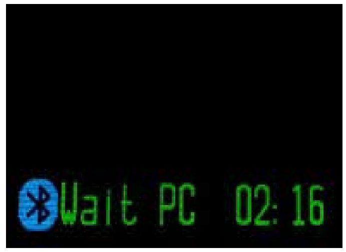


Fig 176

Now go back to the Shearwater Desktop **(Fig. 177)**. Click start from the open “Update Firmware Box” **(Fig. 178)**, or “Download Log” **(Fig. 179)**. The PC will then connect to the Secondary, and send the new firmware.

Fig 177

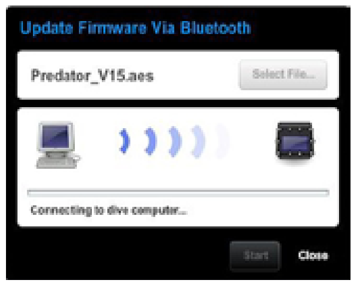


Fig 178

Fig 179

The Secondary Display screen will give percentile updates of receiving the firmware **(Fig. 180)**, then the PC will read “Firmware successfully sent to the computer” **(Fig. 181)**.

Fig 180

Fig 181

The Secondary Display will now Decrypt **(Fig. 182)**, which will take approximately 4 minutes.

Warning: Do not remove the battery during this time.

After decryption the Secondary will process, which will take an additional 4 minutes **(Fig. 183)**.

Fig 182

Fig 183

The screen upon completion of processing will read `Tissues Cleared` which must be confirmed. The screen will then read `Upgrade Reset` which also must be confirmed.

The Secondary Display now has the most up to date firmware.

System Setup (Fig. 184)

System Setup contains configuration settings that are only set between dives. This menu item doesn't appear during dives.
Each of the items in the System Setup menu can only be accessed on the surface.

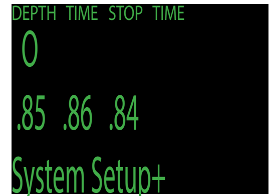


Fig 184

All of the submenus contained within System Setup make use of a convenient user interface. The MENU and SELECT buttons are context sensitive to each sub menu and individual setting **(Fig. 185)**.

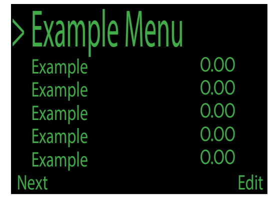


Fig 185

When cycling through the sub-menus, MENU will carry the user to the next sub-menu, while SELECT will allow the user to edit the options in this submenu.

Once the user has pressed SELECT to edit a submenu, MENU will cycle the user through the different submenu listings, while SELECT will let the user edit those listings **(Fig. 186)**.

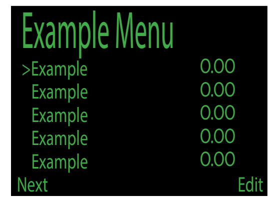


Fig 186

Once the user has pressed SELECT to edit a submenu listing MENU will be used to change the context sensitive variable, while the SELECT button will be used to move to the next field. Once the user has pressed SELECT through all the fields, the new user preferences will be saved **(Fig. 187)**.

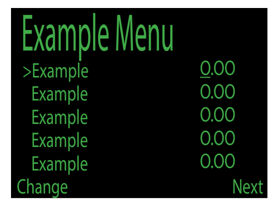


Fig 187

Dive Setup (Fig. 188, 189)

The first submenu is Dive Setup. The options contained here are the same as those accessed from the "Dive Setup" section described above, except under System Setup all of the functionality is conveniently placed on one screen as opposed to the multiple screens seen is the above described "Dive Setup" menu.

Fig 188

For a description of the functionality of each option, please see the above "Dive Setup" section.

Conservatism

The final setting in the Dive Setup Submenu, conservatism, is not found under the above 'Dive Setup' section. The Secondary Display implements Gradient Factors by using levels of conservatism. For a more detailed explanation of their meaning, please refer to Kevin Watt's article on page 40 and Erik Baker's excellent articles: *Clearing Up The Confusion About "Deep Stops" and Understanding*

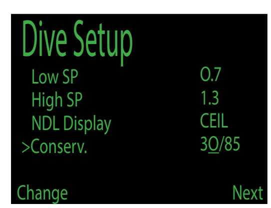


Fig 189

M-values. The articles are readily avaiable on the web. You might also want to search for “Gradient Factors” on the web.

OC Gases **(Fig. 190)**

The second submenu is OC Gases. This menu allows the user to edit the open circuit gases. The options contained here are the same as those in the “Define Gases” subsection of the “Dive Setup” section contained earlier in this manual. The interface conveniently displays all five gases simultaneously.

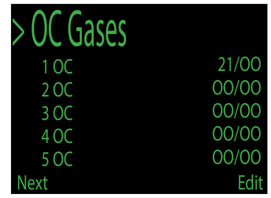


Fig 190

For a description of how to appropriately set each gas, please see the above Define Gas section.

CC Gases **(Fig. 191)**

The third submenu is CC Gases. This menu allows the user to edit the closed circuit gases. The options contained here are the same as those in the “Define Gases” subsection of the “Dive Setup” section contained earlier in this manual. The interface conveniently displays all five gases simultaneously.

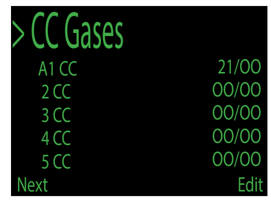


Fig 191

For a description of how to appropriately set each gas, please see the above Define Gas section.

O_2 Setup **(Fig. 192)**

The fourth submenu is O_2 Setup. This menu allows the user to edit the Oxygen settings.

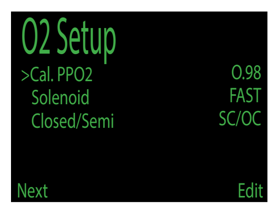


Fig 192

Cal. PPO_2 **(Fig. 193)**

This allows the user to set the expected PPO_2 for calibration. It is used in three situations.

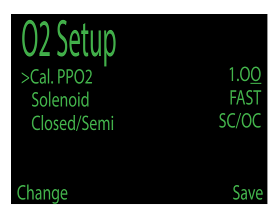


Fig 193

The first is when pure oxygen isn’t available and the oxygen is being generated by a membrane system. The oxygen in that case might be 96% O_2 and a few percent of Argon. (See full explanation on page 70).

The second is when you are using a calibration kit and are assured of using 100% O_2 with no water vapor.

If any change is made in this screen, the current calibration will be discarded. The computer must be re-calibrated with the new setings.

When to use the Cal. PPO$_2$ function
Diving your Prism 2 with O$_2$ fills of less than 99.8% purity

In some parts of the world, usually remote locations, it can be difficult to obtain oxygen fills that are, for all intents and purposes, free of inert gas. In some of these locations, a process of gas separation called "Pressure Swing Adsorption*" (PSA) is used where cryogenic or large scale compressed cylinder storage is not feasible.

PSA is a good choice for economical small-scale production of nearly, but not quite pure oxygen separated from air. The gas produced by PSA systems and used in medical applications in these locations is perfectly safe for the intended uses.

So, how does PSA work? When air is passed under pressure through an adsorbent bed of microporous aluminosilicate minerals called zeolites that attract Nitrogen (N_2) but pass through O_2, the N_2 will remain (be adsorbed) into the zeolite bed, and the gas coming out of the adsorption chamber will be enriched in oxygen. When the zeolite becomes super-saturated with N_2 and can adsorb no more, reducing the pressure releases the adsorbed N_2, regenerating the zeolite. The adsorption chamber is then ready for another cycle of producing oxygen-enriched air.

The issue with using PSA derived oxygen in hyperbaric applications, especially rebreathers, is that the absorbents used to capture and then release N_2 gas during the pressure swing cycles, has an inconvenient *aversion* to another inert, but highly narcotic gas (at elevated partial pressures) found in air: Argon(Ar). Therefore, argon is passed through along with the oxygen. This is not an issue for the intended medical or industrial purposes, so the presence of increased percentages of argon is usually not addressed.

The first problem that we closed circuit divers encounter when mixing any inert gas with our O_2 delivery, is that every time you need to inject O_2 to maintain setpoint, you are also adding an inert gas that over a short time will build up in the loop, thereby adding unwanted volume. With a gas like N_2 at recreational depths, this is more of a buoyancy challenge than anything else. However, because of Argon's heightened narcotic properties over N_2 (2.33X), even at recreational depths, the increased percentages of Argon in the breathing loop can become debilitating if left unchecked. At deeper depths, it can quickly reach dangerously narcotic pressures in the breathing loops. Go deep enough and a just a few injections from the O_2 tank can immediately incapacitate a diver. Most mixed gas divers simply avoid this issue by planning well in advance of their expedition and have a purer grade O_2 shipped in, often at great expense.

How do you dive O_2 of less than 100% with the Prism 2? First you will need to analyze the content of oxygen in the cylinder. Make sure to adjust for temperature and humidity when setting up your analyzer so you get the most accurate reading you can. This is especially important if you will be diving at deeper recreational depths.

Once you know the O_2 content, turn on your Secondary Display and navigate to your O_2 setup menu. The first sub-menu item is “Cal. PPO_2”. The default is 0.98. Adjust the value to 2/100’s under whatever your O_2 analyzer showed. So, if the O_2 content came in at 0.96, set the Cal. PPO_2 to 0.94. This will build a buffer in to your decompression algorithms to account for any residual inert gasses left in the loop during a calibration loop flush.

When diving with any oxygen mix containing an inert gas, you will need to purge the loop every so often to reduce the amount of inert gas that rides along with every oxygen injection into the loop. It is especially important to purge the loop regularly when that inert gas has increased narcotic properties and decompression issues . Remember, the lower the percentage of oxygen in PSA separated O_2, the higher the percentage of argon.

You will also want to account for any added decompression obligations incurred from breathing a heavier inert gas during diving. Because there are no tables we know of that specifically address this issue (argon is not considered a “breathable” inert gas), for recreational depth and times you may want to err on the side of caution and extend your safety stop.

Field Notes

Adsorbent? Don’t you mean absorbent?

“Adsorption: Definition: The adhesion of a chemical species onto the surface of particles. Adsorption is a different process from absorption in which a substance diffuses into a liquid or solid to form a solution.”

So why do we call CO_2 sequestration in soda lime an “absorption”?

Solenoid Speed (Fig. 195)

The firing pattern of the solenoid can be changed between fast and slow on controllers. The FAST setting adjusts the PID controller's algorithm to use frequent short injections of oxygen and is generally more accurate.

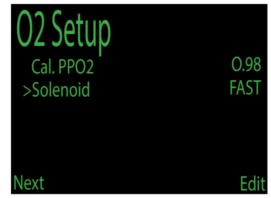


Fig 195

The SLOW setting is more familiar to many users, as it tends to mimic non-PID controlled solenoids.**(Fig. 196)**

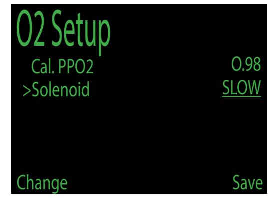


Fig 196

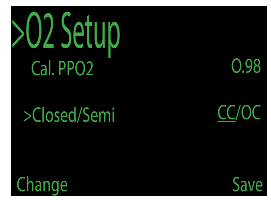


Fig 197

Set SC Identity **(Fig. 197,198,199)**

This function is used to switch between Semi-Closed circuit and Closed circuit operation. It allows the computer to make accurate projections based on the way the PPO_2 changes during ascents. It allows much more accurate predictions for Time To Surface (TTS) if the Prism 2 is dived in Semi-Closed mode.

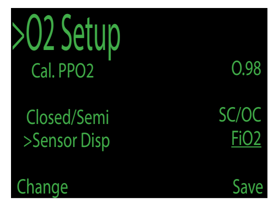


Fig 198

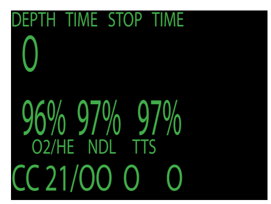


Fig 199

Auto SP Switch

Auto Setpoint Switch configuration sets up the setpoint switching. It can be set up to switch up only, down only, both, or neither **(Fig. 200)**.

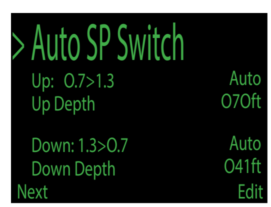


Fig 200

The first option is the switch up function. This configures the switch up from the low set point to the high setpoint. Pushing MENU switches it back and forth between "Auto" and "Manual." **(Fig. 201)**

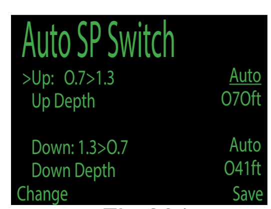


Fig 201

Note: The Up Auto SP switch occurs during the descent.

The next option is still a part of the switch up function, and enables the editing of the switch depth. **(Fig. 202)**

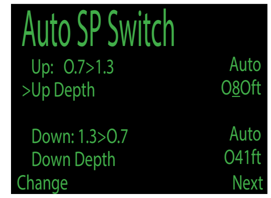


Fig 202

Next is the switch down function. This configures the switch up from the high set point to the low setpoint. Pushing MENU switches it back and forth between “Auto” and “Manual.” **(Fig. 203)**

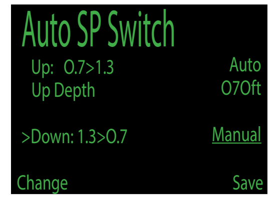


Fig 203

The final option is still a part of the switch down function, and enables the editing of the switch depth. **(Fig. 204)**

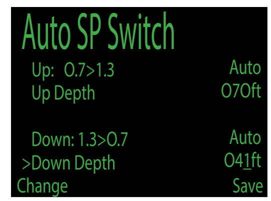


Fig 204

Either switch can be turned on or off independent of the other switch.
The system limits the allowable setpoint settings. Switching up is allowed from 20-999 feet and from 6-999 meters. Switching down is allowed from 9-999 feet and from 2-999 meters.

If you enter a setting that is outside the allowed range, the existing (valid) setting is retained with no change.

Display Setup **(Fig. 205, 206)**

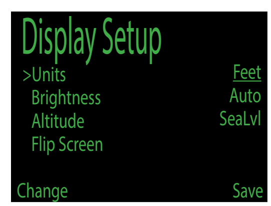


Fig 205

Units
The first ‘Display Setup’ changeable option is ‘Units,’ which allows the computer to switch back and forth between Metric and Imperial units of measurement.

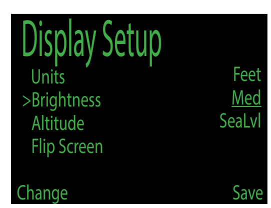


Fig 206

Brightness Range

The next ‘Display Setup’ changeable option is ‘Brightness’ which allows the computer to switch between four brightness settings: Auto, Low, Medium and High.**(Fig. 207)**

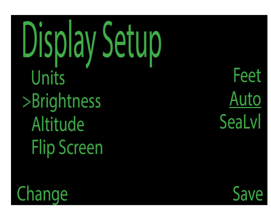


Fig 207

It should be noted that Hollis Gear suggests the use of the auto function, as it makes use of a light sensor to provide maximum brightness when there is an excess of ambient light, yet will dim when there is less ambient light in order to conserve battery life.

Altitude **(Fig. 208)**

The altitude setting when set to ‘Auto’ will compensate for pressure changes when diving at altitude. If all your diving is at sea level, then setting this to ‘SeaLvl’ will assume that surface pressure is always 1013 mBar (1 atmosphere).

Fig 208

Important: When diving at altitude you must set this option to ‘Auto’ (the default setting is ‘SeaLvl’).

Further, when diving at altitude, you **must** turn the computer on at the surface. If the auto-on safety feature is allowed to turn the computer on after a dive has started then the computer assumes the surface pressure is 1013 mBar. If at altitude this could result in incorrect decompression calculations. **(Fig. 209)**

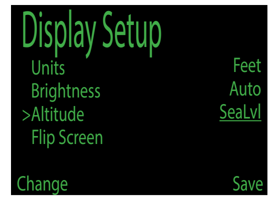


Fig 209

Flip Screen

This function displays the contents of the screen upside down.   It allows the computer to be worn on the right arm. **(Fig. 210)**

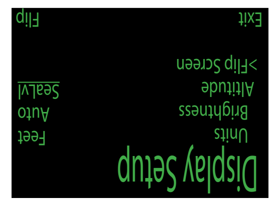


Fig 210

System Setup

Date

The first 'System Setup' changeable option is 'Date,' which allows the user to set the current date.

The date will have to be re-entered after a battery change.

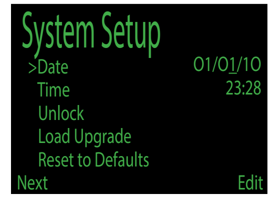


Fig 211

Time

The next 'System Setup' changeable option is 'Time,' which allows the user to set the current time.

The time will have to be re-entered after a battery change.

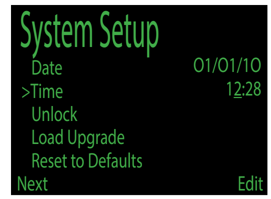


Fig 212

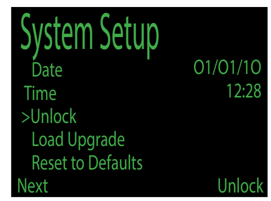


Fig 213

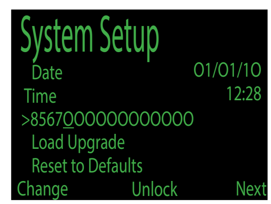


Fig 214

Load Upgrade

The next 'System Setup' changeable option is 'Load Upgrade,' which allows for the user download version upgrades.

The documentation on how to use the 'Load Upgrade' option can be found in the above 'Firmware Upload and Dive Log Download Instructions.'

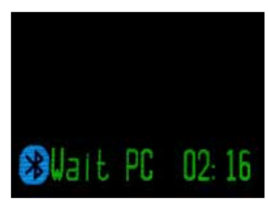


Fig 215

Reset to Defaults

The final 'System Setup' option is 'Reset to Defaults'. This will reset all user changed options to factory settings and clear the tissues on the Secondary Display. 'Reset to Defaults' cannot be reversed.

Note: This will not delete dive logs or reset dive log numbers.

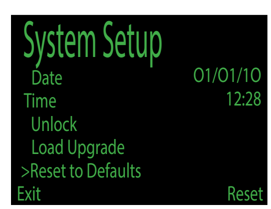


Fig 216

Advanced Configuration Menu

The Advanced Configuration sub-menu allows changes for values that will not need frequent adjustment.

The Advanced Configuration is accessed after the System Setup menu page.

Fig 217

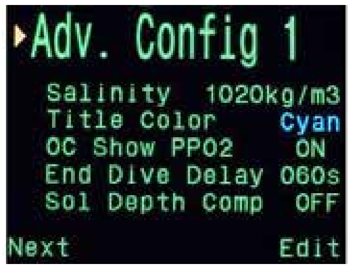


Fig 218

Fig 219

Figures 217-219: Advanced Config Screens

At the top level menu, you can either enter the Advanced Configuration or reset the Advanced Configuration values to their defaults.

Advanced Configuration Page 1:

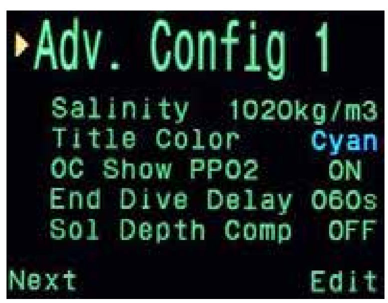


Fig 220

Salinity:

The salinity setting sets the density of water in kilograms per cubic meter [kg/m^3]. A cubic meter of pure water weighs 1000kg. Therefore, this value sets the weight of the dissolved salts in the water. For example, a value of 1030 kg/m^3 means there are 30kg of salts per 1000kg of water.

Since the depth sensor actually measures pressure, this value affects the displayed depth. Note that decompression profiles are computed using the actual measured pressure (and not the somewhat arbitrary depth).

Common values:

1000 kg/m^3 = Fresh water

1020 kg/m³ = EN13319 value, Predator default (between fresh and salt water)
1025kg/m³ to 1035 kg/m³ = Salt water (varies by location).

Title Color:

The title colors can be changed for added contrast or visual appeal. Default is Green.

Fig 221

Fig 222

Figures 221-222: Cyan and Gray Title Colors (green and blue also available)

OC Show PPO_2:

When in OC Only mode, sets whether the GasPO2 value is displayed on the main screen. Default is On.

Note: This setting has no effect on Closed-Circuit enabled models (unless the "OC Only" setting is turned on).

End Dive Delay (and End Dive menu option):

Sets the time in seconds to wait before ending the current dive.

This value can be set from 20 seconds to 600 seconds (10 minutes). Default is 60s.

Since the Predator can stay in dive mode for a longer time, a new "End Dive" menu option has been added. This is the first menu option when the Predator is still in dive mode AND is at the surface.

Advanced Configuration Page 2:

Advanced Config Page 2 allows changing of PPO_2 limits:

Warning: Do not change these values unless you understand the effect. See descriptions below.

All values are in absolute atmospheres [ATM] of pressure (1 ATM = 1.013 Bar)

Fig 223

OC Min. PPO_2: PPO_2 displays in flashing red when less than this value. (Default 0.19)

OC Max. PPO_2: PPO_2 displays in flashing red when greater than this value. (Default 1.65)

OC Deco. PPO_2: The decompression predictions (TTS and NDL) will assume that the gas in use at a given depth is the gas with the highest PPO_2 that is less than or equal to this value. Also, the suggested gas switches (when the current gas is displayed in yellow) are determined by this value. If you change this value, please understand its effect. For example, if lowered to 1.50, then oxygen (99/00) will not assumed at 20ft/6m. (Default 1.61)

Note: Semi-closed (SC) PPO_2 alarms and gas switch depths use the OC values.

CC Min. PPO_2: PPO_2 displays in flashing red when less than this value. (Default 0.40)
CC Max. PPO_2: PPO_2 displays in flashing red when greater than this value. (Default 1.60)

Note: In both OC and CC mode, a "Low PPO_2" or "High PPO_2" alert is displayed when the above limits are violated for more than 30 seconds.

Error Displays

The system has several displays that alert an error condition. All of these displays share a common limitation of error alarms. There is no way to distinguish between an error alarm that is not in alarm, and an error alarm that is broken.

For example, if an alarm is silent when it is not in alarm and is silent when it is broken, then there is no way to be sure that the alarm isn't broken.

So by all means respond to these alarms if you see them, but NEVER depend on them.

Each of the alarms will display the message in yellow until dismissed. The error is dismissed by pressing SELECT.

Other functions continue to operate as normal, so that the MENU button will take you into the menu, and a push on both buttons will show the millivolt display. The error message will keep returning until it is dismissed with a SELECT.

This message will appear if the average **PPO_2** goes **above 1.6** for more than 10 seconds. It will come back after being dismissed if the situation occurs again.

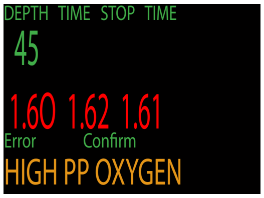


Fig 224

This message will appear if the average **PPO_2** goes **below 0.4** for more than a few seconds. It will come back after being dismissed if the situation occurs again.

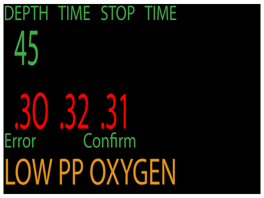


Fig 225

It is not unusual to get this error immediately after submerging with a hypoxic mix. The first breath after submerging floods the loop with low PPO_2 gas.   The situation is usually resolved by increasing depth such that when the error is noticed, the PPO_2 is no longer low.

This condition will also cause the "LOW PP OXYGEN" display to appear. Here, the computer does not have two sensors that have confirming values. There is no way to know the actual PPO_2, and the average PPO_2 will be calculated as 0.00.

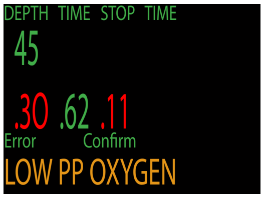


Fig 226

This message will appear when your internal battery reads less than 3.2V for 30 seconds. The battery needs to be changed. The computer will also flash the battery symbol red.

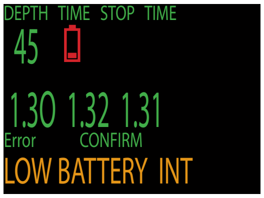


Fig 227

This alarm is a notification that there has either been a very fast ascent for a short period of time, or that there has been an ascent of more than 66 fpm / 20 mpm maintained for over a minute.

This alarm may return after being dismissed if the condition occurs again.

Fig 230

The alarm occurs when the diver has been above the minimum depth for a decompression stop for more than one minute.

This alarm will only appear once during a dive, but it will also appear once on the surface after the dive.

Fig 231

This alarm will show every time the computer loses power. All decompression information has been lost.

Fig 232

This alarm happens when the computer does not complete all of its tasks in the time allotted. It can happen occasionally from a transient problem like a battery bounce after an impact. It can also be the result of a hardware problem.

Fig 233

This reset shows up after a software update. This is the normal event that shows the computer has been rebooted after the software update.

Fig 234

This error usually occurs when the battery dies while the computer is asleep. If the battery gets too low to maintain system integrity, the hardware will force the system into reset.

Fig 235

The following messages are reporting internal hardware failures. The system will continue to retry and may recover, but they would normally mean that something that should never happen has happened. These messages should always be recorded and reported to the factory or your local service center.

Fig 236

This is not an exhaustive list. There are other errors that could be reported and more checks are added with each software update.

Fig 237

Fig 238

Fig 239

Battery Change

The Secondary Display has a battery compartment in the side of the case.


Fig 240

Unscrew the battery cap counter-clockwise with a large coin.

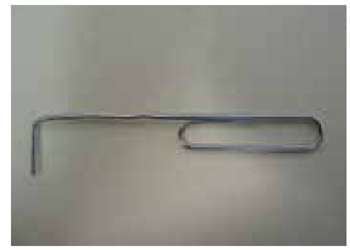


Fig 241

Bend a paperclip into a hook shape.

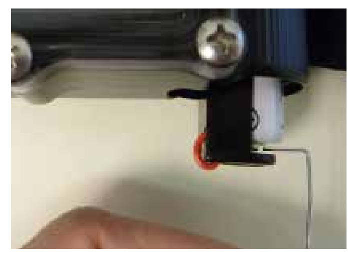


Fig 242

Hook the battery holder with the paperclip and pull it out.

Replace the battery with a SAFT LS14500.


Fig 243

Push the wires into the battery compartment before inserting the battery holder.

Align the flat edge of the battery holder towards the button.

Gently press the battery holder into the battery compartment.


Fig 244

Tighten the battery cap clockwise with a large coin until it is flush with the case.

Storage

The Secondary Display should be stored dry and clean. Do not allow salt deposits to build up on your Secondary Display. Wash your Secondary with fresh water to remove salt and other contaminants. Do not use detergents, benzene or other cleaning chemicals. Allow to dry naturally before storing.

Do not wash under high pressure as it may cause damage to the depth sensor. Also do not remove the strap bracket assembly as it acts as protection for the depth sensor

After cleaning, store the apparatus upright, out of direct sunlight in a cool, dry and dust free place. Avoid exposure to direct ultra-violet radiation and radiant heat.

Caution

There are no user serviceable parts inside the Secondary Display.

Do not tighten or remove the faceplate screws.

Service of the Secondary Display may only be done by a Hollis authorized service center.

Specifications

Atmospheric Range: 800 - 1050 mBar

Transducer Depth Range: 14ATA
Transducer Depth Accuracy: +/- 2.5%

Depth of Dive Time - Start: 1.6m of Sea Water
Depth of Dive Time - Stop: 0.9m of Sea Water

Operating Temperature Range: +4ºC to +32ºC
Short-Term (hours) Temperature Range: -10ºC to +50ºC
Long-Term Storage Temperature Range: +5ºC to +20ºC

Crush Depth Limit: 185m

Weight: 0.4 kg

Recommended Battery: SAFT LS14500 3.6V Lithium 2250mAh AA Size

Battery Operating Life (Display Medium Brightness): 100 Hours Plus 1 Year Standby

Part 3

Setting up your Prism 2 eCCR

Matthew Addison

Shark Feeder, Cave Diving Instructor, Prism Diver
and Women Divers Hall of Fame Member
Cristina Zenato
Ben’s Cavern, Grand Bahama

Packing the Prism 2 CO_2 Scrubber

To pack your Prism 2 scrubber, you will need the following items: ***(Fig. 245)***

1 towel
Paper towels or newspaper sheets
1 ea. top and bottom absorbent basket foam pads
Approximately 6 Lbs. (2.7 Kg) fresh unused 8-12 CO_2 absorbent
1 pair surgical gloves
1 painter's or surgical mask
1 eye protection

Fig. 245

Warning
If you ever ingest CO_2 absorbent due to a loop flood, (known as a "Caustic Cocktail"), immediately seek emergency medical treatment and drink copious amounts of water.

DO NOT INDUCE VOMITING unless instructed to do so by medical professionals.
For more information, see the Material Safety Data Sheet in the Apendix, and contact your local Poision Control Center.

The Prism 2 scrubber is easy to pack, and with experience should only take 5 to 10 minutes from set-up to clean up.

Find a dry area away from and downwind of other people. If necessary, take a moment to let people around you know that you will be working with caustic materials, and request they stay upwind from where you will be working.

Fig. 246

Before handling the caustic CO_2 absorbent, put on your personal protective gear including gloves, breathing mask and eye protection (***Fig. 246).*** A dive mask may look silly, but works quite well as eye protection.

Spread out a towel or other soft covering on the ground in a flat area, and lay a few sheets of paper towel or newspaper on top of that. Place the bottom foam pad (larger center hole) in the basket making sure it lays flat against the bottom and sides of the basket ***(Fig. 247)***. Take a piece of paper, golf ball or absorbent container cap and cover the top of the center tube. This will keep absorbent from going down the center tube as you pour it into the scrubber basket. ***(Fig. 248).***


Fig. 247


Fig. 248

Pour the absorbent slowly from about 12” above the basket, allowing the wind to carry off any dust. The absorbent should be granular and not produce much dust while pouring ***(Fig. 249)***. If the material looks crushed or is exceptionally dusty, don’t use it, as that can be an indication that the absorbent has been mishandled and may not scrub CO_2 properly during a dive.


Fig. 249

Continue pouring until the absorbent reaches the first horizontal brace on the basket ***(Fig. 250)***. Unless you were exceedingly careful, some material will have fallen onto the paper around the basket. Lift the basket off the paper and pour the granules from the paper into the basket. If the material on the paper is mostly dust, dispose of it carefully rather than pouring it into the basket.


Fig. 250

With the basket on the towel-covered ground, gently begin tapping the basket where the vertical and horizontal braces meet ***(Fig. 251)***. This will begin to settle the granules in the basket. The trick is to tap hard enough on the cross braces that the vibrations cause the material to settle, but not so hard that the granules jump around. Make sure you do not tap the mesh as that will only displace the material from the sides.
While tapping the cross braces, rotate the basket so you tap all sides of the basket. Spend at least a minute tapping the basket sides. You may notice that the absorbent level drops as the granules settle.

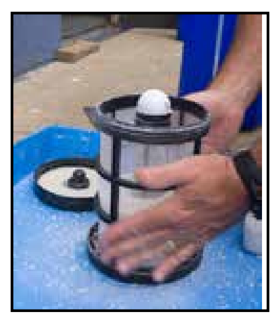


Fig. 251


Fig. 252

Repeat the filling process up to the second horizontal brace, then tap to settle the granules as before. Repeat the filling process to the top of the bucket, leaving a small hill of absorbent on the top ***(Fig. 252)***. Tap and settle the material as before. You will probably be ably to settle this material until it is almost level with the basket top.

Once the basket appears to be full, pour a few extra mound of absorbent onto a cup or other small container and put it aside.(A mask box works well!) Remove the material you used to block the center tube.


Fig. 253

Lay the top foam pad (smaller center hole) on top of the mound of absorbent, and place the basket cover on top of the foam pad ***(Fig. 253)***. Slightly tighten the basket top onto the first threads. Do not force the top on. If you cannot easily start the top onto the basket threads, remove a bit of absorbent and try again.

Once you have started the top onto the basket threads, clean the towel of loose absorbent, then pick up the basket by the top horizontal brace and using your thumbs to hold the basket and top together securely, lift the basket a few inches above the ground and tap the basket slowly and firmly **3 times** on the towel covered ground ***(Fig. 254)***. Never tap the basket on uncovered ground, as that can damage the basket to exhale plenum sealing surface **(Fig. 255**). The sealing area on the basket must be kept clean of caked-on absorbent, so don't tap the basket down on loose absorbent. Doing so will just make extra work and make any post-packing scrubber basket cleanup take longer.


Fig. 254

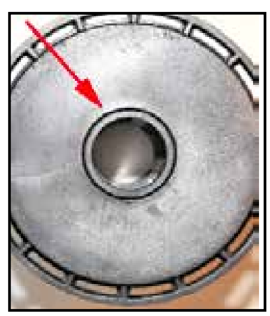


Fig. 255

Field Notes:
Resist the urge to blow on the packed basket to get rid of dust, as the dust will get in your eyes, nose and throat.

3 Taps then Turn

Once you have tapped the basket 3 times on the ground, turn the basket top until in makes contact with the absorbent. Do not force the top! Tap 3 times again and turn the top. Repeat this process until the top is sealed completely on the threads.

Using the 3 tap and turn method will insure that you do not overpack the bottom of the basket while leaving the top material loose. Also, making a repeatable process your habit will insure that all you are packing your scrubber the same each time. Arbitrary methods lead to arbitrary results!

Remove the top and foam pad, and using more of the absorbent you set aside on the paper, refill the basket until you again have a small mound of absorbent on the top. Replace the foam pad, re-seat the top on the basket threads and repeat the process.

Once you have fully seated the top onto the basket a second time, check the firmness of the material. The top and bottom of the basket should be equally firm and you should not be able to displace absorbent grains by applying moderately firm pressure against the mesh.
If the top is not as firm as the bottom, turn the basket upside down and tap three times on the basket top. If the material is still loose or unevenly packed, open the basket, add some more absorbent and repeat the process then check firmness again.

Once the basket is packed to your satisfaction, use a clean paper towel to carefully remove any dust collected on the outside of the basket. Collect any left over absorbent that you had set aside for packing and if it is not dusty, you may pour it back in the absorbent container. Seal the absorbent container and store it in a cool, dry place.

Field Notes:
There is no set number of times you will need to remove the basket top to add material, but spending more time settling the material as you fill the basket will help reduce it.

Pre-Packing the Prism 2 Scrubber

While pre-packing the scrubber well in advance of a dive, or transporting packed scrubbers is not advised due to potential absorbent settling issues, we recognise there are instances where packing a scrubber on-site is either impractical or impossible.

If you will not be using the packed scrubber immediately, put the basket in an airtight container and seal it. Put tape across the seal on the outside of the airtight container and write your name, the date you packed the basket, and the absorbent material used ***(Fig. 256)***. Since this is a fresh fill write “0 hours used” on the tape. Store the container in a cool, dry place.

Fig. 256

After short-term storage or transportation, you must check the scrubber for settling or loose scrubber material prior to installing it in the rebreather.

Cleaning Your Empty Scrubber

After use, it is always a good idea to wash and dry the scrubber basket, basket pads and bucket to remove residual dust and used absorbent. Use fresh water and make sure to wash out any loose granules.

If you notice that the threads of the basket or top are becoming clogged by crushed, caked absorbent dust or the absorbent is beginning to cake-up ***(Fig. 257)***, you will need to soak the top and basket threads in 50% to 100% white vinegar for 15 to 30 minutes, which will dissolve the caked on absorbent and return the basket to like-new condition. Heating the vinegar to 120^{0}F/49^{0}C will make it work faster, but will make you unpopular with anyone close by. Wash the cleaned parts thoroughly with fresh water until the smell of vinegar is completely gone.

Fig. 257

Disposing of used CO_2 absorbent

You have probably heard that used absorbent is simple calcium carbonate, the same stuff seashells and reefs are made from. Eventually that will be true, but even spent absorbent is still highly caustic and will be for some time. Never dump freshly spent absorbent in the ocean! It is best to find a covered pail or a garbage bag in which to store the spent material, and mark the container as containing a caustic substance.

WARNING

If you do need to store the scrubber or transport it to your dive site, YOU MUST check the scrubber basket for absorbent material settling prior to inserting it in the rebreather. If the absorbent seems loose at all, top-off the basket with additional absorbent prior to use. Failure to insure a properly packed scrubber may lead to injury or death.

Caution

To avoid damage, use only factory-tested cleaning solutions

See the list of approved cleaning solutions in the Addendum for further information.

Setting up your PRISM 2 using the checklists

The importance of using your Prism 2 checklists

Imagine you are sitting on a commercial airliner watching the pilot ready the plane for takeoff. The copilot turns to the captain and asks if he is ready to go through the pre-flight checklists. The pilot does a cursory scan of the cockpit, turns to the copilot and says, “Everything looks good to me, we can skip them”. How comfortable would you feel flying at 32,000 feet with that captain at the controls?

The importance of working with checklists when setting up your Prism 2 cannot be overstated! If you have not set-up your Prism 2 using the checklists, DO NOT dive the rebreather.

Case study of a close call:

A rebreather diver, self-described as being “very experienced” with his rebreather, has completed two 1½-hour dives. He changes out the scrubber with fresh absorbent to complete a third 2-hour dive later in the day. He reports that he was feeling “rushed” because he was delaying his buddies from lunch. After quickly re-packing the scrubber, relying on memory instead of his checklist, he reassembles the rebreather and then joins his buddies.

An hour after lunch, he dons the rebreather and enters the water. After completing his 15ft checks, he descends to 35 feet whereupon he begins to feel short of breath. Still clear-headed enough to realize this could possibly be a sign of CO_2 toxicity, and deciding to err on the side of caution, he bails out to open circuit and aborts the dive.

Once safely back, the diver disassembles the unit and finds that an O-ring sealing the breathing loop is missing, allowing his exhaled gas to bypass the scrubber completely and enter the inhalation side of the rebreather.

Fortunately, due to his quick actions, this incident resolved without tragedy.

Lessons learned

In his on-line report, the diver stated he had learned a hard lesson from this life threatening incident. The first and most obvious was he had not followed his training, relying on his memory instead of using the checklist. He also reported that “to be honest”, this was not the first time he had skipped using a checklist. He vowed never to make that mistake again.

Field Notes

Don’t allow yourself to become rushed or distracted when setting up or working on your rebreather. An inattentive rebreather diver is an accident waiting to happen. Take your time while setting up your rebreather and when diving.

Why a multiple list format?

One thing that became clear to us as we talked to rebreather divers about their use of checklists was that a simple, one-size-fits-all checklist often does not follow the stages in which they normally set-up their rebreathers. The checklist becomes an encumbrance to safety if divers have to skip around the checklist, ticking off only those items needed to get to the next phase.

For instance, some divers set-up and test their rebreather days in advance of the dive, and leave the rebreather assembled during transport to a dive site. A start to finish checklist may not take into account the checks required once the unit arrives at the site.

We have broken the Prism 2 checklists into 4 distinct sub-lists which should follow the steps encountered in the majority of real world diving situations. If, over time, you find that this checklist does not meet your needs, call us and we will work closely with you to personalize a factory approved checklist for your diving needs.

To follow is the group of 4 “expanded” checklists, which includes the incremental steps you need to complete to accomplish each step on the checklist. We have also included the more commonly seen “condensed” list which you can find in the Appendix, that lists all the same tasks, but not the incremental steps to complete each step. We include this with the rebreather for field use as a reminder list only. It is always recommended that you use the “expanded checklist” whenever you set up your Prism 2 for diving operations.

Prism 2 Component Inspection

Step by step descriptions are located in the user manual

KEY:
W = Wear
O = Operation
I = Install

- ☐ **Check H-Plate / harness / BC for wear, damage or missing parts (7 steps)**
  - ☐ H-plate
  - ☐ harness (W)
  - ☐ fabric (W)
  - ☐ inflator / alt. air source (O)
  - ☐ dump valve(s) (O, W)
  - ☐ removable weight pockets (W, I)
  - ☐ fastening clips (W)
- ☐ **Inspect counterlungs (7 steps)**
  - ☐ fabric (W)
  - ☐ drains (O)
  - ☐ threaded DSV/BOV assembly rings (W)
  - ☐ breathing hoses, Oetiker clamps, & o-rings (W)
  - ☐ O_2 addition valve (I, O)
  - ☐ automatic diluent addition valve (ADV)(O)
  - ☐ over-pressure valve (OPV)(O)
- ☐ **Inspect DSV/BOV breathing hoses (4 steps)**
  - ☐ hoses,
  - ☐ Oetiker clamps (W)
  - ☐ o-rings (W)
  - ☐ inhalation hose mushroom valve (only on inhale hose for DSV supplied systems) (O, W)
- ☐ **Inspect DSV/BOV (4 steps)**
  - ☐ shut-down/OC assembly (O)
  - ☐ water drain (O)
  - ☐ mouthpiece, zip-tie
  - ☐ DSV/BOV exhalation mushroom valve (O, W)
  - ☐ inhalation hose mushroom valve (only on inhale side of BOV) (O, W)
- ☐ **Inspect regulators and hoses (6 steps)**
  - ☐ 1st stages (W)
  - ☐ pressure relief valves
  - ☐ LP hoses & connectors (W)
  - ☐ HP hoses & connectors (W)
  - ☐ diver installed gas supply hoses (if installed)
  - ☐ pressure gauges
- ☐ **Inspect wiring (2 steps)**
  - ☐ LED primary display (W)
  - ☐ secondary display (W)
- ☐ **Battery compartment, batteries & o-rings (4 steps)**
  - ☐ solenoid batteries (I)
  - ☐ LED primary display battery (I)
  - ☐ o-rings (2) (W)
  - ☐ cover, cover latches & keepers (O, W)
- ☐ **Solenoid operation** (O) (if proceeding immediately to assembly and operational checks, you can skip this step)
- ☐ **Inspect head assembly (5 steps)**
  - ☐ red CO_2 seal (I, W)
  - ☐ head to bucket o-rings (2) (W)
  - ☐ latch keeper (W)
  - ☐ o-ring seats (W)
  - ☐ nut bars, head bolts, head cover bar and head cover (W, I)
- ☐ **Oxygen sensors (3 steps)**
  - ☐ 3 oxygen sensors and sensor holders installed (I)
  - ☐ oxygen sensor wiring harness (I)
  - ☐ mV readings within range(O) (8.5mV to 14 mV in air)
- ☐ **Bucket assembly (3 steps)**
  - ☐ basket compression spring and pad(I)

    - ◻ latches (3) (W, O)
    - ◻ 1 moisture pad (I)
- ◻ **Basket assembly (4 steps)**
    - ◻ check mesh (W)
    - ◻ center tube o-ring (I)
    - ◻ top and basket threads clean (O)
    - ◻ top and bottom foam pads (I)

Field Notes

It is always recommended that you do a full set-up and “pre-dive” check before any trip, as that is the only sure way to verify all systems are fully functional.

Prism 2 Assembly Order

Step by step descriptions are located in the user manual

- ☐ **Fill scrubber basket with CO_2 absorbent & store in airtight container, Label container: grade, date filled, user, time used.**

Date Packed:___________ Grade:_________ Time Used:___________ Time left:___________

Maximum Scrubber Duration: 260min (0.5% SEV CO_2) using 6-12 @ 40F/4.4C, 1.35slpm CO_2, 40lpm RMV, 60fsw/28msw

- ☐ **Fill O_2 & Diluent cylinders, analyze contents, label cylinders with name, date, contents**.

O_2 %_______ Pressure _______psi/bar Dil Contents________ Pressure _______psi/bar

MOD________

- ☐ **Install regulators and hoses on H-plate**
  - ☐ O_2 system on right (head facing up) Run all lines under bottom tank strap
- ☐ **Install head assembly onto H-plate (2 steps)**
  - ☐ 4 button head Allen screws & SS washers
  - ☐ run O_2 solenoid line between right side head mount flange & H-plate. Tighten hose to solenoid
- ☐ **Install BCD, yoke and backplate onto H-plate (4 steps)**
  - ☐ long screw on top, short screw on bottom. Secure with nylon keepers
  - ☐ install BCD on plate - inflator facing H-Plate
  - ☐ install yoke harness - fastex clips facing BCD
  - ☐ install backplate and harness – place on washers and tighten butterfly nuts
- ☐ **Attach counterlungs to yoke (3 steps)**
  - ☐ insure inhale counterlung is on right side (with bladder & yoke face-up)
  - ☐ clip fastex buckles in place
  - ☐ line up Velcro parts and compress
- ☐ **Install counterlung breathing hoses to head (2 steps)**
  - ☐ clean and lubricate o-rings, o-ring groves and mating surfaces
  - ☐ install hose nuts only finger tight. Do not over-tighten.
- ☐ **Attach gas supply lines to diluent and oxygen addition valves on counterlungs & BCD inflator (2 steps)**
  - ☐ longer diluent hose feeds BCD inflator
  - ☐ attach all 3 QD fittings. Pull on hoses to make sure they are secure
- ☐ **Assemble DSV/BOV and hoses, check and install (6 steps)**
  - ☐ open/close, purge, mouthpiece
  - ☐ check mushroom valve seals and flow direction.
  - ☐ install hoses onto DSV/BOV
  - ☐ perform a mushroom valve sealing test (stereo check)
  - ☐ install DSV/BOV onto counterlungs paying attention to flow direction arrow
  - ☐ install LED primary display holder fix/attach cable to breathing hose
- ☐ **Clean head to bucket sealing rings, o-ring groves and lube o-rings**
  - ☐ remove o-rings per manual instructions, clean & replace if needed
- ☐ **Clean Red CO_2 Seal and secure in place (2 steps)**
  - ☐ make sure there is no debris, dust or lubricant. Clean seal grove
  - ☐ make sure the red CO_2 seal is firmly seated in its grove (triple check!)
- ☐ **Check filled CO_2 scrubber basket (2 steps)**
  - ☐ basket top secure
  - ☐ check for settling and firmness of absorbent bed
- ☐ **Scrubber bucket (4 steps)**
  - ☐ ensure bucket sealing surface is clean
  - ☐ basket compression spring installed and functional
  - ☐ install bucket moisture pads
  - ☐ make sure the pad is not resting on or interfering with the basket compression spring
- ☐ **Place CO_2 basket in bucket, confirm center tube opening up, mount and seal bucket to head** (record usage time on operational checklist)

Prism 2 Operational Checklist

Step by step descriptions are located in the user manual

*Name:*________________________________ *Date:*________________

Intra -Dive: ☐ No ☐ Yes

Scrubber: ☐ New ☐ Used – Total time used on scrubber __________

Maximum Scrubber Duration: 260min (0.5% SEV CO_2) using 6-12 @ 40F/4.4C, 1.35slpm CO_2, 40lpm RMV, 60fsw/28msw

- ☐ **Install analyzed and properly labeled gas cylinders**
- ☐ **Turn on Secondary Display. Check O_2 cell mV readings in air, replace if out of range (8.5mv to 14mv)**
- ☐ **Setpoint to 0.19** (8X menu of left button)
- ☐ **Oxygen system leak test (3 steps)(Hold for 30 seconds minimum)**
  - ☐ open oxygen valve, close valve
  - ☐ watch oxygen pressure gauge for pressure drop
  - ☐ open oxygen valve
- ☐ **Negative Pressure test (4 steps)(Hold for 1 minute minimum)**
  - ☐ open DSV/BOV
  - ☐ inhale from DSV/BOV in CC mode, exhaling through nose until counterlungs fully collapsed
  - ☐ close DSV/BOV
  - ☐ allow to sit for one minute, watch for signs of leaks on Secondary Display PO_2 readings
- ☐ **Positive pressure test (4 steps) (Hold for 1 minute minimum)**
  - ☐ close OPV
  - ☐ fill loop fully with oxygen using manual oxygen addition valve until OPV engages
  - ☐ allow to sit for one minute, watch for signs of leaks on Secondary Display PO_2 readings
  - ☐ open DSV/BOV, evacuate loop contents
- ☐ **Flush loop with O_2 (3 steps) (do this step twice)**
  - ☐ close DSV/BOV
  - ☐ fill loop with oxygen until OPV engages
  - ☐ open DSV/BOV to equalize pressure to ambient pressure. Close DSV/BOV.
- ☐ **Calibrate Secondary Display Electronics (3 steps)**
  - ☐ menu to calibrate (2X menu of left button)
  - ☐ press select button (right button) twice to calibrate
  - ☐ record mV readings in O_2: #1:______#2: ______#3: _____ (acceptable range 40.6mv to 66.9mv)
- ☐ **LED Primary Display On and battery check** ☐OK ☐replaced & OK
- ☐ **Calibrate LED Primary Display**
  - ☐ 3 rapid presses (within 1 second) on LED Primary Display piezo power switch
- ☐ **Record oxygen pressure after loop flush**: ______________ psi/bar
- ☐ **Solenoid check**
  - ☐ setpoint to high (>1.0)
  - ☐ solenoid fires and oxygen injection is verified
  - ☐ change active setpoint to .19
- ☐ **Solenoid Batteries check** (6X select) ☐OK ☐replaced & OK
- ☐ **Secondary Display battery check** ☐OK ☐replaced & OK
- ☐ **Adjust user selected low/high set points to desired settings** (0.4 - 1.5)**(4 steps)**
  - ☐ menu to dive setup+
  - ☐ menu to edit low setpoint (adjust as needed) low set point: ________________
  - ☐ menu to edit high setpoint (adjust as needed) high set point: ________________
- ☐ **Diluent system leak test (2 steps)(Hold for 30 seconds minimum)**
  - ☐ open diluent cylinder, charge lines, turn off diluent tank valve
  - ☐ watch gauge for pressure drop
- ☐ **Confirm alternate air source operation if supplied / Flush loop (ADV test) (3 steps)**
  - ☐ open diluent cylinder
  - ☐ inhale from on-board alternate air source if supplied
  - ☐ open DSV/BOV, inhale from loop until ADV engages, drop loop PO_2
- ☐ **Check buoyancy compensator inflation, air holding and deflation mechanisms**
- ☐ **Record diluent pressure**: ________________

<u>If diving immediately</u>
continue with "Immediate pre-dive checks" checklist.

*If **<u>NOT</u>** diving immediately*

- ☐ **Close O_2 and diluent cylinder valves & drain hoses, turn off electronics and secure unit**

Warning

Have you ever jumped in the water while diving an open circuit system only to find out you forgot to turn your air on? It's a pretty obvious oversight the moment you try to inhale gas. If you do that on a closed circuit rig with your O_2 tank, the consequences may be delayed (you can still breathe on the loop) but may be fatal. Always verify that your gas supply cylinders are turned on prior to entering the water

Immediate pre-dive checks

*Name:*________________________________ *Date:*___________________

- ☐ **Verify dive plan with buddy**
- ☐ **Install weights (3 steps)**
  - ☐ counterlung
  - ☐ BCD
  - ☐ trim weights
- ☐ **Verify LED primary display is powered on**
- ☐ **Don unit, secure fasteners, tighten straps**
- ☐ **Verify oxygen and diluent valves on** (3 steps)
  - ☐ diluent valve check
  - ☐ oxygen valve check
  - ☐ activate manual gas addition valves while watching SPGs
- ☐ **Secure secondary display on wrist**
- ☐ **Verify secondary display is powered on**
- ☐ **Switch active setpoint to "Low Setpoint" (=/>.4)**
- ☐ **Verify loop contents are within user set limits on secondary display**
- ☐ **Pre-Breathe Checklist:**
  - ☐ check ADV operation: automatic and manual
  - ☐ solenoid oxygen addition
  - ☐ manual oxygen addition
  - ☐ BCD inflation/deflation
  - ☐ verify SPG's: oxygen, diluent, open-circuit bailout supplies
  - ☐ observe setpoint maintained within user set limits on Primary and Secondary Displays

<u>Don't forget to do your in-water bubble checks, and have a safe dive!</u>

Field Notes

Get in the habit of checking off each item on the checklist as you go and DO NOT skip around on the list. Good checklist habits are the best way to insure that you have assembled your Prism 2 correctly, and have not left out a critical step.

As you can see from the preceding checklist, it is broken down into 3 main setup sections: **“Prism 2 Component Inspection”, “Prism 2 Assembly Order” and “Prism 2 Operational Checklist”**. The fourth sub-section of the operational checklist, **“ Immediate pre-dive checks & system settings”** are for final “systems go” verifications prior to entering the water. You can use the 3 main sections individually as follows:

Prism 2 Component Inspection: This section of the checklist is used to help you verify that all parts of a complete Prism 2 are present and visually undamaged prior to packing it for transport. There is nothing worse than boarding a local dive boat or landing in a foreign country just to find out that you left your DSV/BOV in your dive locker back home.

Prism 2 Assembly Order: This is the list you will normally use to “build your rebreather” from component parts.

Prism 2 Operational checklist: This is the section where you will test all assembled components of the rebreather to make sure they are functioning properly prior to entering the water. You will complete these steps after assembly and between dives, or if a piece of the functioning rebreather has been disassembled at any time. This is the most critical part of the entire set up process, since a non-functional rebreather will always become evident at some point as you go through the operational checks. Do not dive the rebreather if it has not passed every step of this checklist.

Immediate pre-dive checks & system settings:
These are the final few checks done with the unit secured to your body before jumping in the water. While most checks are verifications of previously checked items, it is absolutely imperative that you check these again before entering the water.

An O-ring cleaning primer

O-Rings are an integral component of almost every part of a functioning rebreather and as such, you must be adept at properly inspecting and caring for them. For the sake of brevity we will give you a generic description of how to prepare the O-rings in the Hollis Prism 2 for use, below. In the checklist "step-by-step" to follow, unless there are unusual design issues, access or handling considerations for a particular O-ring, we will simply state,

"Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged."

Remove the O-ring from the O-ring channel using a non-metal O-ring removal tool ***(Fig. 258)*** *being careful not to over-stretch the O-ring. Never use a sharp metal O-ring pick or any metal object as that can damage the O-ring, the O-ring groove or O-ring mating surface.*

Fig. 258

Field Notes
You can use a clean, dry, lint-free cloth on opposite sides of an O-ring, then putting pressure on it, push toward the middle (Fig. 259). This will create a hump that you can grab with your fingers and roll it out of the groove. In a pinch, the tapered end of a plastic Zip Tie can be used to help pull an O-ring up and out from its groove.

Clean the O-ring with a soft, dry lint-free cloth, **(Fig. 259)** being careful to remove any debris and old Tribolube. Run your fingers around the O-ring feeling for uneven surfaces, abrasions, sand or other debris that could cut the O-ring. If you feel any damage, replace the O-ring. Never dive with a damaged O-ring, as a flood will result.

Fig. 259

Clean the O-ring channel and area surrounding the channel of debris and old lubricant **(Fig. 260).** Place a small amount of Tribolube on your finger and coat the O-ring lightly. Inspect the O-ring to make sure there is no debris, lint or hairs on it. Carefully replace the O-ring in its cleaned O-ring channel.

Make sure to clean the O-ring's mating surface (the surface the O-ring seals against) of all lubricant, dirt and lint.

Fig. 260

Prism 2 Component Inspection

1: Check H-Plate / harness / BC for wear, damage or missing parts (7 steps)

a: H-Plate
Look for any bent or broken parts on the H-plate. Verify that the rubber cylinder pads are firmly glued in place on the inside seating surface of the cylinder rests. Check the cylinder bands for wear.

b: harness (w)
Check the webbing for excessive wear. Check D-rings, buckle, crotch strap and any diver installed hardware such as knives or equipment pouches are present and in working order.

c: BC fabric (W)
Lay the BC down flat and inspect the fabric for any tears or signs of excessive wear. Pay special attention to areas around inflators and areas that experience chaffing during use. Never dive the rebreather with a buoyancy compensator that is not in good condition.

d: inflator/deflator or Hollis 410 (if installed) (O/W)
Depress the inflator and deflator buttons feeling for smooth actuation. If there is any binding or sticking of either button this usually indicates that salt has dried inside the mechanisms. Dried salt can abrade O-rings and cause slow leaks. If you do find that the inflator buttons stick on first actuation, clean with fresh water or repair as needed.

You will complete a pressurized test of the inflator later on in the operational checks. However, it is always a good idea to test each component, but especially important if you find that the buttons have been sticking. Finally, partially inflate the buoyancy compensator by manually blowing air into the valve **(Fig 265)** while depressing the deflator button. Check that the buoyancy compensator is holding air and not leaking. Do not deflate the buoyancy compensator – See step e: dump valves.

Fig. 265

If your rebreather is equipped with a Hollis 410 Inflator/Alternate Air Source:
To test the Hollis 410, you will need to temporarily install a diluent tank onto the diluent pneumatics and charge the system **(Fig 266)**.

Fig. 266

Breathe from the alternate air source to verify that it works correctly. DO NOT simply depress the purge button, as that will not reveal if the second stage diaphragm is intact and properly seated. If your initial exhalation is met with resistance, that usually indicates that the second stage was not rinsed sufficiently with fresh water after use and the exhalation mushroom valve has become stuck to its seating surface. Soak the alternate air source in fresh water for at least 20 minutes to remove all salt and other residue and test again.

e: dump valve(s) (O, W)
Inspect the buoyancy compensator dump valves. Momentarily open each valve and let a bit of air from the buoyancy compensator out to make sure they open and close freely. Also inspect the air dump pull cords **(Fig 267)** to make sure they are in good condition and not entangled.


Fig. 267

f: removable weight pockets (W, I) (if installed)
Verify that you have 2 weight pockets **(Fig 268)**. Check that their Velcro flaps, quick-lock and the pull handles in good working condition. Secure them in place.

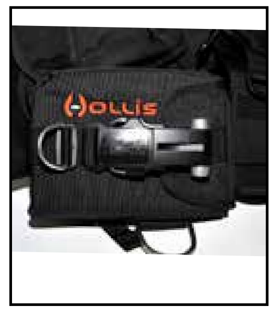


Fig. 268

Field Notes:
Integrated weight pockets are one of the most frequently lost or left behind pieces of dive gear! Do you know where your weight pockets are?

g: fastening clips (W)
Check for broken or cracked parts in the following areas:
- a) waist strap (Buckle) **(Fig 269)**
- b) large counterlung retainer clips attached to waistband (male Fastex)**(Fig 270)**
- c) small lateral counterlung adjusting straps (male Fastex) **(Fig 271)**


Fig. 269


Fig. 270


Fig. 271

2: Inspect counterlungs (7 steps)
a: fabric (W)
Lay the counterlungs out and inspect the fabric for tears or obvious signs of abnormal wear. While the counterlungs are quite robust, you must never dive with counterlungs that show signs of excessive wear or damage, as counterlung integrity failure during a dive would cause immediate and catastrophic flooding of the breathing loop. Shake the counterlungs to make sure no foreign objects have entered the counterlung during storage or transportation. Smell the inside of each counterlung. They should not have any distinct odor.

b: drains (O)
Unscrew the locking collar and actuate the valve by depressing the nipple inward toward the body of the valve **(Fig 272)**. Blow into the valve to make sure it is not clogged or broken. The valve should pop back out when you let go of the valve. If it does not, it must be serviced. Re-tighten the locking collar.

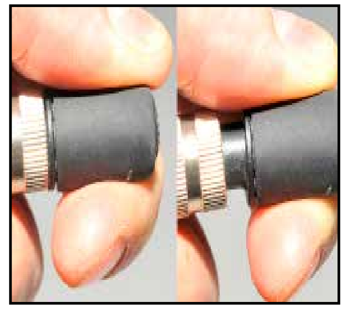


Fig. 272

c: threaded DSV/BOV hose assembly rings (W)
Check for cracks and thread stripping. The hose mount rings **(Fig 273)** are welded to the counterlungs. Make sure the rings are firmly welded to the counterlung fabric.

Fig. 273

d: breathing hoses, Oetiker clamps & o-rings (W)
Check the counterlung-to-head hoses for holes, wear or age cracking **(Fig 274)**. Stretch the hose slightly and inspect the rubber material. If you can see separation or light spiderweb cracking in the rubber, it is beyond it's serviceable life and must be replaced. Never dive with breathing hoses that show signs of rubber ageing, as immediate and catastrophic loop flooding will occur if the hoses fail during diving.

Fig. 274

Fig. 275

Wipe the interior surface of each breathing hose with a clean, dry towel then look at the spot on the towel where you wiped the hose interior **(Fig 275)**. If the towel has foreign particles or dirt on it, re-clean the counterlung and hose using a bottle brush to remove any foreign material in the hose corrugations. (see maintenance section for further cleaning instructions).

The counterlung-to-head attachment hardware has an O-ring seal **(Fig 276)**. Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged. Also at this stage you will want to make sure there is no debris in the hose connectors on the head **(Fig 277)**. Locate the two hose connectors on the head and run your finger inside them. If you feel any debris, clean the inside with a lint-free cloth. If there was any debris on the exhalation side head connector, especially old absorbent particles, some absorbent may have fallen into the exhaust plenum **(Fig 278)**, which is located on the underside of the head. Clean out any debris that may have collected in the exhaust plenum prior to unit assembly.


Fig. 276


Fig. 277


Fig. 278

e: O_2 addition valve (O)

Check the oxygen addition valve on the right counterlung for tightness by holding the base of the valve from the back of the counterlung through the counterlung fabric and attempt to slightly tighten (twist clockwise) the top of the valve **(Fig 279)**. There should be no movement. If the valve has come slightly loose, hand tighten the valve as needed until it will not turn further. (See maintenance section for further information). Activate the valve button to make sure it operates smoothly. It should not feel stiff or difficult to depress. You will check the valve again for proper operation during your operational checks. See the maintenance section if the button does not move freely.


Fig. 279

f: Automatic diluent addition valve (ADV) (O)

While holding the valve body located on the left counterlung, depress the actuator lever from behind the counterlung **(Fig 280)**. It should move freely. (You will check the valves automatic and manual addition of diluent into the breathing loop during your operational checks.) For a closer inspection, or if you think the valve may be damaged, you can unscrew the valve body from the counterlung by turning the outer sleeve counter-clockwise until the valve comes loose from the lung.


Fig. 280

g: Over-pressure valve (OPV) (O)
The over-pressure valve is located on the right (exhale) counterlung slightly below the threaded hose opening **(Fig 281)**. Rotate the body open and closed. You should feel a slight ratcheting as you twist the body. Rotate the OPV body clockwise until it is fully closed in preparation for the oxygen flush during your operational check. If you want to remove the OPV from the counterlung for closer inspection, grasp the valve body on its lower ring (closest to the counterlung fabric) and turn the valve counter-clockwise until it comes free from the counterlung.

Fig. 281

Field Notes: The Sniff test
Sniff the air inside of the counterlung. It should smell clean and possibly have a hint of disinfectant smell to it. This is normal when using Hollis approved breathing loop cleaners, however a distinct smell of disinfectant is not normal and is probably due to inadequate rinsing after cleaning.

3: Inspect DSV/BOV breathing hoses (4 steps)

a: inhalation and exhalation hoses (W)
While holding the hose by each end, gently stretch them to insure the ends are secure. If there is any movement, check the hose clamps and hose material next to the clamps **(Fig 282)** for wear or tears. While holding the hose, gently pull on the seating flanges to insure they are secure. If there is any movement, check the hose material next to the clamps for tears.

Fig. 282

While continuing to stretch the hose, look along the hose length at the rubber for signs of wear or age cracking. If you see signs of abrasions or spider web cracking, the hose must be replaced. Never dive with breathing hoses that show signs of rubber ageing, as immediate and catastrophic loop flooding will occur if a breathing hose fails during diving.

b: Oetiker clamps
Check to make sure the clamps are securely locked down onto the hoses and then cover them with the silicone clamp covers so they do not snag fabrics such as wetsuit material while putting on and taking off the rebreather.

c: o-rings (W)
There are two O-rings on each breathing hose assembly. You will find the first O-ring under the counterlung elbow-retaining nut of each hose assembly. Pull the elbow retaining nut back with your thumb and forefinger and using an O-ring pick, gently remove the O-ring from its groove. Remove, clean and prepare the O-ring(s), O-ring Grove and mating surface for use, or replace if worn or damaged.

The O-ring under the DSV/BOV threaded nut counterweight is a bit trickier as you cannot fully retract the nut to expose the O-ring. However, you can usually remove the O-ring with a pick.

Pull the counterweight as far as back from the hose opening as possible. You should be able to see the O-ring. Carefully extract the O-ring from its groove, making sure not to scratch the mounting hardware. Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged.

To clean the O-ring grove, you can use a Q-tip **(Fig 284)**, but be careful not to allow cotton fibers to remain behind. If there are dirt particles on the O-ring when you remove it from the grove, dis-assemble the threaded counterweight side of the DSV/BOV hose assembly by removing the Oetiker clamp and thoroughly clean the O-ring grove.

Fig. 284

d: inhalation hose mushroom valve (only on inhalation hose for DSV supplied systems) (O, W)
If your Prism 2 is supplied with a DSV, the inhalation side breathing hose will house a one-way mushroom valve **(Fig 285)**. (The inhalation mushroom valve on BOV supplied systems is housed in the BOV on the inhalation side of the BOV body).

To test the sealing integrity of the valve, place your the hose elbow on your mouth and put the DSV counterweight in your other hand. While looking at the mushroom valve gently inhale. You should see the mushroom valve seal around the outside surface of the 6-spoke mushroom valve seat **(Fig 286)**. You should not feel or hear any air movement from the valve. If you can inhale air, clean the mushroom valve and seat with water. If it continues to leak after cleaning,

Fig. 285

Fig. 286

you must replace the valve (and possibly the valve seat), then repeat the test.
The mushroom valve seat has an O-ring which mates to the hose fitting. Because the O-ring is static (does not encounter movement) it is not usually a point where you might find leaks. However, it is always a good idea to clean the O-ring during a thorough leak diagnosis.

If you remove the valve seat for inspection or repair, you must clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged.

4: Inspect DSV/BOV (5 steps)

a: shut-down/OC assembly (O)
Open and close the DSV/BOV to make sure the inner barrel operates smoothly and does not bind. If it is hard to open or close, or if you hear a scraping sound during barrel movement, the DSV/BOV will need to be serviced.


Fig. 287

DSV: There are three sealing O-rings on the DSV rotating barrel **(Fig 287)**. You will be checking the sealing of these during your positive and negative pressure tests. If any of these O-rings should fail, you will need to service the DSV. Check the maintenance section of the manual for further information.

BOV: The BOV barrel is a 3-position barrel. Rotate the barrel fully through all 3 positions making sure that it stops in place prior to rotating back up into the “fully closed” (not closed circuit) position, and that pulling up on the knob releases the barrel to travel into the closed position


Fig. 288

b: water drain (O)
On the underside of the DSV/BOV you will see a small hole just under the mouthpiece **(Fig 288)**. This is the water drain hole. Check to make sure it is not clogged.

Place the DSV/BOV in your mouth with the valve closed and blow into the mouthpiece. You should be able to blow air through the drain hole, but you will feel some back-pressure. If you cannot blow air through the drain hole, debris may have clogged the hole or become lodged in the drain channel in the rotating stainless steel sleeve. You will need to service the DSV.

c: mouthpiece, zip-tie
Check for holes or torn bite tabs in the mouthpiece. Replace as needed. Check that the zip-tie retainer is present and holding the mouthpiece securely onto the DSV/BOV.

d: DSV/BOV exhalation mushroom valve (O, W)
Open the DSV/BOV to the CC position. Place your palm over the left side opening of the DSV/BOV, fully blocking it, and attempt to gently draw air in. There should be no air movement.
If you are able to draw air in, clean the exhalation mushroom valve and seat with water. If it

continues to leak after cleaning, you must replace the exhalation side mushroom valve and seat, then repeat the test.

e: inhalation hose mushroom valve (only on inhale side of BOV) (O, W)
(BOV ONLY): Open the BOV to the CC position. Place your palm over the right side opening of the BOV, fully blocking it, and attempt to gently exhale. There should be no air movement. If you are able to exhale air, clean the exhalation mushroom valve and seat with water. If it continues to leak after cleaning, you must replace the exhalation side mushroom valve and seat, then repeat the test.

5: Inspect regulators and hoses (6 steps)
a: 1st stages (W)
Remove the cap on the first stage DIN valve and inspect the DIN fitting for signs of previous water ingress such as discoloration or salt buildup **(Fig 289)** on the filter surface. If there are signs of water ingress, do not dive the unit until the first stage, hoses and pressure gauges attached to it have been serviced by a Hollis authorized repair facility. Failure to properly maintain the first stages could result in a free-flow of gas into the breathing loop and lead to serious injury or death. Verify that the DIN valve's tank O-ring is in place and clean. Replace it if there are any signs of wear.

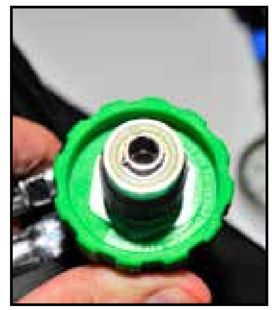


Fig. 289

b: pressure relief valves
Check that the pressure relief valve is in place and the body of the valve has not sustained any impact damage. You will verify that the valve is sealed when you pressurize the first stage. Should the valve activate and discharge gas, suspect a malfunctioning first stage. You can verify if the intermediate pressure is outside of operating parameters with an in-line pressure gauge outfitted with a low pressure QD fitting.

c: LP (low Pressure) hoses and connectors (W)
Check each hose leading from the first stages for signs of wear or age **(Fig 290)**. Replace as necessary only with Hollis approved parts. Check all LP quick disconnect hardware for corrosion and verify that the Shrader valve is clean of debris, salt or corrosion. If the QD fittings are becoming stiff or are built-up with corrosion, a 1/2 hour soak in white vinegar may remove the build-up.


Fig. 290

Warning:
It is important to understand that all of the LP oxygen supply hoses contain in-line flow restrictors, and must never get exposed to salt water. Never replace an O_2 side low or high-pressure hose with anything other than the correct Hollis part.

d: HP (High Pressure) hoses and connectors (W)
Check each HP hose leading from the first stages for signs of wear. Replace as necessary only with Hollis approved parts.

If any other gas supply hoses are attached to diluent first stage such as a dry suit hose or second stage, check them for signs of wear. Replace as needed.

d: diver installed gas supply hoses (if present) (W)
If you have installed any after market gas supply hoses on either the diluent or O_2 first stages, check them for wear.

e: pressure gauges (O, W)
Look at both pressure gauges and verify that the needle is resting at 0 psi / 0 bar. If it is not, have the pressure gauge repaired or replaced. Unless there are obvious signs of impact damage to the faulty gauge, suspect water ingress through the first stage and have the rebreather gas supply system serviced by an authorized Hollis repair facility. It is especially important for the Oxygen side of the system to remain free from contamination, as all parts must remain oxygen clean. (Refer to maintenance section for further information).

6: Inspect wiring (2 steps)
a: LED primary display (W)
Check the LED primary display and wiring for damage. Turn the unit power on and verify that all three of the LED's illuminate **(Fig 291)**. If all three lights continuously blink orange for 30 seconds, the primary display battery must be changed. Once checked, turn off the LED Primary Display. (See the primary display light states section of the manual for display explanations.)

Fig. 291

b: secondary display(W)
Inspect secondary display and wiring for wear or damage. Turn on the secondary display by depressing both the menu and select buttons **(Fig 292)**. After the splash screen, the system will switch to the main information screen. Leave the Secondary Display powered on to complete the battery checks (step #9) below.

Fig. 292

7: Battery compartment, batteries & O-rings (4 steps)(W)

Fig. 293

a: solenoid batteries

The solenoid runs on two 9V alkaline (Duracell or equivalent quality only) batteries wired in parallel and located in the battery compartment of the electronics housing **(Fig 293)**. With the secondary turned on from the previous step, depress the select button six times until you see the bottom of the screen display the voltages for the external battery (solenoid) and the internal battery (display) **(Fig 294)**. A voltage above 7v, as reported by the secondary display, is considered by the electronics as acceptable for use with the solenoid, however beginning a dive with a battery voltage of at least 7V is strongly recommended.

EXT V	INT V
8.8	3.4

Fig 294

The computer measures the dynamic voltage of the solenoid batteries, which means the voltage is being measured while the solenoid is firing and the batteries are under load. This is the most accurate way to verify the actual working capacity of the batteries. Using a voltmeter that does not put a load on the battery can give you a higher voltage reading, but the measurement will not be nearly as accurate a gauge of actual battery capacity. This is why we do not recommend relying on a voltmeter to test the solenoid batteries.

Field Notes: Solenoid Battery

For the computer to measure the dynamic load of the solenoid battery, the Prism 2 must have a valid calibration stored in memory to allow the solenoid to fire. If, when you turn on the secondary display, all three sensors display "fail", the solenoid will not fire and the voltage display for the solenoid battery will show "?". You will not be able to verify the dynamic voltage of the solenoid batteries until the system has been calibrated, which will then allow the solenoid to fire.

b: LED Primary display battery
The LED Primary Display battery is located in the battery compartment. It is a SAFT 3.6V AA battery.

c: O-rings (2) (W)
There are two O-rings sealing the battery compartment. A “compression seal” O-ring sits inside the O-ring grove at the top of the electronics stack **(Fig 295)**, and its mating face is the underside edge of the battery cap. Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged.
The second “Radial seal” O-ring resides in a grove on the inside edge of the battery cap **(Fig 296)**, and its mating edge is the inside surface of the electronics stack. Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged.

Fig. 295

Fig. 296

d: cover, cover latches & keepers (O, W)
The aluminum battery cap is held in place by two Nelsen Sessions stainless steel locking latches **(Fig 297)**. Operate the latches and check that they are free of debris, and the locking mechanism locks firmly into place. Damaged latches must be replaced before immersing the Prism 2 in water.

Failure to keep the battery compartment latches in working order can result in flooding of the battery compartment.

Fig. 297

The cap houses the Electronics/Solenoid compartments over-pressure valve. This is a self-closing valve and as such should not require any pre-dive intervention beyond normal post-dive cleaning.

The latch keepers are molded into the battery compartment cap. Make sure there is no impact damage which could have cracked the aluminum keepers.

Warning

The Battery cap is equipped with a pressure relief valve. If the battery compartment were to flood, battery acid and poisonous gasses will form inside the compartment. You must never expose yourself to either the acid or gasses from a venting battery compartment.

Should the compartment flood during diving operations, the pressure relief valve will rupture and vent the pressurized gasses and acid into the surrounding water.

Because the Solenoid and Primary Display batteries are in this compartment, if the compartment floods, the batteries will quickly lose their charge and the Primary Display and the Solenoid will stop working.

After a battery compartment flood, you must take precautions while cleaning and disposing of all the materials within the compartment, and must not dive again until you have replaced the battery cap pressure relief valve. (See the maintenance section for further information on recovering from a flooded battery compartment)

8: Solenoid operation (O,W) - (if you are proceeding immediately to assembly and operational checks, you can skip this step)

While you will be verifying the operation of the solenoid with the operational checks, it is always a good idea to verify its operation at this stage if you will be traveling away from immediate repair support.

To check the solenoid operation now, you will need to hook up the oxygen side 1st stage, solenoid supply hose and a pressurized oxygen cylinder to the solenoid and power up the Prism 2 to check that the solenoid is firing and adding O_2 to the breathing loop.

Install the oxygen supply hose onto the solenoid. Install an oxygen cylinder onto the oxygen side first stage. This is temporary and you will be removing the O_2 tank after this test, so you can leave the tank on loosely **(Fig 298)**. Slowly open the O_2 tank valve to charge the lines, then close the valve.


Fig. 298

Turn on the Secondary Display and change the setpoint to either low or high setpoint. Listen for the solenoid firing and watch the oxygen pressure gauge. You should see the pressure in the lines drop as oxygen is injected into the head. Allow the solenoid to continue firing until the pressures in the lines are drained. Remove the O_2 first stage from the tank valve and the supply hose from the solenoid.

If you can hear the solenoid click, but the pressure in the lines does not decrease as shown on the pressure gauge, most likely you have a clogged flow restrictor. If the solenoid does not fire, make sure you have selected an active setpoint. Remember, if all 3 cell outputs read "fail", there is no valid calibration stored in memory and the solenoid will not fire regardless of the active setpoint. If all the O_2 sensor readings on the secondary show "fail", you will need to calibrate the unit prior to verifying solenoid operation. If the Secondary Display does show readings for the O_2 cells and the battery display shows charged batteries, it may be that water has gotten into the oxygen pneumatics, or the solenoid has simply failed. Have the unit serviced by an authorized Hollis service center. Never dive your Prism 2 with a failed solenoid.

9: Inspect head assembly (3 steps)
a: Red CO_2 Seal (I, W)
The Red CO_2 Seal is a thick, spongy-feeling red gasket that resides on the underside of the head in a channel on the face of the exhaust plenum adjacent to the three O_2 sensors **(Fig 299)**.


Fig. 299

DO NOT LUBRICATE THE Red CO_2 Seal.

The Red CO_2 Seal **MUST** be checked now and prior to sealing the bucket to the head. The Red CO_2 Seal is a critical component of a properly functioning breathing loop. If the gasket were left out during operation **(Fig 300)**, you would have 100% CO_2 breakthrough, possibly leading to injury or death.


Fig. 300

WARNING:
You must verify that the Red CO_2 Seal is in place, seated properly in its groove and is clean and undamaged anytime you load the CO_2 scrubber basket into the unit. Failure to check the Red CO_2 Seal may lead to serious injury or death.

b: head to bucket O-rings (2) (W, I)
The head to bucket sealing flange **(Fig 301)** incorporates two bucket sealing O-rings **(Fig 302)**. You must check and clean both O-rings and their seating surfaces whenever the bucket has been removed from the seating flange.


Fig. 301

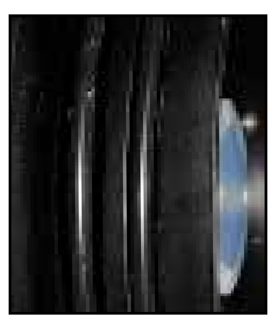


Fig. 302

To begin the cleaning process, using the supplied O-ring removal tool which came with your Prism 2, remove the two O-rings from their grooves starting with the O-ring closest to the head (#1) **(Fig 303)** and lay it on a clean towel. Next, remove the O-ring closest to the edge of the bucket flange (#2) **(Fig 304)**.

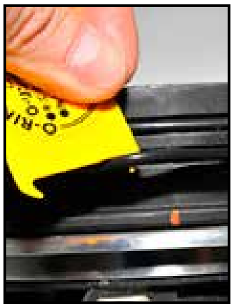


Fig. 303

Fig. 304

Never use any sharp or metal objects to remove the O-rings, as that would damage the O-ring and/or the seating surface. Never over-stretch the O-rings while removing them.

Field Notes: Order out of chaos
Removing the O-rings in the order stated above keeps you from having to drag an O-ring across an empty O-ring groove, which can result in nicked, stretched or broken O-rings.

Clean any debris (usually small particles of soda lime) and silicone on the O-rings with a lint-free towel. Once clean, run the O-rings through your fingers feeling for any nicks or left over debris while visually inspecting them at the same time. There must be no lint, hair, or particles of any kind on the cleaned O-ring, since debris on the O-ring would cause a seal failure. If you find any damage to the O-ring, it must be replaced with a new O-ring from your spares kit.

Lay the 2 cleaned, but not yet lubricated O-rings aside on a clean surface. Clean the seating surface on the head flange, making sure to remove any debris that may have collected in the O-ring grooves.

Field Notes: Lubricants: The amazing dirt magnets.
Never lay a Tribolube-treated O-ring down, even on a seemingly clean surface. The Tribolube will pick up an amazing amount of surrounding debris that your eyes didn’t see.

Put a small dab of lubricant on your forefinger and lightly coat each O-ring with a sheen of lubricant by running the O-ring between your forefinger and thumb. While you are doing this, feel for any leftover debris and if found, re-clean the O-ring and reapply fresh lubricant. Immediately replace all cleaned and lubricant-treated O-ring back on the head after you lube them, in the opposite order in which you took them off.

To re-install the O-rings, start by putting the first O-ring in the bottom groove (#2) on the head. This will make putting the subsequent O-ring in place easier by not having to work the O-ring past an empty groove. (See step 11B and accompanying field note, above)

Once the head to bucket sealing surface has been cleaned and the treated O-rings are in place on the flange, it is recommended that you temporarily replace the bucket on the head. This will keep debris off the cleaned surfaces until you are ready to mount the absorbent-filled basket assembly on the head in preparation for diving.

Warning:
All screws that secure the bucket latch seat onto the head must be in place and in good condition. Never dive the unit if any retaining screws are missing or damaged. Never replace the screws with non-approved hardware. Doing so could cause the latch seat to fail and the unit to experience an immediate and catastrophic flood, possibly leading to injury or death.

c: bucket latch keeper (W, O)
The bucket latch keeper is a stainless steel channel that runs around the face of the head and is screwed into place. Verify that the 4 screws are in place and the seat is not loose **(Fig 305)**. If the seat were to fail during a dive, the Velcro bucket strap would most likely keep the bucket firmly seated on the head, however with a failed latch keeper, a catastrophic flood could result.

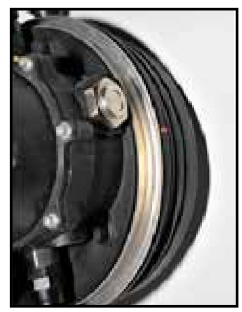


Fig. 305

Field Notes: Spares kit
Immediately log any item you are taking from your spares kit in your Maintenance/ Repair Log to remind you to re-order new spares. Otherwise, next time you need a spare, it won't be there.

10: Oxygen sensors (3 steps)
a: 3 oxygen sensors and sensor holders installed (I)
The three oxygen sensors are mounted on the underside of the head in removable, vibration resistant cell holders **(Fig. 306)**. Each cell holder is held in place by two pins. Make sure all three-cell holders are firmly seated on the pins and are in good condition. You should never allow any silicone or other lubricant to get on the sensor housings or the sensor holders, as that could allow the sensor to slide out of the holder during a minor transit impact, thereby damaging the sensor. If there is grease on the sensor housing or holder, gently clean both with a mild surfactant cleaner such as Simple Green™, taking care not to get any on the sensor's hydrostatic membrane. (See the list of approved cleaning agents in the appendix).

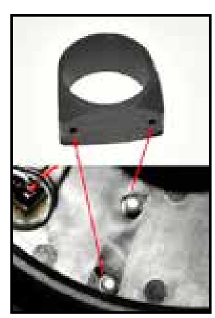


Fig. 306

b: oxygen sensor wiring harness (W)

The O_2 sensor-wiring harness has one locking Molex connector **(Fig 307)**, which connects into the head and three locking 3 pin (2-wire) Molex connectors that go to each sensor. The connectors are the high pressure 4 sided pin capture. The wiring is silver-coated copper stranded wire. It really does not matter which 3 pin connector goes to which O_2 sensor as they are mounted in the head, but for diagnostic purposes, the wiring color designation is as follows:

Fig. 307

Color	**O_2 Readout on Primary/Secondary Displays**
RED/BLK =	#1
WHT/BLK=	#2
BLU/BLK=	#3

c: mV readings within range(O) (8.5mV to 14mV in air)

The Analytical Industries PSR-11-39-MD O_2 sensor voltage output should be between 8.5 and 14mV in air, and 40 to 67 mV at sea level in 100% oxygen (the valid mV reading (as far as the computer is concerned) for 98% O_2 calibration is 30-70 mV). On the secondary, switch the display to the sensor's mV readings and verify that the sensors are in range for the gas to which they are exposed.

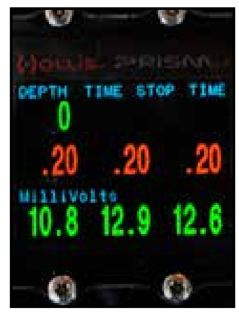


Fig. 308

From the main screen, depress the select button until the cell readouts display their millivolt readings **(Fig 308)**.

11: Bucket assembly (3 steps)

The scrubber bucket is made from high density, high-pressure injection-molded clear urethane **(Fig 309)**. It is an extremely rugged, durable and strong material that also helps thermally protect the scrubber material by creating an insulating gas space around the scrubber. Because high pressure Urethane is a very poor thermal conductor compared to other commonly used materials, such as aluminum or stainless steel, it also acts to preserve the heat needed for efficient CO_2 sequestration.

Fig. 309

a: basket compression spring and pad (I)

The scrubber basket compression spring **(Fig 310)** sits on a retaining pin that is molded into the bottom of the scrubber bucket. The spring is designed to keep the inhalation tube area of the scrubber basket firmly sealed on the red Red CO_2 Seal, mounted on the exhaust plenum in the head.

Confirm that the spring seat and locking nut are in place and that the spring compresses by pushing down on it.

Fig. 310

b: latches (W, O)
There are four Nielson Sessions stainless steel hinged latches **(Fig 311)** mounted on the stainless steel band toward the top of the bucket. Operate the latches and check that they are free of debris or rust or excessive wear. Verify that the locking mechanism lock firmly into place.

Fig. 311

Warning:
Damaged or worn latches must be replaced before immersing the Prism 2 in water or commencing diving operations. Failure to verify that the scrubber bucket latches are in good working order, or diving with broken or worn latches can result in a catastrophic flooding of the loop, possibly leading to serious injury or death.

c: 1 moisture pad (I)
Check that you have a bucket moisture pad installed at the bottom of the bucket. The moisture pad should be capable of absorbing the majority of condensation moisture that collects along the bucket wall, dripping to the bottom of the bucket during use.

Warning:
You must use only Hollis approved bucket moisture pads. Never use a moisture pad that can interfere with the compression spring and clearances of the scrubber basket. Using moisture pads that were not designed for the Hollis Prism 2 could damage the basket, bucket spring, bucket latches, Red CO2 Seal or latch seat. A failure in any of these areas during diving operations could lead to serious injury or death.

12: Basket assembly (W) (4 steps)

The basket assembly comes in four basic parts **(Fig 312)**: the basket, the basket lid, the center tube and the center tube O-ring. The basket assembly utilizes a strong nylon mesh to avoid rips and is also somewhat elastic so it will not create dust by abrading the absorbent along its walls during packing, transit or handling. The nylon mesh is also thermally non-conductive which helps keep the absorbent material and its absorbing capacity as thermally efficient as possible.

Fig. 312

a: check mesh (W)

Look at the mesh of both the basket and the center tube. There must not be obvious tears or abrasions of the mesh. Do not attempt to repair a basket with torn or abraded mesh, as any material or repair failure during diving operations would cause the absorbent to spill out of the basket, resulting in an instant and catastrophic CO_2 bypass.

Warning:
Never attempt to repair or dive a scrubber basket that has torn mesh. Doing so could lead to injury or death.

b: center tube O-ring (I)

The center tube screws into the basket base and is sealed with an O-ring. You do not normally have to remove the center tube for cleaning, but if you do, remove, clean the O-ring, O-ring groove and mating surface for use, or replace if worn or damaged. It is neither necessary or advisable to lubricate the center tube O-ring.

Caution
You must insure that you replace the center tube O-ring during assembly. Failure to do so could allow some gas to channel through the top of the scrubber.

c: top and basket threads clean (O)

Keeping the scrubber clean is very simple, but one of the problems between cleanings is crushed absorbent dust caking up in the scrubber basket threads **(Fig 313)**. The more humid the environment in which you are packing your absorbent basket, the more you will find the material is building up in the threads. While not a safety concern in and of itself, caked-on absorbent can make it more difficult to screw down the top of the basket, which can be a safety concern if the basket top is not fully engaged onto the threads.

Fig. 313

The easiest way to remove absorbent that has built up in the threads is to soak the top and basket threads in 100% white vinegar for 10 to 15 minutes. If time is an issue, heat the vinegar to 100F/38C, and soak the parts. Rinse thoroughly and dry the basket before re-packing it. While in use, you can use a small flat head screwdriver to clean the threads.

Warning:
If you use a screwdriver or a dull scraping tool to scrape away caked-on absorbent from the basket top threads, be very careful! It is very easy for the tool to accidentally slip on the threads and tear the mesh, your skin, or both.

d: top and bottom foam pads (I)
The foam pad with the larger diameter center hole is placed on the bottom of the basket prior to filling **(Fig 314)**. The second pad goes on top of the absorbent filled basket, under the basket top. Both the bottom and top pads are used to impede any laminar flow of gas which might occur along the smooth surfaces of the basket top and bottom.


Fig. 314

After many uses and cleanings, the foam pads will begin to deteriorate, and the pads will start to become thin. At this point, you must replace the pads.

Prism 2 Assembly checks

13: Fill scrubber basket with CO2 absorbent & store in an airtight container. Label container: Grade, date filled, user, time used
Date packed______ Grade______ Time Used ______ Time left______

maximum scrubber duration: 260 minutes (0.5%SEV CO2) using 6-12 @40F/4.4C, 1.35slpm CO2, 40lpm RMV, 60fsw/28msw

Fill the scrubber basket in accordance with the directions on pages 85 - 87. Record the date you packed the scrubber, the grade used (6-12 or 8-12), any usage time you have put on the scrubber since it was packed and the time left before the CO_2 absorbent must be disposed. It is important to remember that using the scrubber beyond the factory tested maximum allowable time of 260 minutes per fill with 6-12 or 8-12 diving grade CO_2 absorbent is extremely dangerous and can lead to injury or death.

14: Fill O_2 & diluent cylinders, analyze contents, label cylinders with name, date, and contents.

Have the Oxygen cylinder filled with pure, E grade (usp) or higher O_2* (See Article, “Speaking the language: Oxygen” on page 168). Fill the diluent cylinder with an appropriate diluting gas for the planned dive (s). Never use a hypoxic mix of diluent with a BOV or alternate air source plumbed in. Crack the diluent cylinder and sniff the gas. It should have no odor. If it does, suspect contaminants in the fill, have the cylinder inspected by a qualified inspector, then have it re-filled from a new source. Verify the oxygen content of BOTH bottles using a calibrated oxygen analyzer **(Fig 262)**. The oxygen should read 100%* and the diluent (if air) 20.9% (see your oxygen analyzers’ directions for calibration and environmental variance information).

Fig. 262

*You can dive the Prism 2 using oxygen of less than 100% purity. See the instructions on page 67 for details.

O_2 %__ Pressure ___psi/bar Dil Contents____Pressure ____ psi/bar MOD_____
Record contents and pressures for both gas supplies and the maximum operating depth (MOD) for the diluent.

$$MOD(fsw) = 33\left[\left(\frac{ppO_2}{fO_2}\right) - 1\right]$$

$$MOD(msw) = 10\left[\left(\frac{ppO_2}{fO_2}\right) - 1\right]$$

15: Install regulators and hoses on H-Plate

Install the oxygen regulator and hoses on the right side (head facing up) by running all the hoses under the tank band straps on the inside of the tank bracket (side facing the bucket) with the DIN valve facing outward toward where the tank will be installed. Install the diluent regulator and hoses on the left side (head facing up) by running all the hoses under the bottom tank band strap on the inside of the tank bracket with the DIN valve facing outward. Run the ADV supply hose and pressure gauge under the top tank band but leave the solenoid supply hose loose as you will be running it separately when you install the head assembly in the next step.

16: Install head assembly onto H-Plate (2 steps)

a: 4 button head Allen screws and SS washers
Bolt the head onto the H-Plate using the 4 stainless steel button-head Allen key button head bolts. Make sure to place a nylon washer between the stainless steel bolt and the aluminum H-Plate.

b: Run O2 solenoid hose between right side head mount flange & H-plate. Tighten hose to solenoid
Run the solenoid supply hose in the channel created between the right side head mount flange and the bucket mount. Screw the hose fitting onto the solenoid and tighten with a small crescent wrench.

17: Install bladder, yoke and backplate onto H-Plate (4 steps)

a: Long carriage bolt on top, short carriage bolt on bottom. Secure with nylon keepers.
Install the longer of the two carriage bolts (1 1/2 ”) on the top square bolt hole and secure it in place with a nylon bolt keeper. Install the shorter 1” carriage bolt on the bottom square bolt hole and secure it in place with a nylon bolt keeper.

b: install bladder on H-plate (inflator facing H-plate)
Carefully install the bladder onto the 2 harness mounting bolts of the H-plate, making sure that the inflator mechanism is facing the H-Plate. Take care to not accidentally push the mounting bolts out of the nylon keepers as you run the bolts through the bladder mounting holes.

c: install yoke harness - fastex clips facing bladder
Place the counterlung yoke on top of the bladder with the plastic Fastex clips facing the bladder. Take care to not accidentally push the mounting bolts out of the nylon keepers as you run the bolts through the yoke mounting holes.

d: install backplate and harness - place washers and tighten butterfly nuts
Place the backplate and harness carefully on the two mounting bolts and secure the assembly in place using the two stainless steel washers and butterfly nuts. Tighten the butterfly nuts by hand.

18: Attach counterlungs to yoke (3 steps)

a: insure inhale counterlung is on right side (bladder & yoke facing up)
Verify that the inhale counterlung is on the right side by checking that the lung you are installing on the right has the ADV on the front. The exhalation lung will go on the left side.

b: line up Velcro parts and compress
Press the Velcro pieces together to assure a firm adhesion of the parts **(Fig. 315)**.


Fig. 315

c: clip fastex buckles in place
Attach the plastic Fastex clips of the yoke to the counterlungs making sure they lock into place **(Fig 316)**. Attach the lower large fastex buckle on the waist belt webbing onto the Fastex buckle at the back of the counterlung. **(Fig. 318)** and the side strap webbing attached to the backplate to the small Fastex clip at the lower side of the counterlung.


Fig. 316


Fig. 318

19: Install counterlung breathing hoses to head (2 steps)

a: clean and lubricate O-rings, O-ring groves and mating surfaces
Remove, clean and prepare the O-ring(s), O-ring grove and mating surface for use, or replace if worn or damaged.

b: install hose nuts finger tight. Do not over-tighten.
To properly attach the counterlung hoses to the head, put the hose mount into the head connector **(Fig 319)** and push down until firmly seated against the stainless steel ring on the fitting. Hand-tighten the nut, but do not over-tighten it, as over-tightening will only make removal more difficult. Gently pull on the hose to insure that the assembly is firmly in place.


Fig. 319

20: Attach gas supply hoses to diluent and oxygen addition valves on counterlungs & BCD inflator (2 steps)

a: longer diluent hose feeds BCD
Pull both diluent hoses up (BCD inflator hose and ADV hose) and measure them against each other. The longer hose feeds the BCD inflator.

b: attach all 3 QD fittings. Pull on hoses to make sure they are secure
Each counterlung will have one supply hose which needs to be firmly attached to its corresponding gas addition valve. Verify you are attaching the correct supply hose to its valve on the counterlung, then pull up on the locking sleeve, insert the female quick disconnect attachment onto the male nib and release the sleeve. Pull on the hose to verify that the hose is securely connected. Connect the longer diluent hose to the BCD inflator.

21: Assemble DSV/BOV and hoses, check and install (6 steps)
In steps 5 & 6 of the pre-assembly checks you verified the operation of the three main sub-assemblies that make up the DSV/BOV assembly. Now you will put together the assembly, check its operation and install the assembly on the counterlungs.

a: open/close, purge, mouthpiece
Open and close the DSV/BOV shut down lever to make sure it is not binding or was damaged during transit. With the DSV in the closed position, blow into the closed mouthpiece to make sure the water purge hole is not obstructed.

b: check mushroom valve seals and flow direction
Look at the top of the DSV/BOV. The arrow denotes the gas flow direction **(Fig 320)** and points at the exhalation mushroom valve **(Fig 321)**. Make sure the mushroom valve is intact and in good condition and the seat is firmly seated in the DSV/BOV assembly.


Fig. 320


Fig. 321

c: install hoses onto DSV/BOV
Take the inhalation hose (mushroom valve installed in the counterweight side of the hose on DSV hose) **(Fig 322)** and screw the nickel-plated brass counterweight onto the inhalation side of the DSV/BOV (the flow direction arrow on the DSV/BOV points away from the inhalation side). Leave the counterweighted nut slightly loose until you adjust the mouthpiece angle after you have mounted the assembly onto the counterlungs.

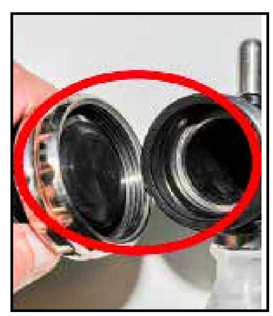


Fig. 322

Take the exhalation hose and screw the nickel-plated brass counterweight onto the DSV/BOV exhalation side. Leave this nut slightly loose as well.

d: perform a mushroom valve sealing test ("stereo check")
To test that the assembly will flow gas in one direction only, open the DSV/BOV and place the mouthpiece in your mouth. To check the inhalation mushroom valve, seal the exhale hose elbow on your right cheek and put the inhale hose elbow by your left ear and blow gently into the DSV/BOV. You should not be able to exhale, or hear any air escaping from the inhale side. To check the exhale mushroom valve, reverse the elbows (left on cheek, right at ear) and attempt to inhale from the DSV/BOV. If either mushroom valve fails to seal, dis-assemble the DSV/BOV assembly, clean or replace the failing mushroom valves and re-test.

e: install DSV/BOV onto counterlungs paying attention to flow direction arrow
Take the inhalation side elbow and insert it into the counterlung at approximately an outward facing 45° angle (away from the unit's center) **(Fig 324)**. Both elbows are keyed **(Fig 325)** so the DSV/BOV assembly cannot be accidentally reversed. If they are accidentally reversed and screwed down, they will not lock in place and you will be able to spin them even when they are fully secured. Screw the inhalation hose onto the inhalation counterlung (left) and tighten it down. Do the same with the exhalation hose elbow, installing it on the exhalation (right) counterlung.


Fig. 324


Fig. 325


Fig. 326

Turn the DSV/BOV until the mouthpiece is approximately 45° up facing in towards the rebreather **(Fig 326)**. This should be a good starting point for the mouthpiece angle, but the angle should be set for the diver's preference. You can continue to rotate the mouthpiece angle to find out what works best for you.

Field Notes: Twisted breathing hoses
When mounting and adjusting the DSV/BOV on the hoses, be very careful not to adjust the angle of the mouthpiece by twisting one of the hoses as this could cause the hoses to kink during diving. If there is any doubt about hose twisting, unscrew the counterweight from the DSV/BOV and watch how the hose comes to rest against the counterlung. Lift the hose up to its diving position. (You can look at the hose clamp to visually mark where the top of the hose should be). Re-install the DSV/BOV.

f: install LED primary display holder. Fix/attach cable to breathing hose


Fig. 327

The Primary Display is held on to either the right or left DSV/BOV counterweight by a plastic c-clamp **(Fig 327)**. The c-clamp is designed to come off from the counterweighted nut fairly easily in the event of an impact or entanglement. This design protects the wiring from damage.

How the wiring is run is user choice, but take caution not to run the wiring in such a way as to make it an entanglement hazard. The Primary Display wiring from the head can come down the inside of the breathing tubes and be held in place by Velcro straps

22: Clean head to bucket sealing O-rings, O-ring grooves and channel and lubricate O-rings

In the pre-assembly checklist (step 11B) you checked and cleaned the bucket sealing O-rings. If you are assembling the Prism 2 right after your pre-assembly checks, you do not need to re-clean the O-rings. You can simply use this step to verify that nothing had fallen onto the O-rings that could cause a leak during dive operations.

If the Prism 2 has been transported or disassembled in such away that debris could have gotten on the O-rings, we recommend repeating this step. We have duplicated these steps here, instead of making you go back to page 114 of the manual. (If you don't need to clean the O-rings, skip ahead to step 22 on page 125):

The head to bucket sealing flange incorporates two bucket sealing O-rings. It is important that you clean and check both O-rings and their seating surfaces whenever the bucket has been removed from the seating flange.

To begin the cleaning process, using the supplied O-ring removal tool which came with your Prism 2, remove the two O-rings from their grooves starting with the O-ring closest to the head (#1) and lay it on a clean towel. Next, remove the O-ring closest to the edge of the bucket flange (#2). Never use any sharp or metal objects to remove the O-rings, as that would damage the O-ring and/or the seating surface. Never over-stretch the O-rings while removing them.
Clean any debris (usually small particles of soda lime) and silicone on the O-rings with a lint-free towel. Once clean, run the O-rings through your fingers feeling for any nicks or left over debris while visually inspecting them at the same time. There must be no lint, hair, or particles of any kind on the cleaned O-ring, since debris on the O-ring would cause a seal failure. If you find any damage to the O-ring, it must be replaced with a new O-ring from your spares kit.

Lay the 2 cleaned (but not yet silicone treated) O-rings aside on a clean surface. Clean the seating surface on the head flange, making sure to remove any debris that may have collected in the O-ring grooves.

Put a small dab of silicone on your forefinger and lightly coat each O-ring with a sheen of silicone by running the O-ring between your forefinger and thumb. While you are doing this, feel for any leftover debris and if found, re-clean the O-ring and reapply fresh silicone. Immediately replace all cleaned and silicone-treated O-ring back on the head after you lube them, in the opposite order in which you took them off.

Fig. 331

23: Clean Red CO_2 Seal and secure in place (2 steps)
The Red CO_2 Seal is a large soft red silicone gasket that resides on the underside of the head in a channel that face of the exhaust plenum which is next to the three O_2 sensors **(Fig 331)**.

Warning:
The Red CO2 Seal is a critical component of a properly functioning breathing loop. If the gasket were left out during operation, the unit will not scrub any CO_2 and you will have 100% breakthrough. For this reason, you must verify that the gasket is in place, seated properly in its groove, clean and undamaged. Failure to check the Red CO2 Seal will lead to serious injury or death.

a: make sure there is no debris, dust or lubricant. Clean seal groove
Check the face of the red CO2 seal to insure there is no old absorbent or other debris that could compromise a proper seal of the basket. Remove the seal and check that there is no lubricant in the seal channel that could cause the seal to come loose during assembly. Do not lubricate the red CO2 seal. Clean the seal channel of any debris or lubricant.

b: make sure the red CO_2 seal is firmly seated in its groove (triple check)
Check that the gasket is in place and securely seated in its channel in the exhaust plenum by pushing down on it all the way around the gasket. Re-check that the gasket is properly seated just before you install the scrubber basket and bucket assembly on the head.

24: Check filled CO_2 scrubber basket (2 steps)
Regardless of whether you packed your scrubber basket ten minutes ago or ten days ago, you must re-check the basket one final time before loading it into the rebreather. This is especially true if the absorbent might have had an opportunity to settle during transportation, or if the basket top came loose in handling. Remember, a properly packed absorbent basket is essential for a safe dive.

a: basket top secure
Make sure the basket top is tight and fully seated on the basket. The bottom of the basket top should line up with the bottom of the threaded section of the basket cage **(Fig 332)**.


Fig. 332

b: check for settling and firmness of absorbent bed
Just as you do when packing the basket, feel the absorbent from bottom to top. It should feel evenly dense throughout. Put slight pressure on the mesh by squeezing it should not displace grains of absorbent. If the absorbent is not tight and even throughout, you must re-pack the scrubber.

25: Check scrubber bucket (4 steps)

a: clean bucket sealing surface
Before mounting the bucket to the head, give the bucket flange O-rings one last look for hair, lint, dirt or anything that might have fallen onto the silicone grease. Clean the sealing surface of the bucket with a clean, lint-free cloth. Check that there is no debris or hairs left on the sealing surface that could cause a slow leak into the bucket.

b: basket compression spring installed and functional
Press down on the basket compression spring, making sure that the spring is functioning correctly and is firmly held in place by the retaining nut.

c: install bucket moisture pads
Place the supplied moisture pad at the bottom of the bucket


Fig. 333

d: make sure the pad is not resting on or interfering with the basket compression spring
Make sure the absorbing pad is laying flat and it is not hung up on the spring or basket retainer **(Fig 333)**.

26: Place CO_2 basket in bucket, confirm center tube opening up, mount and seal bucket to head
Gently place the basket in the bucket **(Fig 334)** making sure the **center breathing tube is facing up (Fig 335)**.


Fig. 334


Fig. 335

Push down on the basket top and make sure it springs back. If it does not move, you have either placed the basket in the bucket up side down, or the spring assembly is not working correctly. Open up the nylon bucket strap and slide the bucket underneath making sure the top 2 bucket latches are centered and facing away from the backplate. Open all 4 bucket latches and fold back the hooks, so they do not get caught between the bucket and head.

Put your hand at the bottom of the bucket and push it up towards the head, making sure not to twist or push at an angle.

When the bucket is close enough to the head that the latches can catch onto the mounting flange, flip the two side latches onto the flange and lock them in place. Verify that the latches are locked by attempting to pull up on the latches. Then flip the two top latches into place and lock them down and verify they are locked. Look at the two O-rings through the clear bucket to verify that they are in their grooves and are not twisted.

Field Notes: I Can't breathe!

If you cant inhale from the loop once you seal the bucket on the head it's most likely because you installed the scrubber basket upside down in the bucket. The bucket spring forces the flat basket top onto the Red CO2 Seal as a safety precaution, stopping gas flow around the loop.

Prism 2 Operational Checklist

27: Install analyzed and properly labeled gas cylinders
Place the diluent tank under the two tank straps on the divers left. Place the O_2 tank on the divers right. It is very important that you put the correct tank in the appropriate position. Screw the DIN first stage into the valve and then do the same with the oxygen side of the system.

28: Turn on Secondary Display. Check O_2 cell mV readings in air, replace if out of range (8.5mV to 14mV) Record O2 Cell mV readings in air: #1_____ #2_____ #3_____
Turn on the secondary display and switch to the Calibrate screen and record the mV outputs for each cell. You will use these readings to check linearity once you have flushed the loop with pure O_2.

29: Setpoint to 0.19 (8X menu - left button)
Make sure you have the active setpoint ay 0.19 so the computer is not automatically injecting O_2 into the loop. Depress the menu button 8 times until you see the “Setpoint .19” menu item, then press the select button once to select it.

30: Oxygen system leak test (3 steps)
You will check to make sure there are no small leaks in the oxygen delivery system (1st stages, hoses QD fittings, valves).

a: open oxygen valve, pressurize hoses, close valve
Slowly open the oxygen cylinder valve. Allow the hoses to fully pressurize. Shut off the oxygen cylinder valve.

b: watch oxygen pressure gauge for pressure drop
Listen for leaks and check that the pressure on the gauge has not dropped after a minute or two.

c: open oxygen valve
Open the oxygen valve.

31: Negative Pressure test (4 steps) (hold for 1 minute minimum)
The negative pressure test will check for the types of leaks that may not show during a positive pressure test. These types of leaks are fairly rare but are just as potentially dangerous, so it is extremely important to perform the test. Make a mental note of either the mV readings or the PO_2 readings on the secondary display prior to starting the test. If the negative pressure in the loop during this test is strong enough, you will notice that the readings drop a point or two and will remain at those values as long as there are no leaks in the loop. If the readings do not drop at all, it is possible that you cannot create enough of a vacuum to drop the values, or you have a leak in the system that will not allow a vacuum to form at all.
We do the negative pressure test at this stage of the checklist because we are also preparing the loop for an oxygen flush, which we will begin doing during the positive pressure test. Performing the negative pressure test now removes as much inert gasses from the loop as possible.

a: open DSV/BOV

Open the DSV/BOV and press on both counterlungs **(Fig 339)** to remove as much gas as possible from the counterlungs.


Fig. 339

b: inhale from DSV/BOV in CC mode, exhaling through nose until counterlungs fully collapsed

Now place the open DSV/BOV in your mouth, and while inhaling from your mouth and exhaling through your nose, get as much gas as possible out of the loop. Continue until the counterlungs have fully collapsed and you cannot pull any more air out of the loop, leaving a slight vacuum in the loop or "negative pressure".

c: close DSV/BOV

With the loop drained of as much gas as possible and the DSV/BOV still in your mouth, shut down the DSV/BOV. Do not allow air back into the loop while shutting down the DSV/BOV.

d: Allow to sit for one minute, watch for signs of leaks on Secondary Display PO_2 /mV readings

After you pull a slight vacuum on the loop, the counterlungs will be fully collapsed and hard to the touch **(Fig 340)**. Allow the loop to sit for at least one minute while you watch the Secondary Display mV or PO_2 readings for a change and/or watch the counterlungs to see if the fabric appears to relax **(Fig 341)**. If the loop does appear to be losing vacuum, you must track down and fix the leak, or leaks, prior to diving.

Leaks that only show up in negative pressure tests but not positive pressure tests are rare. However, they are the hardest to find because you cannot do a simple bubble check to find them. Usually they are the result of a counterlung drain locking collar not being tightened which could cause the negative pressure in the loop to open the valve and allow air in. (This problem would not occur during diving). Make sure both counterlung drain locking collars are shut tight **(Fig 342)**. Another possibility is debris in the OPV mushroom valve or seat. A flush with fresh water might remove the material creating the leak. Worn O-rings in the DSV/BOV may also show up in the negative leak test. Never dive a Prism 2 that shows signs of a leaking loop, as that could compromise the integrity of the loop, possibly leading to injury or death.


Fig. 340


Fig. 341


Fig. 342

Field Notes: What's a few minutes?
At any time, but especially for extended range diving, it is advisable to allow the loop to sit for at least 5 minutes before checking to see if vacuum or pressure is being lost. Small leaks may not allow enough pressure or vacuum to escape in the first minute or two of the tests to be noticeable by palpation of the counterlungs, but may allow enough water into the loop during diving to become problematic. Small leaks will also usually show up in the preliminary bubble check (step 41) but it is usually less time-consuming to identify and correct leaks at this stage of set-up.

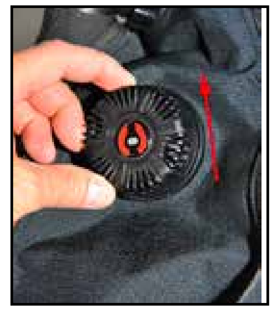


Fig. 336

29: Positive pressure test. (4 steps) (hold for 1 minute minimum)
The positive pressure test will identify most leaks in the breathing loop.

a: close OPV
Make sure the DSV/BOV is still closed and turn the OPV (over-pressure valve) fully counter-clockwise to restrict its flow**(Fig 336)**.

b: fill loop fully with oxygen using manual oxygen addition valve until OPV engages.
Depress the manual oxygen addition valve on the exhalation counterlung. Continue adding oxygen into the loop until the over-pressure valve on the front of the exhalation counterlung (right) begins to release pressure. The counterlungs should feel firm to the touch and remain that way. If the counterlungs lose pressure, you must track down and fix the leak or leaks prior to diving. If the leak is small such that you can not hear gas escaping while the loop is under pressure, you can submerge the rebreather in water and look for a trail of bubbles. (Tanks must be mounted on the first stages prior to submerging the unit to avoid flooding the first stages.) Do not submerge a fully built and absorbent packed unit that rapidly loses air because you could fully flood the unit, ruin your absorbent and destroy the O_2 sensors. Never dive a Prism 2 that shows signs of a leaking loop, as that could lead to injury, and possibly death.

Field Notes: Fail, Needs Cal
If the secondary electronics do not have a valid O_2 calibration stored in memory, the solenoid will not fire when the system is turned on. If the secondary display reads "FAIL" on the O_2 sensor readouts (Fig 344) you will need to use the mV readings to verify a proper loop flush.

c: allow to sit for one minute, watch for signs of leaks on Secondary Display PO_2 / mV readings.
After you have fully filled the loop with oxygen with the OPV closed until it engages and allows gas to escape, you will have created a positive pressure environment which will slightly raise the PO_2 / mV output of the O_2 sensors so long as the loop remains slightly pressurized. Make a mental note of the values on the display as soon as you stop adding O_2. Allow the loop to

sit for at least a minute, watching if those values drop slightly, which could indicate a leak. Be careful not to jostle the counterlungs as any added pressure could cause the OPV to allow the excess pressure to escape. You can also palpate (feel) the counterlungs after filling them and after a few minutes see if they feel the same as they did when you first filled the loop. This is the preferred method if you are on a moving boat where the counterlungs will most certainly experience some jostling.

d: open DSV/BOV, evacuate loop contents
Fully open the DSV/BOV in CC mode and push on the counterlungs to remove as much gas as possible from the loop.

30: Flush loop with O_2 (3 steps) Since the DSV/BOV is open at this stage, pull another negative.

a: close DSV/BOV
Once you have pulled the negative, close the DSV/BOV

b: fill loop with oxygen until OPV engages (Do this step twice)
Press the Manual Oxygen Addition valve as before and fill the loop until the OPV engages.

c: open DSV/BOV to equalize pressure to ambient pressure. Close DSV/BOV.
Crack open the DSV/BOV momentarily to let any positive pressure escape from the loop.

31: Calibrate Secondary Display Electronics (3 steps)
This step will calibrate the Secondary Display .

a: menu to calibrate (2X menu - left button)
Depress the menu button (left) twice to get to the calibrate screen if the screen has timed-out during the loop flush or you were not on the calibrate screen during the previous step. If you are already on the calibrate screen, continue on to the next step, below.

b: press select button twice to calibrate
Depress the “select” button twice to calibrate. Once the Secondary Display accepts calibration, all 3 PO_2 display values will match with the “Cal. PPO_2” value programmed into the computer during system setup (see “Cal PPO2” programming on page 69). The system default is 0.98 PO_2.

c: Record mV readings in O_2: #1_____ #2_____ #3_____ (acceptable range 40.6mV to 66.9mV)
We want to record the millivolt readings so we can monitor the health of the O_2 sensors over Time. As the cells age, the current output in both air and pure O_2 will decrease to a point where they can become unstable and unpredictable. Usually, the cells will exceed their “Use by” date and need to be retired before they become a problem, but occasionally you may get a cell which “goes bad” during its service life (which is printed right on the cells’ label for your safety). Recording these mV readings will allow you to better track cell behavior.
Also, recording the mV values in oxygen and comparing those values with previous values can

give us a good indicator if we have done a thorough flush of the loop. For instance, if the last time you calibrated the system, the mV values were 55, but a week later they are outputting 45 mV post-flush, you may want to consider flushing more oxygen through the loop to see if those mV values increase as you add more O_2, which would indicate an incomplete loop flush. Finally, after you have satisfied yourself that your loop is thoroughly flushed with oxygen, you can do a 2 point field linearity check by multiplying the readings in air from step 28 "**Turn on Secondary Display. Check O_2 cell mV readings in air"** by 4.76. You should get a number that is within a few percentage points of the mV readings recorded here in pure O_2. While this field test is not a true linearity test as it only compares 2 points, both of which are at ambient pressure and cannot take the place of a true full range (ambient + hyperbaric) linearity test, it is easy to do and doesn't hurt the cell, so why not do the math. (Poor loop flushes or O_2 less than 100% purity will affect these comparisons adversely). Cells which are not linear or are current limited must not be dived.

Field Notes: Flush twice?

The electronics might catch an inadequate oxygen flush, as the Millivolt readings from the O_2 sensors in a loop which has not been fully flushed might be too low and the software would reject calibration. Recording the pre and post O_2 pressures is one tool in your kit of diagnostic clues when your electronics are rejecting calibration.

32: LED primary display On and battery check OK replaced & OK

Turn the Primary Display power on with a single press of the piezo switch on the back of the electronics stack on the head and verify that all three of the LEDs illuminate, first green then red. If all three lights continuously blink orange for 30 seconds upon start-up, the primary display battery must be changed before diving.

33: Calibrate LED primary display

Press the Primary Display power switch 3 times in rapid succession (within 1 second) to lock in the calibration. All three LEDs will turn red for 5 seconds, then begin reporting their PPO_2s. It may take some practice with tapping the switch quickly to get the Primary Display to calibrate.

Warning:

The Primary Display will only give a battery warning on start-up and will not alert the user to a critically low battery while diving. Therefore, you MUST change the Primary Display battery whenever the electronics blink the 3 LEDs orange for 30 seconds upon start-up.

34: record oxygen pressure after loop flush: __________ psi/bar

Record the pressure in the oxygen tank after the loop flush This will give you a good indicator over time of how much O_2 is usually needed to do a good flush of the loop. For instance, if you find that you normally use about 200psi/13.8bar O_2 during a flush, but notice that the last flush only used 50psi/3.4bar, this may be an indicator that you did not fully flush the system prior to calibration. Plus, recording O_2 pressure will remind you just how much O2 you have in the cylinder.

35: Solenoid check (3 steps)
This step will check that the solenoid is adding oxygen to the breathing loop when it fires.

a: setpoint to high (>1.0)
The active setpoint is presently .19 which was set in step 29. Depress the menu button 3 times until “Switch .19 > xx” is displayed on the screen. Depress the select button once to select the programmed low setpoint. Repeat to choose the programmed high setpoint.

b: solenoid fires and oxygen injection is verified
As long as the high setpoint is greater than 1.0 PO_2, the solenoid will begin firing to add oxygen to the loop. If the high setpoint is less than 1.0 PO_2, will either need to drop the loop PO_2 by injecting diluent via the ADV or increase the high setpoint in the System Setup menu. Once the solenoid begins injecting O_2, you should be able to hear the oxygen entering the loop at the exhaust plenum, but if you are in a noisy environment, such as on a boat, you can simply turn off the O_2 cylinder valve momentarily and watch for the pressure gauge needle to drop as the solenoid fires or release some pressure from the loop by manually pressing the OPV, then watch as the counterlungs expand as the O_2 enters the loop. Make sure to turn the oxygen valve back on if you momentarily shut the valve during the test.

c: change active setpoint to .19
Once the solenoid has fired and you have verified that oxygen is getting into the loop, change the active setpoint back to .19 by depressing the menu button 8 times until “Setpoint .19” shows on screen **(Fig. 348)**. Depress the select button once. The solenoid should stop firing.

36: Solenoid Batteries check OK replaced & OK
From the main screen depress the select (right) button six times until the EXT V (external [solenoid] voltage) and INT V (internal [secondary] voltage) readings are display on the bottom of the screen **(Fig 349)**. Record the EXT V in the space provided. A voltage greater than 7V is considered Ok and below 7V indicates the alkaline batteries must be replaced before diving. Do not use a voltage meter to check battery state as most meters do not put a load on the battery and will give artificially high readings as a result.

Fig. 349

Fig. 348

Warning:
Always replace both alkaline batteries at the same time. Using one fresh and one used battery may give false voltage readings to the computer and may cause the solenoid to stop working, possibly mid-dive. Both Solenoid (9V Alkaline X 2) batteries MUST be replaced at the same time. Failure to do so could lead to injury or death.

37: Secondary display Battery check   OK   replaced & OK
On the same display screen as the solenoid battery (EXT V) is the battery voltage for the Secondary Display battery shown under "INT V" **(Fig 350)**. Check and record the "INT V" value in the space provided. If the voltage value is flashing yellow or red, you must replace the battery before diving.

Fig. 350

Field Notes: Time out.
The voltages screen is timed and will automatically go back to the main screen after 20 seconds. To make your life easier, it would be a good idea to record both battery voltages at the same time.

38: Adjust user selected low/high set points to desired settings (0.4 - 1.5) (3 steps)
The Secondary Display has user programmable low and high setpoints. The default low setpoint is 0.7ata O_2. The valid range for low or high setpoints are 0.4 – 1.5. Page 53-54 contains full details on how to program setpoints.

a: menu to dive setup+
Depress the menu (left) button until you come to the "dive setup+" screen **(Fig 352)**.

b: menu to edit low set point   low set point: ___________
Press the select button (right) to enter the "edit low SP" screen **(Fig 353)** Press the select button again to edit the low setpoint value. Pressing the menu button will change the value incrementally and continue to roll over until a value is saved using the select button.

Fig. 352

Fig. 353

Fig. 354

c: menu to edit high set point high set point: ________
Press the select button (right) to enter the “edit high SP” screen **(Fig 354)**. Press the select button again to edit the low setpoint value. Pressing the menu button will change the value incrementally and continue to roll over until a value is saved using the select button.

39: Diluent system leak test (2 steps)
This test will determine if there are any leaks in the diluent system.

a: turn off diluent tank valve

b: watch gauge for pressure drop
Watch the diluent pressure gauge for at least a minute, looking for any pressure drop. If the diluent pneumatics are slowly losing pressure you can use a spray bottle filled with soapy water to track down the leak **(Fig 338)**. Never dive the Prism 2 with leaks in the diluent system as catastrophic loss of pressure could occur during a dive. Turn the diluent tank back on.


Fig. 338

40: Confirm alternate air source operation
If your Prism 2 is equipped with a BOV, switch to open circuit mode and breathe from it to verify that it is operational. If your Prism 2 is equipped with a Hollis 410 or other alternate air source, breathe from it. If your diluent system has multiple alternate air sources attached, switch from one to the other.

41: Check buoyancy compensator inflation, air holding and deflation mechanisms
Auto-inflate the buoyancy compensator partially and verify that it is holding pressure. Deflate the buoyancy compensator by letting a little air out of each deflation mechanism.

42: Record diluent pressure: ________________
How much diluent did you use during set-up, and how much diluent do you have left? Is it enough? Recording the post-setup diluent pressure will insure that you are aware of how much gas you have prior to commencing dive operations.

If diving immediately, continue with immediate pre-dive checks now.

Skip to step # 43

If NOT diving immediately:

Close O_2 and diluent cylinder valves & drain lines, turn off electronics and secure unit

Immediate pre-dive checks & system settings

43: Verify dive plan with buddy
Make sure that you and your buddy have gone over the dive plan and you are both clear on the stated objectives of the dive and any emergency or contingent planning or considerations that should be discussed prior to entering the water.

44: Install weights (3 steps):
After some trial and error you will figure out how much weight you will need to safely dive the Prism 2. How you choose to distribute that weight is mostly a comfort issue, based on your physical build. The Prism 2 has weight pockets sewn into the back of each counterlung, and waist dump pockets on the factory supplied buoyancy compensator and several locations to mount trim weights. The only hard and fast rule regarding weight distribution is that the majority of the weight must be easily ditch-able in the event of a catastrophic loop flood on the surface or any event requiring an emergency buoyant ascent from depth.

a: counterlung
Each counterlung can hold up to 5 pounds of either hard or soft lead. How much lead you use is up to you, but most people report that 3 or 4 pounds is sufficient to offset counterlung buoyancy.
Some Prism 2 divers prefer not to add weight to the counterlungs. Again, weight distribution is mostly a comfort issue. What works for one person may not work for another.

b: buoyancy compensator
The detachable weight pockets can hold up to 10 pounds each of hard or soft weight.

c: trim weights
Depending on your system configuration, you may have various trim weights on the system.

Since trim weights are not easily ditch-able in an emergency, use them sparingly, and make sure that the total non-detachable weights, plus the weight of a fully flooded loop (17 Lbs.) is not greater than the buoyancy compensator can lift and maintain positive buoyancy on the surface.

45: Verify LED primary display is powered on.
Turn on the primary electronics while watching the LED Primary Display. All LEDs on the LED Primary Display should begin to blink, reporting the O_2 content of the loop. (If the primary display blinks orange for 30 seconds at start-up, you must change the battery before diving (step 34).

46: Don unit, secure fasteners, tighten belts
Attach counterlung straps, crotch strap(s), cummerbund and waist strap, and tighten as needed.

47: Verify oxygen and diluent valves on (3 steps)
a: diluent valve check:

Reach behind you with your left hand and verify that the diluent valve is ON (rotate valve downward). Check the diluent pressure gauge.

b: oxygen valve check:
Reach behind you with your right hand and verify that the oxygen valve is ON (rotate valve upward). Check the oxygen pressure gauge.

c: activate manual gas addition valves (O_2 and diluent) while watching SPGs.
While watching the diluent pressure gauge, momentarily depress the ADV.
While watching the oxygen pressure gauge, momentarily depress the O_2 manual addition valve.

48: Secure secondary display on wrist.
The Secondary display has 2 elastic bands with plastic fastening clips. The easiest way to mount the display on your wrist is to rest it upside-down on your thigh, place your wrist on top of the display and place the straps around your forearm, clipping them together. Tighten the straps down as required.

If you are diving with a dry suit or heavy gloves, it may be easiest to ask for assistance in securing the secondary to your wrist.

49: Verify secondary display is powered on
Turn on the secondary by depressing both switches. Look at the secondary display and verify the content of the loop, that all three O_2 sensors readings agree, the battery is charged and the set point is set correctly for the dive.

50: Switch active setpoint to "low setpoint" (>/= 0.4)

51: Verify loop contents are within user set limits on secondary display
You should not attempt to breathe from the loop if the secondary display indicates the O_2 content in the loop is less than your pre-set low setpoint.

At this point in the set-up, the computer should be monitoring the O_2 content of the loop and adding O_2 to keep the loop at your user selected low setpoint. If the loop PO_2 is low, check that you have not accidentally switched from low setpoint to the 0.19 PO_2 setting in the computer.

Do not dive your Prism 2 until the computer can maintain your pre-set loop PO_2.

51: Pre-breathe checklist (6 steps)
Pre-breathing gives you time to verify that all systems are go prior to entering the water. It is unlikely that even a 5 minute pre-breathe can identify a problem with the absorbent, or even verify that you have installed the absorbent basket in the loop! So don't allow a pre-breathe regimen to lull you into a false sense of security. Remain vigilant, especially during the first few minutes of a dive, for any signs or symptoms of CO_2 buildup, and bailout to OC at the first hint of trouble.
To do a proper pre-breathe, block your nose by pinching it and remain securely seated throughout the pre-breathe while constantly monitoring and maintaining a safe loop PO_2.

a: check ADV operation: Automatic and manual
Breathe the loop down (breathe in from mouth, exhale from nose) while watching the diluent SPG, until the diluent addition valve fires. The SPG needle should not move. Now depress the ADV body until the valve fires. This will lower the loop PO_2 and may lower it enough to cause the electronics to fire the solenoid (see next step). Continue breathing from the loop.

b: solenoid oxygen addition
If the previous step brought the loop PO_2 low enough that the solenoid fired to raise the PO_2 back to setpoint, this step can be considered completed. If it did not, you can continue to breathe from the loop until you metabolize enough O_2 to cause the solenoid to fire. Do not assume that the solenoid will fire! Watch your PO_2 on the Secondary Display. Continue breathing from the loop.

c: manual oxygen addition
Momentarily depress the manual oxygen addition valve while watching the O_2 SPG. You should hear (or feel) oxygen enter the loop and the SPG needle should not move.

d: BCD inflation / deflation
Partially inflate the BCD and then check that all the deflation mechanisms of the BCD are operational and easily accessible.

e: verify SPG's: oxygen, diluent, open circuit bailout supplies
Check the pressure in each cylinder and verify that you have the planned amount of gas available in each cylinder. Continue breathing from the loop.

f: observe setpoint maintained within user set limits on Primary and Secondary Displays
Once you have metabolized enough loop O_2 that the electronics register the drop and fire the solenoid, watch how the O_2 sensors react. They should not register a large jump in PO_2 but an incremental increase over 3 or 4 breaths back to the active setpoint. If you see a wild swing in PO_2, DO NOT DIVE THE REBREATHER as that would indicate a serious problem with the electronics that could lead to possible injury or death.

Don't forget to do your bubble and cell limiting checks at 15ft/5m and have a safe dive!

Warning:
Never begin diving operations until a loop pre-breathe has been successfully completed. Failure to adhere to this pre-dive rule can result in injury or death.

Field Notes
Save gas, manually inflate the BCD during setup when feasable!

Post-Dive Operations

Matthew Addison

The Post-dive Checklist

Name: ____ Date: ____/____/________

- ☐ Verify and record batteries, Turn off electronics

Solenoid battery:	V:________	Good ☐	Replaced ☐
Secondary display battery:	V:________	Good ☐	Replaced ☐
Primary Display:		Good ☐	Replaced ☐

- ☐ Secure secondary
- ☐ Drain counterlungs of fluid
- ☐ Remove CL weights
- ☐ Remove weight pockets, weights, rinse and hang to dry
- ☐ Soak complete, sealed unit in fresh water for 20 minutes if possible or hose off with fresh water
- ☐ Turn off O_2 and drain lines, remove tank
- ☐ Turn off diluent and drain lines, remove tank
- ☐ Detach Bucket from head, record absorbent usage or discard absorbent material

  Stored for re-use ☐ Discarded ☐

  Date packed: ___/___/_____ Size: ______ Total hours used: __________
- ☐ Disinfect bucket.
- ☐ Inspect O_2 sensors, record readings in air

  Sensor 1: _________ Sensor 2: ___________ Sensor 3: __________
- ☐ Disassemble mouthpiece to counterlung hose assembly, disinfect, hang to dry
- ☐ Remove counterlungs, disinfect, hang to dry
- ☐ Drain and hang BCD/backplate/head assembly in shaded area to dry
- ☐ Review maintenance/repair log and address any repairs if required

Post-dive Checklist – Step by step

During the post-dive tear-down, pay attention to each part looking for any damage or wear that would require maintenance or repair. Record the damage in your maintenance/repair log and address the needed repairs immediately after finishing your post-dive checklist.

☐ **Verify and record batteries, Turn off electronics**
This is a good time to verify that the batteries in your Prism 2 have enough power for continued use. Should you need to replace a battery, it is better to find out now than to be scrambling for new batteries during set-up.

Solenoid battery: **V:________** **Good ☐** **Replaced ☐**
Secondary display battery: **V:________** **Good ☐** **Replaced ☐**

From the main menu, depress the select button (right) six times until the lower display shows the solenoid (ext) and secondary display (int) batteries. A voltage reading of less than 3.28 volts for the secondary display and a voltage of 4 volts for the solenoid indicate a battery that must be changed. If you change a battery, make sure to notate it on your maintenance log so you remember to replace the battery in your spares kit.

Primary Display: **Good ☐** **Replaced ☐**
Turn off the primary display then turn it back on. If the display blinks orange continuously for 30 seconds upon turn-on, the battery must be replaced. Otherwise, consider the battery to be good, but have a spare in your kit just for safety. Remember, both the Primary and Secondary displays use SAFT 3.6V AA batteries.

☐ **Secure secondary**
Secure the secondary so it is not damaged during cleaning or tear-down. Pay particular attention to make sure the wiring is secured so you cannot snag it while moving the unit during cleaning and tear down.

☐ **Drain counterlungs of fluid**
Your exhale counterlung will have fluid in it which contains both water from your dive environment (fresh or salt) and saliva and other bio-fluids. Open the counterlung drain by loosening (unscrewing) the stainless steel locking collar and push the tip in toward the body of the drain. A viscous fluid, either clear or slightly milky white will drain from the exhale lung.

The Inhale lung should have no fluid in it. If it does, that would indicate a leak somewhere on the inhale side of the loop. Do not dive the unit until you have found and repaired the leak.

□ **Remove CL weights**
Remove any weights you had in the counterlung weight pockets. Not having the additional weight in the counterlungs will make them easier to handle.

□ **Remove weight pockets, weights, rinse and hang to dry**
Remove weight pockets if supplied, or any other removable weights from the unit. Soak the pockets in fresh water then hang to dry.

□ **Soak complete, sealed unit in fresh water for 20 minutes if possible or hose off with fresh water**
Submerge the rebreather in a fresh water rinse tank if one is available. Put the unit in the water and drain all the air from the counterlungs by holding the mouthpiece above water and opening it to let the gas escape from the loop. Also, drain all gas from the buoyancy system. Allow the unit to soak for 20 minutes.

If a rinse tank is not available, rinse the unit as best as you can with a hose. Pay special attention to the core of the system (head, bucket, bladder, pneumatics). Any items that will be removed for disinfecting in the following steps can be soaked separately in a bucket or other small container.

□ **Turn off O_2 and drain lines, remove tank**
Turn off the O_2 tank valve. Depress the manual O_2 addition valve until the pneumatics are fully drained. Unscrew the O_2 first stage, loosen the tank straps, remove the tank. Make sure to put the cover on the first stage DIN fitting.

□ **Turn off diluent and drain lines, remove tank**
Turn off the diluent tank valve. Depress the ADV until the diluent pneumatics are fully drained. The diluent first stage, loosen the tank straps, remove the tank. Make sure to put the cover on the first stage DIN fitting.

Detach Bucket from head, record absorbent usage or discard absorbent material

Stored for re-use □ Discarded □

Date packed: ___/___/_____ Size: ______ Total hours used: __________

It is extremely important that any absorbent that is not immediately thrown out is stored shortly after removal in an airtight container. This will insure that the moisture in the absorbent pellets necessary to maintain the chemical reactions that scrub CO_2 does not evaporate.

It is also extremely important that you track the usage of the absorbent pack so you do not accidentally over-use the absorbent pack beyond its serviceable life. Never use absorbent beyond its serviceable life. Using absorbent beyond its serviceable life can lead to injury or death. If you are ever in doubt, throw out the absorbent and re-pack with fresh material. Your life is worth far more than the cost of 6lbs/2.7kg of absorbent.

- ☐ **Disinfect bucket**
  If you are using Steramine or other dissolving disinfectants, the scrubber bucket is a great vessel to mix up 1 gallon / 3.78L of disinfectant and soak the breathing hoses, DSV/BOV and moisture pad, then pour the remaining disinfectant into the counterlungs to disinfect them.

  For 1 gallon / 3.78L, fill the bucket to ¾' / 19mm below the latch strap.

  After using the disinfectant, either dry the bucket with a clean, dry towel or turn the bucket over and allow it to drip-dry.

- ☐ **Inspect O_2 sensors, record readings in air**
  Sensor 1: _________ Sensor 2: ___________ Sensor 3: __________

After settling in air for a few moments, each O_2 sensor should read 0.21ata O_2. Record the readings in either mV or atmospheres of O_2, whichever you feel is more relevant to your record keeping.

Acceptable millivolt range for a sensor in air is 10mV +/- 3mV.

- ☐ **Disassemble mouthpiece to counterlung hose assembly, disinfect, hang to dry**
  Disassemble the sub-assembly, open the DSV/BOV shut-down valve and let soak in the disinfectant. Stretch each hose and allow excess fluid to drain out, then place the hoses in the disinfectant, making sure there are no air pockets trapped in the hose.
  Remove the hoses and mouthpiece from the disinfectant and hang to dry.

- ☐ **Remove counterlungs, disinfect, hang to dry**
  Remove both counterlungs from the harness and drain any left over fluids by turning the lungs upside down and allowing the fluids to drip out of the hoses. Pour ½ of the disinfectant from the bucket into each counterlung, then slosh the liquid around inside the counterlung and hose. Drain the disinfectant and hang the lungs to dry.

Field Notes: Why disinfect your loop daily?

***A rebreather "loop" collects all sorts of biological material during a dive. There is your saliva, which fortunately is composed of 98% water. However the other 2% consists of compounds such as electrolytes, mucous, blood and various enzymes that normally begin the process of breaking down food, and probably food particulates. Then you add in seawater (if you are diving in the ocean) or freshwater, both of which contain living and dead microscopic creatures. Add the two together and you get a solution of microscopic creatures, undigested food particulates and various bodily fluids. Now, imagine allowing this solution to sit and putrefy for a few days in a dank, dark hole, all the while collecting more and more dead and dying biomass while you continue diving. Would you knowingly want to breathe from this? I didn't think so. Make it your habit to disinfect your breathing loop after each dive day and you will never have to think about this again*.**

☐ **Drain and hang BCD/backplate/head assembly in shaded area to dry**
Drain any water that might have collected in the buoyancy device then hang the unit core to dry somewhere away from direct sunlight and allow the fabric to dry.

❒ **Fill out maintenance/repair log and address any repairs if required**
Any items which you notated in your maintenance / repair log during the post-dive breakdown should be reviewed, and the parts in question re-examined closely and repaired or replaced as required. If parts are used from your spares kit, make sure to notate that so you can re-order replacements from your local Hollis Prism 2 dealer.

Prism 2 eCCR
Maintenance/Repair Log

Owner________________________________ **Date of report** _________________

Reason for maintenance (check one)

☐Pre-Dive Failure

☐Post-Dive Maintenance

☐Preventative/Scheduled Maintenance

☐ Part Replaced Reason

☐ Parts needing service Action

Operational Observations

____
____
____
____
____
____
____
____
____

☐ Replacement Parts need to be ordered to complete this maintenance

Date Part(s) ordered__________________ Expected delivery ____________________

Signed___________________________

Part 4

In-Water Skills

Prism 2 water skills and drills

Pre-Dive Equipment Check - The rebreather equipment check is similar to the buddy check you learned in your first open circuit diver course, with a few additions. The most obvious addition is that you will have to verify multiple gas sources. Lets quickly review the steps of your standard equipment check and add in the rebreather specific items:

B – Buoyancy Device: Check that all dump valves work, inflator is hooked up and working and the buoyancy device is holding air (not leaking).

W- Weights: Make sure the detachable weight system is in place and secure. (do not forget counterlung weights!)

Field Notes
Defining proper weighting
With all weights installed in your rebreather, you should float at eye level with minimum loop volume (see Field Notes: "Minimum, maximum and optimal loop volumes, and work of breathing" on page 155 in your counterlungs, holding a normal volume of air in your lungs. Upon exhaling out of your nose, you should begin sinking. For further information on weighting the Prism 2, refer to the article "Stability" on page 18.

R – Releases: Make sure all attachment points are secure (including tank straps), and you are familiar with their operation. Verify there are no entanglement issues and no hoses or other equipment are crossed over the front of the diver, making quick removal of equipment more complicated.

G – Gasses: *(This is where you will notice a departure from your open circuit class).* Verify all gas supply tank valves are open, and all gauges are showing full tanks. Verify that your diluent and O_2 addition valves are working by manually depressing them. Verify that all on and off-board bailout sources are operational (410,BOV, off-board bailout system) by breathing from them while monitoring their respective SPGs to insure proper function.

E – Electronics: If your electronics (primary and secondary) are not already powered up, turn them on and verify that the loop contents are within your pre-set values, and no alarms are showing.

Pre-Breathing your scrubber

Once you have completed your checklist and have donned the rebreather, you will complete a pre-breathe of the loop. This important safety step must be done to try and verify that the chemical reactions which take place in the scrubber bed and are needed to sequester gaseous CO_2 begin, and to warm up the scrubber bed.

Warning

Despite doing a pre-breathe, it is entirely possible that unhealthy levels of CO_2 can build up in the breathing loop for any number of seen and unforeseen reasons. You must remain vigilant for the symptoms of CO_2 poisoning at all times while diving a rebreather.

First, you must begin the pre-breathe by sitting someplace where, in the unlikely event you were to succumb to the effects of elevated CO_2 due to scrubber or equipment failure, you would not fall and get hurt.

To insure a proper seal of the loop and evaluation of loop integrity, either wear your scuba mask or pinch your nose to make sure you are not accidentally breathing in and out of your nose. If you do wear a scuba mask, make sure a buddy is close by and able to remove your mask should you become incapacitated.

Breathe normally, frequently looking at your primary and secondary display. Manually add oxygen as needed to keep your loop PO_2 slightly above its low setpoint, thereby conserving the solenoid battery. Monitor yourself for signs of carbon dioxide build-up, such as rapid breathing, shortness of breath or feelings of air starvation, dizziness, confusion, uneasiness or irritability and finally, unconsciousness. Also, monitor the loop for excessive work of breathing or strange smells or taste. If any of these issues present themselves, bail-off the loop immediately and look for the cause of the problem.

After breathing from the loop for a bit, shut down the DSV/BOV and continue your last minute pre-dive preparations. If you have to make any adjustments to the unit after discovering and resolving an issue, re-run your checklist and complete another pre-breathe prior to entering the water.

Skill #1 - The in-water bubble check

During your pre-dive checks, you immersed your Prism 2 in water for a preliminary bubble check. Now, you will complete your primary bubble check, this time with a buddy when you are in the water and ready to dive. This primary bubble check is critical to insure no part of the breathing loop has been compromised, damaged or dislodged during storage, donning or getting in the water. It is also a second pair of eyes, which will help insure nothing was overlooked during your pre-dive bubble check.

To do a proper buddy-assisted bubble check enter the water with your buoyancy device fully inflated, the DSV/BOV in your mouth, breathing from the loop. Make sure you hold the DSV/BOV securely in your mouth when getting in the water.

Warning

If you are doing a giant stride entry, the force of the gas in the loop being displaced by the water against the counterlungs will want to push the DSV/BOV out of your mouth. Keep your palm firmly against the DSV/BOV in your mouth until you settle comfortably in the water.

Field Notes

Buoyant entry

Whenever you first enter the water with a rebreather, your buoyancy device should always be fully inflated because should the rebreather experience a "catastrophic flood" on entry (the entire breathing loop fills with water), you would quickly become negatively buoyant. Without the buoyancy device inflated to offset that buoyancy loss, you could immediately begin to sink below the surface

Surf entries on rebreather might be a situation where you would want to enter the water breathing on the loop with the buoyancy device deflated so you can dive under the incoming waves. Once you are past the surf zone fully inflate the buoyancy system and begin your buddy checks. You and your instructor will discuss entry options.

Once you are in the water and ready to go, while holding onto a down-line, slowly deflate your buoyancy device until you submerge the unit a few feet below the surface. Your buddy will check for the telltale sign of leaking into the breathing loop... a stream of small bubbles. Also, your buddy will check inside the clear scrubber bucket for any signs of water intrusion. While your buddy is doing a full check, you should check the mouthpiece, hoses and counterlungs.

Initially there may be a small amount of air trapped in the buoyancy device material but they should dissipate quickly. If there are a lot of bubbles coming from everywhere, give the fabric a few moments to shed the trapped air. Sometimes, tapping the rebreather on one of its hard bits, or shaking the unit will help shed superficial bubbles quickly.

Warning

The one place where a leak could occur and you would not notice initially is the battery compartment. If you have a leak in the battery compartment, the primary display will stop functioning as will the solenoid. It is therefore important that you keep an eye on the primary display before you begin your descent, and for the first few minutes of the dive. If the display is not lit, bail-out to open circuit and discontinue the dive immediately.

Skill #2 – Controlled Descent

Prior to your initial descent you must verify that the oxygen content in your breathing loop is at your low set point with minimum fluctuation of O_2. Look at your primary and secondary O_2 sensor readings to verify your breathing gas is within these limits, and the readings are steady. If you had taken the DSV/BOV out of your mouth while on the surface, exhale the air in your lungs while you put the DSV/BOV in your mouth. Continue exhaling through the DSV/BOV purge hole to clear any water in the mouthpiece. Open the DSV/BOV valve and breathe normally. Signal your buddy to begin your descent. Purge your buoyancy device of air and begin slowly descending, using a down line, if available, to control your descent. Don't forget to equalize.

Field Notes

Exhale first

The reason you should exhale all the air in your lungs prior to opening the loop is two-fold. First, you will expel any water that may have been in the mouthpiece, and second, you do not want to introduce any outside gases into the breathing loop, unintentionally changing the gas mix.

Skill #3 – DSV and BOV shut-down

Whenever the DSV/BOV is out of your mouth, it must be shut down, so loop gas does not escape and water does not enter the loop. This is probably one of the most difficult skills to get used to, other than buoyancy; if you are used to working with open circuit equipment. Practice the DSV/BOV shut down drill until it becomes second nature. An accidentally flooded loop ruins a perfectly good dive.

DSV Operation

To accomplish the DSV shut-down drill, put one hand on the mouthpiece body to hold it in place and operate the mouthpiece barrel knob with the other hand, pulling it down toward your chin - Verify that it is sealed by blowing into the DSV - You should see bubbles coming out of the purge orifice. Eventually you may find you can shut-down the valve with one hand, but for now use two hands to make sure you do not accidentally pull the mouthpiece out of your mouth while it is still open. Once you have verified the valve is sealed, re-open the mouthpiece and resume normal breathing.

BOV Operation

The bail-out valve (BOV) operates in much the same way as the DSV, but when you rotate the mouthpiece lever in a downward position, you are closing the loop and switching it to open circuit mode. The BOV works the same as the “open up” and “shut down” DSV, but has the addition of a third position wherein the lever also pulls out and up to seal the breathing chamber. Sealing the chamber prevents the BOV from free flowing, either on the surface or underwater. To complete shut-down skill with the BOV, simply “shut-down” the BOV to open circuit mode, take a breath or two in OC mode, exhale the OC gas then “open up” the valve and breathe from the loop.

Mouthpiece skills are “habit drills” and your old habits of spitting out your OC second stage may prove hard to break initially. Your instructor will have you repeat DSV/BOV shut down many times throughout your course. DSV/BOV shutdown, whether underwater or on the surface is an integral step in all emergency bailout drills, so it MUST come as second nature muscle memory.

Field Notes
“Open-Up, Shut-Down”
When Operating the DSV/BOV lever, try to remember “open up” to open the loop and “shut down” to close the loop.

Field Notes
The Hollis 3-position BOV
On the surface with the BOV, you will want to pull the lever up past the closed circuit mode stop and into the sealed mode so the BOV second stage does not free flow when you let the BOV second stage drop into the water.

Skill #4 - Mask Clearing

Unlike Open Circuit mask clearing where you might exhale fully to clear a mask, in rebreather diving your objective is to clear the mask of water, but not exhale more gas that is absolutely necessary. Therefore, when you clear your mask, try to do so without a great stream of bubbles coming out of the mask after you have displaced the water by exhaling through your nose. You will find that a bit of patience and more attention to the skill will help you accomplish this easily, and minimum gas mask clearing will become second nature quickly.

Skill #5 - Remove, clear and replace DSV/BOV

In skill # 3, you practiced shutting down your DSV/BOV while it remained in your mouth. In the DSV/BOV removal drill, you will shut down the DSV/BOV as before, then remove it from your mouth. In so doing, the mouthpiece portion will fill with a small amount of water.

Remember to exhale tiny bubbles whenever the mouthpiece is out of your mouth.

To purge the water, simply replace the DSV/BOV in your mouth and blow a small amount of air into it with it in the shut position. This will force the water through the purge hole in the bottom of the DSV or through the drain valve in the BOV. As soon as you see or hear bubbles coming from the purge hole/drain, switch the DSV/BOV to closed circuit mode and resume breathing normally.

Field Notes

Unlike Open Circuit systems, there is no "purge button" on the DSV to purge water from the mouthpiece if you do not have enough breath in your lungs. If you ever find that you have removed the DSV/BOV from your mouth but do not have enough gas to manually purge it, switch to your on-board alternate air source (see skill #6 below), take a breath from it, switch back to the DSV/BOV and purge. Remember to fully exhale that breath through the purge prior to opening the DSV/BOV.

Skill #6 - Emergency Bailout - Onboard breathing gas

If you have equipped your Prism 2 diluent-side second stage, you will practice switching between the breathing loop and the second stage to simulate an emergency bailout. If your Prism 2 is not equipped with an onboard bailout, you will skip this skill.

For systems using DSV

First, locate the second stage, then close down the mouthpiece and remove it from your mouth.

Remember to blow tiny bubbles whenever the mouthpiece is out of your mouth

Put the alternate air source in your mouth and purge it by blowing air into it, or depressing the second stage's purge button. Take a few breaths from the alternate air source, and then switch back to the DSV. Remember to fully purge the air in your lungs by blowing through the DSV purge orifice prior to opening the mouthpiece. Failure to do so will introduce a breathing gas with a lower oxygen content thereby changing the mix in your breathing loop, and altering your buoyancy. If you forget, simply exhale from your nose to lower the loop volume, then adjust PO_2 as needed.

For systems using a BOV

Exhale fully into the loop and then pull the BOV lever down to the open circuit position. Clear the BOV by pressing the purge button on the face of the BOV. Take a few breaths, then exhale fully and open up into closed circuit mode and breathe normally.

Skill # 7 - Manual addition of diluent

The Prism 2 comes equipped with an Automatic/Manual diluent addition valve (ADV) located on the front of your left (inhale) counterlung, slightly below the breathing loop elbow. During descent, as the volume of gas in your loop decreases, the automatic diluent addition valve will add gas volume to the loop when the actuator in the valve hits the strike plate inside the counterlung.

However, there may be times you want to add additional diluent to the loop manually, such as when you want to "fly" the rebreather at a set point other than is programmed into the on-board computer, if you find that the PO_2 is too high and wish to quickly bring it down or if you simply wish to add gas volume to the loop to match your breathing volume.

To manually activate the valve, simply depress the body of the valve inward toward the strike plate until you hear gas entering the loop. You can control how much gas enters the loop by using short bursts of gas, until the desired effect is achieved. If you are attempting to reduce the PO_2 of your loop, add a small amount of diluent, breath normally for approximately 5 breaths while watching the readouts of the 3 oxygen sensors on your secondary display. Continue to add diluent and repeat the breathing cycle until the desired PO_2 has been reached or the desired gas volume is achieved.

Field Notes
Gas physics and the Diluent addition valve
Remember, as you descend in the water column, the partial pressure of oxygen in your loop will increase as overall volume decreases, so the addition of diluent is critical at this stage. Your instructor will teach you, and you must understand completely, the gas physics of ascent and descent before you enter the water.

Skill # 8 - Manual addition of oxygen

The Oxygen manual addition valve is located on the inside bottom of the right (exhale) counterlung facing the left counterlung. It is a "manual only" addition valve.

To increase the PO_2 in your loop, add one short burst of gas by depressing the button on the valve. Cycle your breathing approximately 5 times while watching the readout of the 3 oxygen sensors on your secondary display. Continue to add oxygen and repeat the breathing cycle until the desired PO_2 has been reached.

Be extremely conservative when manually adding oxygen to your loop, as it is essential that you do not add too much oxygen. Remember, a PO_2 above 1.4 should not be used under normal circumstances. Also, manually adding oxygen during descent should be done quite conservatively, if at all, as your PO_2 will increase simply by going deeper.

Skill # 9- Minimum (optimal) loop volume and the over-pressure valve (OPV)

The loop over-pressure valve is located on the front right (exhale) counterlung. It is designed to purge excess gas pressure from the loop automatically, such as during ascent from depth when the volume of gas in the breathing loop is increasing. The OPV should be continually adjusted as needed throughout a dive to maintain minimum loop volume.

To decrease the sensitivity of the OPV, thereby increasing the pressure and volume of gas inside the breathing loop, turn the OPV valve clock-wise several clicks. To increase sensitivity and purge excess pressure and volume, rotate the OPV counter-clockwise several clicks.

Your body position in the water will have an effect on the OPV. If you are in a horizontal diving position, the static loading on the OPV will be less than if you are in an upright position. You may find that when you change from a horizontal to vertical position while diving, the OPV will automatically vent gas. This is normal and is caused by the change in static loading. Adjust the valve as needed to maintain a comfortable volume of gas in the loop (see "Field Notes" below).

During ascent to the surface, you may want to fully open the OPV to allow the expanding gas in the loop to quickly bleed off. However, because the oxygen manual addition valve is on the same counterlung as the OPV, when manually adding oxygen during ascent you will want to add oxygen after the valve has purged excess pressure. Otherwise, your added oxygen will simply bleed out of the OPV and not enter the breathing loop and not increase the PO_2. You can also exhale excess gas volume from your nose to keep the OPV from actuating while injecting oxygen . Oxygen injected by the solenoid will not be affected as it is injected in the exhaust plenum, after the OPV.

Minimum, maximum and optimal loop Volumes, and work of breathing

By Dr. Richard Pyle

The volume of gas contained in a rebreather loop (the hoses, canister, and counterlung(s) of the rebreather plus the diver's lungs) is seldom fixed. I define "minimum" loop volume as that volume of gas occupying the rebreather loop when the counterlung(s) are completely "bottomed-out", and the diver has completely exhaled the gas from his or her lungs. Conversely, "maximum" loop volume is the volume of gas in the breathing loop when the counterlung(s) are maximally inflated, and the diver has maximally inhaled gas into his or her lungs. Although the magnitude of the difference between these two volumes $([Vmax] - [Vmin])$, *will vary from one rebreather design to another, it will always be non-zero.*

Rebreather divers must learn to maintain the loop volume close to its optimal level for their particular model of rebreather. If the volume is maintained too close to $[Vmin]$ *the counterlungs will tend to "bottom-out" on a diver's full inhalation. If the loop volume is maintained too close to* $[Vmax]$ *the overpressure relief valve will tend to vent excess gas at the peak of a diver's full exhalation. Furthermore, total loop volume will influence work of breathing due to hydrostatic effects.*

On rebreather models with a relatively large value of $([Vmax] - [Vmin])$, *the optimal volume should ideally be closer to* $[Vmin]$ *for models with a relatively small value of* $([Vmax] - [Vmin])$, *the optimal loop volume should be ideally close to the mid-point. In either case, the diver should maintain the loop volume at whatever level results in the minimum total work of breathing and gas loss.*

Skill # 10 - Manually maintain set point while stationary

Manually maintaining set point is simply a function of replacing the oxygen in the loop as it is metabolized. As easy as it sounds though, in practice, it takes concentration since we use O_2 at different rates throughout a dive. When you hear people discussing “flying manually” this is the skill set they are discussing. “Flying manually” means you must continually monitor your PO_2, adding oxygen via the manual O_2 addition valve to replenish the metabolized oxygen in your loop. In effect, you become the computer.

Your Instructor will have you set your computer to .7atm O_2 setpoint with the electronics on for safety, however at this stage of your training your instructor will give you a new higher set point, which you will learn to maintain manually while learning new skills and mastering skills you have already practiced.

Remember to allow for several breath cycles after manually adding O_2, as the gas has to move from the exhale counterlung, through the scrubber and up to the O_2 cells to register on your electronics. Your breathing is the engine that moves the gas through the loop. Repeat the process to manually maintain the required set point.

Skill # 11 - Manually maintain set point during descent

As you read in your training manual, while descending to depth on a rebreather, several things are happening. The volume of gas in your loop is decreasing and the PO_2 is increasing. Because the gas molecules are compressing, you will need to add diluent to the loop to keep the volume of gas adequate for comfortable breathing. The automatic/manual diluent addition valve on the inhale counterlung will automatically add diluent as you breathe to compensate for the increased pressure/decreased volume in your loop. But what about the increasing PO_2?

Fortunately, this is where the diluting capacity of the diluent comes into play. By adding diluent, you automatically drop the PO_2 in your loop. However, when descending on a rebreather, you must do so slowly, watching your PO_2 on your secondary to make sure it does not go above your set point. Should you find that the PO_2 is too high at any point during descent, you can exhale from your nose and add a compensating amount of diluent to the loop, thereby slightly dropping the PO_2. It is recommended you use a descent line to easily arrest your descent should you need time to adjust your PO_2 to keep it from spiking. If you find that your PO_2 has dropped below your setpoint, descend until the PO_2 reaches your setpoint. You will rarely need to add oxygen during descent.

Skill # 12 - Neutral Buoyancy practice

Neutral buoyancy is not something which can be mastered in a classroom. We can teach the physics of neutral buoyancy and how to attain and maintain neutral buoyancy, but until you are in the water practicing the skill you will not begin feeling it. Neutral buoyancy is all about “feel”. As you learned in your open water class, you know that inhaling a lung full of gas will increase your displacement of water, making you lighter so you can ascend, and exhaling will decrease your displacement of water, making you heavier so you can descend.

In closed circuit diving, none of this applies. Remember, you are simply moving your breathing gas from one flexible membrane (your lungs) to another flexible membrane (your counter-lungs). Therefore we must rely on our buoyancy device to maintain neutral buoyancy. Every open circuit trained diver who takes a rebreather class always comments in frustration that they have to re-learn their buoyancy skills. This is normal and you will quickly learn to adjust.

This means the fin pivot as a way of attaining neutral buoyancy is out. It won’t matter how much you breathe in or out. Your buoyancy won’t change.

To maintain depth with a rebreather, you will add just enough air to your buoyancy device to get you neutrally buoyant and when swimming, use your body as a rudder and your fins as propeller. If you want to go up slightly, bend your body so your head and chest are higher than your lower body and kick with your fins. If you want to descend slightly, put your head and shoulders down while kicking.

As you change depths, inflate or deflate your buoyancy device as needed but never use your buoyancy device as an elevator button, allowing the equipment to control your ascent or descent. Remember, ascents and descents on a rebreather must be slow and deliberate to control and maintain your PO_2.

Skill # 13 - Manually maintain setpoint swimming

With this skill, we are combining two important skills into one and creating a real-world scenario. When practicing your setpoint maintenance while remaining stationary, you were able to concentrate solely on that single aspect of rebreather diving. You have practiced your buoyancy and now have an idea of what the equipment feels like when you are “dialed in”.

Start swimming while watching the 3 oxygen sensor displays on your primary and secondary displays, verifying that all 3 sensors are at your target setpoint. Since you will be swimming, your oxygen metabolism will increase and your PO_2 will fluctuate if you are changing depths. Try to maintain your setpoint within 1/10th of an atmosphere PO_2. Continue watching your oxygen sensors as you work with your manual gas addition valves.

This skill is as much about building muscle memory (instinctively knowing where the gas addition valves are) as it is about holding setpoint. Don't get frustrated if your setpoint initially swings more than 1/10th ata PO_2. You'll get it!

Skill # 14 - Manually maintain setpoint on ascent

On ascent, our PO_2 will be dropping and our loop volume will be expanding which is exactly the opposite of what happens on descent.

To begin your ascent, watch your secondary display, verify that your OPV is opened sufficiently to easily vent the expanding gas and place one hand on the manual oxygen addition valve.

Begin to slowly ascend (no faster than 10m/30fpm) watching your PO_2 on your secondary display. Add oxygen to maintain your setpoint, but remember that you should not add oxygen while your OPV is venting gas as the added oxygen will vent with the expanded gas. One trick is to exhale some of the expanded loop volume from your nose while adding oxygen to offset the added pressure of that added oxygen without actuating the OPV.

Field Notes

Buoyancy Warning

During your ascent from depth, the Prism 2 will be automatically adding O_2 to maintain loop PO_2, and that can have a significant effect on the buoyancy of the diver. You will need to dump gas from your buoyancy device, dry suit and counterlungs to avoid an uncontrolled ascent. It is very important that you ascend no faster than 10m/30fpm per minute to avoid a runaway ascent on your CCR. Until you have sufficient experience with your Prism 2, you should use an up line during ascent.

You will want to be continually dumping air from your buoyancy device, dry suit and counterlungs (exhale through your nose) to maintain minimum loop volume

Field Notes
PO_2 Warning
Never allow the PO_2 in your loop to go above 1.4ata oxygen. If you do accidentally spike your PO_2, exhale through your nose and inject diluent, then breathe normally and monitor the drop in your PO_2. Repeat if necessary to bring your PO_2 back to your target. Continue to monitor your PO_2 on your primary and secondary display and add gas as needed to maintain your new setpoint.

Skill # 15- Clear water from hose

Since learning skill # 3, DSV/BOV shutdown, you have become quite proficient at closing your DSV/BOV before removing it from your mouth underwater and on the surface. In a perfect world that would be the end of it. Water would never enter your breathing loop. But this world isn't perfect and neither are the divers around you. Someone, some day, may accidently kick that DSV/BOV out of your mouth. You, however, will NEVER remove an open DSV/BOV from your mouth, right? Because, through all that practice you are now perfect!

Accidental flooding is not the only way to get fluids into your counterlungs. If your dive is long enough, you may find that water has entered the loop around your lips and enough has drained into your exhalation counterlung that you hear bubbling in the exhale counterlung whenever you manually add oxygen. Water leaking around your lips is normal and does not mean that you should chastise yourself for allowing a small amount of water into the loop. Even through normal breathing, the moisture in your exhaled breath will condense in the exhale hose and collect in the bottom of the exhalation counterlung as a viscous fluid mix of saliva, salt water and fresh water.

On your instructor's signal, remove the DSV/BOV from your mouth with the valve open and the mouthpiece facing downward (remember to blow any bubbles when the mouthpiece is out of your mouth). Turn the mouthpiece up for 1 or 2 seconds and then put the mouthpiece back in your mouth and exhale forcefully to move the water from the valve chamber past the exhalation valve into the exhalation hose. There are two methods to clear the exhale hose of water.

Lean slightly to your right and allow the water to drain into your exhalation counterlung. The directional mushroom valves inside the DSV will block the water from entering the inhalation side of the loop, so it can only go to the exhalation side. You can also close the mouthpiece, lift the hose assembly above your head and allow the water to drain into the exhalation counterlung.

Remember to blow tiny bubbles whenever the mouthpiece is out of your mouth

Each of your counterlungs has a drain valve located on the bottom of the counterlung. On the end of the drain valve you have a silver twist lock, which should be closed for diving. Fully loosen the lock mechanism. During your exhale cycle, push the drain nib back towards the valve body. This will open the drain and allow the liquid inside the counterlung to vent out. You only open the valve during exhale so the back pressure inside the counterlung helps force the fluid out. Let go of the nib during your inhale cycle. Repeat the process until you see a stream of bubbles exit through the drain valve.

Draining the counterlung can be a very slow process. It may take a minute to fully drain the counterlung, depending on how much water has entered. If you are in salt water, you may see that the fluid exiting the drain creates a halocline (salt water mixing with fresh water) as it vents. If you are absolutely positive that no draining is occurring, you may increase the pressure in the loop slightly by adding a small amount of diluent too increase loop pressure and help fluid out of the drain. Watch your buoyancy though, as adding diluent will increase your positive buoyancy.

Warning

Inhalation lung flooding

If you find a lot of water collecting in your inhalation counterlung during a dive, this IS NOT normal and indicates a potentially dangerous leak in the loop. If you find water building up in your inhalation lung, immediately switch to your bailout and abort the dive. Once safely on land, track down and repair the leak prior to diving again.

There are four areas where water could be entering the inhalation side of the loop and draining into the inhalation counterlung

The first and most critical area would be the absorbent bucket. A leak here would soak the CO_2 absorbent and create a caustic fluid, which will then travel into the inhalation counterlung And, If left unchecked, eventually into the divers mouth, causing skin burns and great discomfort if not serious injury. (see medical directives in MSDS)

Usually these types of floods occur slowly enough that you will notice the work of breathing getting harder and you may hear gurgling water when you attempt to breathe in. If you suspect an inhalation side leak, bail out immediately and signal your buddy to have a look in your clear bucket.

A hole or tear in either inhalation side breathing hose will also cause water to leak into the counterlung, but if the leak is in the DSV inhalation hose, the water will also drain directly into the mouthpiece.

Lastly, the counterlung or the attached hardware itself could be leaking. Check that the silver locking collar on the counterlung drain is tight. Check that the ADV and hose elbow are screwed down completely.

Skill # 16 - Diving with off-board open circuit system (bailout tank)
Up to this point in your training, you have been using your on board diluent as an emergency bail out system for dives down to 60fsw/18msw if so equipped. We will now introduce into your kit an off-board bailout system for dives deeper than 60fsw/18msw.

The Prism 2 has D-rings incorporated into the design specifically for use with a bailout tank. The tank must have the necessary attachment hardware installed for you to clip the bottle to the D rings. Always clip the tank with the valve facing forward. This will make it easy to verify that the air is on, and remove any entanglements that may occur during a dive.

Adding an off-board bailout system to your rebreather will add weight and bulk to the system on the surface, but you will find that once underwater, the added weight and bulk of the system will mostly disappear. It is important that you spend a moment adjusting your buoyancy to accommodate the added weight of the off-board cylinder. If you find that you are having difficulty carrying the added weight on the surface, carry the bailout tank to your ingress point before donning the rebreather, and then clip the bailout tank on once you are in the water. Your instructor can help you do this until you become familiar with finding the D-rings by feel. It is far better to stage your equipment close to the water and get assistance, than jump in the water already exhausted from unnecessary exertion.

Before beginning your dive, turn on the bailout tank valve and fully charge the regulator. Verify that the bottle is full by checking the pressure gauge, then shut off the valve leaving the regulator fully charged. We turn off the air so there is no chance that a leak or free-flow can drain the air from the system while we are entering the water. We leave the regulator charged so if you do need to suddenly switch to your bail out during entry, there is at least 1 breath available to draw from while you are turning on the tank. Once underwater, turn the bailout tank on and do not turn it off until you are out of the water.

Your Instructor will demonstrate the skill then will give you the out-of-air signal. Pull the regulator second stage hose free from the elastic hose stowage cords. Make sure the second stage is right side up and place it in your mouth while verifying that the tank valve is turned fully on. Close the DSV/BOV and remove it from your mouth.

Place the bailout second stage in your mouth, purge it and breathe normally. Signal your buddy and prepare for your ascent.

Remember to exhale tiny bubbles whenever the mouthpiece is out of your mouth.

Check your secondary to verify that you are at your set point. Stow the regulator hoses back under the stowage cords to avoid entanglements. Close the bail out tank valve, leaving the regulator charged.

Now that you have two bailout systems available, the question arises as to which one to deploy first in an emergency. Always deploy your off-board system first and leave your diluent supply available to fill your buoyancy device once you are on the surface. Should you need to deploy the bailout bottle to assist another diver in an out-of-air emergency, give them the bailout regulator, remembering to check that the air supply is turned on.

Field Notes
Do not ascend
Because we are only practicing switching to bailout, for now you can take a few breaths, remove the second stage and place the DSV back in your mouth. Fully purge any air from your lungs through the DSV/BOV purge hole then open the DSV/BOV and resume normal breathing.

Skill # 17 – Off-board bailout assist of another diver
Should you be called on to supply air to another diver, you should deploy your off-board bailout system. It may be preferable under certain circumstances to unclip the bailout system, and hand it off to the out of air diver once they are breathing from the second stage. Once you have handed off your bailout system, you must begin your ascent to insure that you reach the surface safely with whatever diluent remains in your onboard tank. Remember, you only have the small amount of diluent which remains in your on-board tank to get you to the surface if you too have an emergency.

Your instructor will give you the out of air signal and have you deploy your bailout regulator. Once your buddy or instructor is breathing comfortably on your bailout regulator and has given the OK signal, unclip the tank and hand it off. Once you have completed the skill successfully, your instructor will hand back your bailout system for you to secure back onto you kit.

Skill # 18 – Valve shutoff drills
In the unlikely event that one of the two pneumatic systems (oxygen/diluent) on the Prism 2 loses containment, you would want to first isolate which system is leaking, so you can make a judgment on how to safely return to the surface.
Since we are most concerned with preserving our bailout gas, turn off the diluent tank first.

Diluent Pneumatics

If the diluent system is found to be leaking, but the oxygen side appears fine, you must abort the dive, but you can stay on the loop during your ascent to the surface. Since you won't need diluent until you reach the surface (unless an on-board bailout is required), turn the diluent valve until only a trickle of gas is escaping from the leak. Maintaining positive pressure in the pneumatics will keep the diluent side of the loop from flooding. If you did need to breathe from the on-board bailout for some reason during your ascent, you could "feather" the valve, which means turn the valve on when gas was needed and almost fully shut when it was not. Once at the surface, you would need to turn on the tank to inflate your buoyancy device (or manually inflate the buoyancy compensator), and then turn the tank back to almost fully off to conserve diluent until you were "feet dry".

Oxygen Pneumatics

Now lets deal with the oxygen pneumatics. The first rule of a closed loop is, anytime you turn off oxygen, you must first switch to open circuit bailout. Never breathe from a closed loop that does not have a working supply of oxygen.

If the oxygen side of the loop had lost containment, immediately switch to open-circuit bailout. While you are ascending to the surface, turn the O_2 cylinder valve *almost* fully off but leave the valve cracked slightly so only a trickle of gas is escaping. This will allow some pressure into the pneumatics to keep the oxygen pneumatics from flooding.

Warning

Malfunctioning oxygen feed

Do not dive or breathe from a closed loop if any part of the O_2 pneumatics system normal operation is compromised. The correct course of action for an O_2 feed malfunction is for the diver to bailout to open circuit and abort the dive.

Skill # 19 – leak detection: Disconnecting quick disconnects underwater

Diluent Pneumatics

There are two quick disconnects on the diluent side of the rebreather. One is on the ADV and the other on the inflator. Should either system begin leaking, you can disconnect the gas feed hose.

If the leak is in the ADV and disconnecting and reconnecting the hose does not correct the problem, you must end the dive rather than continue diving with the ADV hose disconnected as that could allow water to enter the loop which could lead to a loop flood. If you must stay on the loop, you may "feather" the diluent cylinder valve (open valve only when gas injection is required)

O_2 Pneumatics

The one quick disconnect on the O_2 side feeds the manual oxygen addition valve. By disconnecting the manual O_2 addition valve hose, you can diagnose whether the O_2 leak into the loop is coming from the solenoid or the manual O_2 addition valve, as these are the only two oxygen paths into the breathing loop.
Disconnect and reconnect the hose. If you have a leak on the oxygen side of the system, you must bail out to open circuit while you deal with the problem. If you cannot correct the problem, stay on bailout; leave the O_2 manual addition valve disconnected and abort the dive.

Warning
Loss of gas containment
If your rebreather were to ever lose gas containment, such a malfunction requires that you bailout to open circuit and abort the dive immediately.

(See Field Notes: "Malfunctioning oxygen feed" above)

Skill # 20 – Changing computer set-points underwater

To manually change from low to high or high to low setpoint while underwater, from the main dive screen, press the MENU button once to go to the "Switch (value 1) -> (value 2) ". Press the SELECT button to switch.

Skill # 21 – Bailing out the computer to open circuit underwater

Depress the MENU button 3 times until you see "SWITCH (value)->(value)" where value is either OC or CC mode. Press the SELECT button to switch.

Skill # 22 – Deploying a surface marker buoy (SMB)

An important part of your rebreather kit will be an SMB (surface marker buoy) and line reel. The SMB will be used any time you are ascending to the surface or safety stop in open water and need to mark your location for a safe ascent.

To deploy the marker, uncoil the SMB and clip or tie the reel line to it. Keeping the SMB and line in front of you at all times, place your second stage alternate gas source below the bottom opening of the SMB and add enough gas to partially inflate the SMB. It is not necessary and you should not attempt to fully inflate the SMB underwater, as the gas in the SMB will expand as it ascends toward the surface. Holding the line reel at arms length, check to ensure that the line is clear of all your equipment. Let go of the SMB and allow the reel to unspool, keeping slight tension on the reel so the line does not become tangled mess (also known as a "birds nest"). Watch your depth and do not allow the SMB to pull you towards the surface as it ascends. It is very important to keep the reel and line in front of you at all times so you do not become entangled in it, and get pulled to the surface.

You can use the SMB line to maintain your depth once it is on the surface and doing so will keep the SMB standing up in the water so it is easier to see from a boat or shore. Reel the line in as you ascend and once on the surface you can re-stow the SMB and reel as you make your way back to the shore or boat.

Field Notes: Using a drysuit with a rebreather

Except in the coldest environments where argon gas is used for dry suit inflation or when using a helium mix in the diluent, most people simply plumb their dry suits into their on-board diluent gas. This is acceptable if you are doing short and shallow dives (1 hr. or less, 60ft or less) without a lot of depth changes. However, if you will be doing longer and/or deeper dives, or dives with a lot of depth changes, to properly manage and conserve bailout gas you should consider using a small-dedicated dry suit inflation system.

Skills and Drills Completion List

Pre-dive equipment check

1. **Calibrate oxygen sensors**	STUDENT________	INSTRUCTOR________
2. **Assembly, disassembly, cleaning, examining**	STUDENT________	INSTRUCTOR________
3. **Proper scrubber packing**	STUDENT________	INSTRUCTOR________
4. **Evaluating systems operations**	STUDENT________	INSTRUCTOR________
5. **In-water bubble check**	STUDENT________	INSTRUCTOR________
6. **Controlled descent**	STUDENT________	INSTRUCTOR________
7. **DSV/BOV shut-down**	STUDENT________	INSTRUCTOR________
8. **Mask clearing**	STUDENT________	INSTRUCTOR________
9. **Remove & replace DSV/BOV**	STUDENT________	INSTRUCTOR________
10. **Emergency bailout: On-board gas**	STUDENT________	INSTRUCTOR________
11. **Manual addition of diluent**	STUDENT________	INSTRUCTOR________
12. **Manual addition of oxygen**	STUDENT________	INSTRUCTOR________
13. **Minimum loop volume / OPV operation**	STUDENT________	INSTRUCTOR________
14. **Manually maintain setpoint: Stationary**	STUDENT________	INSTRUCTOR________
15. **Manually maintain setpoint: Descent**	STUDENT________	INSTRUCTOR________
16. **Neutral buoyancy**	STUDENT________	INSTRUCTOR________
17. **Manually maintain setpoint: Swimming**	STUDENT________	INSTRUCTOR________
18. **Manually maintain setpoint: Ascent**	STUDENT________	INSTRUCTOR________
19. **Clear water from hose**	STUDENT________	INSTRUCTOR________
20. **Diving with off-board bailout**	STUDENT________	INSTRUCTOR________
21. **Off-board bailout assist of another diver**	STUDENT________	INSTRUCTOR________
22. **Valve shutoff drills**	STUDENT________	INSTRUCTOR________
23. **Disconnecting quick disconnects**	STUDENT________	INSTRUCTOR________
24. **Changing computer setpoints underwater**	STUDENT________	INSTRUCTOR________
25. **Bailing-out the computer to OC underwater**	STUDENT________	INSTRUCTOR________
26. **Working with Prism2 Checklists**	STUDENT________	INSTRUCTOR________
• **Optional Skills**		
27. **Deploying an SMB**	STUDENT________	INSTRUCTOR________
28. **Using a drysuit with your rebreather**	STUDENT________	INSTRUCTOR________

By initialing each skill above, the student and instructor certify that the listed skill can be completed with mastery and no further remediation is required to move onto the the next skill. The student also certifies by initialing the skill theat he/she will continue practicing the skills after formal training has been completed.

______________________________	______________________________
Student	Instructor

The Language of Oxygen

When we talk about getting oxygen fills for our rebreathers, we speak about different grades of oxygen, such as “medical” grade, “aviation” grade and “welding” (or “industrial”) grade. Since we know from high school chemistry that oxygen only has one box on the periodic table, what do these different grades of oxygen signify?

To start off the conversation intelligently, we have to understand that different countries have different methods and nomenclatures for designating grades fit for a particular purpose. There is no sense going to all the trouble to purify or certify oxygen for medical use that is destined for a welding machine, is there? Being that the United States is the Prism 2’s home country, we might as well talk about the way things are done here.

The first thing to clear up is something that is heatedly debated on internet forums and that is, “Is oxygen a controlled substance in the United States requiring a prescription to get a cylinder filled?” The answer as with most things governmental is of course, yes and no.

USP Grades and their contents (in ppm)

Content	A	B	C	D	E	F	G
Oxygen Min. % (mole)	99.0	99.5	99.5	99.5	99.6	99.995	99.5
Water (v/v)			50	6.6	8	1.0	2
Dew Point (°F)			-54.5	-82	-80	-105	-97
Methane				50			
Nitrogen							100
Ethylene				0.4			
Acetylene				0.1			
Carbon Dioxide	300			10		1.0	5
Carbon Monoxide	10					1.0	
Total Hydrocarbons (as methane)					50	1.0	25
Ethane & Other Hydrocarbons				6			
Nitrous Oxide				4		0.1	2
Halocarbons				2			
Solvents				0.2			

The Designator USP that you often see associated with breathing gasses in the U.S. stands for “United States Pharmacopoeia” which is a standards group that has set forth minimum standards which must be met to wear the USP stamp.

USP oxygen is divided into 7 grades, designated simply as A, B, C, D, E, F and G. Grade A is the minimum requirement for USP oxygen. Grade E is commonly called “aviator’s grade”.

What divers can get without a prescription is the E, or “Aviator’s Grade” oxygen that while certified USP, does not require a prescription.

Recently, dive shops have been carrying oxygen with the designator “GMP” which stands for “Good Manufacturing Practice” and is equivalent to USP O_2 but is not classified as a controlled substance, similar to USP grade E, but is usually less expensive than USP oxygen.

What you do notice about all these grades of USP oxygen (and GMP) is that they are all almost devoid of contaminants, and completely stripped of argon. This is because they are manufactured by turning pure liquid oxygen (LOX) obtained through fractional distillation in a cryogenic air separation plant (a far more complex method than Pressure Swing Absorption: {see pg 70}) into its gaseous form.

PART 5

MAINTENANCE
&
TROUBLESHOOTING

Before we delve into maintenance of the various parts of the Prism 2, here is a list of parts which **ARE NOT** user serviceable and must be sent to your local Hollis Prism 2 dealer for service.

NON-USER SERVICEABLE PARTS

Solenoid
Solenoid Chamber Pressure Relief Valve
Primary Display
Secondary Display
Primary Display Piezoelectric switch
Electronics Compartment including printed circuit boards
Oxygen first stage
Oxygen Pressure gauge
Bail Out Valve (BOV)
Diluent first stage
Diluent pressure gauge
(Exhalation Lung) Loop Over Pressure Valve (OPV)
Counterlung drains

(DO NOT ATTEMPT TO UNSCREW THE WIRING FROM THE HEAD. THE CONNECTOR IS NOT A THREADED PART. YOU WILL DESTROY THE WIRING AND POSSIBLY THE HEAD HOUSING.)

(DO NOT ATTEMPT TO UNSCREW THE WIRING FROM THE CORE OR THE SECONDARY DISPLAY. THE CONNECTORS ARE NOT THREADED PARTS. ATTEMPTING TO UNSCREW THE WIRING WILL DESTROY THE WIRING AND QUITE POSSIBLY THE SECONDARY CASE AND/OR CORE HOUSING.)

The reason these parts are not considered user serviceable is because each part requires either specialized tools or processes to disassemble and reassemble without causing damage, or specialized calibration equipment to make sure the part is operating within certain design parameters.

If you wish to take a factory approved maintenance course that will teach you how to service some, but not all of these parts, contact your Hollis Prism 2 dealer. They can schedule a maintenance course in your area.

Attempting to disassemble or service any of the above listed parts will void the warranty coverage for those parts.

Prism 2 Preventative Maintenance Schedule

"S" = Service
"R" = Replace

Part	As needed	12 months	36 months	5 Years
Head to Inhalation Counterlung hose	S/R		R	
Head to counterlung hose connector O-rings	S/R	R		
Inhalation Counterlung	S/R			
ADV	S/R	S		
Inhalation mushroom valve	S/R			
Inhalation mushroom valve seat	S/R			
Inhalation Hose	S/R		R	
DSV O-rings (3)	S/R	R		
Exhalation mushroom valve	S/R			
Exhalation mushroom valve seat	S/R			
Exhalation hose	S/R		R	
Exhalation counterlung	S/R			
Manual O_2 Addition Valve	S/R	S		
OPV	R			R
Head to Enhalation Counterlung hose	S/R		R	
Exhaust Plenum O-Ring (Not Gasket)	S/R			R
Red CO2 Seal	S/R	R		
Scrubber basket	S/R			
Basket Spring	S/R			
O2 cell holders	S/R			R
O2 cell wiring harness	S/R		R	
Battery Cap sealing O-rings (2)	S/R	R		
Battery Cap Latches	R			
Battery Cap Pressure Relief Valve	R	R		
Bucket sealing O-Rings	S/R	R		
Oeteker Clamps	R		R	
Bucket Latches	R			
Oxygen First Stage	S	S		
Diluent First Stage	S	S		
O2 LP Hoses & QD	S/R	S		R
O2 HP Hose & QD	S/R	S		R
O2 Gas restrictors	S/R	S		
Diluent LP Hoses & QD	S/R	S		R
Diluent HP Hose	S/R			R
O2 Pressure gauge	S/R	S		
Diluent Pressure gauge	S/R	S		
Oxygen Solenoid	S/R	S		R
Solenoid Chamber Pressure Relief Valve	R	R		

Battery Compartment Housing

The wiring harness in the battery compartment is attached to a male Molex connector at the base of the battery compartment stack. To remove the harness, gently pull on the wiring harness until the Molex connector comes out.

The Molex connector at the base of the battery stack is potted in place and is not a user-replaceable part. If this part is damaged due to compartment flooding or mishandling, you will need to bring the head in to your local Hollis dealer for replacement.

Warning!

Recovering from a Battery Compartment Flood.

If the battery compartment ever floods, the batteries inside the compartment will leach acids and gasses into the compartment, which can cause the Pressure Relief Valve to vent the gasses and liquids so you must take precautions against being exposed to these toxic substances. There is also a heightened risk of spontaneous combustion when LiON batteries come into contact with water, so do not put the rebreather in an enclosed environment if you suspect a battery compartment flood.

Replacing the Battery Cap Pressure Relief Valve

AWAITING DIRECTIONS FROM FACTORY

Battery Cap Locking Latches:

Tools needed:
1/16th Allen head wrench

The two Nielson Sessions locking latches that secure the battery cap are held in place by two 4-40 button head hex screws at the base of the latches. To replace a broken latch remove the two hex screws, replace the latch and replace the two Hex screws. Be sure not to strip the screw holes by over-tightening the screws.

Stainless Steel roll bar/cover holder

Tools needed:
Medium bit Phillips head screwdriver
6” (small) adjustable wrench
7/32nd hex wrench

Should you ever need to take the roll bar off the head mounting hardware which it is screwed into, remove the Phillips head screw and locking nut from both sides of the bar and pull up. Note that the stainless steel head mount hardware will fall off the head when you remove the roll bar if you have not secured them in place.

If the roll bar has sustained an impact sufficient to cause it to bend, it may need to be replaced since it acts as the top connecting point for the head protection cover, and has to line up just right to fit the cover in place. DO NOT attempt to bend the roll bar back in place while on the rebreather as you could shear off parts of the unit, causing significant damage. Instead, remove the part and using a bench vice and a rubber mallet, slowly re-bend the part, checking fit every so often, or simply return the part to your Hollis Prism 2 dealer for repair.

Electronics Stack

The electronics stack sits on an O-ring sealed housing directly under the battery compartment. Inside the compartment are the O_2 Sensor Routing Board and Primary Display Logic board. The bulkhead connectors for the batteries and electronics wiring also terminate in the Electronics Stack. There are no user serviceable parts inside this compartment.

Your Prism 2 comes from the factory with this compartment having undergone clean room assembly and rigorous pressure testing. Please do not break this seal. Breaking the clean room seal on the compartment unnecessarily makes it far more likely that flooding will occur in the compartment. Your local Hollis Dealer will gladly take you on a full tour of the “guts” of the Prism 2 should you wish to see what the interior of this compartment looks like.

Solenoid Chamber

Underneath the Electronics Stack sits the O-ring sealed Solenoid Chamber. Inside the chamber is the Solenoid and the bulkhead electronics connector going out to the controller. There is also an Over-Pressure Relief Valve built into the chamber wall that is designed to vent gas to the outside of the rebreather if the solenoid were to ever lose gas containment.

Like the Electronics Stack, your Prism 2 comes from the factory with this compartment having undergone clean room assembly and rigorous pressure testing. Please do not break this seal, as doing so makes it far more likely that an accidental flood will occur.

Exhaust Plenum

Tools Needed: 1/16th inch Allen Head Wrench

The exhaust plenum cover is held in place by four 4-40 SS button head screws and washers and sealed with an O-ring. Under normal circumstances, there is no need to open the plenum cover. If however you have fully flooded the rebreather, you may want to open the chamber and using a clean, damp cloth wipe and caustic materials off the surfaces. DO NOT pour water into the Exhaust Plenum when cleaning it as the compartment contains the oxygen inlet from the solenoid, and doing so may accidentally introduce water into the solenoid. Clean the O-ring prior to re-installing the cover. There are no mechanical parts inside the Exhaust Plenum.

Red CO_2 Seal

Tools Needed: None

If the gasket gets dirt or absorbent dust on it, remove the gasket from its grove and clean the surface of the gasket with warm, soapy water, rinse and allow to air dry. The gasket should feel “gummy” but not sticky to the touch. If the gasket has hardened or has cuts or abrasions on its surfaces it needs to be replaced. DO NOT use lubricant of any kind on the Red CO_2 Seal.

O_2 Sensor holders

Tools Needed: None

Each of the three O_2 sensor holders are held in place by 2 pins molded into the head assembly. They are made of a soft silicone. Remove the holders from their pins and clean with warm soapy water then rinse off and allow to air dry.

During annual service these will be checked to see if they are beginning to harden and will be replaced as necessary. Do not attempt to repair a torn cell holder.

O_2 Sensor Harness

Tools Needed: None

Use one drop of Deoxit Gold electrical contact cleaner on the contacts and wipe off any excess contact cleaner before re-installing the harness in the head. If the wiring is showing excessive oxidations or the insulation is cracking, replace the harness.

O_2 sensors

Tools needed: Cell checker

Each sensor should be checked periodically during its service life for linearity and voltage limiting using a cell checker. If you do not have one, contact your local Hollis Prism 2 dealer for assistance. For further information, see the article on O_2 sensor care in this manual.

Inhalation Counterlung hoses

Tools needed: Oeteker clamp pliers, Large Bottle Brush, Tribolube

Every ten hours of use you should scrub the inside of the counterlung hoses with a bottle brush and Steramine. First, remove the hose from the counterlung by removing the 2 Oeteker clamps holding it in place. This will insure that any debris scrubbed from the hose will not simply settle in the counterlung. Place the bottle brush inside the hose and place the hose in the bucket of Steramine. Move the brush in and out of the hose to scrub the interior. Clean the hose attaching hardware as well. Finally, clean the attaching hardware O-ring, O-ring grove and treat it with Tribolube.

Inhalation Counterlung & Drain

Tools needed: Oeteker clamp pliers, Large Bottle Brush, Tribolube, Steramine, Clean dry cloth.

You may choose to remove the breathing hose, or you can clean it as a piece with the counterlung.

Remove the ADV hardware from the counterlung by unscrewing the ADV threaded collar and set it aside. Fill the counterlung with Steramine and thoroughly clean the inside with the bottle brush, being sure to scrub all sides, bottom and top. Loosen the Counterlung drain locking collar and allow some Steramine to run through the drain hole. Pour the Steramine out of the counterlung and re-drain the counterlung drain.

If you removed the hose for cleaning, reattach the hose using the Oeteker clamps and hang the counterlung to dry. It is always recommended that if you hang the counterlungs to dry in an area where bugs can enter, you stuff all the holes in the counterlungs using paper towels. This will allow the interior of the lungs to dry while blocking bugs from getting in and making a home.

Automatic Diluent Addition Valve

Tools needed: Steramine, toothbrush or sponge, Schrader Valve tool

Remove the plunger-retaining nut and the plunger and clean both pieces with Steramine and a toothbrush. Looking down into the core of the valve, look at the Stainless Steel Schrader valve. It should appear shiny without any “rouging” (light rust). It is not necessary to remove the valve unless it looks worn or is leaking. If either condition exists, remove the valve and the quick disconnect fitting on the outside of the valve and run a stream of fresh water through the hole. Clean the O-ring on the quick-disconnect fitting, threat with Tribolube and replace the fitting being careful not to over-tighten it. Thread in a new stainless steel Schrader valve using the Schrader valve tool being careful not to over-tighten it.

DSV/BOV Inhalation hose & fittings

Tools needed: Oeteker clamp pliers, Large Bottle brush, toothbrush, sponge, Tribolube, Steramine

The inhalation side of the DSV/BOV hose assembly contains the inhalation side mushroom valve and valve seat. Before cleaning the hose, it is important to remove the mushroom valve and seat. Removing the part will allow you to run a bottle brush through the hose, but the valve and valve seat require special, separate treatment as described in the next section.

To remove the valve seat, remove the 2 Oeteker clamps holding the valve seat and DSV/BOV counterweight, pull the part from the hose, and set it and the counterweight aside. Also remove the 2 Oeteker clamps holding the elbow and remove the elbow from the hose.

Place the hose and elbow in a bucket of Steramine and run the bottle brush back and forth through the hose several times. Remove the hose and set it aside to dry. Using the toothbrush, clean the inside of the elbow then set it aside to dry as well.

The mushroom valve and valve seat are delicate parts and should be cleaned with care. Remove the O-ring on the outside edge of the valve body and set it aside. Using a soft sponge soaked with Steramine, gently wipe down the topside of the mushroom valve and then gently lift the valve off the valve seat and wipe down the underside of the valve as well as the valve seat.

Clean the O-ring groove and set aside the valve body to dry. Clean the O-ring you had set aside, treat it with Tribolube and reinstall it in its grove.

There is no need to sterilize the counterweight, but if you like keeping your gear shiny and looking new, you can soak it in water then wipe it down with a clean dry cloth to restore its shine.

Once the parts are dry, you can re-assemble the hose and fittings. Make sure that you put 2 clamps back in each hose fitting with the clamp openings 180 degrees opposed from each other.

Test the valve operation by attempting to gently inhale. You should see the mushroom valve firmly seat itself against the valve body but not be able to pull any air through. If the valve does not seal, the assembly must be replaced.

DSV/BOV Exhalation hose & fittings

Tools needed: Oeteker clamp pliers, Large Bottle brush, toothbrush, Tribolube, Steramine

Since there is no valve on the end of the hose assembly, you do not need to take the hose assembly apart for a simple cleaning. You can simply put the hose in a bucket filled with Steramine and clean the interior of the hose with a bottle brush. DO NOT attempt to force the bottle brush through the elbow fitting. Use the toothbrush to clean the fitting**.**

If you need to treat the O-ring under the counterweight, you will need to remove the 2 Oeteker clamps and pull the fitting from the hose. Put the counterweight aside. Remove the O-ring, clean and treat it and its mating groove, then replace the O-ring and reassemble the hose.

DSV (Dive Surface Valve)

Tools needed: Dikes or knife (to cut-off mouthpiece retaining strap), __ Hex wrench, Tribolube, clean dry cloth, sponge, Steramine
Replacement parts needed: New mouthpiece retaining strap
Because the DSV barrel is opened and closed frequently and over time can become hard to actuate as the Tribolube migrates away from the sealing O-rings, it is always a good idea to service the valve during a routine cleaning. As long as the O-rings do not appear worn or flattened, they can be re-used.

If you are using a short hex wrench you may need to remove the mouthpiece so the hex wrench will reach the knob retaining screw. If you are using a T-handle hex wrench (long shaft), you will not need to remove the mouthpiece.
If required, cut the mouthpiece-retaining strap using the dykes. If you cannot find dikes and must use a knife or scissors, use extreme caution to protect yourself from cuts.

Remove the mouthpiece and insert the hex wrench into the knob retaining screw and turn the hex wrench counter clockwise to loosen the screw. Once removed, set the screw aside and pull the knob off the barrel. There is a small O-ring sealing the knob to the barrel. Locate it and set it aside along with the knob.

Insert both thumbs into the exhale side of the DSV body and push on the stainless steel barrel until it comes out of the body. There are 3 O-rings on the barrel: One on each side of the barrel and one rectangular O-ring around the opening for the mouthpiece. (Don't look in your spares kit for a rectangular O-ring. You won't find one. While the channel it sits in is rectangular, the replacement O-ring is round and takes a rectangular shape only after it has been in place for a while.)

Remove the three O-rings and set them aside. Clean the barrel and the sleeve in Steramine making sure to remove old lubricant from their surfaces and channels. Set them aside to dry. Take the O-rings and clean off old lubricant and check them for wear. If they are in good shape, lubricate them with Tribolube and put the O-rings back in their grooves. You may need to coax the "square" O-ring back into its groove. (You may need to hold it in place until the barrel is back in the sleeve.) Add a little extra Tribolube in the groove around each O-ring as this will help keep them lubricated better and for a longer period between cleanings.

Reinsert the barrel into the inhale side of the DSV body making sure the O-rings are not rolling out of their channels and getting pinched between the barrel and DSV body. Once the barrel is in the center of the body and properly aligned, clean and lube the knob O-ring and place it and the knob in its hole in the barrel and screw it in place using the hex screw. Rotate the barrel to make sure it turns easily, then close it and blow through the purge. If the barrel does not rotate easily, you have probably pinched an O-ring while re-installing the barrel. Any O-ring that gets pinched will need to be replaced with a new one. Replace the mouthpiece and mouthpiece-retaining strap.

Last, but most important is the exhalation mushroom valve. The mushroom valve and valve seat are delicate parts and should be cleaned with care. Remove the O-ring on the outside edge of the valve body and set it aside. Using a soft sponge soaked with Steramine, gently wipe down the topside of the mushroom valve and then gently lift the valve off the valve seat and wipe down the underside of the valve as well as the valve seat.

Clean the O-ring groove and set aside the valve body to dry. Clean the O-ring you had set aside, treat it with Tribolube and reinstall it in its grove. Replace the valve and seat in the exhalation side of the DSV.

Test the valve operation by attempting to gently inhale from the inhale side of the DSV with the mouthpiece closed. You should see the mushroom valve firmly seat itself against the valve body but not be able to pull any air through. If the valve does not seal, the assembly must be replaced.

Exhalation Counterlung & drain

Tools needed: Oeteker clamp pliers, Large Bottle Brush, Tribolube, Steramine, Clean dry cloth.

Remove the Manual O_2 Addition Valve hardware from the counterlung by unscrewing it's threaded collar and set it aside. Also make sure to remove the valve gasket and set it aside as well. Remove the OPV by grasping its base and turning it counterclockwise.

You may choose to remove the breathing hose, or you can clean it as a piece with the counterlung.

Fill the counterlung with Steramine and thoroughly clean the inside with the bottle brush, being sure to scrub all sides, bottom and top. Loosen the Counterlung drain locking collar and allow some Steramine to run through the drain hole. Pour the Steramine out of the counterlung and re-drain the counterlung drain.

If you removed the breathing hose for cleaning, reattach the hose with the Oeteker clamps and hang the counterlung to dry. It is always recommended that if you hang the counterlungs to dry in an area where bugs can enter, you stuff all the holes in the counterlungs using paper towels. This will allow the interior of the lungs to dry while blocking bugs from getting in and making a home.

Manual Oxygen Addition Valve (Use O_2 Clean Lubricants only)

Tools needed: Oeteker clamp pliers, flat-head screwdriver, Tribolube, clean lint-free towels

Because the Manual Oxygen Addition Valve is exposed to pure oxygen, all parts of the valve must be treated as oxygen clean parts. If contamination is suspected, all parts must be O_2 cleaned as part of the maintenance routine.

The Quick-disconnect gas inlet fitting is threaded into the valve body and is sealed with an O-ring. You do not normally need to remove this part unless the entire assembly requires O_2 cleaning.

To disassemble the valve from the valve body, depress the valve button to lift the c-clamp off the valve body. Using a small screwdriver, pull the c-clamp off the valve stem. There is a spring on the underside of the valve button that will cause the valve stem to separate from the valve body once pressure is slowly released from the valve button.

Both the C-clamp and valve spring are made from Stainless Steel, however if there are signs of “Rouging” (a patina of rust) on the surface of either piece, that piece should be replaced. Rinse both parts in fresh water and set them aside.

The valve stem has two O-rings. The O-ring closest to the valve button keeps gas from escaping out into the water column. The O-ring closest to the C-clamp channel on the valve stem keeps gas from flowing into the counterlung until the valve is depressed.

To service the valve, remove both O-rings and discard them. Soak the valve body and seat in fresh water and then clean them with a clean dry, lint-free towel. Remove all traces of old Tribolube.

Treat both replacement O-rings with fresh Tribolube then place the first O-ring into the O-ring groove closest to the C-clamp channel. Then put the next O-ring in place in the channel closest to the valve knob. Replace the spring between the valve know and the valve body and insert the valve stem into the body being careful to insert it straight into the valve body. Press the valve knob all the way into the body until the stem protrudes into the underside of the valve body and you can fully access the C-clamp channel. Rest the C-clamp on the valve body next to the valve stem and raise or lower the stem until the C-clamp channel lines up with the C-clamp. Using a small flat-headed screwdriver, push the C-clamp into the channel until it is fully seated in the channel.

To test the valve, connect the oxygen LP hose to the valve and charge the lines with oxygen. Place the valve in a large glass of fresh water and check for leaks. Finally, depress the valve and check that the actuation feels smooth and gas flows freely when the valve is pressed.

Re-install the valve onto the exhalation counterlung making sure to put the gasket between the fitting and valve. The valve seat is keyed to insure that the valve does not rotate in the fitting, so once you have started to thread the valve retaining nut onto the mounting flange, rotate the valve so the QD fitting faces up toward the breathing hoses.

Scrubber Bucket & basket spring

The scrubber bucket does not need cleaning beyond rinsing with fresh water and, if absorbent material builds up on the clear urethane, a wipe with pure vinegar and fresh water rinse.

The Stainless Steel band and 4 Nielson Sessions latches should remain free of rust as long as it is soaked in fresh water after use. There is no need to use any lubricants on the latches, and it is recommended that you do not do so as the lubricants can travel and get onto O_2 clean parts.

The Stainless Steel band is held in place using surface pressure applied by tightening the band using the two nuts and bolts on the band. Check that both nuts are tight and the band is firmly in place.

The scrubber basket-retaining piece and pressure spring are held onto the spring assembly-retaining stem with a stainless steel nylon locking nut and washer. The spring assembly-retaining stem is molded into the Urethane bucket. Neither part requires maintenance beyond normal cleaning with fresh water and checking that the locking nut is firmly in place.

Scrubber basket

Tools needed: White Vinegar, stiff toothbrush
The scrubber basket requires cleaning after each use. Depending on the CO2 absorbent used, the basket threads can become clogged with crushed absorbent, making screwing down the top difficult.
If absorbent dust does become caked in the threads, soaking the threads in 100% white vinegar for 15 to 20 minutes will usually dissolve all the material. You may need to remove any residual material with a stiff toothbrush. After cleaning rinse the basket thoroughly in fresh water.

The center tube is removable in the event that it requires service or replacement.
Should you wish to remove the center tube for cleaning you can do so. There is an O-ring at the base of the center tube. You can remove it for cleaning but DO NOT lubricate the O-ring as doing so will only collect absorbent dust onto the O-ring.

Buoyancy device

After use, always drain the buoyancy device before hanging to dry and packing. Every so often, you may want to flush the inside of the buoyancy device with warm fresh water to clean the interior.

To clean the bladder, remove the inflator hose from the bladder and run fresh water into the bladder. Open the bottom drain and allow some water to run through the drain hole. Once the bladder is fully flushed with fresh water, turn the bladder upside down and drain the water. Hang the bladder upside down and allow the bladder to dry overnight. If you are hanging the bladder outside or where bugs can get in, stuff the opening with a paper towel to keep the bugs out while the interior of the bladder dries.

H-Plate

The H-Plate is made of anodized aluminum. Because the hardware that connects the head to the plate is stainless steel, make sure you put the nylon washers in place wherever the stainless steel hardware comes into contact with the aluminum, otherwise electrolysis pitting will damage the aluminum H-plate.

You can clean the H-Plate with fresh water and allow it to dry.

The tank bands and bucket bands are made from nylon webbing with Velcro bands. Soak the bands with fresh water and allow to dry. Over time, the Velcro will wear out and you will need to replace the bands with new parts.

Troubleshooting

Primary Display

Will not power on

1: Check/change battery
2: Check/change wiring harness in battery compartment

Will not accept calibration

Single cell: Check mV readings in air and pure O_2 are within operational range.

1: Check mV of O_2 cells on Secondary Display are within operational ranges
2: Check wiring harness: clean connections
3: Swap cells - see if failure follows cell
4: Replace cell

All cells:

1: Re-analyse O_2
2: Check for accidental calibration in air
3: Check for properly flushed loop
4: Check mV readings in air and pure O_2 are within operational range.
5: Check wiring harness: clean connections

Secondary Display

Will not power on

1: Change battery

Will not accept calibration

Single cell:

1: Check mV readings in air and pure O_2 are within range.
2: Check wiring harness: clean connections

All cells:

1: Check mV readings in air and pure O_2 are within range.
2: Check wiring harness: clean connections

No O_2 cell output reported

1: Switch wiring lead from missing cell to active cell.
2: Clean molex connectors
3: Change wiring harness

Solenoid

Solenoid will not fire (All parts must be handled as O_2 clean)

1: Check for solenoid alert on Secondary Display
2: Check solenoid battery voltage on Secondary Display
3: Check battery quality (output limited?)(Use name-brand batteries only)

Solenoid doesn't appear to inject O_2 (All parts must be handled as O_2 clean)

1: Pressure drop test
2: Temporarily remove in-line restrictors, re-test

Solenoid is stuck open (All parts must be handled as O_2 clean)

1: Bring to Hollis service immediately, do not attempt field repair

Solenoid adds gas very slowly (All parts must be handled as O_2 clean)

1: Check for clogged restrictors
2: Check for clogged first stage filter
3: Check O_2 first stage IP

Oxygen Pneumatics

Manual O_2 addition valve is free-flowing (All parts must be handled as O_2 clean)

1: Replace O-rings
2: Check Valve body for cracks
3: Check O2 first stage IP

Manual O_2 addition is very slow (All parts must be handled as O_2 clean)

1: Check for clogged restrictors
2: Check for clogged first stage filter
3: Check O_2 first stage IP

Diluent Pneumatics

ADV is freeflowing

1: Check Schrader valve
2: Check plunger for free movement
3: Check diluent first stage IP

ADV is not adding gas

1: Actuate Inflator to check for flow from diluent first stage
2: Check plunger for free movement
2: Check Schrader valve

PART SIX

ADDENDUM

Component Capacities

BUCKET CAPACITY
Total Capacity: 1.75 gallon / 6.6 Liter

To measure 1 Gal / 3.8 Liters for mixing sterilizing agents in the field, fill bucket with fresh water to 3/4” (19mm) under bottom of the SS bucket latch strap.

Counterlungs
3.5 Liters complacent volume per counterlung

On-Board gas cylinder carrying capacity (Standard configuration)
Up to 50 Cu. Ft / L

Breathing Hoses
1 1/2” X 15”

Oxygen Sensors
Analyitical Industries PSR-11-39-MD
Operational Temperature Range: 32^{o}F/0^{o}C - 122^{o}F/50^{o}C
Operational Voltages: Air: 8.5-14mV, 100%O_2: 40.6-67mV

List of approved products for use in your Prism 2 Rebreather.

Cleaning Products
Steramine 1-G Tablet
100% White Vinegar
Dawn (or similar) dish detergent

Maintenance Products
Food Grade Silicone-based lubricants (non-O_2 clean parts only)
Cristo-Lube
Tribolube
DeoxIT Gold G5 Electrical Contact Cleaner

Other products not listed may be appropriate for use with the Prism 2. If there is a particular product which you wish to use, please call the factory to make sure the product does not contain chemical components which may be harmful to components within the rebreather.

CAUTION:
Never Use the following products or families of products on ANY part or surface of the Prism 2 rebreather:

Products which contain alcohol, high concentrations of chlorine, ammonia, gasoline, Benzene or any petrochemical-based solvent (Basically, any product with the suffix “ene” in it.)

Polishes, wax, automotive cleaning products.

Glues, binding agents, plastic fillers other than those specifically listed in the “maintenance and troubleshooting” or “approved products” sections of the manual.

CAUTION:
Never attempt to clean your rebreather, or any part of your rebreather in a dishwasher or any other type of machine that employs high-pressure jets of cold, warm or scalding hot water.

Prism 2 Condensed Checklist
(Not for student or new user use)
Name:________________________________

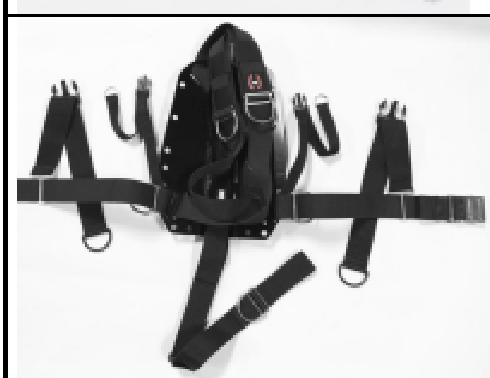
- ☐ Fill O_2 & Diluent cylinders, analyze contents, label cylinders with name, date, contents.
  - O_2 %______ Pressure ______psi/bar Dil Contents______ Pressure ______psi/bar MOD______
- ☐ Fill scrubber basket with CO2 absorbent & store in airtight container, Label container: grade, date filled, user, time used.
  - Date Packed:_________ Grade:___________ Time Used:__________ Time left:___________
- ☐ Check H-Plate / harness / bladder for wear, damage or missing parts
- ☐ Inspect counterlungs
- ☐ Inspect counterlung to DSV/BOV hoses
- ☐ Inspect DSV/BOV
- ☐ Inspect pneumatics
- ☐ Inspect wiring
- ☐ Battery compartment, batteries & o-rings
- ☐ Solenoid operation
- ☐ Inspect head assembly
- ☐ Oxygen sensors
- ☐ Bucket assembly
- ☐ Basket assembly
- ☐ Install head assembly onto H-Plate
- ☐ Install bladder, yoke and backplate onto H-Plate
- ☐ Run pneumatics lines, install solenoid gas hose
- ☐ Attach counterlungs to yoke
- ☐ Install counterlung to head breathing hoses
- ☐ Attach gas supply lines to diluent and oxygen addition valves on counterlungs
- ☐ Assemble DSV/BOV and hoses, check and install
- ☐ Clean head to bucket sealing rings and channel and lube o-rings
- ☐ Clean Red CO2 Seal and secure in place
- ☐ Check filled CO_2 scrubber basket
- ☐ Install bucket moisture pad
- ☐ Place CO_2 basket in bucket, confirm center tube opening up, mount and seal bucket to head
- ☐ Install filled and content verified gas cylinders
- ☐ Record O_2 cell mV in air: #1_____ #2_____ #3_____
- ☐ Positive pressure test.
- ☐ Diluent system leak test
- ☐ Negative loop pressure test/ADV test
- ☐ Oxygen system leak test
- ☐ Solenoid test / Flush loop with O_2
- ☐ Calibrate Secondary Display electronics
- ☐ Record O_2 cell mV in O_2 (Linearity Check) #1_____ #2_____ #3_____ (air mV X 4.76 = +/- 10%)
- ☐ LED Primary Display on and battery check ☐OK ☐replaced & OK
- ☐ Calibrate LED primary display
- ☐ Solenoid batteries check ☐OK ☐replaced & OK
- ☐ Secondary display battery check ☐OK ☐replaced & OK
- ☐ Adjust user selected low/high set points to desired settings (0.4 - 1.5)
  - low set point: _________________
  - high set point: ________________
- ☐ Record oxygen pressure after loop flush: ______________ psi/bar
- ☐ Confirm Alternate Air Source Operation
- ☐ Check BC inflation, air holding and deflation mechanisms
- ☐ Record diluent pressure: ________________ psi/bar
- ☐ Install weights
- ☐ Verify LED primary display is powered on
- ☐ Don unit, secure fasteners, tighten belts
- ☐ Verify oxygen and diluent valves on
- ☐ Secure secondary display on wrist
- ☐ Verify secondary display is on
- ☐ Verify loop contents are within user set limits on secondary display
- ☐ Pre-breathe loop

Don’t forget to do your bubble and cell limiting checks at 15ft/5m and have a Safe dive!

Version 1.4

Prism2 Packing List

	**Scrubber Head with Displays in Box**
	**H Adapter,** **4 tank straps,** **bucket band,** **yoke**
	**Cover** **Bucket assembly** **Basket, 2 end pads, water pad**
	**Oxygen regulator** **SPG** **Solenoid hose** **Inflator hose** **Diluent regulator** **SPG** **2 inflator hoses**
	**Inhale counterlung assy** **Exhale counterlung assy**

	**Breathing Loop Assy**
	**Hardware** **Cover Mounting tube** **4 X 3/8-16 X 1" w washers** **2 X NutbarTube** **2 X ¼-20 X 1"** **2 X ¼-20 LockNut** **2 X 5/16-18 wing nut** **2 X 5/16 washers** **1 X 5/16 -18 X 1.25 lower** **1 X 5/16 – 18 X 1.5 upper**
	**BC and inflator w gasket**
	**Back plate** **Counterlung to waist straps** **Side straps w Book Screws**

Packing order for the Prism2

	**Head w Electronics in protective box** **Bucket nests in H-Adapter** **Regulators on the bottom** **Counterlung outside of the box and and bucket** **Cover mount bar and DSV in remaining spaces**
	**Cover wrapped around Bucket**
	**BC and Backplate w harness on top**

PART SEVEN

Material Safety Data Sheets

and

Product Sheets

MSDSs
DeoxIT
Intersorb
Steramine 1-G Tablets

The material Safety Data Sheets reprinted here are for product safety disclosure only, and should not be considered an endorsement for any product, product family or manufacturer. These MSDS's as printed herein may be outdated.

CAIG LABORATORIES, INC.

MSDS

MSDS #PDP5S

ProGold, DeoxIT & PreservIT - 5% Aerosol

PRODUCT DESCRIPTIONS

ProGold outperforms all other contact cleaners, enhancers and lubricants. Due to its unique properties, it deoxidizes and cleans surface contamination, penetrates plated surfaces and molecularly bonds to the base metals - NO OTHER PRODUCT DOES THIS. ProGold increases conductivity, contact surface area and reduces arcing, RFI, wear and abrasion (the major cause of intermittent signals, distortion and signal loss).
DeoxIT is a fast-acting, deoxidizing solution that cleans, preserves, lubricates and improves conductivity on metal connectors and contacts. As a general rule, use ProGold for best performance and protection on plated surfaces and DeoxIT as a general purpose treatment.
PreservIT seals, lubricates and preserves metal surfaces for protection from oxidation and contamination. For use on clean/new surfaces or those pre-cleaned with DeoxIT. PreservIT contains no cleaners or deoxidizers. It provides long-lasting protection for newly manufactured components or those cleaned by ultrasonics, DeoxIT or other procedures. In some instances, PreservIT is recommended as a final treatment for surfaces that are in constant motion and/or subject to higher degrees of atmospheric contamination.
ProGold, DeoxIT and PreservIT 5% sprays provide a light treatment to metal connector and contact surfaces. The petroleum naphtha (odorless mineral spirits) solvent provides flushing action to assist in removing contaminants without harm to plastics and elastomeric parts.

COMPATIBILITY

ProGold (G5S-6, G5MS-15), **DeoxIT** (D5S-6, D5MS-15) and **PreservIT** (P5S-6) are compatible with most materials. However, in large scale use we recommend compatibility testing for the specific application. Contact manufacturer for guidelines and assistance. Sprays include odorless mineral spirits (OMS) as the carrier solvent to assist flushing away contaminants. It is slow to evaporate but non-aggressive to most materials. Once it evaporates, a thin layer of ProGold, DeoxIT or PreservIT remains. Only thin layers are required for maximum performance. If solvents are not desired, use the 100% liquid (MSDS #PDP100L) or spray (MSDS #PDP100S).

SPRAY SELECTION GUIDE

Selection Guide	Spray Type	Flammable/ Nonflammable	Carrier Solvent Evaporation Rate
ProGold G5 (G5S-6, G5MS-15), DeoxIT D5 (D5S-6, D5MS-15), PreservIT P5 (P5S-6)	Aerosol	Flammable	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

* [illegible]

DIRECTIONS FOR USE

ProGold G5S & ProGold G5MS ***Mini-Sprays***: Ideal for general purpose applications. Contains petroleum naphtha as carrier solvent. Though flammable, it is non-aggressive to almost all materials. Apply a short burst to metal surface then operate device to assist breaking up of oxide layers. For severely oxidized surfaces, apply DeoxIT first, wait a few minutes and using lint-free applicators on accessible surfaces, wipe until surface appears clean. In inaccessible areas, flush away oxides with ProGold G5, CaiKleen 41 or CaiKleen IPA. As a final step, spray a short burst of ProGold for protection. G5 includes precise, three-way adjustable valve for controlled dispensing.
DeoxIT D5S & DeoxIT D5MS ***Mini-Sprays***: Ideal for general purpose applications. Contains petroleum naphtha as the carrier solvent. It is flammable but non-aggressive to almost all materials. Apply a short burst to metal surface and operate device to assist breaking up of oxide layers. For severely oxidized surfaces, wait a few minutes before operating. Then use lint-free applicators on accessible surfaces and wipe until surface appears clean. In inaccessible areas, flush away oxides with DeoxIT D5, CaiKleen 41, CaiKleen A/V or CaiKleen IPA. As a final step, spray a short burst of DeoxIT for protection. Includes precise, three-way adjustable valve for controlled dispensing with minimal waste and overspray.

PreservIT P5S: Ideal for general purpose applications. Contains petroleum naphtha as carrier solvent. It is flammable but non-aggressive to almost all materials. After cleaning metal surfaces, apply a short burst of PreservIT. If accessible, wipe with a lint-free applicator. If discoloration appears, the metal surface is not clean - use DeoxIT or other cleaning method (ultrasonics) first. As a final step, spray a short burst of PreservIT for protection. PreservIT P5 includes precise, three-way adjustable valve for controlled dispensing with minimal waste and overspray.

ProGold, DeoxIT and PreservIT are supplied in liquid solutions for applications sensitive to solvents, requiring extra lubrication or preventing overspray. Refer to MSDS # PDP100L, Directions For Use (# SB-DIR, SB-AE and SB-SPEC) for additional information.

N/A = Not Applicable N/E = Not Established

1. IDENTIFICATION OF SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

1.1 COMMERCIAL PRODUCT NAME: / CODE NO.:

COMMERCIAL PRODUCT NAME	CODE NO.
ProGold G5 Spray, 200 ml	G5S-6
ProGold G5 Mini-Spray, 20 ml	G5MS-15
DeoxIT D5 Spray, 200 ml	D5S-6
DeoxIT D5 Mini-Spray, 20 ml	D5MS-15
PreservIT P5 Spray, 200 ml	P5S-6

1.2 COMPANY: CAIG Laboratories, Inc.
12200 Thatcher Court, Poway, CA 92064 U.S.A.
CUSTOMER SERVICE: 858 / 486-8388
PREPARED BY: Mark K. LeMunyon
REVISION DATE: 07-08-1999
EMERGENCY, SPILL, LEAK, FIRE OR EXPOSURE: CHEMTREC 1-800-424-9300

2. COMPOSITION/INFORMATION ON INGREDIENTS

2.1

	HAZARDOUS INGREDIENTS	SYMBOL(S)	C.A.S. No.	WT. % RANGE
a)	Petroleum naphtha		64742-88-7	75.0%
b)	Isobutane/propane		75-28-5/74-98-6	20.0%
c)	ProGold	Non-hazardous		5%
c)	DeoxIT	Non-hazardous		5%
c)	PreservIT	Non-hazardous		5%

2.2 OSHA HAZARDOUS COMPONENTS (29CFR1910.1200)
a) Petroleum naphtha, 100ppm (PEL/TWA), 100ppm(TLV/TWA)
b) Isobutane/propane, 800ppm/1000PPM (ACGIH-TLV)

TSCA INVENTORY: All ingredients are listed on the TSCA Inventory.
EC DIRECTIVE: Complies with EC Directive 91/155/EEC

3. HAZARDS IDENTIFICATION

Flammable solvent blend. Liquid will irritate eyes and skin under repeated or prolonged exposure. Breathing high concentrations of product vapor may produce drowsiness or headache. Product may be hazardous to fish & wildlife and may contaminate waterways.
California Proposition 65: The California list of chemicals, "known to cause cancer or reproductive toxicity" is so extensive it requires more clarification, research and evaluation. Meanwhile, all chemicals distributed by, or manufactured by CAIG Laboratories, shall be assumed to be on the list or contain detectable amounts of chemical listed.

4. FIRST-AID MEASURES

4.1 SKIN CONTACT: Wash with soap & water. Seek medical attention if irritation persists.
4.2 EYE CONTACT: Immediately flush with plenty of water. Remove any contact lenses and continue flushing for at least 15 minutes. Seek medical attention if irritation develops or persists.
4.3 INGESTION: Seek medical attention immediately. Induce vomiting only as directed by medical personnel.
4.4 INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult give oxygen. Seek medical attention.

5. FIRE-FIGHTING MEASURES

5.1 FLASH POINT: 43°C (110°F)
5.2 FLAMMABLE LIMITS, % VOL: LOWER = 1.0, UPPER = 6.0
5.3 HMIS LABELING: HEALTH: 2 (moderate) FLAMMABILITY: 3 (high) REACTIVITY: 1 (slight)
5.4 EXTINGUISHING MEDIA: Suitable - Alcohol foam, water fog, dry chemical, CO2. Not to be used: Water.
5.5 SPECIAL EXPOSURE HAZARDS: Carbon dioxide, carbon monoxide, hydrocarbons.
5.6 SPECIAL PROTECTIVE EQUIPMENT FOR FIREFIGHTERS: As in any fire, wear self-contained breathing apparatus and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

6.1 PERSONAL PRECAUTIONS: Wear respiratory protection in confined spaces and appropriate personal protective equipment; eye protection, chemically resistant gloves. Ventilate area and remove all sources of ignition.
6.2 ENVIRONMENTAL PRECAUTIONS: Avoid runoff into sewers and ditches that lead to waterways.
6.3 METHODS OF CLEANUP: Observe recommendations for personal protective equipment detailed in Section 8. For large spills, absorb with inert material such as sand, clay or dirt and place in sealed metal container for disposal. Since products are not normally used in large quantities and product is non-hazardous, absorb with inert material and discard as you would mineral oil.

7. HANDLING AND STORAGE

7.1 STORAGE: Store in a cool, dry place, away from heat, sparks or flames. Keep container tightly closed when not in use. Do not store in direct sunlight. Keep out of reach of children.
7.2 HANDLING: Avoid prolonged or repeated contact with skin, eyes or clothing. Avoid breathing product vapor for extended periods of time. Use only with adequate ventilation. General ventilation should be adequate, but use local exhaust ventilation in confined spaces or at points of excessive discharge. Avoid activities that could cause splashing of the spilled material or create mists.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 ENGINEERING PROTECTIVE MEASURES: General ventilation should be sufficient to control airborne vapor levels. Local exhaust ventilation should be used if large amounts are released.
8.2 PERSONAL PROTECTIVE EQUIPMENT
RESPIRATORY PROTECTION: Full-face respirator mask equipped with acid gas/organic vapor cartridge or fume hood or other type of local exhaust ventilation.
EYE PROTECTION: Wear safety glasses, splash goggles or a full-face shield depending on the amount of exposure and likelihood of a splash hazard.
HAND PROTECTION: Wear chemically resistant rubber gloves with repeated exposure.
OTHER: None required for normal conditions of industrial use.
8.3 INDUSTRIAL HYGIENE: Wash hands before eating or smoking when using this product.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 FORM: Aerosol Liquid- see 1.1 for description
9.2 COLOR: ProGold (light-yellow), DeoxIT (light-red), PreserveIT (light-blue).
9.3 ODOR: Ethereal/hydrocarbon odor.
9.4 BOILING POINT: 160°C. 9.5 MELTING POINT: NA
9.6 RELATIVE DENSITY: NE 9.7 VAPOR PRESSURE: <12 @ 38°C
9.8 VAPOR DENSITY (Air=1): NA 9.9 VISCOSITY (Water=1): approx. 1

10. STABILITY AND REACTIVITY

10.1 HAZARDOUS DECOMPOSITION PRODUCTS: Oxides of carbon and unburned hydrocarbons.
10.2 CONDITIONS TO AVOID: Do not spray around open flames, sparks, or hot metal surfaces.
10.3 HAZARDOUS REACTIONS: Hazardous exothermic polymerization will not occur. Not sensitive to pressure, light or shock. Will not react with water. Does not require the use of stabilizers. Will not degrade to unstable products. Change in color signifies exposure to ultraviolet light or exceeding shelf life; discard solution.
10.4 MATERIALS TO AVOID: Strong oxidizing agents.

11 TOXICOLOGICAL INFORMATION

11.1 ROUTES OF EXPOSURE
SKIN CONTACT: Repeated or prolonged contact may cause dryness of skin, wash with soap and water and apply hand cream. Seek medical attention if irritation persists. Gloves are recommended.
EYE CONTACT: Contact with liquids, mists or vapors of this product can cause acute eye irritation, stinging and swelling.
INGESTION: Harmful if swallowed. May cause acute irritation of the linings of the mouth, nose and throat. Vomiting may result, causing aspiration of material into the lungs, with the production of chronic pulmonary edema chemical pneumonia.
INHALATION: Harmful if product vapors are inhaled in high concentrations. May cause irritation to the lining of the lungs, with subsequent chronic pulmonary edema. Acute irritation of the mouth and nasal passages may result from overexposure. Displacement of oxygen by chemical vapors may lead to drowsiness or unconsciousness.
FURTHER INFORMATION: None of the components of this product are known to have carcinogenic, mutagenic, teratogenic, sensitization effects. Breathing high vapor concentrations for long periods of time may lead to narcosis.

12 ECOLOGICAL INFORMATION

12.1 MOBILITY: No product-specific data is available.
12.2 PERSISTENCE AND DEGRADABILITY: No product-specific data available.
12.3 BIOACCUMULATIVE POTENTIAL: No product-specific data available.
12.4 AQUATIC TOXICITY: No product-specific data is available.
12.5 OTHER DATA PERTAINING TO ENVIRONMENT: In large quantities, water runoff may cause environmental damage.

13. DISPOSAL CONSIDERATIONS

13.1 PREPARATION: Product waste is suitable for fuels blending for energy recovery or disposal by incineration. Product may be recoverable by distillation or recycling. Landfilling is not recommended for disposal.
13.2 PACKAGING: Package, transport and dispose of in accordance with local or national regulations that apply to substances & preparations of this nature.

14. TRANSPORTATION INFORMATION

14.1 DOT -
SHIPPING NAME: Consumer Product
CLASS: ORM-D
UN No.: Not required

14.2 IMDG -
SHIPPING NAME: Aerosol Products
CLASS: 2
UN No.: 1950
IMDG CODE: Page 2102
LABEL: Not required

14.3 IATA -
UN No.: ID-8000
CLASS or DIVISION: 9
LABEL: Consumer commodity ORM-D
SUBSIDIARY RISK: None
PACKAGING INSTRUCTIONS: 910

EMS: Chemtrec-USA MFAG NO.: #FDF53
MARINE POLLUTANT: No
14.4 OTHER INFORMATION:

15. REGULATORY INFORMATION

EC HAZARD WARNING LABEL
Symbol and Classification: F Highly flammable
Risk Phrases: Highly flammable, Harmful if swallowed
Safety Phrases: Keep away from sources of ignition - No smoking. Avoid contact with eyes. In case of insufficient ventilation, wear suitable respiratory equipment. Keep out of reach of children. Contains: petroleum naphtha solvent.

To be disposed of as hazardous waste. Users should also refer to any local or national regulations that apply to substance or preparations of this nature.

16. OTHER INFORMATION:

ENVIRONMENTAL IMPACT DATA (percent by weight)

CFC: 0.0%	HCFC: 0.0%	CL.SOLV.: 0.0%
VOC: 95.0%	HFC: 0.0%	ODP: 0.0%

All information and data contained in this literature are believed to be accurate, however, it should not be taken as definitive for all users. All materials may present unknown hazards and should be used with caution. Improper use can cause damage to products and to individual's health. Users should thoroughly test advertised products in their application, and independently determine satisfactory results before use in large scale production or manufacturing processes.

CAIG LABORATORIES, INC.
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TEL: 858 / 486-8388 FAX: 858 / 486-8398
Email: caig123@aol.com Website: www.caig.com

INTERSURGICAL
COMPLETE RESPIRATORY SYSTEMS

Crane House Molly Millars Lane
Wokingham Berkshire RG41 2RZ
T: +44 (0) 118 9656 300 F: +44 (0) 118 9656 356
Contact Number for Quality and Specialist
information: 0044(0)1189 656361
'mhol@intersurgical.co.uk'.
www.intersurgical.com info@intersurgical.co.uk

Material Safety Data Sheet.

Diving grade soda lime's
Intersorb
4 to 8 mesh and 8 to 12 mesh
Non-indicating.

MSDS Ref MH 14052010IntNI

Version 1

1. Product Identification

Brand name: Intersorb NI
Description: Non-indicating Carbon Dioxide absorbent for diving applications: Solid white granules formed from a combination of Calcium Hydroxide and Sodium Hydroxide.
Synonyms: None
CAS No.: Not applicable to mixtures.
Molecular Weight: Not applicable to mixtures.
Chemical Formula: Not applicable to mixtures.
Product Codes: 2181013, 2181015, 2181021
For information call: 0044(0)1189656300

2. Composition/ Information on ingredients.

Ingredient	CAS No	Content (% weight)	Risk Phrase	Hazard Symbol
Calcium Hydroxide	1305-62-0	75 – 80 %	R41	Xi
Sodium Hydroxide	1310-73-2	Under 4 %	R35	C
Water		13.5 – 17.5 %		

Intersorb NI contains no ozone depleting chemicals and no volatile organic chemical. During manufacture no ozone depleting chemicals or volatile organic chemical are used.

3. Hazards Identification

Health rating: Slight.
Flammability rating: None.
Reactivity rating: Slight.

Lab Protective Equip: Dust mask recommended, General purpose rubber gloves, Goggles, Wash after skin contact.

Nature of hazard of finished mixture,
'Xi' Irritant

Risk phrases for finished mixture,
R41 Risk of serious damage to eyes. R 36/37/38Irritating to eye, respiratory system and skin.

Safety Phrases:

S2 Keep out of reach of children, S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S 37/39 Wear suitable gloves and eye/face protection. S 45 In case of accident or if you feel unwell seek medical advice immediately and show label if possible.

Dangerous Component determining label and risk phrases
Sodium Hydroxide (under 4 % weight).

4. First Aid Measures.

Eyes: Get medical aid immediately. Do NOT allow victim to rub or keep eyes closed. Extensive irrigation with water is required (at least 30 minutes).
Skin: Get medical aid immediately. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Remove contaminated clothing in a manner which limits further exposure. Remove contaminated clothing and shoes. Thoroughly clean clothes and shoes before re-use.
Ingestion: Do NOT induce vomiting. If victim is conscious and alert, give copious quantities of water. Never give anything by mouth to an unconscious person. Get medical aid immediately.
Inhalation: Get medical aid immediately. Remove from exposure and move to fresh air immediately.

5. Fire Fighting Measures.

Fire: Product is not considered to be a fire hazard. Packaging may be combustible.
Explosion: Not considered to be an explosion hazard.
Extinguishing Media: Use extinguishing media that is appropriate for the environment. Do not get water inside containers and take care of resulting alkaline water
Flash Point: Not applicable, material is considered to be non-combustible.

NOTE: CO_2 is not suitable as extinguishing media: Exothermic reaction may occur.

6.Accidental release measures.

Health precautions. Do not inhale released dust. Use dust mask type 3M 8710E. Use proper personal protective equipment as indicated in Section 8.
Environmental considerations. Do not discharge into sewer system.

Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container. Avoid generating dusty conditions. Do not get water inside containers.

7. Handling and Storage.

Handling: Wash thoroughly after handling. Use with adequate ventilation and dust extractor if necessary. Minimise dust generation and accumulation. Do not get in eyes, on skin, or on clothing. Do not ingest or inhale. Do not allow contact with water. Keep from contact with moist air and steam.
Storage: Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances. Keep away from strong acids. Store protected from moisture. Store at temperatures ranging from –20°C to +50°C. Do not allow to desiccate (dry out). Facilities storing or utilising this material should be equipped with an eyewash facility.

8. Exposure Controls

Follow instructions for use when handling Intersorb NI

Exposure limits of components where relevant.

CAS No	Material	Occupational Exposure Limit.
1305-62-0	Calcium Hydroxide	5 mg/m^3 8-hour time weighted average.
1310-73-2	Sodium Hydroxide	2 mg m^3 Short Term Exposure Limit.

Personal Protective Equipment
Eyes: Wear chemical safety goggles. **Skin:** Wear appropriate gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: Not necessary as product is provided in pellet form. If dust is generated, use dust mask type 3M 8710E.

9. Physical and Chemical Properties.

Physical State: Solid extrudates of 3 mm diameter.
Appearance: White
Odor: None.
pH: Basic in solution
Bulk density: 830 – 860 g/l.
Solubility in water: Less than 1 g/l at room temperature.
Decomposition Temperature where relevant: Calcium Hydroxide decomposes to CaO at approximately 500°C. Sodium Hydroxide decomposes to Na_2O at very high temperatures.

Molecular Formula: Mixture of chemicals – see section 2

10. Stability and reactivity.

Chemical Stability: Stable at room temperature. Substance readily absorbs carbon dioxide from air.
Conditions to Avoid: Avoid contact with acids – vigorous reactions are possible. Do not use with trichloroethylene and chloroform. Contact with high concentration of Carbon Dioxide will generate high temperatures.
Materials to avoid: Hydrogen gas may be formed when in contact with some metals.
Hazardous Decomposition Products: Toxic fumes of sodium oxide, calcium oxide. Low level of Amines may be released from decomposition of Ethyl Violet.

11. Toxicological Information.

No toxicity data is available for finished mixture. However,

Toxicity of major component.

CAS No	Material	Acute toxicity.
1305-62-0	Calcium Hydroxide	$LD50^{rat}$ of 7,300 mg/Kg

Toxicity of minor components.

CAS No	Material	Acute toxicity.
1310-73-2	Sodium Hydroxide	LD50 rabbit 500 mg/kg (10 % solution)

12. Ecological information.

Intersorb NI is not expected to significantly bio accumulate.
Converts to naturally occurring materials.
Do not discharge into lakes, rivers of sewer systems. When handled properly, Intersorb NI is not likely to prove detrimental to the environment.

13. Disposal Consideration.

Unused and utilized soda lime can be disposed of as commercial solid waste similar to household waste in accordance with local waste disposal regulations.
European Waste Catalogue Category: Waste packaging, Absorbents, Wiping cloths, filter materials and protective clothing.

EAK No 150203: Absorbents.

14. Transport Information.

Intersorb NI is not a dangerous product and may be sent by air, road, sea or post.

Transport Classification	**Irritant**
UN Number	**None.**
Hazard Class	**None.**
Packaging group	**III low danger**

15. Regulatory Information

Identification symbol and indication of danger.
Xi Irritant

Risk Phrases
R41 Risk of serious damage to eyes. R 36/37/38Irritating to eye, respiratory system and skin.

Dangerous Component determining label and risk phrases.
Sodium Hydroxide (under 4 % weight)

Safety Phrases.

S2 Keep out of reach of children, S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S 37/39 Wear suitable gloves and eye/face protection. S 45 In case of accident or if you feel unwell seek medical advice immediately and show label if possible.

16. Other information.

The intended use of this product is as an absorbent for Carbon Dioxide. It is suitable for use within anaesthetic equipment.

The above information represents our current state of experience and is provided in good faith. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person. It is the responsibility of the customer to test whether the product is suitable for the purpose intended by the customer.

Date of issue 14th may 2010
Contact: Mike Holder.
Tel: Quality and specialist information 0044(0)1189656361
e-mail 'mhol@intersurgical.co.uk' or general 'info@intersurgical.co.uk'

MSDS

Material Safety Data Sheet

Complies with OSHA'S Hazard Communication Standard 29CFR 1910 1200

DATE PREPARED 01-10-2010

SECTION 1. PRODUCT IDENTIFICATION

PRODUCT NAME: STERAMINE 1-G TABLETS

EPA REG. NO.: 1561-11

This product is registered and regulated by EPA under FIFRA and regulated by FDA under subpart F of The Food Additives Amendment.

PRODUCT USE: Tablets are dissolved in water to provide sanitising solutions for food contact surface sanitising in the food service industry.

MANUFACTURER:

EDWARDS-COUNCILOR CO., INC.
1427 BAKER ROAD
VIRGINIA BEACH, VA 23455

EMERGENCY PHONE NO: (800)424-9300
PHONE FOR INFORMATION:(757) 460-2401

SECTION 2. HAZARDOUS INGREDIENTS

HAZARDOUS COMPONENT
CHEMICAL NAME: (COMMON NAME)

	C.A.S. NUMBER	% PRESENT	TLV UNITS
ALKYL (C14 95%, C12 3%, C16 2%) DIMETHYL BENZYL AMMONIUM CHLORIDE DIHYDRATE (QUATERNARY AMMONIUM COMPOUND - MYRISTALKONIUM CHLORIDE)	68424-85-1	50%	N/A

HAZARD RATING 1, HEALTH 1, FIRE REACT 0
RCRA HAZARDOUS WASTE CLASS: NON HAZARDOUS
EPA PRIORITY POLLUTANTS: NONE
DOT HAZARD CLASS: NON HAZARDOUS

SECTION 3. PHYSICAL DATA

PHYSICAL FORM: SOLID (TABLET)
APPEARANCE AND ODOR: WHITE, ODORLESS TABLET
SOLUBILITY IN WATER: SOLUBLE
VOLATILES: NON VOLATILE

BOILING PT.: N/A
SPECIFIC GRAVITY: N/A
FLASH PT. PMCC: > 200° F
MELTING PT: > 125° F

SECTION 4. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT, PMCC: >200° F

FLAMMABLE LIMITS: UNDETERMINED

EXTINGUISHING MEDIA: WATER SPRAY, CARBON DIOXIDE, DRY CHEMICALS, FOAM

SPECIAL FIRE FIGHTING PROCEDURES: NONE

UNUSUAL FIRE AND EXPLOSION HAZARD: NONE

HAZARDOUS THERMAL DECOMPOSITION PRODUCTS: CARBON MONO/DIOXIDE

SECTION 5. REACTIVITY DATA

STABILITY: STABLE

INCOMPATABILITIES TO AVOID: STRONG OXIDIZING AGENTS

HAZARDOUS POLYMERIZATION WILL NOT OCCUR

CONDITIONS TO AVOID: CONTAMINATION OF FOOD

SECTION 6. HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: NOT ESTABLISHED

PRIMARY ROUTES OF EXPOSURE:

EYES: UNLIKELY

ORAL INGESTION: YES

SKIN: UNLIKELY

INHALATION: UNLIKELY

THIS PRODUCT, BEING IN SOLID, TABLET FORM, IS UNLIKELY TO PRESENT A HAZARD IN HANDLING TO THE SKIN OR EYES. HOWEVER IF TABLETS ARE CRUSHED AND DUST IS CREATED, THE DUST MAY BE IRRITATING TO THE EYES AND IRRITATING TO THE SKIN IF CONTACT IS PROLONGED. ORAL INGESTION MAY BE HARMFUL.

EMERGENCY AND FIRST AID PROCEDURES:

EYES AND SKIN: IF TABLET DUST GETS IN EYES OR ON SKIN, FLUSH WITH PLENTY OF WATER. IF IRRITATION PERSISTS, GET MEDICAL ATTENTION.

INGESTION: IF TABLETS ARE SWALLOWED, DRINK PROMPTLY A LARGE QUANTITY OF WATER. AVOID ALCOHOL. GET MEDICAL ATTENTION IMMEDIATELY.

NOTE TO PHYSICIAN: PROBABLE MUCOSAL DAMAGE MAY CONTRAINDICATE THE USE OF GASTRIC LAVAGE. MEASURES AGAINST CIRCULATORY SHOCK, RESPIRATORY DEPRESSION AND CONVULSION MAY BE NEEDED.

INHALATION PROCEDURE: SAME AS FOR INGESTION

TOXICITY: ACUTE ORAL TOXICITY IN MICE IN 24 HOURS:

LD50mg/kg = 760 +/- 146

NOTE: INDIVIDUAL TABLETS WEIGH 1.5 GRAMS EACH.
TABLETS CONTAIN AN INGREDIENT THAT TASTES EXTREMELY BITTER, ESPECIALLY TO CHILDREN, TO HELP REDUCE THE CHANCE OF ACCIDENTAL INGESTION OF ENOUGH TABLETS TO BE HARMFUL.

SANITIZING SOLUTIONS PRODUCED WITH THESE TABLETS AT THE CONCENTRATION LEVEL SPECIFIED BY LABEL DIRECTIONS ARE CONSIDERED TO BE NON HAZARDOUS TO MAN OR THE ENVIRONMENT AND ARE IN COMPLIANCE WITH REGULATIONS OF THE EPA AND FDA.

THERE ARE NO CHEMICALS CONTAINED IN THIS PRODUCT THAT ARE LISTED AS CARCINOGENS OR POTENTIAL CARCINOGENS UNDER THE NATONAL TOXICOLOGY PROGRAM, I.A.R.C. MONOGRAPHS, OR OSHA.

SECTION 7. SPILL OR LEAK PROCEDURES

THIS PRODUCT, BEING IN SOLID, TABLET FORM, DOES NOT INVOLVE THE HAZARDS OF SPILLS OR LEAKS ASSOCIATED WITH HANDLING LIQUID OR POWDERED TYPE PRODUCTS.

WASTE DISPOSAL METHOD: THIS PRODUCT IS INTENDED FOR USE IN COMMERCIAL AND INSTITUTIONAL DISHWASHING OPERATIONS AND MAY BE DISPOSED OF WITH WASH WATER INTO THE SANITARY SEWAGE SYSTEM. PRODUCT IS BIODEGRADABLE. DO NOT REUSE EMPTY CONTAINER, WRAP CONTAINER AND PUT IN TRASH.

RCRA HAZARDOUS WASTE CLASS: NON.HAZARDOUS

SECTION 8. SPECIAL PROTECTION/HANDLING INFORMATION

RESPIRATORY PROTECTION: NO
PROTECTIVE CLOTHING/GLOVES: NO
VENTILATION: NO
EYE PROTECTION: NO

OTHER HANDLING PRECAUTIONS: KEEP OUT OF REACH OF CHILDREN STORAGE. STORE IN DRY PLACE. KEEP CONTAINER CLOSED WHEN NOT IN USE.

DO NOT CONTAMINATE FOOD BY STORAGE OR DISPOSAL.

SECTION 9. SARA TITLE III

THIS PRODUCT IS NOT SUBJECT TO THE TOXIC CHEMICAL REPORTING REQUIREMENTS OFSECTION 313 OF TITLE III OF THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 AND 40 CFR PART 372.