BoE(+) mCCR manual

BoE(+) mCCR manual

This user manual can along with the manufacturers manual and the instruction of an InnerSpace Explorers instructor be used for following mCCR units:

- Pelagian
- KISS

Please see Appendix for Manufacturer Approval and unit specific skills.

The Rebreathers used in the class have to be original, unmodified and in perfectly working order!!

ISE´s Rebreather Program is kindly supported by:

KISS Rebreather LLC.

August 9, 2013

InnerSpace Explorers
Achim R. Schloeffel
Freidankstrasse 3a
81739 Muenchen
Germany

Dear Mr. Schloeffel,

RE: InnerSpace Explorers - approved

It is with great pleasure that I write to you, confirming InnerSpace Explorers as a KISS approved training agency.

InnerSpace Explorers is approved to teach the KISS Closed Circuit diving systems using various diluent gases; air, nitrox, Normoxic Trimix and full Trimix.

InnerSpace Explorers is approved to both train KISS divers and to create instructors and instructor trainors.

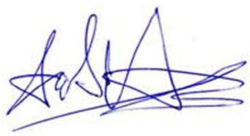
Best regards,

Kim Mikusch
GM

PO Box 3371 Fort Smith Arkansas 72913 United States of America
Email: info@kissrebreathers.com Website: www.kissrebreathers.com

Surat Thani Aug 21 2013

Rebreather Lab Co., LTD. is pleased to announce that effective immediately InnerSpace Explorers, Freidankstrasse 3a 81739 Munich Germany, is authorized to conduct diver training programs on the Pelagian DCCCR closed circuit rebreather.



.....

Andreas Fritz

CEO

Rebreather Lab Co., LTD

Rebreather Lab Co., LTD. Moo 3 Bophut Koh Samui Surat Thani 84320 THAILAND

www.rebreatherlab.com info@rebreatherlab.com Ph: + 66 81 9326149 Fax: +66 77 231389

White Arrow Srl
Via Papa Giovanni XXIII 30/a
Paderno del Grappa, Tv 31017 Italy

To : Coastal Development & Marine Consulting Ltd & Co KG
Dept: InnerSpace Explorers
Freidankstrasse 3a
81739 Muenchen
GERMANY
www.is-expl.com

Dear ISE

I am proud to let you know that training recognition for White Arrow Rebreathers has been **approved**.

Starting on DIC 17th, 2013, ISE will be able to train Divers/Instructors in the proper use of the latest Rebreather technology design and produce by White Arrow Srl.

ISE RB Instructor staff is elegible to participate in actualization for the proper operation and maintenance of the White Arrow Rebreather units as dictated by *WA training standards*, which is currently working on merging the innovative RB Technology in current *ISE standards*. This agreement is valid for 12 months with renewal option, void if the agreed training standards are not followed.

The WA Rebreather Units in this agreement include :

SDV3 System which includes :

-The "**O2 DECO"**, Oxygen Rebreather

-Decompression Rebreather "**SWEET DECO**" in both manual and automatic injection version for mixes of Oxygen and/or any deco gas.

-The Sidemount Rebreather "**SWEET SIDE MOUNT**" a full mixing CCR.

The NT2 System which includes :

-"**EXPEDITON"** Series, pSCR and ApSCR modes, mono or double backmount and sidemount.

-The "**EXPLORER CCR**" traditional back mounted full mixing CCR.

Sincerely,

Nick Toussaint

White Arrow Srl

Disclaimer

Publisher:
Coastal Development & Marine Consulting Ltd. & Co. KG
Dept. **InnerSpace Explorers**
Freidankstrasse 3a
81739 München
Germany
hq@is-expl.com
www.is-expl.com
USt.-Id.-Nr.: DE 283223624

Basics of Exploration mCCR manual English version 1.7

Executive Authors:
Rasmus Dysted
Achim Schlöffel

Authors:
Rasmus Dysted
Achim Schlöffel
Maria Bollerup
Spyros Kollas

Video / Photography / Illustrations:
Hollis
Achim Schlöffel
Rasmus Dysted
Maria Bollerup

Special thank to:
Hollisgear.com, Nick Hollis, Pim van der Horst, Alex Deas, Andy Fritz; Jens Höner, J.W. Bech

Disclaimer
This student manual can only be used together with the manufacturer manual for the specific unit taught. Reading the manuals does not substitute taking a class with a InnerSpace Explorers CCR instructor. This manual gives you a basic knowledge and information about procedures of how to perform diving on a specific CCR unit. This basic knowledge and information alone is not enough to perform dives on CCR rebreathers in a safe and healthy manner. You MUST take a class with an InnerSpace Explorers Instructor certified to teach this class. Even taking a class involve risk accepted by the diver. If you do not take a class, you might injure yourself and others or in worst case die.

BoE(+) mCCR manual

Table of contents

Welcome

Welcome to your InnerSpace Explorers Basics of Exploration rebreather class.

Thank you for choosing InnerSpace Explorer as your training organization for your user class on your CCR unit.
Through this class you will not only learn how to dive the specific rebreather, you will also learn how to become a much better diver in general.

Besides developing both your skills and knowledge, you will during this class learn how to:

✓Assemble, disassemble, clean, disinfect and store your CCR.
✓Dive your CCR to maximum 30 meters with air as a diluent, with a set point of maximum 1,3.
✓If you are taking the "+" class, you can after the class dive to 36 meters using 21/35 trimix as diluent.
✓Handle problem solving within CCR diving.
✓Handle emergency situations within CCR diving.
✓Handle one bail out tank with 32% nitrox and calculate how much bail out gas you need to carry.

Even though your InnerSpace instructor are among the best in the world, we can't guarantee you a certification after this class. You have bought training and will be certified if you full fill the requirements for certification at this level, this decision is entirely up to your instructor.

You can expect world class instruction from our experienced instructor, like we expect you to come prepared every day at your class, have your general diving skills and knowledge up to date, read and understood this and the manufactures manual before the class starts and have the equipment needed to complete this class.
If you attend the class without full filling these requirements, your instructor might ask you to sign up and pay for the next class available.

We are looking forward to some fantastic diving, good company and a lot of fun ☺.

Prerequisites

To attend this BoE(+) rebreather class you have to meet following prerequisites:

✓Be a certified diver with a minimum of 100 dives on OC (open circuit).
✓Be 18 years or older.
✓Read and understood the manufacturer user manual for that specific unit your are taking the class.
✓Read and understood this user class manual.
✓Signed up for the class on the InnerSpace Explorers website.
✓Paid the tuition for this class.

Recommendations:

•Valid cancelation, traveling and diving Insurance.

Duration:

•Minimum 6 days (BoE+ 7 days).
•Minimum 8 dives (BoE+ 9 dives).
•Minimum 500 minutes on the specific unit underwater (BoE+ 550 minutes).

Ratio:

•3:1 (3 students to 1 instructor).
With a certified assistant assisting the course, the instructor are allowed to bring 1 more student in the class.
A certified assistant is an ISE BoE+ instructor who is certified as a diver on any CCR unit.

Crossover program

If you are a certified CCR diver from a another training organization and would like user level on a new unit, but are not yet BoE certified:

- You need to do a full BoE CCR class on the new unit.

If you are a certified CCR diver from another training organization and would like a BoE CCR certification on the unit you are already trained for:

- You need to do a BoE CCR crossover class on the new unit.
- Be a certified diver with a minimum of 100 dives on open circuit .
- Be 18 years or older.
- Have logged a CCR dive within the last 30 days.
- Complete minimum 250 minutes, with at least 5 dives over minimum 4 days during the course.

If you are a certified CCR diver from another organization and would like a user level on a new unit, and are BoE open circuit certified:

- You need to do a BoE CCR crossover class on the new unit.
- Be a certified diver with a minimum of 100 dives on open circuit.
- Be 18 years or older.
- Have a CCR dive within the last 30 days.
- Complete minimum 300 minutes, with at least 5 dives over minimum 4 days.

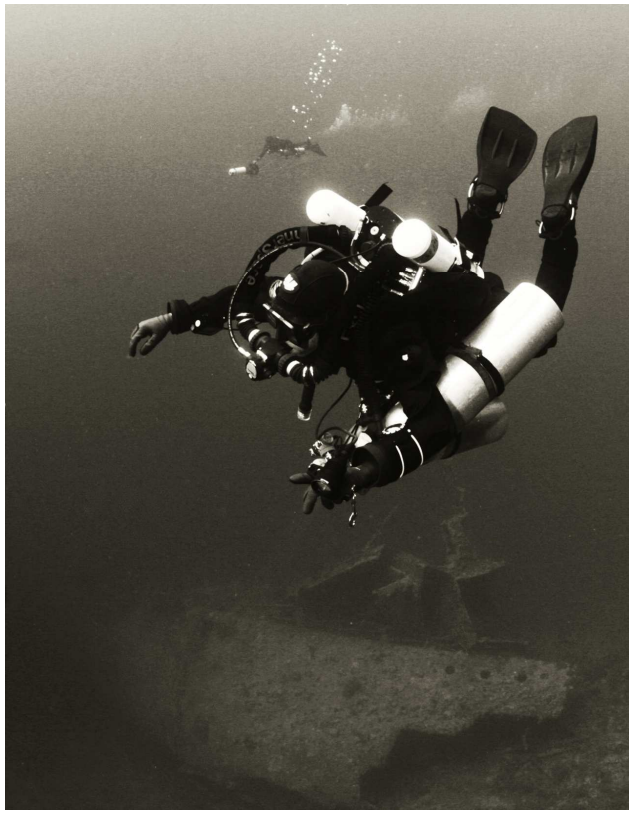
If you are certified BoE CCR diver and would like your BoE CCR user level on a new unit:

- You need to do a BoE CCR crossover class on the new unit.
- Have a CCR dive within the last 30 days.
- Complete 250 minutes of training with at least four dives.

Standards

To qualify for certification on your InnerSpace Explorers Basics of Exploration(+) CCR class, you must demonstrate successful performance in following topics:

✓Swim 15m underwater on one breath with no equipment.
✓Meet the general fitness level for the sport.
✓Understand the knowledge section of this course.
✓The skills to be performed underwater.
✓General behavior and attitude towards diving at this level.



If your instructor evaluates that:
•You need more training.
•Your behavior is inappropriate.
•Your understanding for safe rebreather diving is insufficient.
Then you will not be certified during this class.

Standards your instructor must meet during this course:
✓Be insured to meet requirements by local laws.
✓Bring oxygen to all dive sites and show you how to operate it.
✓Be certified and renewed to teach at this level.
✓No decompression diving during this course.
✓No overhead environment (wreck, caves etc.) during this course.

Standards

How can InnerSpace Explorers keep up the high standards in dive training?

✓ **Quality assurance.**
After successful completion of every course you do with InnerSpace Explorers, you have to fill out a questionnaire on our website prior certification. In this way we can control the quality of all our courses.

✓ **Critical skills.**
In InnerSpace Explorers, we believe that you get the best training if you practice real emergency skills with “hands on”, instead of by signals only. If an emergency situation happened in “real” diving you wouldn’t get a warning. Our goal is to train you for that.

✓**Strict global standards and procedures.**
All instructors are to follow the standards & procedures, to ensure consistency within the training organization.

✓ **Re-qualification.**
All divers and instructors are to re-qualify on their highest certification level every third year. This way we ensure that divers and instructors certified within InnerSpace Explorers are up to date when performing their dives.

✓ **No ‘back to back’ or ‘bundled’ courses.**
The best diver is rarely the one with most certifications, but often the one with most experience. You will learn so many new skills during your InnerSpace Explorers courses, that you need to practice these skills before progressing to the next class.

✓ **Physical endurance.**
Diving is a physical demanding sport. We therefore expect you to live up to these physical demands when you sign up for your InnerSpace Explorers courses.

✓ **Non smoking training organization.**
You know why. However, smokers are allowed on the BoE class, because this a recreational class and not a technical class.

What's next

After certification

- When you have earned your certificate, it is up to you to go practice your new skills and always keep them fresh and up to date.
- Before you participate in your next InnerSpace Explorers class, you need to be sure that the skills you learned during this class, are mastered to perfection. The skills will be the overruling fundament for the next levels.
- Ask your instructor if you are in doubt.
- Remember that you have to re-qualify maximum 3 years after your certification date.

What happens if your instructor evaluates that you are yet not ready for certification?

- Don't worry this happens frequently. Not because of bad divers or instructors, but because you signed up for a class in the worlds toughest training organization and our standards prior certification are higher than others.
- We even have divers signing up for classes knowing that they will not get a certificate, but they want the training.
- Certificate or not, we hope that you learned a lot and will keep practicing on your new skills.
- Discuss with your instructor when you should come back for more training and evaluation.

Good luck and have fun diving ☺

Latest manuals and software

Before we proceed let's check if you have latest:

Manufacturer manual

- **Pelagian**
- **KISS**

History of rebreathers

courtesy http://www.therebreathersite.nl
collection J.W. Beeh

History of rebreathers

- **Around1620:** Cornelius Drebbel builds an oar-powered submarine fit for short dive. His crew was kept alive by heating potassium nitrate in a metal pan, and thereby creating potassium oxide or hydroxide, which absorbs carbon dioxide.

- **1680:** Giovanni Borelli conceives the closed circuit rebreather. He believed recirculating air through a copper tube, cooled by seawater, would allow “impurities” to condense.

- **1774:** Joseph Priestley discovers and recognizes Oxygen and its importance for sustaining life.

- **1808:** Oldest known rebreather based on carbon dioxide absorption built by Sieur Touboulic, a mechanic in Napoleon’s Imperial Navy. Using an oxygen reservoir, air was added and circulated manually through a sponge soaked in limewater.

- **1849:** Patent was granted to Pierre Aimable De Saint Simon Sicard for the oldest known rebreather (for which a prototype was built) - also using an “oxygen reservoir”.

- **1853:** Professor T. Schwann designs a rebreather in Belgium. It held a large back mounted oxygen tank with working pressure of about 13 bar, and two scrubbers based on marine sponges soaked in caustic soda.

- **1878:** Henry Fleuss receive patent on a recirculation device using stored oxygen and absorption of carbon dioxide by rope yarn soaked in caustic potash solution.

History of rebreathers

- **1878:** Dr. Paul Bert publishes *"Barometric Pressure"*. The topics are; oxygen toxicity, hypoxia and decompression sickness.
- **1881:** Patent is given to Achilles, Khotinsky & Simon Lake for a rebreather that uses barium hydroxide as a chemical scrubber to remove Carbon Dioxide.
- **1904:** Patent is given to Siebe Gorman "Oxylite" - a potassium and sodium peroxide mix that liberates Oxygen on contact with water.
- **1905:** A Fleuss apparatus is patented for use in submarine escape.
- **1908:** Development of decompression techniques (Haldane).
- **1912:** Draegerwerk demonstrates a unit (submarine sled) with a two-hour closed circuit supply of O2.
- **1915:** Oxylite rebreathers are used for underwater scenes in the filmatization of Jules Vernes *Twenty Thousand Leagues Under the Sea.*
- **1919:** Patent is given to C.J. Cooke for oxygen-helium breathing mixtures.

History of rebreathers

- **1926:** First self-contained open circuit SCUBA system (Fernez-Le Prieur).
- **1935:** Nitrogen narcosis recognized as an attribute of elevated nitrogen partial pressures.
- **1939:** Heliox Tables published by the U.S. Navy (Albert Richard Behnke – a name worth googling).
- **1939-1944:** O2 rebreathers and EAN rebreathers is highly present in the Second World War. The mix of gas for the EAN rebreathers were classified and was successfully kept secret by the British through WWII.
  Lamerbertson develops the LARU, Lambertson Amphibious Respiratory Unit rebreather.
- **1942:** Hans and Lotte Hass dives a modified Dräger rebreather during the filming of “Man amongst Sharks”. Until now, rebreathers has only been used commercially.
- **1944:** Ex-military rebreathers are used by British cave divers to push cave sumps in the few next coming years
- **1950:** The “Aqualung” (first open-circuit demand valve – invented in 1942 by Émile Gagnan and Jacques Cousteau) reach worldwide popularity and success. Causing the interest of rebreathers to decline.
- **1969:** Walter Starck and John Kanwisher introduces the ‘ElectroLung’ mixed gas rebreather for the sport diver. The unit caused 3 fatalities and was taken off the market in 1970.

History of rebreathers

- **1970:** NOAA launches enriched air nitrox program.

- **1970-1980:** A longer variety of CCR units hits commercial and recreational market. None of these products survive. CCR 1000 and Mk15 from Biomarine are real milestones to be mentioned here and set the base for most CCR's to come.

- **1984:** Nitrox becomes available to recreational divers – although many claims it a dangerous gas.

- **1986:** Dr. Bill Stone is testing the prototype of the fully-redundant MK 1 Cis-Lunar rebreather on Wakulla Springs project. Later, this unit with some modifications is to be the first CCR available for recreational divers.

- **1992:** Another milestone in CCR is reached when Carleton MK 16 rebreather is used to explore the Bahamas Blue Hole cave systems.

- **1995:** Dräger introduces its Atlantis semi-closed rebreather for recreational divers, this popular is later known as the "Dolpin".

- **1995 - 1997:** Recreational rebreather training becomes available through several training agencies. The Cis Lunar MK 5 is now available.

History of rebreathers

- **1997:** AP Valves launches the “Inspiration” the first CCR unit to be “mass produced” for the recreational diver. This was closely followed by big and still present players like; Prism, Megalodon, Ouroboros, Optima and Kiss.

- **2001:** The semi-closed rebreather SCR Azimuth, and the Halcyon RB80 are introduced on the market.

- **2004:** The Evolution (a smaller and lighter version of the Inspiration) along with the Inspiration is launched by APD (Ambient Pressure Diving Ltd.) with the new and advanced “Vision Electronics”.

- **2008:** Poseidon stirs up the rebreather world with the Poseidon MkVI. A unit engineered by Bill Stone, aimed for the recreational rebreather market.

- **2011:** Rebreathers become accessible and available for recreational divers as PADI launches their recreational rebreather course.

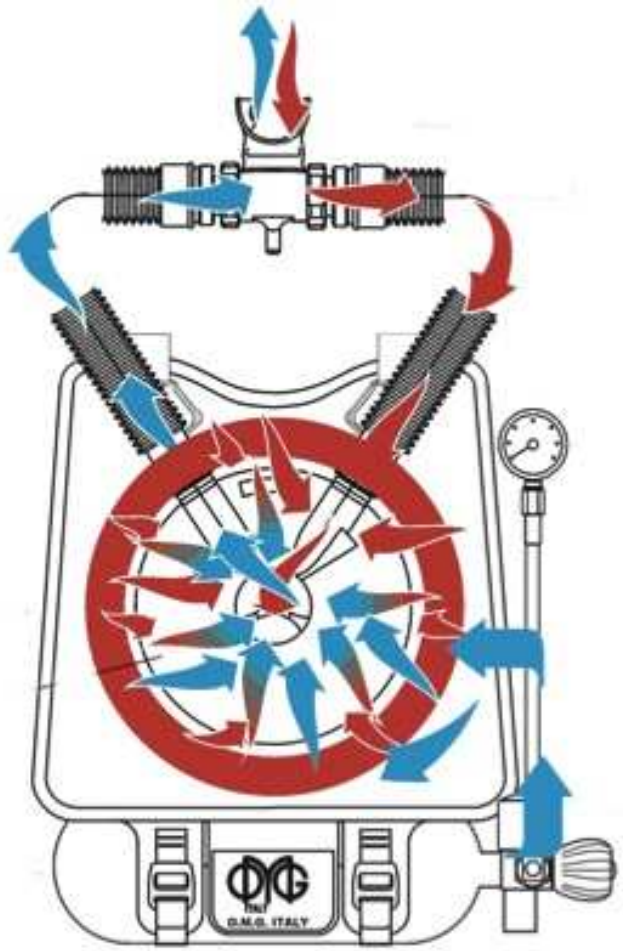
- **Today, the rebreather market is extensive and new advanced electronics and units are introduced to the scene regularly.**

Different types of rebreathers

Different types of rebreathers

Oxygen rebreathers

- First rebreather model on the market.
- Fully closed rebreather.
- Was and is still widely used by the military.
- Very simple construction.
- Limited on depth.
- Seen more and more in recreational diving, specially on female divers.



Different types of rebreathers

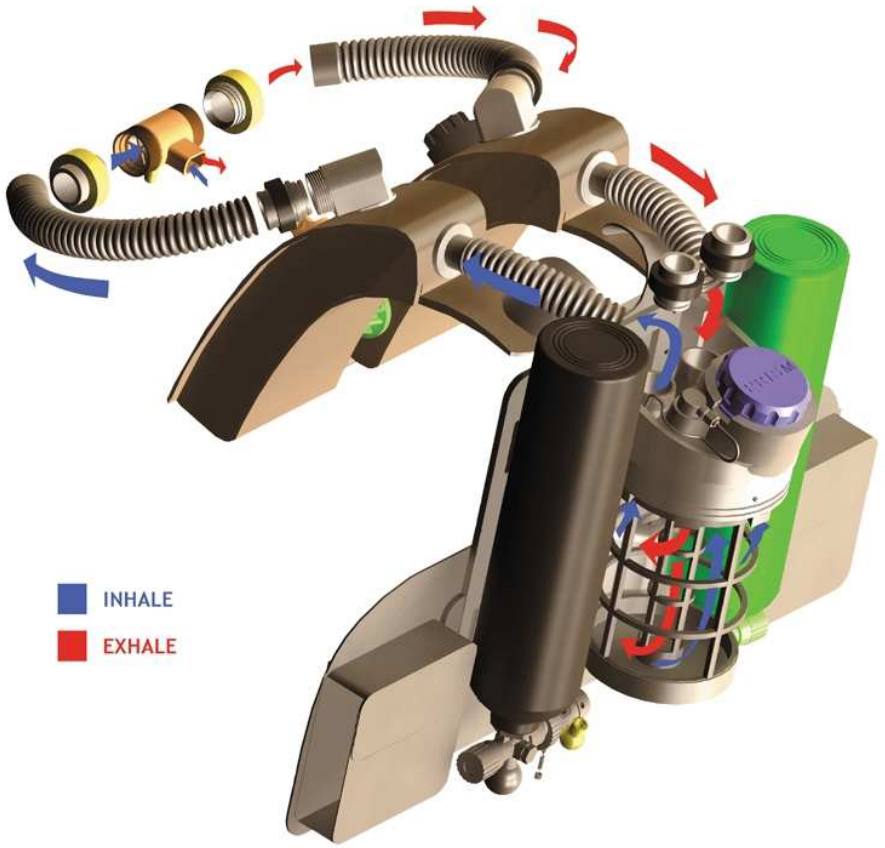
Semi closed and hybrid rebreathers

- Constant flow or passive addition.
- Usually only one tank with nitrox.
- Often cheaper than fully closed rebreathers.
- Allows air to escape regularly.
- Some SCR units is mainly meant for gas extension.
- Several SCR units are depth limited.

Different types of rebreathers

Closed Circuit Rebreathers

- Electronic CCR (eCCR)
  The injection of oxygen can be controlled
  by the electronics in the unit.
- Manual CCR (mCCR)
  The oxygen will either have a constant flow (orifice) or
  a needle valve to adjust the flow .
- Chemical CCR (cCCR)
  A chemical reaction creates oxygen, unfortunately
  The chemicals needed are poisonous.
- Technical CCR (tCCR)
  Can be any of the above, but is
  prepared for technical diving.
- Recreational CCR (rCCR)
  The rCCR is specially made so it can be dived in a
  safe way by divers who do not want a technical unit.
  The opportunities on a rCCR is often limited .



A CCR will give you the “best” nitrox mix for the current depth you are at

Different types of rebreathers

Together with your instructor you will now:

- Look at your CCR in details, take it completely apart and discuss how it works, this includes:
  - Batteries and oxygen sensors.
  - OPV, ADV, and manual add buttons.
  - Completely disassembly and assembly the DSV/BOV and remove and replace the mushroom valves.
- Go through the manufacturer manual in details.
- Assemble your unit following the manufacturer check list.
- Check if the unit is ready for diving.

NOTE:

Never assemble a rebreather without a check list.

Your instructor will give you the ISE check list,

when you start your course.

The check list is made specifically to your rebreather.

Parts in a rebreather

Parts in a rebreather

Different types of scrubbers

- Axial scrubber - gas travels through the absorbent from top to the bottom or opposite.
- Radial scrubber - gas travels down through the middle and out through the absorbent.
- The two types of scrubbers can have different gas flow. Gas flowing inwards, outwards, downwards, upwards and combinations thereof.

What to put in your scrubber

- **Barium Hydroxide**
  The earliest form of absorbent
- **Lithium hydroxide**
  Long lasting and efficient but expensive
- **Soda lime**
  The most common absorbent to be used

Parts in a rebreather

What is the purpose of the scrubber

- To remove CO2 from the breathing loop / your exhalation gas.
- The CO2 is absorbed in the scrubber (soda lime or sodium hydroxide) due to an exothermic chemical reaction that creates heat and moist.
- Check in your manufacturer manual what absorbent to use and what duration your scrubber has with that absorbent.
- You can't reuse the absorbent in any way.
- When you change the absorbent you change it all at the same time.
- Some manufactures install a scrubber duration sensor. The sensor normally react to heat and therefore tells you what part of the scrubber is active. Always follow the manufactures guidelines.
- For deeper dives (+40meters), scrubber duration decreases. On deeper depths the amount of inert gas is greater, which makes it more difficult for the absorbent to "reach" and absorb the CO2 as efficiently as on lower depths.
- Most scrubbers have a water trap in the bottom, the size of the water trap can differ a lot from unit to unit.

Parts in a rebreather

Absorbent duration varies because of

- Temperature.
- Moist.
- Canister design and volume.
- Exertion level of the diver.
- Chemical composition.
- Depth – amount of inert gas.

Caustic Cocktail

- If water get's in contact with the absorbent in your scrubber, it will create a caustic solution called a caustic cocktail.
- If you feel increased breathing resistance and/or white milky water coming from the inhalation side of the breathing loop, there is a high possibility that you have flooded your unit and are experiencing a caustic cocktail.
- The caustic solution is unhealthy and should be avoided. If this happens, bail out and end the dive immediately.

Parts in a rebreather

Channeling

- Gas will always travel the easiest way possible.
- If you do not pack your absorbent correctly the gas might “channel” through the scrubber and the CO2 will then not get absorbed.
- This can resolve in Hypercapnia (more about hypercapnia later).
- If you expect that you are suffering from hypercapnia bail out and end the dive.
- Your instructor will during this course teach you how to pack your scrubber in a safe way.

Dwell time

- Dwell time is defined as the time the gas in the loop dwells in the scrubber absorbent.
- If the gas travels through the scrubber too fast, the CO2 will not be in contact with the absorbent long enough to be absorbed = too little dwell time. This can resolve in hypercapnia.
- The gas can travel through the scrubber to fast if for example:
  - You have modified the breathing loop.
  - Not packed the scrubber correctly.
  - You didn’t fill the scrubber completely (as specified by the manufacturer).
  - The scrubber is too small for the unit.
  - You are breathing heavily for a longer period of time.
  - You are using the wrong scrubber for the unit.

Parts in a rebreather

Oxygen sensors

- How many cells are in your rebreather and why?
- Where are they placed and how do you take best care of them?
- Some rebreather electronics are using a philosophy called “voting logic”. This means that if there are three cells in the rebreather, the two that display the most similar reading will be the “ruling” cells, but it might not be the two that are right! You will learn during this class to validate your cells under water by performing a diluent flush.
- Oxygen cells do not last forever. Over time, the viscosity of the electrolyte dries out and the led anode is consumed. The cells will start to react slower and won’t be able to read high oxygen content called “current limited”. Check in your manufactures manual how often you should change your cells. Most often it is every 12 month. A good rule of thumb is a mV reading of **at least** 8.5 on air and 35.0 in oxygen – if less, change the cells.
- An oxygen cell is unfortunately not just an oxygen cell. There are many different kinds of O2 cells, look in the manufactures manual to find what oxygen cells should be used in your unit.
- Remember to mark your oxygen sensors when you change them.

How do oxygen sensors work

- Gas enters through a delicate Teflon membrane, then passes through a thin layer of electrolyte and on through a cathode (in most cases, the base metal rhodium).
- The amount of Oxygen particles passing through the cathode is then “detected” as an electric current (mV) by the lead-pleated anode. In the other end of the cell there is a small circuit board and the connection to the rebreather electronics.
- The electronics “translates” the mV reading into a set point / PPO2 which is then displayed on your handset and HUD. Some rebreather electronics can also display the mV reading.

Parts in a rebreather

Batteries

- Check in the manufacturers manual what type of batteries, how many, where and how they are installed correctly in your rebreather.
- Change or charge your batteries before they run low to avoid problems with your electronics during a dive.
- Some batteries can be hard to obtain in general stories. Make sure to bring spares when travelling with the unit.

The HUD

- HUD = Head Up Display.
- Is in most cases run on separate battery from the handset(s).
- Displays your set point individually by LED lights in combinations of colors and sequenced flashes.
- Therefore the HUD normally works as either the primary reading or secondary reading of the oxygen cells.
- Study and practice from the manufacturers manual how your HUD is working and how to read it. This will of course be practiced during dives on this course as well.

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

„Smithers Code“ used on most HUDs

Parts in a rebreather

Warning buzzer / audible and visible alarms

- Some rebreathers has installed warning buzzers and/or audible alarms.
- Depending on the unit and user settings, alarms will warn you on high or low PPO2, depths and/or gas levels.
- Audible alarms are usually placed close to your ear.
- Buzzers are usually placed in the mouthpiece.
- Visible alarms are installed where they are – visible – (HUD, Handset).
- If you experience any form of these alarms, you must immediately look at your handset.

The PO_2-Meter

- Depending on the model of rebreather, you can have one or more of these measurement devices.
- They are connected to oxygen sensors in the head of the rebreather and might have an internal and/or an external battery.
- They are displaying your actual set point (PPO2), you must therefore watch it every 1-2 minutes (or the HUD).
- Failing to do so can have fatal consequences! - ALWAYS KNOW WHAT YOU BREATHE.

Parts in a rebreather

Breathing hoses

- Connects the scrubber with the counterlungs and the counterlungs with the BOV/DSV.
- Breathings hoses are corrugated (rippled) to make the gas mix, as it is drawn through the loop.
- You will adjust (twist) the breathing hoses underwater, for a perfect fit of the mouthpiece in your mouth.
- A protective Cordura hose cover looks nice and avoids damage on your breathing hoses.

BOV / DSV

- DSV (Diver surface valve) open or closes the loop. But without the OC option.
- BOV (Bail out valve) works the same way as the DSV and makes it possible to breathe OC (open circuit) gas through your mouthpiece. ISE recommends you have a BOV installed on your unit.
- Never leave the BOV/DSV in CC (Closed Circuit). It WILL flood the unit and have you aboard the dive before it even started. Whenever the mouthpiece is not in your mouth – it should be in OC.

Parts in a rebreather

Mushroom valves

- One of the most important, simple and fragile parts of the breathing loop!
- Ensures that the gas circles through the unit by directing the gas flow. If they are missing, are ripped, has a hole or any small leak, the air you breathe will only be moving back and forth between your lungs and the actual breathing the loop. NOT entering the scrubber.
- Can either be placed in the BOV/DSV or in the breathing hoses.
- Every time you disassemble or “break” the loop, you must inspect and test your mushroom valves before diving the unit again.
- Breathing from a loop with bad functioning mushroom valves is likely to cause an accident due to high CO2 level (Hypercapnia).
- If you feel any signs of hypercapnia - bail out and end the dive.
- If you are not confident in your Mushroom Valves – TEST THEM AGAIN!

T-pieces

- Are mounted on many common counterlungs and is where the breathing hoses attaches to the counterlungs.
- Some T-pieces has a build-in water trap to avoid that water entered through the mouthpiece, travels to the scrubber and the electronics. The “trap” simply directs the water to the countrlungs.

Parts in a rebreather

Counter lungs

- Over the shoulder counterlungs.
- Back mounted counterlungs.
- Front mounted counterlungs.
- Other placement of counterlungs.
- Every time you inhale, you breathe the gas from your breathing loop including the counterlungs. This is why your buoyancy is not affected by the breathing when diving rebreathers. Every time you exhale, you “blow” gas right back into the counterlungs, loosing no gas. (except what you metabolize)
- During diving on your rebreather, you will maintain “optimal loop volume” (or “minimal loop volume”). This means that you will not have more gas in the counterlungs, than you can inhale in a full deep breath. More about this later.
- The positioning of the counterlungs are vital for optimizing the WOB (Work Of Breathing). If they are placed to far down or up it will affect your breathing resistance and it can suddenly be hard to breathe. Your instructor will help you with the right placement of your counterlungs during this course.

Parts in a rebreather

OPV (Over Pressure Valve)

- Is mostly mounted on the exhalation-side counterlung (with exceptions).
- Used to release excess gas from the breathing loop.
- On many rebreathers, the OPV can also be used to recover minor flooding of the breathing loop. (flood recovery)

ADV (Automatic Diluent Valve)

- Automatic injects diluent gas in the breathing loop, when the breathing loop reach a minimum (bottoms out).
  As an example on descend; The increasing surrounding pressure creates a “less than optimal” loop volume. This will activate the ADV and diluent will be added to the loop.
- Is often placed in the BOV, the head or in the inhalation-side counterlung.
- Many ADV’s can also work as a manual add diluent button.

Flow stop

- Is useful if you want to add the diluent manually.
- Is placed on the ADV.
- If a flow stop is mounted on your ADV, be aware that the ADV will NOT automatically add diluent when needed.

Parts in a rebreather

Manual add buttons

- You will normally have both, a manual oxygen button and a manual diluent button.
- On several units the ADV is also working as the manual diluent button.
- This is one of the parts that can make the difference between a tCCR and a rCCR.
- You will learn how to “fly the unit manually” by using the manual buttons to keep your setpoint and optimal loop volume.

Orifice / needle valve

- mCCR’s will either have a constant mass flow (CMF) through an orifice or a needle valve controlled flow.
- Refer to your manufactures manual to see how your rebreather controls the flow of oxygen, and what this means for you while diving.
- Also refer to the section of physiology to understand the process of oxygen metabolism.

Parts in a rebreather

Water drains

- Some counterlung(s) has water drains in the bottom, which makes it easier to drain water and collecting moist. There should not be water on your inhalation-side counterlung. If there are, you either have a leak, has flooded your unit completely or is missing a mushroom valve.

Off board plug in

- Some rebreathers have the option of plugging in off board cylinders.
- This is normally used on dives that demands long decompression and therefore a lot of gas.
- However, it works perfect as a back up solution if you run out of gas on even short shallow dives.
- During this course you will learn how to use your bail out as an off board plug in cylinder.

Parts in a rebreather

Diluent tank

- Looking at the rebreather from behind, the diluent tank is normally placed on the left side.
- Some rebreather divers have diluent cylinders on both sides of the rebreather.
- During this course you will use normal air as diluent.
- On future courses this might change into trimix.

Oxygen tank

- Looking at the rebreather from behind, the oxygen tank is normally placed on the right side.
- Some rebreather divers are staging their oxygen tank.
- Your oxygen tank must at all times be oxygen clean.
- Only fill the oxygen tank with medical or aviation grade oxygen, never with oxygen for welding.

First stages

- You need one 1st stage for your diluent cylinder and one 1st stage for your oxygen cylinder, depending on the CCR model and the configuration, you might need more 1st stages.
- All first stages needs an overpressure valve in case of a 1st stage failure.
- The 1st stage for the oxygen cylinder ***MUST*** be oxygen compatible and therefore oxygen cleaned.

Parts in a rebreather

Hoses from the oxygen 1st stage

- All hoses coming out of the oxygen 1st stage must be oxygen compatible.
- For the most common mCCR units you would need 3 hoses from the oxygen 1st stage:
  1) High pressure hose for your SPG (Submersible Pressure Gauge).
  2) Low pressure hose to connect to the “Kiss”-Valve of the CCR to add oxygen (by flow).
  3) Low pressure hose to connect to the manual oxygen button. (Might be the same as #2)

Hoses from the diluent 1st stage

- Number of hoses coming from the diluent 1st stage varies depending on the configuration you are diving:
  1) High pressure hose for your SPG (submersible Pressure Gauge).
  2) For the ADV (Automatic Diluent Valve) and/or the manual diluent button.
  3) For the buoyancy device you are using for the unit.
  4) If you have a BOV (Bail Out Valve) in your mouthpiece.
  5) If you have an octopus you want to run from you diluent.
  6) Some rebreather divers use the diluent gas in their drysuit, this is not recommended.

Parts in a rebreather

O-rings

- Make sure to visually inspect all the o-rings on the unit every time you assemble it.
- The o-rings should be greased if necessary, be aware that the grease you are using are compatible with the manufactures recommendations, normally oxygen compatible grease on most o-rings.
- When you assembled the unit be careful not to scratch the o-rings, or assemble the parts in a way where the o-ring is “sticking out” between the parts. In general – take care.
- DO ONLY USE O-RINGS IN YOUR REBREATHER THAT IS MEANT FOR THAT UNIT, YOUR LIFE DEPENDS ON IT.

Sponges and moisture pads

- Some rebreathers comes with sponges or moisture pads to collect moist and minor amounts of water.
- Depending on the unit, the sponges and moisture pads can be placed in various places, but often before or after the actual scrubber, or inside the head near the batteries or cells.
- They are a great place for bacteria to live – needs extra good cleaning and to be replaced often.

Parts in a rebreather

Buoyancy device and harness

- Some rebreathers are build with a buoyancy device and a harness system, some comes without.
- In some CCR units you can't change the buoyancy device and the harness, it is a part of the rebreather.
- If you can change your harness and buoyancy device, you want to make sure that the fit is correct and compatible with the unit and that the buoyancy device can hold the weight in the water.

Spare parts and toolbox

- Always have a broad selection of spare parts and tools with you, especially if you travel. You can fix many of the most common problems that can occur. Examples could be o-rings, batteries, mushroom valves, oxygen sensors etc.

Accessories

- Look in the manufacturers manual, on forums and talk with you InnerSpace Explorers CCR instructor of what accessories are available for your unit and if some of these accessories would fit into your diving.

Equipment you need

Equipment you need

Back plate and harness

- The most common materials for back plates are aluminum and steel.
- The difference is the weight of the back plate.
- Not all rebreathers need a back plate.
- The harness has to be a rigid and solid construction.
- We do not accept quick releases, your harness has to be a rigid and solid construction.
- You need 5 d-rings on your harness/rebreather:
  1) Left chest.
  2) Right chest.
  3) Left hip.
  4) On the but, on the crotch strap.
  5) In the front on the crotch strap.
- You want to have the webbing on your right hip free, That's were we mount the canister torch.

BP & harness	Recommended	Required
Basics of Exploration	✓	
Level I		✓
Level II		✓
Level III		✓

Equipment you need

Buoyancy device

- Your buoyancy device must be a durable, streamlined and of solid construction.
- The buoyancy device must not have any external or internal bungees.
- It must be single bladder.
- Suited for the rebreather that you are diving.
- Be able to hold the weight of you and the gear you are carrying.

Buoyancy device	Recommended	Required
Basics of Exploration	✓	
Level I		✓
Level II		✓
Level III		✓

Equipment you need

Bail out cylinder

- Even if you have a BOV on your rebreather, you must always carry a bail out cylinder when diving a CCR.
- A bail out cylinder is an extra tank you stage on your left side. In case the rebreather has a malfunction, you can close the loop and breathe safely from the bail out cylinder.
- The gas in your bail out is normally the same as in your diluent. During this course you will be using 32% nitrox as a bail out since we do not want to bail out to normal air coming from a much higher oxygen content.
  In InnerSpace Explorers we do generally never dive on normal air.
- On the BoE+ class your bail out will be 21/35.
- The size of the cylinder depends on the dive, more about this later.
- Your bail out cylinders should always be aluminum with a DIN valve.

Bail out cylinder	Recommended	Required
Basics of Exploration		X 1
Level I		X 2
Level II		X 3
Level III		X 4+

Equipment you need

Valves

- You should always use DIN valves on your cylinders.
- Your valves must have a rubber handle. Metal or plastic can break and makes it almost impossible to perform a “shut down” underwater.
- Follow the local laws when it comes to threading size etc.
- Ask your instructor about the difference in J and K valves and 200bar vs. 300bar.

Dry suit inflation system (Argon tank)

- On the left side of your back plate / rebreather you will mount a dry suit inflation system (if diving in a dry suit).
- This is normally a 1L cylinder with a 1st stage, overpressure valve and a dry suit inflator hose .
- Some divers fill their dry suit inflation systems with argon, we recommend to fill your tank with normal air.

Dry suit inflation	Recommended	Required
Basics of Exploration		✓
Level I		✓
Level II		✓
Level III		✓

Equipment you need

Weights

- Different rebreathers have different solutions of how to attach weights.
- Look in your manufactures manual and talk to your instructor of where you should place your weights.

Regulators

- Your regulator must be a downstream regulator, ready for cold water diving and be easy to breathe from.
- It must also have a removable faceplate so you can fix eventual problems with the regulator underwater.
- On your Bail out cylinder you will have a regular 1st stage with:
  1 x 2nd stage on a 210cm hose.
  1 x SPG on a 15cm HP hose.
  1 x Back up low pressure inflator hose for the ADV or manually diluent button.

SPG (Submersible Pressure Gauge)

- Your SPG must be solid construction, for example brass with tempered glass.
- It must not have a protective boot of any kind.

Equipment you need

Hoses

- The length of the hoses differs from rebreather to rebreather, but on your bail out it must be 210cm.
- You can have hoses in different materials like rubber and the more soft ones like MiFlex etc.

Primary light

- Your primary light must have a Goodman handle, it doesn't necessarily has to be a canister light.
- It should have a light output for minimum 1.000 lumens.
- The burn time of the primary light must, as a minimum, exceed the dive time by x 3. If you for example make a 60minutes dive, the burn time of the light must be minimum 180 minutes etc.

Back up lights

- You will normally have two back up lights in a solid and robust construction.
- They should have a long lasting battery capacity and a reasonable light output.

Back up lights	Recommended	Required
Basics of Exploration	X 2	X 1
Level I		X 2
Level II		X 2
Level III		X 2

Primary light	Recommended	Required
Basics of Exploration		✓
Level I		✓
Level II		✓
Level III		✓

Equipment you need

Mask

- Always carry a spare mask in your pocket.
- We recommend a mask with black silicone skirt, low volume and with a neoprene mask strap.

Fins

- Your fins must preferably be in rubber, not too long and absolutely not a split model.
- Spring heels are a must.

Bottom timer or computer

- We recommend that you use a trimix computer that is compatible with CCR diving, however a bottom timer can also do the job.
- If your unit already has a CCR trimix computer, you can use a timer as a back up depth gauge.

Mask	Recommended	Required
Basics of Exploration	X 2	X 1
Level I		X 2
Level II		X 2
Level III		X 2

Equipment you need

Compass

- A compass is a must on all dives.

Primary reel

- Your reel should be jam proof and easy to operate.
- The length of the line depends on what type of diving you intend to use it for.
- You should mark the line of your reel with a knot every 3 meters.

Spools

- Depending on what type of diving you are doing, you need a various numbers of spools.
- In general you should have at least 30-50 meters of line on your spool.
- The spool should be a simple finger spool without any mechanics etc.
- You must mark the line of your spool with a knot every 3 meters.

Compass	Recommended	Required
Basics of Exploration		X 1
Level I		X 1
Level II		X 1
Level III		X 1

Primary reel	Recommended	Required
Basics of Exploration		X 1
Level I		X 1
Level II		X 1
Level III		X 1

Spools	Recommended	Required
Basics of Exploration		X 1
Level I		X 1*
Level II		X 1*
Level III		X 1*

* For cave classes you need more spools.

Equipment you need

Surface marker buoy

- Also called a DSMB (Delayed Surface Marker Buoy).
- Your DSMB must be a closed design with an inflator inlet valve.
- Must have an OPV (over pressure valve)

Surface marker	Recommended	Required
Basics of Exploration		X 1
Level I		X 1
Level II		X 1
Level III		X 1

Lift bag

- Can be used for hanging on to for long decompression or drifting.
- Can also be a DSMB with sufficient lift capacity.
- Your lift bag must be a closed design with an inflator inlet valve.
- Must have an OPV (over pressure valve)

Lift bag	Recommended	Required
Basics of Exploration	X 1	
Level I		X 1
Level II		X 1
Level III		X 1

Wetnotes

- Wetnotes is a must, you will use it for communication and documentation.

Equipment guide	Recommended	Required
Basics of Exploration		X 1
Level I		X 1
Level II		X 1
Level III		X 1

Tool box and spare parts

- As an experienced diver, it is common sense that you always have spare parts and tools with you when you go diving.

Equipment you need

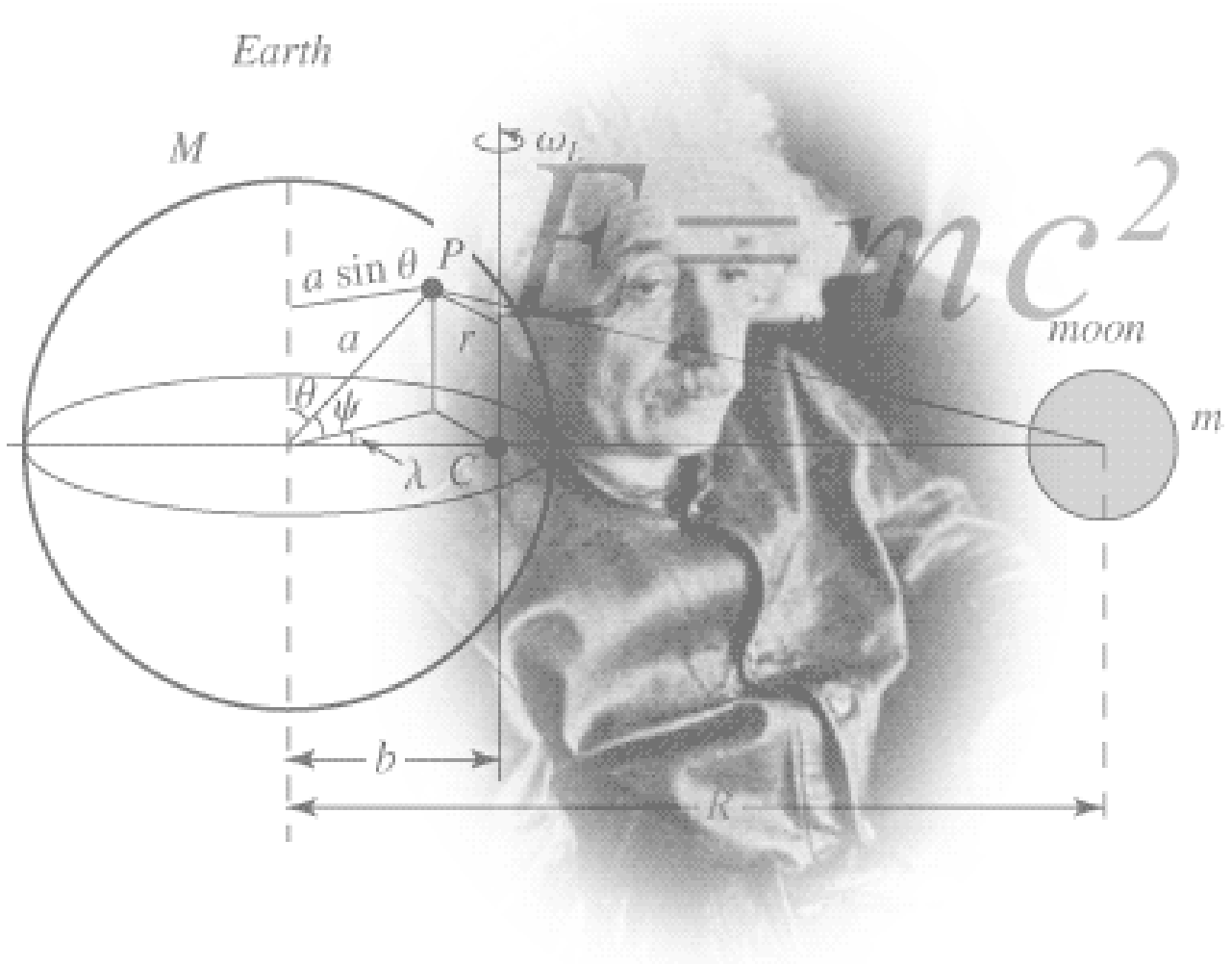
Emergency oxygen kit

- During this course there will, at all times, be an emergency oxygen kit available.
- Before you are doing any dives, your instructor will explain you how it operates.
- It is recommended for all level of divers to have an O2 kit themselves. It can save lives!

Equipment guide	Recommended	Required
Basics of Exploration	✓	✓
Level I	✓	✓
Level II	✓	✓
Level III	✓	✓

Recommended for you as a diver to have, required for your instructor to have available on all dives.

Physics


Earth
M
ω_1
$a \sin\theta$
P
a
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λ
C
moon
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R
$E = mc^2$

Physics

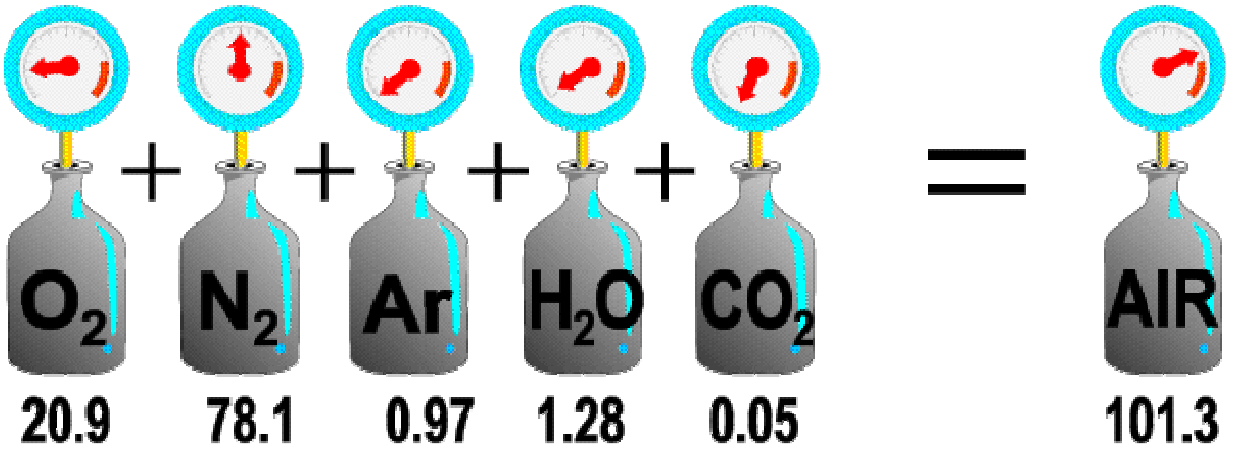
Boyle's Law

- The absolute pressure and volume of a given mass of confined gas are inversely proportional, if the temperature remains unchanged within a closed system.
- *P1V1 = P2V2 (2bar 12liter = 4bar 6liter).*
- What is the volume of a 14liter flexible container at 30meters of saltwater?
  14L : 4atm = 3,5liter.
- If you use 17liters of air on the surface pr minute, how much air do you then use at 26meters?
  17liters x 3,6atm = 61,2liters pr. minute.

Depth	Pressure	Volume	Density
Surface	1 atm	1	X 1
10 meters	2 atm	1/2	X 2
20 meters	3 atm	1/3	X 3
30 meters	4 atm	1/4	X 4
40 meters	5 atm	1/5	X 5

Dalton's Law

- Partial pressure = PP.
- Partial pressure of oxygen = PPO2 (and so on).
- 21% oxygen = 0,21PPO2 / 79% nitrogen = 0,79PPN2 / 100% gas = 1,0PP (and so on).
- Breathing air (21%) on 40meters equals breathing105% oxygen on the surface = 0,21PPO2 x 5atm (40m) = 1,05PPO2.
- When you have a set point of 1,3 on your handset, you inhale the same amount of oxygen that equals breathing 130% oxygen at the surface.



Physiology

Hyperoxia

- Oxygen is vital for us to survive, however too much oxygen can be dangerous, this is called hyperoxia and can lead to CNS toxicity (more about CNS later).
- Hyperoxia is one of the hazards of CCR diving, but fortunately it's easily avoided.
- Watch your set point often - ALWAYS KNOW WHAT YOU BREATH.
- Signs and symptoms of hyperoxia:
  - Visual disturbance
  - Ear ringing
  - Nausea
  - Twitching in fingers and around the mouth
  - Irritability in the lungs
  - Dizziness
- It is most likely that you will not get any warning before getting a "CNS" hit.
- If you think you are suffering from hyperoxia, bail out and end the dive.

PO2	Effect
> 2.0 ppo2	Can be fatal
2.0 ppo2	High CNS toxicity danger
1.6 ppo2	Max. ppo2 in rest (deco)
1.4 ppo2	Max ppo2 in rec. diving
0.8-1.2 ppo2	Bottom ppo2 in technical diving
0.5 ppo2	Oxygen Tracking begins
0.21 ppo2	**NORMOX**
0.18 ppo2	1st Hypoxia Symptoms
0.16 ppo2	Hypoxia starts
0.10 ppo2	Deadly Zone

Hypoxia

- Hypoxia occurs when you breathe a gas with too little oxygen.
- This can easily happen when diving a rebreather. If, as an example:
  - You run out of oxygen or fail to add oxygen manually, especially on ascends.
  - Your solenoid or flow of oxygen is not working.
  - You ascent too fast.
  - Switching to your BOV or bail out with a Hypoxic mix.
  - Ascending with the CCR as an SCR - and this is not done correctly.
- Like Hyperoxia, it is easy to avoid Hypoxia if you get the proper training and follow the guidelines within rebreather diving .
- Signs and symptoms of hypoxia:
  - Cramps
  - Dizziness
  - Confusion
  - Poor coordination
  - Increased breathing rate
- It is most likely that you will not get any warning before passing out.
- If you suspect hypoxia, bail out and end the dive.

PO2	Effect
> 2.0 ppo2	Can be fatal
2.0 ppo2	High CNS toxicity danger
1.6 ppo2	Max. ppo2 in rest (deco)
1.4 ppo2	Max ppo2 in rec. diving
0.8-1.2 ppo2	Bottom ppo2 in technical diving
0.5 ppo2	Oxygen Tracking begins
0.21 ppo2	**NORMOX**
0.18 ppo2	1st Hypoxia Symptoms
0.16 ppo2	Hypoxia starts
0.10 ppo2	Deadly Zone

CNS oxygen toxicity

- CNS = Central Nervous System.
- CNS oxygen toxicity occurs when the body is exposed to a higher oxygen partial pressure for a certain amount of time.
- If you get a “CNS hit”, your body will with little, or no warning, start convulsing.
- Convulsions can vary from person to person, but in the end, it comes down to the PPO2 and for how long time you have been exposed to it.
- If your dive buddy starts convulsing, you (of course) need to bring him to the surface.
- You must not ascend with a convulsing diver, wait till the cramps/spasms stops.
- Ascending while the diver is convulsing, may cause a lung overexpansion injury.
- Do a dill flush or BAIL OUT if you suspect you are close to a CNS hit. Depends on gasses and depths.

PPO2	Max exposure time
1.6	45 minutes
1.5	120 minutes
1.4	150 minutes
1.3	180 minutes
1.2	210 minutes
1.1	240 minutes
1.0	300 minutes

This CNS table shows you for how long time you can be exposed to a fixed PPO2

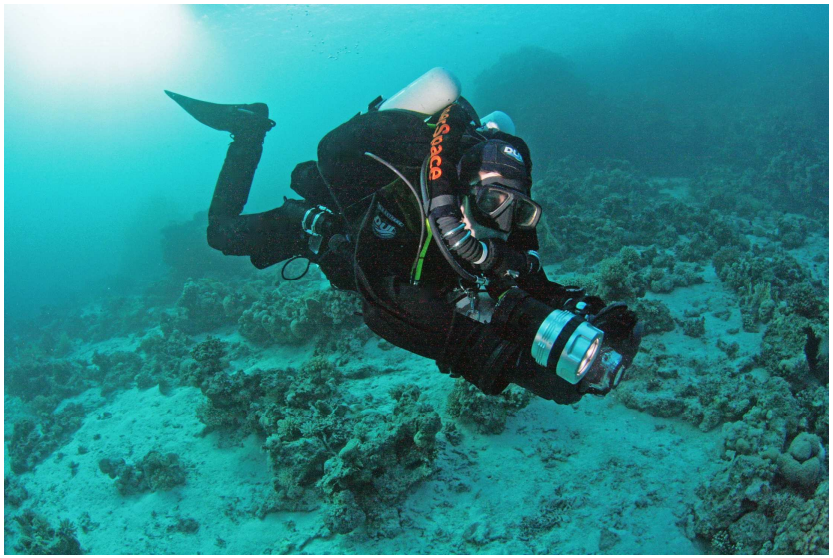
Pulmonary toxicity

- Pulmonary toxicity occurs when you are exposed to a PPO2 of 0,5 or higher for a long period of time.
- To avoid pulmonary toxicity we keep track of our OTU's = Oxygen Toxicity Unit
- Dr. Bill Hamilton defined that 1,0 PPO2 of oxygen for 1 Minute is = 1 OTU

Multi day exposure	Daily dose limit	Total operational limit
1	800	850
2	700	1400
3	620	1860
4	525	2100
5	460	2300
6	380	2520
7	350	2660
8	330	2800
9	310	2970
The following table indicates the maximum dose of OTUs you can tolerate		

Carbon dioxide – CO2

- For every liter of oxygen you metabolize, you produce 0,9 liter of CO2.
- When you feel the need for breathing, it is because you have build up CO2 and not because you need oxygen, so CO2 is the main trigger for us to breathe.
- When using more oxygen you also produce more CO2, as for an example swimming against a strong current.
- If we do not get rid of the CO2 we produce we can suffer from hypercapnia, more about this in a minute.
- If you think you are suffering from hypercapnia, bail out and end the dive.



Hypercapnia

- You will start suffering from hypercapnia if you build up CO2 in your body.
- This can happen in several ways while diving a rebreather:
  - The mushroom valves are not functioning properly.
  - Your absorbent is exhausted or is not packed properly.
  - An o-ring is not holding tight or incorrect assembling of the rebreather.
  - Due to heavy breathing for a period of time.
  - Flooded loop.
- Signs & symptoms of hypercapnia can be:
  - Rapid and spasmodic breathing.
  - Headache, nausea and dizziness.
  - High anxiety level and maybe close to panic.
  - Not able to react correctly, as for example; bail out.
  - A feeling of increased breathing resistance.

- If you starts suffering from a “CO2 hit” (hypercapnia) you have to bail out, get the attention of your buddy and end your dive.
- If your buddy suffers from a CO2 hit you might need to help him bail out and get him to the surface.

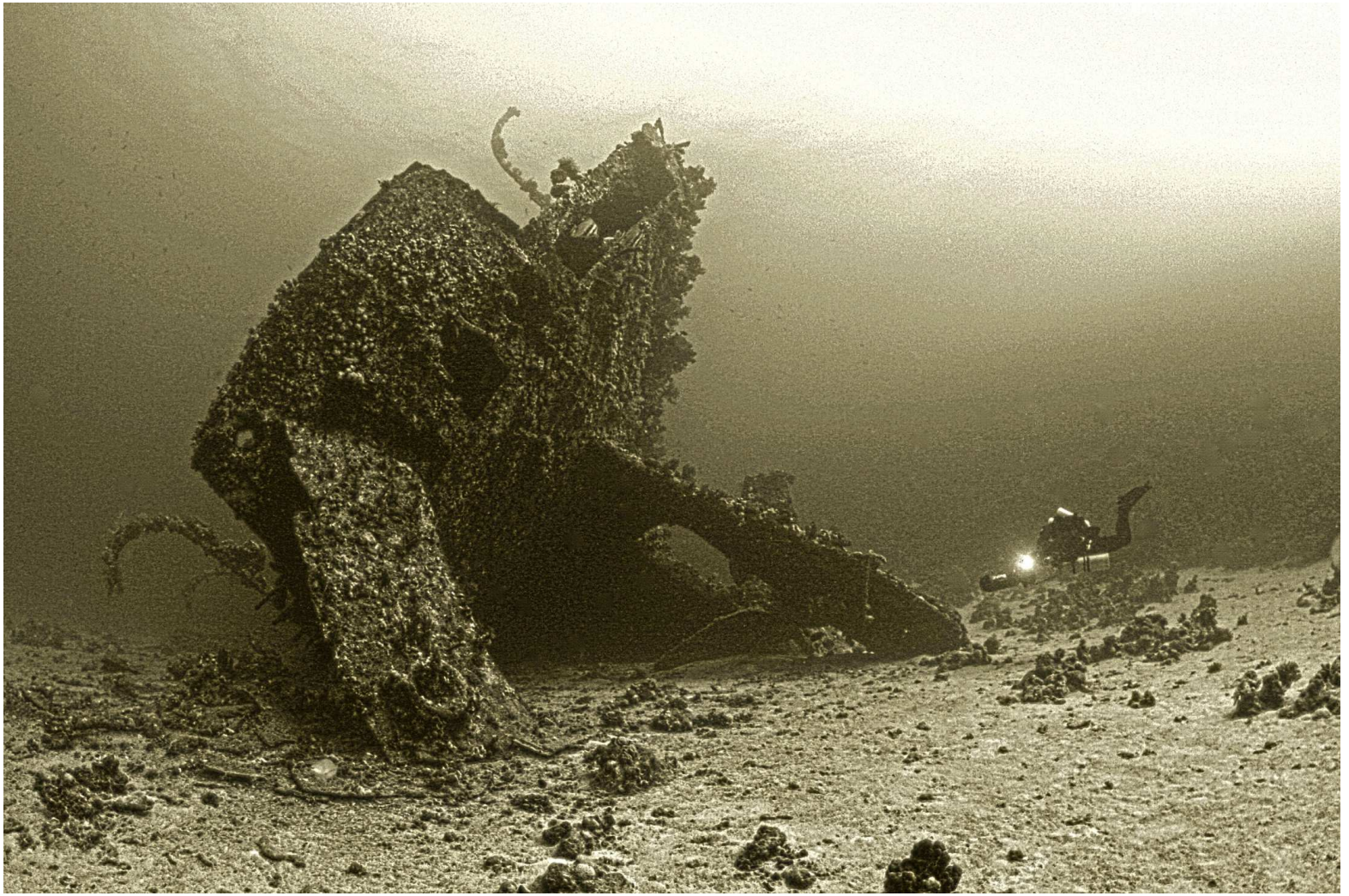
Decompression sickness

- Inert gas (as an example; nitrogen and helium) is absorbed in you body tissues.
- When descending in the water the pressure increases and your tissues absorbs more inert gas.
- When ascending, your tissues releases the gas (for you to breathe it out again). However, if you are ascending too fast compared to the amount of absorbed gas in your body, you will suffer from decompression sickness.
- You know this from when you open a soda bottle that has been shaken:
  - You can't see the bubbles inside the liquid.
  - When you open the bottle, you release the pressure inside the liquid and little bubbles are formed.
  - If you open the bottle very slowly, you also release the pressure slowly, and no bubbles are formed.
- Stay within the no decompression limit to prevent decompression sickness.
- Four different types of decompression sickness:
  1) Bend
  2) Central Nervous System
  3) Inner ear
  4) Musculoskeletal
- Isobaric counter diffusion (more about this later).
- See the sign & symptoms and read more about decompression sickness here…
- See treatment of DCS on the next page.

Decompression illness

- Decompression illness is a term that covers both decompression sickness (DCS) and other pressure related illnesses (barotraumas) like lung overpressure illnesses.
- We have four different lung exposure illnesses (pulmonary barotraumas):
  1) Pneumothorax.
  2) Subcutaneous emphysema
  3) Mediastinal emphysema
  4) Gas embolism
- If you have a diver suffering from any kind of DCI (decompression Illness) you need to:
  1) Get the victim out of the water.
  2) Alert the emergency medical service.
  3) Supply pure oxygen to the victim.
  4) Prevent the victims body to go into chock.
- Never take a person you suspect of having DCI back in the water.

Dive planning



Dive planning

Oxygen

- As you read earlier in this manual, an average diver on an average dive, consumes approximately 1,0 liters of oxygen pr. minute. Depth has no influence on the amount of oxygen your body metabolizes.
- The harder you work, the more oxygen your body “consume”, see the table below.
- If you have a 3 liter oxygen tank filled to 200bar, you have 600 liters of oxygen.
- 600 liters of oxygen will last 600 minutes if you use 1,0 liter of oxygen pr. minute.
- You have to take in consideration that you will waste a little bit of oxygen. As an example; on ascent, you let out gas as the pressure decreases, but adds oxygen to keep your set point. Therefore, You will multiply the amount of needed oxygen with 1,5 as a safety margin during your gas planning.
- Let’s say that you are going for a 90 minute dive. You need 90 liters of oxygen times 1,5 = 135 liters of oxygen.
- In a 3 liter tank you would need 45 bar to dive for 90 minutes and still have spare oxygen.
- Different manufacturers has different recommendations when it comes to minimum liters of oxygen in your tanks. Make sure you check your manufacturers manual.
- ALWAYS analyze your oxygen tank yourself before attaching it to your unit.

Work load	O2 liters pr. minute
Resting	0,3 – 0,5
Light to moderate	1,0 – 1,5
Heavy work	2,0 – 2,5
Maximum work	3,0 – 3,5
This table is a rough guideline	

Dive planning

Diluent

- You need your diluent for “filling” the loop to optimal loop volume (especially on descend) and your buoyancy device, for diluent flushes - validation of your cells.
- Ascending and swimming at a constant depth does not consume any diluent (only the oxygen you are metabolizing).
- If you have a BOV and use it, it will consume gas from your diluent tank.
- You have to bring enough diluent to be able to do a “diluent flush” - more about this later.
- Look in your manufacturers manual and look for special recommendations on minimum amount of diluent.
- If You find no specific recommendations, we recommend you fill it completely.
- You will quickly get an idea of how much diluent gas you use when diving a rebreather**.**
- During this course you will dive with air as a diluent**.**
- BoE+ you will have 21/35 as diluent on your last dive.
- Even though there is only air in your diluent, you must always analyze the tank to confirm. Diving with a higher PPO2 as a diluent can be critical on deeper depths.

Bail out gas

- Always carry enough bail out gas to get yourself safely to the surface in case of a bail out situation.
- To calculate your bail out, you need to understand what we, in InnerSpace Explorers, call “minimum deco”.
- On ALL dives, you do “stops” on ascend: minimum 2 minutes at 9 meters and 4 minutes at 6 meters.
- If you are diving deeper than 18 meters, you also plan “deep stops”; In recreational diving we calculate our first deep stop from 50% of our maximum depth. (So, from 30 meters, your FIRST deep stop will be at 15meters).
- Every deep stop is for 1 minute every 3 meters until you reach 9 meters and starts your minimum deco.
- 1 minute stops means 40 seconds at the actual depth and 20 seconds to ascent to the next stop (3 meters above).
- Your ascend rate is 10 meters pr. minute. So it will take you 2 minutes (1,5 minutes rounded up to 2 minutes) to get from 30 meters to your first deep stop at 15 meters and the average depth between 30 meters and 15 meters is 23meters (30meters+15meters divided by 2 = 22,5meters) round this up to 23meters.
- If a problem occur at depth and you decide to bail out, we calculate 1 minute to solve the problem.
- Since you have a problem, you must calculate with a SAC (Surface Air Consumption) rate of minimum 30 liters pr. minute. You always calculate your bail out gas as if you have to bail out on the deepest part of the dive.
- Due to the fact that you might bail out because of hypercapnia, a SAC rate of 30 liters pr. minute might not be realistic. Therefore will you multiply your needed amount of bail out gas with 1,5.
- Always analyze your bail out cylinder before entering the water. Like with the diluent and oxygen tank you must do this yourself, do not let anyone else do this for you!

Bail out gas - Example

- You are planning for a dive to 30 meters and needs to calculate the amount of bail out gas you need to carry:
  1) You need 1 minute to solve the problem at depth – 4atm x 30liters x 1 minute = 120liters.
  2) Your ascend to your first deep stop is 2 minutes - 3,3atm x 30liters x 2 minutes = 198liters.
  3) Your first deep stop is for 1 minute at 15 meters - 2,5atm x 30liters x 1 minute = 75liters.
  4) Your second deep stop is for 1minute at 12meters - 2,2atm x 30liters x 1 minute = 66liters.
  5) Your next stop is your first stop of “minimum deco” - 1,9atm x 30liters x 2minutes = 114liters.
  6) Your last stop is at 6meters for 4minutes - 1,6atm x 30liters x 4minutes = 192liters.
- Adding the numbers, gives you your needed amount of bail out gas = 765liters.
- Multiply that by 1,5 and now you have your final amount of bail out needed = **1.147,5liters**.
- If you are carrying a 7liter bail out tank, you only need to fill it to 164bar to have enough gas. 1.147,5 : 7 = 163,928bar = **164bar**.

Minimum deco

Depth	Time	atm	SAC rate	Bail out
6	4	1,6	30liters	192liters
9	2	1,9	30liters	114liters
12	1	2,2	30liters	66liters
15	1	2,5	30liters	75liters
23	2	3,3	30liters	198liters
30	1	4,0	30liters	120liters

No decompression limit

- Even that you are diving with a “real time” CCR computer, we still recommend that you always know your “numbers”, how much time do you have on a given depth before entering decompression.
- To calculate your no decompression limit (NDL), you need to know following:
  - Your set point.
  - Your EAD (Equivalent Air Depth) or have a nitrox table.
  - The no decompression limits on an air dive table.
- During this class you will dive with a maximum set point of 1,3.
- You are diving at a depth of 30meters with a set point of 1,3 what will your maximum dive time then be at depth?
  - 1,3 set point : 4 ata = 0,325 = 32% oxygen (equivalent breathing).
  - Now look in your nitrox table to see your no decompression limit on 30 meters breathing 32% nitrox.
  - If you only have an air table you need to find your EAD.
  - 0,68 PPN2 x 4ata = 2,72 PPN2 : 0,79 PPN2 = 3,44 ata = 24,4 meters rounded up to 25 meters.
  - So breathing Nitrox 32% at 30 meters of depth equals breathing air at 25 meters.
  - Look in your air table and see what the no decompression limit is for air diving at 25 meters and that is your result.

Dive planning

CNS oxygen toxicity

- This table is your maximum allowed exposure time of a constant partial pressure of oxygen.
- If you are diving with a set point of 1,3 you can dive for maximum 180 minutes before reaching 100 CNS%.
- If you are diving with a set point of 1,3 for 70 minutes: 70 minutes : 180 minutes = 0,38888 = 39 CNS%.
- After every 90 minutes on the surface you will half this value. So after 180 minutes on the surface you are down to 25 CNS%.
  After 90 minutes = 100 CNS% : 2 = 50 CNS%.
  After 90 minutes more = 50 CNS% : 2 = 25 CNS%.

PPO2	Max exposure time
1.6	45 minutes
1.5	120 minutes
1.4	150 minutes
1.3	180 minutes
1.2	210 minutes
1.1	240 minutes
1.0	300 minutes
The accumulated CNS halves every 90min	

Dive planning

Pulmonary toxicity

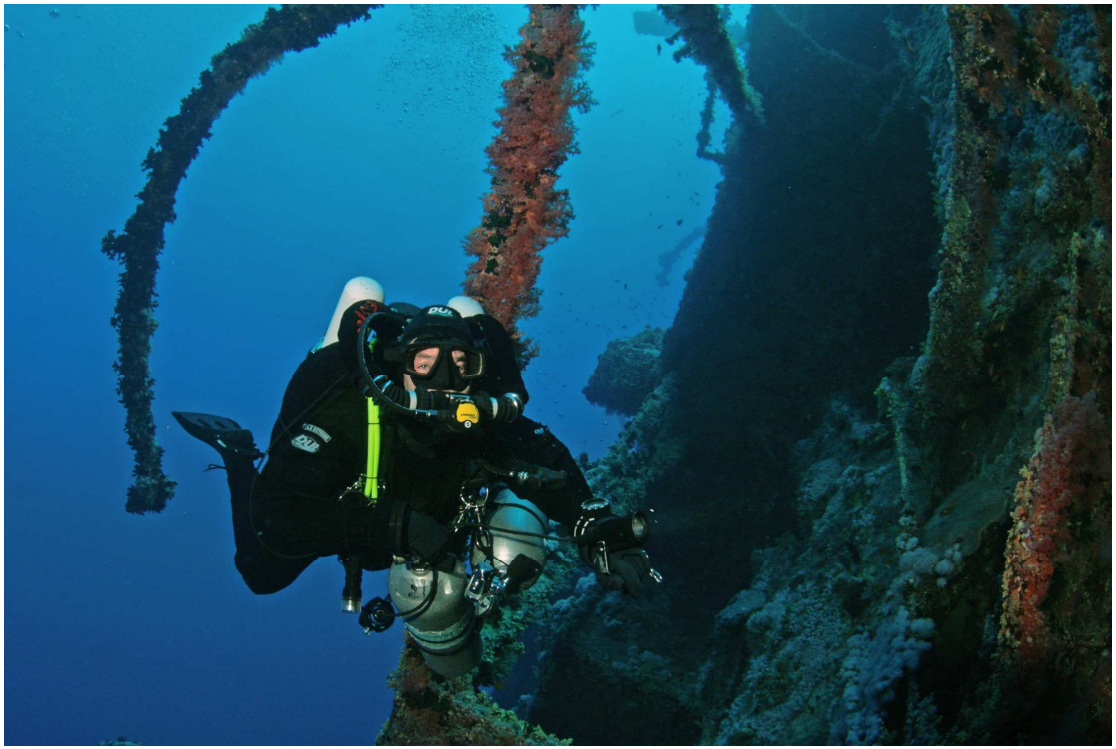
- As you learned earlier in this manual, Dr. Bill Hamilton defined that 1,0 PPO2 of oxygen for 1 Minute is = 1 OTU.
- So, to calculate your OTU's on a rebreather, with a fixed set point is very easy.
- Simply multiply your set point with your dive time, then you have your OTU for that dive.
- Let's say that you are diving for 85minutes x 1,3set point = 110,5OTU's.
- In the schematic below you can see your daily and "multi day" maximum exposure.

Multi day exposure	Daily dose limit	Total operational limit
1	800	850
2	700	1400
3	620	1860
4	525	2100
5	460	2300
6	380	2520
7	350	2660
8	330	2800
9	310	2970
The accumulated OTUs reset after 24 hours on the surface		

Dive planning

Scrubber duration

- Please again take a look in the manufactures manual to check the scrubber duration for your unit.
- The deeper dives you do, the more often you should change your scrubber.
- The colder the water is the more often you should change the scrubber.



Dive planning

Standard gases in InnerSpace Explorers

- As you've already read in this manual, we do not dive with regular air within InnerSpace Explorers, but you also read that you will use normal air as a diluent during this course, why is that?
- Having air as a diluent in a rebreather does not make you breath air. Remember that you or the rebreather will constantly add oxygen and make a nitrox mix within the breathing loop.
- Because of the way we calculate our decompression, which you will learn on your exploration level 1 class, we always use standard gases.
- This schematic does only apply for rebreather divers.

Diluent Gas	Bail out gas	Operational Depth	Max depth	END	ISE class
Air 21%	Nitrox 32%	0-30 Meter	30meter	30m = 30m	BoE
Trimix 21/35	Trimix 21/35	0-36 Meter	36meter	36m = 20m	BoE(+)

Diving the rebreather

Diving the rebreather

Pre dive

- You have already assembled the unit with your instructor by following the InnerSpace Explorers check list.
- If you have done the assembling and checks before transporting the unit, you should do the positive and negative pressure test again once you arrive at the dive site. To make sure nothing happened to the unit during transport.
- It is recommended that you at this time have a set point of 0,7 Unless manufacturer recommends differently.
- Get yourself in to the habit of ALWAYS opening the unit before mounting it. In general, the unit should be ready to dive before you get in it. Only exception could be the pre-breathe.
- You should pre-breathe the unit just before entering the water. When you pre-breathe, you are sitting down in a place where you can't fall if you pass out. Fatal accidents has happened due to people standing while pre-breathing.
- The reason for pre-breathing the unit, is to check that everything on the rebreather is functioning as it should. A common misunderstanding is that "you have to warm up the scrubber" - this is wrong.
- You are pre-breathing your unit before entering the water to check the behavior of the oxygen sensors, how the cells are reacting etc.
- Before jumping in the water, you put the mouthpiece in the mouth, exhale all the gas you have in your lungs into the mouthpiece, and THEN you open the loop. There is two reasons for this; Firstly, you want to remove all the water in the mouthpiece. Secondly, you don't want to exhale any of your "low oxygen" gas from the lungs into your rebreather.
- Check your manufacturers manual to see how long time you should pre-breathe your unit, normally 3-5minutes.

Diving the rebreather

On the surface

- If you are breathing from the loop on the surface, you must watch PO_2-Meter, just as you would under water.
- If you fail to add oxygen to the breathing loop on the surface whilst you are breathing from it, you will suffer from Hypoxia and pass out.
- Never take the mouthpiece out of your mouth without closing the loop first!
- Before you descent, your instructor will teach you how to do the necessary pre dive checks.

Diving the rebreather

Descending

- The counterlungs will be affected by the increased water pressure. This will automatically activate your ADV (Automatic Diluent Valve) which will then inject diluent into your breathing loop, unless you have flow stop activated.
- During descend, you will be in a horizontal position facing your buddy(s). You will check and confirm, that all their gear is in the right place, and that there are no bubbles coming from the rebreather.
- When you are descending, you will notice on your PO_2-Meter and HUD, that the set point is climbing. Even when you, or the ADV, adds diluent. This is because of the rising level of PPO_2, due to the increase of the surrounding pressure. (While your set point will fall, due to a decrease in pressure, while ascending) – more about ascending later.
- So, on top of adjusting your drysuit and/or buoyancy device you also have to adjust your breathing loop.
- Optimal loop volume (also called minimum loop volume), is keeping the amount of gas in the breathing loop at a level where you do not activate the ADV breathing normally but activate it when you take a DEEP breath.
- Having too little gas in the counterlungs, gives you a feeling of shortness of breath/limited breath. Having too much gas in the counterlungs, makes the buoyancy more difficult to obtain and keep. You will feel that your cheeks are like two overfilled balloons - resistance when you exhale.
- Depending on how fast you are descending, you will either change from low to high set point during descend, or when you reach “the bottom” of your descend.

Diving the rebreather

Diving a rebreather

- When diving a rebreather, you get in the habit of staying at same depth, instead of constantly varying the depth. (You'll be swimming around objects instead of over etc.)
- Remember that you can't adjust your buoyancy with your breath any more. You have to adjust your buoyancy with your drysuit or buoyancy device, every time you change your depth.
- You will learn, that emptying your mask or blowing bubbles for other reasons (ascending, removing the loop from your mouth etc.), will require that you add a little gas to the loop again. If not, your buoyancy will get negative.
  So - only blow bubbles when necessary!
- During your InnerSpace Explorers CCR class, you will learn to dive your rebreather manually.
- This means, that you will use your manually gas addition buttons, to inject both diluent and oxygen during the dives, holding your set point manually. It is good procedure diving your unit manually also if you would use an eCCR.
- You will discuss and practice emergency procedures in detail with your ISE instructor during this course.

Diving the rebreather

Diving a rebreather

- When arriving at depth; get optimal loop volume, check SPG's, check PO2 & HUD.
- If you have a high PO2, it's likely because you made a fast descend and have what is called an "oxygen spike".
- Just vent a little gas from your mouth or nose and add diluent until you reach the wanted PO2– keep breathing.
- If the PO2 keeps rising, you will during your training dives, learn how to deal with that in several ways.
- From you put the mouthpiece in your mouth, and until you take it out again, you should at all times be able to tell your instructor what your set point is "without looking" – ALWAYS KNOW WHAT YOU BREATHE!

Ascending

- Before you start your ascend you will, as always, check your PO2.
- It is important, that you are extra alert of your PO2, during your entire ascend.
- As the surrounding water pressure decreases as you ascend, your PO2 will decrease as well.
- On shallow depths, you will notice a big difference in PO2 by ascending a few meters. Don't let your PO2 drop too much for too long!
- From OC (Open Circuit) dives, you are used to vent excess gas from your lungs, drysuit and buoyancy device while ascending.
- You still have to do this when diving rebreathers, but you have to add oxygen to the breathing loop at the same time.
- If there is not added sufficient oxygen to the breathing loop while ascending, you will suffer from hypoxia which can have fatal consequences!
- This is another reason to maintain a maximum ascend speed of 10meters pr. minute.
- During this course, you will also learn how to dive and ascend while "running" your unit in SCR (Semi Closed Rebreather) mode.
- It is of extreme importance, that you do not ascend too fast, and that you vent the breathing loop often when ascending while diving a CCR in SCR mode. You can only do this when you have a breathable gas as a diluent for that depth! This will be explained more in details when you are taking your exploration level 2 class.
- NEVER TURN OFF YOUR FLOW OF OXYGEN BEFORE YOU ARE ON DRY LAND!

Diving the rebreather

Post dive procedures

- When back on dry ground, you will rinse the unit with fresh water before you close the cylinders.
- Look in the manufacturers manual to check how to disassemble and disinfect your unit correctly.
- Together with your instructor, you will completely disassemble and disinfect your unit at least 3 times during this course
- If you will use the unit again within 24 hours, you do not need to completely disassemble and disinfect the unit. But, you must as a minimum rinse the breathing hoses, mouthpiece and counterlungs with fresh water.
- You will also “open the head” to dry out moist and condense - leaving the oxygen cells in place.
- You can repeat this simple break down and rinse for 3 days as a maximum. After 3 days of diving, and/or if you will leave the unit for more than 24hrs, you will need to do a complete disassembly and disinfection of the unit. Please refer to the manufacturers manual for recommended disinfect.
- From the manufacturers manual, you already know the maximum duration time for your scrubber. Do NOT exceed this time limit.
- In case you have only used half (or less) of your scrubber duration time, you can store it in a sealed plastic bag for the day after.
- You can only do this one time and only if you are using the scrubber the day after.

Trimix diving

Trimix diving

What is trimix

- Trimix (TMX) is a mixture of oxygen, nitrogen and helium.
- Helium is a very light and thin gas, which make it travels a lot faster.
- On the last dive of your BoE+ course you will dive with a mix called 21/35 as your bail out
- This means that you have a mixture of 21% oxygen / 35% helium / 44% nitrogen in your tank.
- With this certification you can dive to a maximum of 36meters.

Why use trimix

- When mixing helium into your breathing gas (and at the same time take out some of the nitrogen), you have two major benefits:
  1) Less narcotic potential.
  2) Ease of breathing.
- In InnerSpace Explorers we do not accept diving deeper than 30meters without trimix, because of the narcotic potential of the nitrogen and oxygen.

END - Equivalent Narcotic Depth

- You already know that your mix is a 21/35TMX and your max. depth is 36meters, but how do you find out what narcotic depth, this mix (on this depth) equals when diving on air?
- Before showing you this calculation, you need to understand that it is not just the nitrogen in the gas that is narcotic, it is also the oxygen. Therefore the term “nitrogen narcosis” is misleading.
- Now that you know that both the oxygen and the nitrogen is narcotic, you add the fraction of both gasses together, which in a 30/30 mix is 70% (30%O2 and 40%N2) = 0,7. You multiply the fraction of narcotic gases with the atm of the depth = 4,6ata. Now you have the ata for the equivalent air depth 3,22ata = 22,2meters.
  0,7 (fraction of narcotic gasses) x 4,6ata = 3,22ata = 22,2meters.
- Lets do one more example. During the BoE+ course, you will be diving with a 21/35mix to 36meters. The narcotic gasses (oxygen and nitrogen) is now 65% = 0,65 multiplied by the ata at depth = 4,6ata (36meters) and now you have your equivalent narcotic ata = 2,99ata = 19,9meters.
  0,65 (fraction of narcotic gasses) x 4,6ata = 2,99ata = 19,9meters.

Trimix diving

Other considerations when diving with trimix

- You already know that helium is much thinner than oxygen and nitrogen.
- Some scientist believe that the helium is actually so thin that it can travel into your tissues through the skin if you put helium inside your dry suit at depth, this is called “isobaric counterdiffusion”.
- Isobaric counterdiffusion can lead to DCS (Decompression Sickness) because your tissues are absorbing more gas than normally.
- Never put gas (trimix) in your drysuit that contains helium, there is two reasons for this:

  1) Helium is a very bad isolator and you will therefore most likely be cold during your dive.

  2) With helium in your drysuit you may experience isobaric counterdiffusion.

Training dives

Training dives

Standards:

- The diver must perform all skills within one dive before progressing to the next.
- The diver must do at least 3 complete assembles of the unit during the course.
- The diver must do at least 3 complete disassembles including disinfection of the unit during this course.
- The Instructor is recommended to add skills the diver already master into any dive for more practice. However the instructor must not come up with skills that are not included in this manual.
- All crossover students has to complete all skills within this manual in a satisfactory way prior certification.

Duration:

- Minimum 6 days (BoE+ 7 days).
- Minimum 8 dives (BoE+ 9 dives).
- Minimum 500 logged minutes on the specific unit (BoE+ 550 minutes).
- There are different rules when it comes to crossovers. For more info, please check in the beginning of this manual.

Ratio:

- 3:1 (3 students to 1 instructor).
  With a certified assistant assisting the course, the instructor are allowed to bring 1 more student in the class.
  A certified assistant is an ISE BoE+ instructor who is certified as a diver on any mCCR unit.

Training dives

Training dive #1

Standards:
•Team leader: The instructor
•Environment: Pool or confined water
•Minimum depth: 3meters
•Maximum depth: 10meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)
- Practice open and closing the loop in the surface

•Final adjustment including harness, HUD, counterlungs etc.

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Remove and replace the mouthpiece
- Recover mouthpiece: 2 sequences
- SPG check
- Bail out to open circuit
- Drain the loop: 2 sequences
- Drain exhale counterlung
- No mask – stationary
- Diluent flush and cell check
- Valve failures - shut down of both tanks
- Oxygen spike (oh shit drill)
- Inject and holding a set PO2 manually
- Buoyancy and trim
- Underwater swim
- DSMB deployment
- Ascend 1-1

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #2

Standards:
•Team leader: Student
•Environment: Pool or confined water
•Minimum depth: 3meters
•Maximum depth: 10meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Buoyancy and trim
- Frog kicks
- Minor frog kicks
- Modified flutter kicks
- Back kicks
- Helicopter turns
- No mask swim
- Circle of Basics (CoB)
- Inject and holding PO2 manually
- DSMB deployment
- O2-Flush for Cell validation (current limiting)
- Ascend 2-4

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #3

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 5meters
•Maximum depth: 15meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
- Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Start dive with a PPO_2 of 1.2
- Buoyancy and trim
- Remove and replace the mouthpiece
- Drain the loop in two different ways
- Drain exhale counterlung
- Lower PPO_2 to 0.9 and keep it
- Circle of basics
- DSMB deployment
- Raise PPO_2 to 1.3 and keep it throughout the entire ascent.
- Bail out ascend 2-4

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #4

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 5meters
•Maximum depth: 15meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Donate bail out gas to buddy while swimming
- Circle of Basics (CoB)
- Diluent flush and cell check
- MAV Check. At constant depth, monitor PPO2 drop over several minutes
- Valve failures shut down of both tanks
- Oxygen spike (oh shit drill)
- DSMB deployment
- Donate gas with no mask and ascend 2-4

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dive #5

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 10meters
•Maximum depth: 20meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Circle of Basics (CoB)
- SCR mode stationary
- Feathering the oxygen valve stationary
- DSMB deployment
- O2-Flush for Cell validation (current limiting)
- Ascend
- Deep stop and minimum deco

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #6

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 15meters
•Maximum depth: 25meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Circle of Basics (CoB)
- Wetnotes, spool and compass drill
- Circle of basics
- Diluent flush
- Valve failures shut down of both tanks
- DSMB deployment
- SCR mode ascend
- Deep stop and minimum deco

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #7

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 20meters
•Maximum depth: 30meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
- Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Circle of Basics (CoB)
- Oxygen spike (oh shit drill)
- OOG+OOM+OOB swim drill
- Surfacing the unresponsive CCR diver
- DSMB team deployment
- Feathering the oxygen valve ascend
- Deep stop and minimum deco

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dive #8

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 25meters
•Maximum depth: 30meters
•Diluent gas: Normal air.
•Bail out gas: 32% nitrox (or air if not available)
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Experience dive
- O2-Flush for Cell validation (current limiting)
- Ascend
- Deep stop and minimum deco

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

Training dives

Training dive #9 (BoE+)

Standards:
•Team leader: Student
•Environment: Open water
•Minimum depth: 30meters
•Maximum depth: 36meters
•Diluent gas: 21/35
•Bail out gas: 21/35 trimix
•Maximum set point: 1.3

Pre dive:
•Assemble the unit according to the checklist
•Plan the dive
•Dive briefing
•Pre breathing
•Surface pre dive check:
- Flow check all tanks open
- PO2 and Instrument check
- Unit, BOV and bail out breathable
- SPG check and announcement
- Gear matching
- Torches check
- Long hose deployment (bail out)

Under water:
- PO2 and Instrument check
  Descend
- Passive bubble check
- Keep optimal loop volume during the dive
- Diving the unit manually for the entire dive
- Buoyancy and trim
- Experience dive
- Ascend
- Deep stop and minimum deco

Post dive:
- Quick debrief by team leader
- Quick debrief by instructor
- Video review and discussion
- Disassemble the unit

The end

Thank you, we look forward to see you on your next class ☺

Appendix I – PELAGIAN DCCCR

ISE is authorized to conduct diver training programs
on the Pelagian DCCCR, closed circuit rebreather providing the following terms are adhered to:

1. In the event of contradictions between ISE training materials such as standards, manuals, power point presentations and instructor outlines and the information contained in The Pelagian DCCCR Operations Manual from Rebreather Lab, the latter shall apply. It is the responsibility of ISE to clarify this to their students.

2. ISE is required to administer the Pelagian DCCCR Final Exam to their students. Passing score is minimum 80%. The instructor is required to fully explain any incorrectly answered question until the student fully understands them.

3. ISE is required to use the official Pelagian DCCCR pre-dive check list during training programs. The check list is to be signed by both student and instructor. The check list should be kept in the student record file for 7 years.

4. In the event ISE or their appointed Pelagian DCCCR instructor provides a Pelagian DCCCR unit to their student during training it is the responsibility of ISE to ensure the student signs the waiver of liability provided by Rebreather Lab. The waiver is to be kept in the student record file for 7 years.

5. The highest level of Pelagian DCCCR training ISE is authorized to conduct is the highest level of training their appointed Pelagian DCCCR instructor has received instructor training for.

Appendix I – Specific Skills for the PELAGIAN DCCCR

Under water:

1. Swim while keeping Setpoint with needle valve closed
2. Set Point Toggle: Maintain 0.6 Bar PO2 for a minute while swimming and keeping depth constant. Then change to 0.9 Bar PO2 for a few minutes. Alternate as needed until able to stay within +/- 0.1 Bar of set point. Needle valve closed
3. Instant Cell Validation – Exhale through nose then one slow inhalation once the ADV triggers.
4. Cell moisture removal – Exhale through nose and one fast inhalation once the ADV triggers
5. Metabolic Rate – Swim at surface in relaxed pace while keeping set point at 0.8 Bar PO2 and adjust needle until no manual additions are needed. Exit the water measure flow with flow meter and note result on check sheet. Turn down needle slightly.
6. Set Point Swim With Needle – Needle should be set so PO2 decays slowly. Practice rolls and various body positions. Note where ADV fires.
7. Needle Valve Reference – Reference the needle valve setting mechanically, i.e “how many turns open from filly closed”? Close needle valve and re-open to original setting. Repeat eyes closed.

Unit specific skills HAVE to be implemented in the regular skill dives of this ISE class by the instructor!

Under water:

8. Flush loop 3 times with Oxygen prior to descent. Validate Your sensor readings.
9. Descent to 6 meters while breathing from the BOV or your Bailout. Make sure that the sensor reading is 1.6 and the sensor reading rises linear to this point. Bring your setpoint back within Bottom-Limts (< 1.4) before you continue your descent.
10. Cell Validation every 20 Minutes. Blow sensors dry and validate readings by a Diluent / Depth.

Unit specific skills HAVE to be implemented in the regular skill dives of this ISE class by the instructor!

REBREATHER LAB

Pelagian DCCCR dive planning and pre dive safety checks

Student name: Course start date: Students metabolic rate light work lpm
Dive buddy: Instructors name:

Assembly and function	Pool dive	Dive 1	Dive 2	Dive 3	Dive 4	Dive 5	Dive 6
Date							
Tanks analyzed. O2 / DIL / BAIL	/ /	/ /	/ /	/ /	/ /	/ /	/ /
Scrubber filled properly / rem. time							
Battery test satisfactory							
Air calibration / check with head off							
Hose check valves / P-con. orings							
Co2 Pipe Seated in Socket							
Tees & plugs “twist and tug”							
Assembly satisfactory							
Remaining pressure O2 / DIL / BAIL	/ /	/ /	/ /	/ /	/ /	/ /	/ /
Flow rate @ surface set to							
O2 feed / ADV / Bail reg tested							
Gauges tested O2 / DIL / BAIL							
Positive pressure test satisfactory							
Negative pressure test satisfactory							
Pre-breathe 10 minutes satisfactory							
Cells 0,97 - 1,03 PO2 after 4 purges							
Sensor readout at 6m in O2							

Dive plan	Dive 1	Dive 2	Dive 3	Dive 4	Dive 5	Dive 6	Remedial
P. G. after surface interval							
Max depth							
Set point							
EAD (set point - 0,1 bar)							
NDL on Buhlmann Air Table							
CNS % (set point+0,1 bar)							
Theoretical tank duration							
Scrubber duration							
Actual bottom time							
RNT							
Pressure group							
Surface interval							
Signature Student							
Signature Instructor							

Notes:

Reference

MOD = *1,3 / Tank FgO2 - 1 x 10*
Loop mix = Set point / depth (ATA)
EAD = *FgiN2 / 0,79 x (MOD + 10) - 10*
O2 duration = *Volume x BAR / Flow rate*
OC Bail Requirement = *TxPxSACx2*
Scrubber dur. = 360 min tropical water / 240 min cold water
MassFlow increase = *1% / m deeper than surface*

PO2	Single dive	% / min	24 hour
1,6	45	2,22	150
1,5	120	0,83	180
1,4	150	0,67	180
1,3	180	0,56	210
1,2	210	0,48	240
1,1	240	0,42	270
1	300	0,33	300

Note; For calculations for EAD, NDL / Deco assume set point is 0,1 BAR Po2 less than planned.
For CNS % assume set point is 0,1 BAR Po2 higher than planned.

Appendix II – Specific Skills for the KISS Classic / Explorer Rebreather

Dry Run:

- Measure and adjust the constant flow of Oxygen through the MAV
- Choose the right size of counterlungs for the diver

Dry Run:

- Use of the BOV
- Diluent add with ADV & BOV

Dry Run:

- A second ascent from at least 18 meters on OC bailout
- Diluent add with ADV & BOV
- Demonstrate appropriate response to the following emergencies. Each dive should have a minimum of 2 of these emergencies that the diver must react to.
  - A) Hyperoxia
  - B) Hypoxia
  - C) Hypercapnia
  - D) Diluent Gas Loss
  - E) Oxygen Gas Loss
  - F) Sensor(s) failure
  - G) Dive Computer Failure
  - H) PPO2 Display Failure
  - I) Water In Loop

Unit specific skills HAVE to be implemented in the regular skill dives of this ISE class by the instructor!

ISE KISS – Classic / Explorer CCR Exam

Name of Student_____Date_____
Instructor:_____Exam-Score_____
……..

1. How many % is the drop in Oxygen after one respiration cycle
   A. 1%
   B. 7%
   C. 4%
   D. 10%

2. The main four types of rebreathes include:
   A. Nitrox SCR, nitrox CCR, oxygen CCR and manual CCR
   B. Manual CCR, electronic CCR, oxygen CCR and SCR
   C. Air SCR, manual CCR, electronic CCR, oxygen CCR
   D. None of the above

3. Air is an appropriate gas to drive a SCR
   A. True
   B. False

4. What is the main difference between the manual and electronic CCR?
   A. Cost
   B. Increased work of breathing with the manual CCR
   C. The manual CCR does not use 100% oxygen
   D. The PO2 is controlled by the operator with the manual and is electronically controlled on the electronic CCR

5. The main components of the breathing loop are:
   A. Counterlungs, DSV, over pressure relief valve, scrubber, and connecting hoses
   B. Counterlungs, over pressure relief valve, scrubber, and connecting hoses
   C. Counterlungs, DSV, over pressure relief valve, scrubber, connecting hoses, oxygen and diluent cylinders
   D. All of the above

6. The scrubber media:
   A. Adds oxygen to the exhaled gas
   B. Filters out carbon dioxide from the exhaled gas
   C. Filters out carbon dioxide from the inhaled gas
   D. Supports a chemical reaction that removes carbon dioxide

7. Which counterlung configuration offers the best work of breathing no matter what the divers position / trim is in the water?
   A. Over the shoulder
   B. Back mounted
   C. Front mounted
   D. Rear mounted

8. Which scrubber media is the most caustic when wet?
   A. Sodalime
   B. Lithium hydroxide
   C. Barium hydroxide
   D. None of the above

9. The gasflow through the scrubber of the KISS Classic is _____
   A. Radial
   B. Bi-axial
   C. Axial
   D. Non of the above

10. The KISS Classic has 2, 4 and 6 liter lungs available, how do you know what the best size is for the individual diver?
   A. On deep inhalation the overpressure relief valve activates
   B. On forceful exhalation the lungs are full
   C. On deep inhalation the ADV is activated, on forceful exhalation the OPRV is activated
   D. Both A and C

11. Always know your PO2, it is recommended to check the PO2 displays every:
   A. 1-4 minutes
   B. 5-10 minutes
   C. 10-15 minutes
   D. 15-20 minutes

12. The PO2 displays FO2 at any given depth.
   A. True
   B. False

13. A typical RMV and metabolic oxygen requirement for a physiologically normal individual resting at sea level is:
   A. 25 LPM and 10 LPM
   B. 10 LPM and 25 LPM
   C. 10 LPM and 1 LPM
   D. 25 LPM and 1 LPM

14. A diver with a RMV of 15 LPM would use _____LPM at 40 m/ 132 ft:
   A. 75 LPM
   B. 65 LPM
   C. 80 LPM
   D. There is not enough information to answer

15. The oxygen partial pressure range that a diver will likely not experience any “oxygen ill” effects is:
   A. 0.1-1.6 atm
   B. 0.12-1.5 atm
   C. 0.15-1.6 atm
   D. 0.16-1.6 atm

16. The likely end result of oxygen toxicity will be seizures without warning.
   A. True
   B. False

17. Accepting a total of 100% CNS as the absolut maximum, a diver can stay for _____ min at a PPO2 of 1.3
    A. 45 min
    B. 90 min
    C. 180 min
    D. 270 min

18. If a diver reaches his 24 hr oxygen maximum he needs to stay out of the water for:
    A. 6 hrs
    B. 10 hrs
    C. 12 hrs
    D. 24 hrs

19. Pulmonary oxygen toxicity can result in:
    A. seizures
    B. productive cough
    C. Non-productive cough
    D. unconsciousness

20. How can a CCR dive achieve hypoxia
    A. rapid ascents
    B. not monitoring the PO2
    C. Diving with hyperoxic mixes in the diluent tank
    D. Both a and b
    E. All of the above

21. How can a CCR diver achieve hypercapnia?
    A. Over using the scrubber
    B. Working hard
    C. Improper packing the scrubber
    D. All of the above

22. Increased carbon dioxide levels can increase your oxygen toxicity seizure threshold.
    A. True
    B. False

23. The CCR diver is subject to the usual diving related squeezes and the following CCR specific squeezes:
    A. Improper trim ear squeeze
    B. Lung squeeze
    C. Sinus squeezes
    D. Both a and b

24. If on a dive you allow your PPO2 to get lower that your planned set-point you are at increased risk for:
    A. DCS
    B. Hypoxia
    C. Hypercapnia
    D. Narcosis

25. Not having the sensors calibrated correctly could lead to:
    A. DCS
    B. Hypoxia
    C. Hyperoxia
    D. All of the above

26. Carbon monoxide comes from:
    A. Waste gas of metabolism
    B. Poorly filled oxygen or diluent cylinders
    C. A and B
    D. None of the above

27. Number the following steps in the classic preparation (1 is first 8 last)
_____Fill scrubber
_____Calibrate
_____Attach scrubber
_____Analyze tanks
_____Attach counterlungs
_____Stereo check
_____Attach DSV and hoses to CCR
_____DSV gas flow check

28. Unit verification consists of:
    A. Calibration
    B. Positive negative pressure checks
    C. OPRV and ADV operation
    D. All of the above

29. Pre-dive checks all consist of:
    A. _____
    B. _____
    C. _____
    D. _____
    E. _____
    F. _____
    G. _____
    H. _____

30. The best way to pack the scrubber for the classic is:
    A. Pour___ tap then fill remainder and tap
    B. Pour 1/3 tap then pour 1/3 more tap then fill and tap
    C. Pour_____ tap pour_____ tap then fill and tap
    D. Gently tap and pour until full

31. The stereo check is used to verify:
    A. The hoses are attached correctly
    B. The flapper valves are operating properly
    C. The DSV 2nd stage is operating correctly
    D. The CCR is ready to use

32. The oxygen flow rate for the KISS should be between
    A. 0.5-1.0 LPM
    B. 0.6-1.2 LPM
    C. 0.6-0.8 LPM
    D. 0.7-0.9 LPM

33. Once the backlight one the displays goes out the batteries are good for how many hours:
    A. None. The batteries have to be replaced at once.
    B. 15 hours but best to replace batteries as soon as possible
    C. 20 hours but best to replace batteries as soon as possible
    D. 30 hours but best to replace batteries as soon as possible

34. The oxygen sensors should be replaced every:
    A. 12 months
    B. 48 months
    C. 36 months
    D. When needed

35. A diver wishes to dive to 40 m/ 132 ft within the no decompression limits. His SAC rate is 25 L/min, and he wishes to be able to do a 5 minute safety stop at 4.5 m/ 15ft even if in a CCR failure mode. How much bailout gas will he need to carry to complete a bailout from 40 m/ 132 ft. Assume an ascent rate of 10 m/min or 33 ft/min.
    A. 700 L
    B. 819 L
    C. 600 L
    D. 619 L

36. If you are using an air computer or air dive tables and plan to use a set-point of 1.1 PO2 at what depth will the loop contain air?
    A. 42 m/ 140 ft
    B. 39 m/ 130 ft
    C. 38 m/ 124 ft
    D. 33 m/ 108 ft

37. You are planning to dive with a single gas nitrox computer on your KISS CCR with a set-point of 1.3 PO2. You will go no deeper than 40 m/132 ft, but will spend most of the dive at 30 m/90 ft. What FO2 do you program into the nitrox computer for this dive?
    A. 27%
    B. 32%
    C. 33%
    D. 26%

38. You are planning to dive with a two gas nitrox computer on your KISS CCR with a set-point of 1.3 PO2. You will go no deeper than 30m/99 ft, but will spend most of the dive at 20 m/66 ft. What FO2 do you program into the nitrox computer for this dive?
    A. 32% & 43%
    B. 33% & 44%
    C. 26% & 33%
    D. 27% & 32%

39. What percent of the CNS oxygen clock would be used on the following dive: 40 m/132 ft 55 minutes followed by 20 minutes of decompression at 20 fsw (6 msw) assuming a set point of 1.3 for the dive and a set point of 1.4 for the decompression?
    A. 50.25%
    B. 42.0%
    C. 30.8%
    D. 44.2%

40. What are the 12 hour single and the 24 hour oxygen exposures for a PO2, of 1.2?
    A. 180 & 210
    B. 210 & 240
    C. 240 & 270
    D. 240 & 240

41. What are the 12 hour single and the 24 hour oxygen exposures for a PO2 of 1.0?
    A. 210 & 300
    B. 240 & 300
    C. 300 & 310
    D. 300 & 300

42. What FO2 is in the loop for a CCR diver at 20 m/66 ft if their PO2 is 1.3?
    A. 43%
    B. 42%
    C. 45%
    D. 32%

43. The number one rule for diving a CCR especially a KISS CCR is:
    A. always check the sensors
    B. always dive within your limits
    C. always dive with a buddy capable of helping you
    D. always know your PO2

44. If you do a complete diluent flush at 40 m/132 ft (assuming the diluent was air, what would the resulting PO2 be?
    A. 1.05 atm
    B. 1.15 atm
    C. 1.3 atm
    D. 1.2 atm

45. If you do a complete diluent flush at 40 m/132 ft (assuming the diluent was 23% nitrox, what would the resulting PO2 be?
    A. 1.05 atm
    B. 1.15 atm
    C. 1.3 atm
    D. 1.2 atm

46. In what position will the diver experience “chipmunk” cheeks?
    A. Face down
    B. Feet up
    C. Face up
    D. Feet down

47. Minimum loop volume is when:
    A. The diluent tank is low on gas
    B. The counterlungs are at the smallest point in the dive
    C. The counterlungs are properly fitted to the diver
    D. The loop contains the same amount of gas needed for a complete breath

48. Buoyancy control can be more challenging on a CCR as compared to OC diving due to the counterlung buoyancy:
    A. True
    B. False

49. As long as you keep the DSV out of the water it is okay to have it in the open position.
    A. True
    B. False

50. You should monitor the PO2 displays every:
    A. 1-5 minutes
    B. 1-4 minutes
    C. 10-20 minutes
    D. When you hear the ADV or OPRV

51. On ascent the PO2 will
    A. Increase
    B. Decrease
    C. Stay the same
    D. All of the above

52. On descent the PO2 will
    A. Increase
    B. Decrease
    C. Stay the same
    D. All of the above

53. If you notice a PO2 of 1.9 the best thing to do is:
    A. Panic
    B. Blow out through your nose and inhale allowing the ADV to add diluent
    C. Go to OC for sanity breaths then return to CC and adjust the PO2
    D. Manually add oxygen

54. What can happen to a KISS CCR diver who is working hard
    A. Hypoxia
    B. Hypercapnia
    C. Hyperoxia
    D. B & C
    E. A & B

55. Choose the best solution to Hyperoxia (PO2>1.8)
    A. Add diluent via the ADV
    B. 2 sanity breaths, loops flush, monitor PO2
    C. Stop descent / ascent flush loop
    D. None of the above

56. Choose the best solution to Hypoxia
    A. Add diluent via the ADV
    B. 2 sanity breaths, loop flush, monitor PO2
    C. Stop descent / ascent flush loop
    D. None of the above

57. Choose the best solution to hypercapnia
    A. Add diluent via the ADV
    B. 2 sanity breaths, loop flush, monitor PO2
    C. Stop descent / ascent flush loop
    D. OC bailout

58. Choose the best solution to caustic cocktail
    A. Add diluent via the ADV
    B. 2 sanity breaths, loop flush, monitor PO2
    C. Stop descent / ascent flush loop
    D. OC Bailout

59. If a diver experienced DCS you should:
    A. Call 911
    B. Give oxygen and activate EMS
    C. Take them to the nearest chamber
    D. Do a 5-minute neural exam

60. If your buddy is unconscious underwater the best response is to:
    A. Do a loop flush and take them to the surface
    B. Add oxygen and take them to the surface
    C. Close the DSV and take it out of their mouth, ascend give oxygen and activate EMS
    D. All of the above

.....

I certify that I understand or have had explained to me all of the questions I have missed and I have a full understanding of all material in this test and the text for this class .

_____ _____/_____/_____
Student signature date (mm/dd/yy)

Student answered a minimum of 90% of the exam correctly and I explained I detail the questions that had been answered incorrect.

_____ _____/_____/_____
Instructor signature date (mm/dd/yy)

MCCR-Rebreather Evaluation Form

Has to be printed out and signed by the student before the end of the class!

Are you certified as a _____ diver with a minimum of 250 dives?	Yes / NO

Did your instructor cover the following?

Theory

Hypoxia	YES / NO
Hyperoxia	YES / NO
Hypercapnia	YES / NO
PPO2s	YES / NO
CNS Toxicity	YES / NO
OTUs	YES / NO
Did you receive and read the manual?	YES / NO

Unit maintenance

Direction of gas flow	YES / NO
Water traps	YES / NO
Mouthpiece	YES / NO
Counterlungs	YES / NO
Hoses	YES / NO
Sofnolime (packing/changing/lifetime)	YES / NO
1st stages	YES / NO
Second stages (bail-outs)	YES / NO

Appendix III – Rebreather Evaluation Form – Please fill out with your instructor

Cleaning of the unit

Boddy Clean	YES / NO
Disinfecting	YES / NO

Use of the unit

Pre-dive checks	YES / NO
Checking sofnolime	YES / NO
Contents of oxygen	YES / NO
Bailouts (when to)	YES / NO
Low and high PO2s	YES / NO
Warning signs	YES / NO
Bubble check	YES / NO
Buoyancy on descent & ascent	YES / NO
PO2 checking	YES / NO
Pressure gauge checking	YES / NO

Swimming Pool or confined water

Was your instructor present all the time? YES / NO

Estimated pool or conf. time

Please list your exercises:

Open Water

Was your instructor present all the time? YES / NO

How many dives did you do?

Total in water time.

Please list exercises:

Do you think you can dive a MCCR Rebreather on your own?

If no, why not? YES / NO

I_____ understand that diving rebreather has potentially more risk than OC Scuba. Mistakes and errors that occur – due to my fault or others might kill me whithout warnings.

I _____understand that I have to flush the Rebreater AT LEAST 3 times whenever I go on the Rebreather or when I switch gases.

I _____understand that it is leathal to use the MCCR with the O2 not connected and or the flow not checked / verified.

I _____understand that I have to maintain my Oxygen Level manually and ongoing at all times and that I will die if I fail to do so.

BE AWARE OF YOUR PO2s ALL THE TIME – IF IN DOUBT GO OC!!

I _____ have completed and understood all the above and am aware of the risk involved in diving this type of Rebreather.

DATE _____ SIGNATURE_____

DATE_____ WITNESS_____