WARNING
Life support equipment, which includes the INSPIRATION Rebreather, requires specialist training before use.

Several problems may arise when using a rebreather, many of which, if not dealt with properly, may have fatal consequences. It is, therefore, essential that you understand exactly how this rebreather works, the maintenance which must be carried out, the purpose of every component and the operational requirements. This manual is not the definitive guide to rebreather diving and is no substitute for proper training and closed circuit rebreather experience.

Build up your experience gradually. Do not expect to be a good rebreather diver straight away. It takes time and practice to perfect buoyancy control and to become aware of the idiosyncrasies of rebreather diving and of the apparatus.

Most of the problems you can experience are referred to in this instruction manual. It is in your interest that you take the time to read and study it.
Manufactured in the UK by Ambient Pressure Diving Ltd, Unit 2C, Water-ma-Trout Industrial Estate, Helston, Cornwall TR13 0LW. Telephone: 01326 563834. Fax: 01326 573605

For details of diver and instructor training telephone Ambient Pressure Diving.

EC Type approved by SGS YICS Ltd, SGS House, Camberly, Surry, GU15 3EY. Notified Body number 0120, assisted by DERA (Defense Equipment Research Agency), Alverstoke. The INSPIRATION is CE approved to 50m using an air diluent and 100m using an Heliox diluent, though it is recommended to limit your depth to 40m when using an air diluent.
CLOSED CIRCUIT SURVIVAL

Rule No 1. Know your ppO₂ at all times. - This cannot be over emphasised.

When you dive closed circuit you need to change the way you think: When you dive with conventional or open circuit equipment you need to know: “Will I have something to breathe?”
But when you dive with closed circuit equipment you need to know: “What am I breathing?” - Never breathe from any rebreather without knowing what you are breathing.

⚠️ Warning ⚠️ If you fail to watch your ppO₂ and understand the implications - you will die, it is only a question of where and when.

The primary warning device for ppO₂ is the Master/Slave hand displays.

The audible warning device is purely an additional safety aid and warns of excessive changes in ppO₂ only.

All divers, not just those with a hearing impediment, must watch the displays and never rely on just the audible warning.

If you are unable or unwilling to monitor your ppO₂ displays regularly then you must not use the INSPIRATION.

Attitude keeps you alive: Normally, closed circuit rebreathers are used by experienced open-circuit divers. This can bring a level of over-confidence which can lead to serious problems. You are a novice again, please accept that and build your rebreather experience gradually.
Vision Test

Your eye-sight must be checked before using the Inspiration, wearing your normal dive mask.

MUST BE READ LESS THAN 16INCHES (40cm) FROM EYES

Please ask your instructor or partner to test you.
User Registration:

Rebreathers are only sold to persons who have successfully completed an approved training course, such as the IANTD/TFI/ANDI closed circuit courses, with a module specific to the INSPIRATION. The diver’s qualifications must be suitable for the type of diluent gas and planned depths. The initial training course for non-decompression diving certification must be a minimum of 4 days. The diver should then build up their experience gradually, through shore dives and inflatable and hard boat dives before attending a Module 2 rebreather decompression course. The need to build experience gradually must not be underestimated. For an up to date list of approved instructors and course details, please contact Ambient Pressure Diving.

Every user must register their full name and address, certification details and contact telephone numbers with Ambient Pressure Diving. Every unit is serial numbered to enable full traceability to the authorised user. In the event that you change address or sell the apparatus, please advise Ambient Pressure Diving so that our records may be updated. If the apparatus is resold to an uncertified user then Ambient Pressure Diving Ltd withdraw all product warranty and relinquish all liability.

Counterlung Serial No.: ____________________________
Scrubber Assembly Serial No.________________________
Buoyancy Compensator Serial No._____________________
Date of Purchase:_________________________________
Place of Purchase:_________________________________

Name:__________________________________________________________________________________________

Address: _______________________________________________________________________________________

Telephone No._________________________Fax No.____________________________

Email: ___________________________Join Inspiration Email Forum....Yes/No?_______
Date of Purchase: ______________________________Place of Purchase:__________________________

Counterlung Serial No.: ____________________________
Scrubber Assembly Serial No.________________________
Buoyancy Compensator Serial No._____________________

5
3.5.3 Interpreting the ppO₂ Displays
3.5.4 Effect of Moisture on the Cells
3.5.5 Setpoint Selection
3.6 Duration of the CO₂ Scrubber
3.6.1 How do I know when the CO₂ absorbent can no longer absorb CO₂?
3.6.2 Extra considerations
3.7 Oxygen Limits for Diving Operations
3.8 Symptoms Associated with Low and High Oxygen levels, High CO₂ Levels and Oxygen Toxicity
4.5 Colour Coding of Convoluted Hose Connections
4.6 Diluent and Oxygen Inflators
4.7 Weight Pocket
4.8 Buoyancy Compensator and Harness
4.9 Audible Warning Device

Section 5 Power On 32
5.1 General
5.2 Switching On and Off
5.3 Oxygen Cell Check
5.4 Battery Check
5.5 Elapsed On Time
5.6 Check Diluent
5.6 The Slave Oxygen Controller

Section 6 Calibration 35
6.1 Must Calibrate!
6.2 Calibrate
6.3 Ambient Pressure
6.4 Oxygen %
6.5 Open Mouthpiece
6.6 Open O₂ Valve
6.7 Flushing Bag
6.8 No Oxygen - Check Valve
6.9 Cell Stuck
6.10 Out of Range
6.11 Flushing bag
6.12 Master
6.13 Slave
6.14 Verification of ppO₂
6.14.1 Indicators to look for during calibration
6.14.2 Periodic Calibration Check
6.14.3 Linearity Check
6.14.4 Checks prior to each use
6.14.5 Verifying the ppO₂ during the dive

Section 7 Dive Mode 42
7.1 High/Low Setpoint Switch
7.2 Slave Oxygen Controller
7.3 Backlight

Section 8 Menu Mode 44
User Adjustable Setpoints
Backlight Brightness/Screen Contrast
Elapsed On Timer - RESET

Section 9 Warnings and Remedies 45
9.1 Low Oxygen Warning
9.2 High Oxygen Warning
9.3 Cell Warning/Error
9.4 Two faulty cells occurring simultaneously, resulting in low oxygen or high oxygen risks
9.5 Low Battery
9.6 Master Oxygen Controller - Power Failure
9.7 Reset Other Unit
9.8 Error Assesment

Section 10 Maintenance
10.1 CO₂ Absorbent Replacement
10.2 Gas Cylinders
10.3 First Stages
10.4 Low Pressure Oxygen Hose
10.5 Post-Dive Maintenance
10.5.1 Cleaning and Disinfecting the Unit
10.5.2 BUDDY Clean Disinfectant
10.5.3 Lubrication
10.5.4 Oxygen Sensors
10.6 Storage
10.7 Precautions When Using High Pressure Oxygen
10.8 Service Intervals

Section 11 Emergency Procedures
11.1 Bail-Out (Emergency Breathing)
11.2 Emergency Procedures
11.3 Diluent Flush
11.4 Emergency Rescue of an Unconscious Inspiration Diver
11.5 Flooded Loop
11.6 Manual Control of ppO₂
11.6.1 Manual addition of O₂ and O₂ flush method
11.6.2 Manual addition of diluent
11.6.3 Using the Inspiration as a pure oxygen rebreather

Section 12 Briefing Open Circuit Dive Partners
12.1 The rebreather Diver- What to Expect, what to Do
12.2 Classic Problems, Causes and resolutions

Section 13 Warranty

Section 14 Important Cautionary Notes

Section 15 Technical Data

Appendices
Appendix 1 Power On
Appendix 2 Determining the Oxygen Purity (when the gas quality is not certified)
Appendix 3 Self Check Questions
Appendix 4 Decompression Tables
Appendix 5 Buddy Clean Data Sheet
Appendix 6 Sofnolime Transportation Declaration
Appendix 7 Pre-Dive Checklist
Pre-breathe sequence checklist
In Water Checks and Important Procedures
SECTION 1

IMPORTANT INFORMATION

This Section describes some of the problems you may encounter in the early stages of using the INSPIRATION

⚠️ READ THIS SECTION BEFORE ENTERING THE WATER !

1.1 Gas

There are two 3 litre cylinders on board. One contains oxygen and the other a diluent or dilutant. Normally, the oxygen is fed into the breathing circuit via a solenoid operated oxygen valve, the diluent is fed manually. The oxygen is added to replace metabolised oxygen and to maintain the oxygen pressure during ascents and is an automatic process requiring you, the diver, to simply monitor it. The purpose of the diluent is to dilute the oxygen concentration to enable us to safely breathe the mixture in the breathing circuit (or loop) below 6m and also maintain the counterlung volume during the descent. Once at your target depth the diluent is no longer used, that is until you accidentally exhale through your nose- losing loop volume, or you descend again. This leaves a useful reserve of gas for BC inflation, suit inflation, oxygen cell checks and OC (open circuit) bailout.

The correct type of diluent is essential. Ideally, it should be breathable throughout the entire dive. So, at the start, use normal diving quality breathing air in the diluent cylinder. This is suitable for all depths down to your air diving limit (35 to 50m). Using a setpoint of 1.3, 50m is the maximum depth with an air diluent. Below 40m Heliox or Trimix is strongly recommended. Below 50m, Heliox or Trimix is essential. But, let’s not consider diving deep just yet though. Let’s get the basics right first. Build up your Closed Circuit experience gradually.

NEVER, NEVER use pure gases in the diluent cylinder such as pure Helium or pure Nitrogen - when something as simple as a manual diluent flush could and most likely will render you unconscious. The diluent must always contain a sufficient oxygen percentage to sustain life.

1.2 Weighting

How much lead is required? When experienced you will find that you only need to carry the same weight as you do when you dive with a single 15 litre cylinder. You would probably find it more comfortable though, to move 2-3 kg from your weight belt and put it in the weight pocket on the top of the unit. This aids in-water trim helping to keep you horizontal. During your first dives you may experience problems descending, so insert 2-3 kg in the weight pocket in addition to your normal weight belt. Using the counterlungs at minimum volume, i.e just enough gas to take one full breath, brings many advantages including a minimum lead requirement, a better swimming position with reduced back strain and early warning of gas usage from the loop.

1.3 Buoyancy Control

Buoyancy control will be different from open circuit and, whilst not being difficult, it does require some thought. When you breathe from a rebreather your buoyancy does not change. Consequently the dry suit or BC must be used for buoyancy control, as minor adjustments cannot be made by inhaling or exhaling. If a dry suit is worn then we recommend using only the dry suit for buoyancy control and we recommend fitting a variable exhaust valve so this can be set for automatic venting during the ascent. These are particularly good when used on membrane dry suits. If operating at a constant depth, buoyancy control is much easier than open circuit, but the problems start when you conduct “saw-tooth” profiles. With any obstruction in your path you should now consider swimming around it, rather than over it. To go over the obstruction will almost certainly require venting of gas during ascent and inflation on return to the original depth.
1.4 Familiarity of Controls and Harness.
Adjust all the straps to fit you prior to reaching the dive site. Ensure the inflator hose from your dry suit, connected to the LP port of the diluent cylinder’s first stage, has a long enough hose to reach your dry suit inflator.

Practise locating and operating all the rebreather and BC controls including:

i) opening and closing the mouthpiece
ii) opening and closing the oxygen cylinder valve
iii) opening and closing the diluent cylinder valve
iv) operating the diluent inflator
v) operating the oxygen inflator
vi) operating the variable exhaust valve (use the high pressure setting (rotate clockwise fully) when testing for leaks and use the low pressure setting (rotate anticlockwise fully) during the dive)
vi) operating the BC’s inflator and exhaust valves
viii) locating and using the emergency open circuit regulators (both diluent and oxygen)
ix) switching from low to high setpoint on the oxygen controller
x) ensure the counterlungs will be held down on your shoulders and will not float up when in the water

1.5 Understanding ppO₂
The ppO₂, or oxygen pressure, in the breathing circuit is what keeps you alive. A thorough understanding of ppO₂ is the most important aid to safe rebreather diving. You need to know what happens to your ppO₂ when you descend, when you ascend, when your work rate increases and what risks are present at different stages of the dive. The following self check questions are designed to validate your understanding of the system and its use. Answers are included in Appendix 3.

a. What are the risks when you first enter the water?
b. What risks may become apparent during a surface swim prior to the dive?
c. During the descent what is usually seen on the ppO₂ display?
d. How often do you expect the solenoid to operate during the descent?
e. Once below 20m what would be the effect of staying on the low (0.7bar) setpoint?
f. Once on the bottom how often would you expect the solenoid to operate and for how long would the oxygen inject?
g. What is the effect on the ppO₂ of adding diluent to the loop, for example after mask clearing?
h. If a diluent flush is carried out at: 10m what will be the ppO₂ in the loop? 20m what will be the ppO₂ in the loop? 30m what will be the ppO₂ in the loop? 40m what will be the ppO₂ in the loop?
i. How often should you check your ppO₂ whilst on the bottom?
j. Why is it important to check your ppO₂ prior to the ascent?
k. As you ascend how often would you expect the solenoid to operate and for how long?
l. How would this vary with ascent speed?
1.6 Setpoint Selection
At first, use the INSPIRATION’s default settings of 0.7 bar for the low setpoint and 1.3 bar for the high. Use the low setpoint at the surface and for the whole descent, this helps to prevent the ppO₂ from spiking. On the bottom, or once below 20 to 30m, switch to the high setpoint.

If you attempt to surface whilst using the High Setpoint Mode, continual inflation will be experienced as you approach the shallows. If the high setpoint is 1.3, then from 3m upwards the O₂ controller will be continually injecting oxygen. If your setpoint is 1.5 then it will be continually injecting from 5m upwards. This continual inflation will bring you to the surface unless gas is purged from the breathing loop. The cure is to select the Low Setpoint Mode before reaching the critical depth, at approximately 6m, or when you are about to leave the 4m decompression stop.

If the ppO₂ is much lower than the setpoint, a quantity of oxygen is fed into the breathing loop, which may make you positively buoyant. This problem is experienced when the high setpoint is selected during shallow dives, down to 10m. During these dives it is easier to continue to use the Low Setpoint Mode. If the high setpoint is definitely required at these shallow depths, then gas will have to be purged from the loop when positive buoyancy is experienced, until the gas in the loop is close to the required setpoint.

Be sure to switch to the High Setpoint Mode once on the bottom, this is extremely important on dives below 10m. Be sure to monitor the ppO₂ to ensure that it is close to the setpoint. Variations away from the setpoint will affect your dive planning for decompression.

Remember: check the ppO₂ display every minute. Know your ppO₂ at all times!

1.7 Descending
At first you may find it difficult to submerge. The problem is that air is held in four locations: the dry suit; the BC; the counterlungs; and in your own lungs.

Whilst on the surface concentrate on removing air from the BC and dry suit. Once this is done then the only air to be vented is that in your lungs and the rebreather’s counterlungs. By continually breathing in through your mouth and out through your nose, you will quickly deplete the retained gas and reduce the buoyancy. Depending upon your weighting, it may at this time be necessary to do a “duck dive” in order to submerge. At a depth of 1 to 2m you will attempt to take your first breath. You will probably be unable to do so because of the external pressure squashing the counterlungs. At this time you should press the diluent inflator with your left hand, operating it in short bursts until you have sufficient gas volume to take full, deep breaths. Practise the use of the diluent inflator before entering the water.

Descend slowly to avoid ppO₂ overshoot. Normal descent speeds are possible using the low setpoint but extreme caution must be taken if the high setpoint is used during descent.

At the 6m point carry out a check of your equipment for leaks by looking upwards for tell-tale bubbles.

1.8 Mask Clearing and Pressure Equalisation
During the descent the pressure in your mask will have to be equalised by exhaling through your nose. However, exhaling through the nose depletes the counterlung volume and should, therefore, be kept to a minimum. During your instruction you will have been advised not to exhale through the nose. However, it is beneficial to do so during familiarisation with the apparatus, in a safe environment, to experience the effect this has on the counterlung’s volume, your ability to take another breath and the importance of being able to properly locate the diluent inflator.
Remember: if you continually breathe out through your nose you are effectively on open circuit and your gas endurance will be greatly diminished.

1.9 Mouthpiece
It is important to close the mouthpiece before removing it, both underwater and on the surface. Failure to do so will result in loss of buoyancy and water entry. Practise opening and closing this valve before entering the water.

1.10 Ascending
To prevent lung damage during the ascent when using open circuit equipment, you would simply breathe out. Unfortunately, with a rebreather this will only increase the volume of gas in the counterlungs. Unless air is vented during the ascent you will notice both the counterlungs inflating and an increase in exhalation resistance. Eventually the variable exhaust valve will vent. The low pressure setting on the exhaust valve has a release pressure below that which would over pressurize a human’s lungs. However, you will find it difficult to control your ascent speed if you rely entirely on this valve. It is therefore best to vent the loop yourself, before the overpressure valve operates. The aim is to maintain neutral buoyancy and retain enough gas in the breathing loop for one full, deep breath. When possible, practise your first ascents up a shot or anchor line.

There are three ways to manually vent gas from the loop:

1) Dump air periodically using the pull cord knob on the dump valve, the same method as used with a buoyancy compensator.

2) Exhale through the nose. This is effective for dumping gas from your lungs but the pressure in the counterlungs will continue to increase as you ascend, so it is important to continually breathe gas from the counterlung and out through your nose. In practice, it is easier to exhaust air around the outside of the mouthpiece, whilst exhaling. This dumps air from both the counterlung and from the lungs simultaneously.

3) One of the easiest methods is to simply hold the dump valve open for the complete ascent. As the gas volume increases it is exhausted from the counterlungs automatically. However, you must continue breathing.

Do not forget to deflate your dry suit and buoyancy compensator during the ascent.

1.11 Breathing Resistance
The Work of Breathing of the Inspiration is under 3 joules per litre at 50m. This is the limit specified for open circuit diving regulators. The counterlungs are in the best possible position for overall ease of breathing in each orientation of the diver. The work of breathing is well under 3 joules per litre at 100m when Heliox is used in the diluent cylinder.

Please note that the volume of gas in the counterlungs greatly affects the breathing characteristics. The volume of gas in the counterlungs is controlled by you. Too much gas will make it difficult to exale and with too little it will be difficult to inhale. The ideal method is to retain only just enough gas in the counterlungs for one deep breath.

Gas may be added to the counterlungs by using the diluent inflator located on the left counterlung, the inhalation counterlung. Be sure to use this inflator and not the oxygen inflator on the right or your dry suit inflator. Be sure to rehearse the operation of the diluent inflator before entering the water. This is very important. Apart from the fact that it needs to be second nature to find it, you need to ensure gas is flowing to this inflator before submerging.
1.12 Counterlung Choice
The breathing bags/counterlungs are available in two sizes - medium and large. Select the counterlungs according to your body size. See section 4.1 for more details.

1.13 Gas Consumption
Normally, for a 1 to 1 1/2 hour dive, the gas consumed from each cylinder will only be 30-40 bar per dive. Much more than this and your close circuit diving techniques should be examined.

Exhaling through your nose: If you carelessly exhale often through your nose you lose gas from the breathing circuit (the loop), you then have to add diluent to allow you to breathe, this lowers the ppO2 and so the oxygen controller opens the solenoid to bring the ppO2 back up to setpoint, so in fact you use gas unnecessarily from both cylinders.

Swimming over objects uses gas: swimming over an object often requires a vent of gas from the buoyancy compensator and/or counterlungs. If a vent from the counterlungs is necessary then diluent addition will be required as you descend again back to your original level which weakens the ppO2, so the oxygen controller compensates by adding oxygen to bring it back up to setpoint. Again you use gas from both cylinders. Swim around objects if you can rather than swim over.

Ascents: The time when the system uses most oxygen is during the ascent. The ppO2 drops with the decreasing ambient pressure and the oxygen controller opens the solenoid often and for longer periods than during other times on the dive. You must vent the loop during the ascent but if you vent the loop around your mouth then virtually all of the fresh oxygen added by the solenoid is dumped overboard, a big waste of gas. What you should do, particularly if the oxygen supply is diminished is use the pull cord dump valve to vent the loop. This way some of the fresh oxygenated gas is used for metabolism and some goes back around the loop to raise the ppO2 around the oxygen sensors, reducing the opening time of the solenoid for the next injection and increasing the time between injections.

Dry Suit: your dry suit dump valve may be exhausting accidentally when you roll over.

Learn to look out for gas leakage in addition to often checking the gauges. Do not be lulled into a false sense of security and do check the gauges regularly, particularly for the first few minutes. If gas consumption is high it is better to know earlier in the dive rather than later.

1.14 System Integrity - Leaks
It is extremely important to cure any leaks before diving. A small leak is irritating and saps confidence.

Be aware that it is very unusual to lose buoyancy or gas from the breathing loop. If there is a constant need to inject diluent to breathe from the bag then it is very likely that there is a leak in the system. The other problem is that this constant injection of diluent lowers the ppO2 in the loop, making your decompression schedule invalid.

Test the complete apparatus for positive pressure leaks by closing the exhaust valve by rotating it clockwise to the pre-dive/test position and either inflate by mouth, closing the mouthpiece afterwards, or by using the diluent inflator. One of the most practical methods of testing for leaks is to inflate the system using the diluent inflator until the pressure relief valve operates. If the counterlungs remain firm for over 40 minutes then there are no significant positive pressure leaks on the system. Ensure the exhaust/pressure relief valve is set to the low pressure position (fully anti-clockwise) prior to diving.

Test with negative pressure by sucking a vacuum on the apparatus, crush one or two of the convoluted hoses whilst sucking the vacuum and then close the mouthpiece. If air leaks into the system the crushed hoses will spring back towards their original shape. It is extremely important to find any small leaks and rectify them before diving. Water will ingress into the apparatus through the smallest of leaks.

Water in the exhale tube will be apparent because of an audible gurgling noise. If, despite continually clearing it by
closing the mouthpiece, holding the mouthpiece overhead and shaking it, water is still apparent, it may be entering around the outside of the mouthpiece. Also confirm the mouthpiece is fully open. As the mouthpiece is opened and closed, an O ring seal which is used to seal the inner tube against the outer, will be seen. If the mouthpiece valve is only partially open, an O ring will be visible when viewed through the mouthpiece and water will be allowed to enter the loop from the water vent. Finally, ensure the mouthpiece ty-rap is secure. Incorrect tensioning during replacement could result in a leak.

1.15 System Integrity - Indications
Know your ppO₂ at all times! Learn how to evaluate the information provided by the oxygen controllers - Section 3.5 to 3.5.6, Sections 6, 7 and 9.

Listen out for the solenoid. It should be operating in short bursts. If you think it has been open longer than normal or it has not been heard for a long while - it is time to take a look at the ppO₂ display.

Compare the cell readings. While breathing, the cell readings change. Bearing in mind that these oxygen cell readings are shown in real time, the ability to see all three sensors simultaneously is a great diagnostic aid. If one is failing to react as quickly as the others, there may be water on the cell’s sensor face. The modifications made to the sensors prevent large quantities of moisture reaching the face and affecting the internal circuitry. It is, therefore, essential to use only oxygen cells supplied by Ambient Pressure Diving.

1.16 Batteries
Each oxygen controller has its own battery and circuitry. However, both batteries share the same battery box door, so it is imperative to ensure this door is fastened properly. The 6 volt Lithium batteries - Energizer EL223APCRP2 or direct equivalent, are readily available and last for approximately 35 hours when used for the Master controller and approximately 70 hours when used for the Slave.

The controller does not power down when not in use. It is, therefore, very important to ensure that both controllers are switched off after use to preserve battery life.

1.17 Surface Swimming
When swimming forward, face down, on the surface, only partially inflate the BC. Over inflation will cause increased body angle and extra drag. Deflate the BC and adopt a horizontal, head down, streamlined swimming position.

1.18 Surface Buoyancy and Trim
By rotating the counterlung’s pressure relief valve to the high pressure setting, and with the mouthpiece closed the counterlungs can be inflated and used for additional surface buoyancy. The volume of gas admitted to the BC must be regulated to ensure an upright floating position.

1.19 Quick Post-Dive Checks
Check the exhale counterlung for residual water by unscrewing the oxygen inflator, see Section 4.6. If water is present, drain and check the downstream side of the first water trap. If water is present, remove the scrubber and check the Sofnolime at the bottom of the scrubber. If it is soaked replace the Sofnolime before the next dive.

It is important to keep the unit upright if water is suspected to have entered the scrubber. This prevents the Sofnolime and water from damaging the oxygen sensors.
1.20 Practice
Learn to ascend without adding diluent. This enables you to surface normally, even in the event of having lost your diluent gas for some reason, perhaps you’ve given it to your dive buddy?

Learn to operate the system with the solenoid failed in the closed position. This may be achieved by manually adding O₂ to reach a ppO₂ of 0.9 when a ppO₂ of 0.7 is selected.

Learn to operate the system with the solenoid failed in the open position. Practice this in the swimming pool by selecting a high set point of 1.5 and controlling the injection of O₂ by opening and closing the cylinder valve.

1.21 Solenoid operation and the main oxygen risks during the dive

<table>
<thead>
<tr>
<th>PHASE OF THE DIVE</th>
<th>NORMAL SOLENOID OPERATION</th>
<th>OXYGEN RISKS</th>
<th>POSSIBLE CAUSES</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Breathing</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - HIGH risk Hypoxia - NO risk</td>
<td>Hypoxia - oxygen cylinder valve closed, oxygen cylinder empty, solenoid jammed shut, oxygen controllers switched off. Before the descent there is only one oxygen risk - Hypoxia or low oxygen pressure. Hypoxia can occur within a minute or so when on the surface. Look often at the ppO₂ displays! Listen for the oxygen injecting.</td>
<td></td>
</tr>
<tr>
<td>Jumping In</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - NO risk Hypoxia - SLIGHT risk</td>
<td>Hypoxia - NO risk, providing the oxygen content of the diluent is suitable for the shallows. Hypoxia - manual addition of oxygen or solenoid jammed open.</td>
<td></td>
</tr>
<tr>
<td>On the surface</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - LOW risk Hypoxia - HIGH risk</td>
<td>Hypoxia is a low risk simply because it takes so long to happen and you should be looking at the ppO₂ displays, ensuring your ppO₂ is close to the (HIGH) setpoint to ensure you don’t suffer decompression sickness.</td>
<td>Listen for the solvent, you expect short bursts with 6 second closed periods. If it adds oxygen for longer than a fraction of a second then check your ppO₂ displays.</td>
</tr>
<tr>
<td>Descending</td>
<td>Closed</td>
<td>Hypoxia - NO risk Hypoxia - SLIGHT risk</td>
<td>The main risk during the descent is the diluent. Is the diluent switched on? - Check this before you get in the water! Are you pressing the diluent button or the oxygen button? Left hand is diluent. (LEAN - left, RICH - right) Listen for the solvent, it shouldn’t be opening. If it does, check the ppO₂ displays.</td>
<td></td>
</tr>
<tr>
<td>Bottom portion of dive</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - HIGH risk Hypoxia - MEDIUM risk</td>
<td>Hypoxia - oxygen cylinder valve closed, oxygen cylinder empty, solenoid jammed shut, oxygen controllers switched off. Hypoxia - manual addition of oxygen or solenoid jammed open.</td>
<td></td>
</tr>
<tr>
<td>Ascending</td>
<td>Closed 6 secs, Open &gt; 1 sec</td>
<td>Hypoxia - HIGH risk Hypoxia - MEDIUM risk</td>
<td>Hypoxia - the ascent is potentially a very dangerous time. Check your ppO₂ BEFORE the ascent and then often during. Listen for the solvent, expect long bursts of oxygen addition - the opening time will vary with your ascent speed but at a normal ascent speed 4 will be approx. 4 or 5 seconds followed by 6 seconds closed. This can be 17 seconds open, 6 seconds closed. Hypoxia - there is a reducing risk of hypoxia as you ascend.</td>
<td></td>
</tr>
<tr>
<td>Decompressi-on Stop</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - LOW risk Hypoxia - MEDIUM risk</td>
<td>Hypoxia is a low risk simply because it takes so long to happen and you should be looking at the ppO₂ displays, ensuring your ppO₂ is close to the (HIGH) setpoint to ensure you don’t suffer decompression sickness. The risk of O₂ toxicity increases with the duration of the decompression stop - ensure you stay within the NO AA CNS guidelines.</td>
<td></td>
</tr>
<tr>
<td>Surface swimming</td>
<td>Closed 6 secs, Open ≤ 1 sec when the ppO₂ is close to and below the setpoint</td>
<td>Hypoxia - HIGH risk Hypoxia - NO risk</td>
<td>Hypoxia - oxygen cylinder valve closed, oxygen cylinder empty, solenoid jammed shut, oxygen controllers switched off. Hypoxia can occur within a minute or so when on the surface. Look often at the ppO₂ displays! Listen for the oxygen injecting.</td>
<td></td>
</tr>
</tbody>
</table>

Do use the checklists at the back of this manual to aid preparation.
OXYGEN DANGER POINTS

- If P02? Cells Moving?
  - Check Display
  - Listen for Solenoid
- If Set/Check High Setpoint
- If P02 = 2.55?
  - Check Display
  - EMERGENCY DRILL!
- If CNS limit?
  - 1.3 bar = 3 hours
  - 1.4 bar = 2 ½ hours
- Do I check?

Danger of High O2: Bigger Star = Bigger Risk
Danger of Low O2: Bigger Star = Bigger Risk

Graphics original by Lynne Weller.
### SECTION 2

#### DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBIENT PRESSURE:</td>
<td>That pressure surrounding the diver/rebreather. Rough values are 1.0 bar at the surface, 2 bar at 10m, 3 bar at 20m, 4 bar at 30m etc. When calibrating the cells prior to diving, the ambient pressure is the atmospheric pressure on the day. This varies with altitude and weather.</td>
</tr>
<tr>
<td>BAILOUT:</td>
<td>An emergency breathing system.</td>
</tr>
<tr>
<td>BREATHING LOOP:</td>
<td>The entire breathing gas pathway including the diver’s lungs and airways; the mouthpiece; the counterlungs; the convoluted hoses; and the scrubber.</td>
</tr>
<tr>
<td>CALIBRATION:</td>
<td>All the oxygen cells have to be calibrated before use. This is a fairly simple procedure, it takes about 25 seconds to complete and is done on the complete unit prior to the dive.</td>
</tr>
<tr>
<td>CARTRIDGE:</td>
<td>Sofnolime is retained in a diver-refillable container/cartridge which is inserted into the scrubber.</td>
</tr>
<tr>
<td>CCR:</td>
<td>Closed Circuit Rebreather.</td>
</tr>
<tr>
<td>CNS OXYGEN TOXICITY:</td>
<td>Central Nervous System Oxygen Toxicity. Oxygen toxicity is a combination of oxygen pressure and time. The exposure limits are shown later in this manual.</td>
</tr>
<tr>
<td>LOW OXYGEN:</td>
<td>This is displayed when the ppO₂ in the loop is 0.4 bar or less.</td>
</tr>
<tr>
<td>HIGH OXYGEN:</td>
<td>This is displayed when the ppO₂ in the loop is 1.6 bar or higher.</td>
</tr>
<tr>
<td>HYPERCAPNIA:</td>
<td>An excess of carbon dioxide.</td>
</tr>
<tr>
<td>HYPEROXIC:</td>
<td>For the purposes of this manual, hyperoxic is classed as all breathing mixtures with a ppO₂ greater than 1.6 bar.</td>
</tr>
<tr>
<td>HYPOXIC:</td>
<td>When the ppO₂ is less than 0.16 bar.</td>
</tr>
<tr>
<td>OTU:</td>
<td>Oxygen toxicity unit.</td>
</tr>
<tr>
<td>ppO₂/PO₂:</td>
<td>Partial pressure of oxygen. ppO₂ is used throughout this manual.</td>
</tr>
<tr>
<td>OXYGEN CELLS:</td>
<td>Cells or sensors used to monitor the ppO₂ in the breathing circuit (loop).</td>
</tr>
<tr>
<td>SCRUBBER/CANISTER:</td>
<td>The complete, back mounted, canister used for CO₂ removal and, in this rebreather, oxygen analysis and oxygen addition.</td>
</tr>
<tr>
<td>SETPOINT:</td>
<td>The pre-selected setting about which the oxygen controller attempts to maintain the actual ppO₂ in the breathing loop.</td>
</tr>
<tr>
<td>SOFNOLIME:</td>
<td>The absorbent used in the scrubber to remove CO₂ from the exhaled gases.</td>
</tr>
<tr>
<td>LUBRICATION:</td>
<td>Any approved oxygen compatible grease. DO NOT USE silicone or hydrocarbon based grease or oil on high or medium pressure oxygen fittings.</td>
</tr>
</tbody>
</table>
SECTION 3

OPERATIONAL CONSIDERATIONS

3.1 General

The INSPIRATION is a closed circuit rebreather (CCR) in which the exhaled gases are recirculated within the apparatus so the diver can breathe them again and again. A CO\textsubscript{2} scrubber chemically removes the CO\textsubscript{2} whilst the oxygen controller monitors the exhaled gases and, when necessary, injects oxygen to maintain the oxygen partial pressure (ppO\textsubscript{2}) at preset levels, known as setpoints.

Oxygen is supplied directly from a cylinder containing pure oxygen. As the diver descends, gas needs to be added to maintain the breathing volume. Providing this gas has a lower oxygen content, this gas dilutes the oxygen and is known as a dilutant or diluent. By diluting the oxygen the diver can go deeper than the 6 m limit set for pure oxygen closed circuit rebreathers.

The INSPIRATION’s depth limit is governed by two factors. The first is the gas used as the diluent and the second is the volume of bail out/emergency breathing gas. If air is used as a diluent then the INSPIRATION can be used at all depths down to the air diving limit, normally 40 to 50m. Air is the diluent of choice for normal sport diving depths. Normal diving-quality compressed air is used.

If Heliox is used as a diluent then, as with open circuit diving, the mix limits the depth. Experimental dives using Trimix are being conducted.

The volume and type of bailout gas carried is extremely important in determining the depth range. It must be sufficient in order to breathe at depth and bring you back to the surface.

The INSPIRATION is CE approved to 50m using an air diluent and 100m using an Heliox diluent, though it is recommended to limit your depth to 40m when using an air diluent.

The INSPIRATION is designed to be used only with a separate face mask and mouthpiece. If experimenting with full face mask configurations the diver must ensure the INSPIRATION’s original mouthpiece is retained and inserted in the diver’s mouth.

3.2 Gas Consumption

Only a fraction of the air we inhale, approximately 4% at the surface, is used, most of which is converted into CO\textsubscript{2} and exhaled along with the 96% of the gas not used. By recirculating the exhaled gases, removing the CO\textsubscript{2} waste product and replenishing the oxygen, we can limit the gas removal from the oxygen cylinder to the same volume that we consume for metabolism, between 0.5 and 3.5 litres per minute depending on the person and work rate. Mr. Average consumes approximately 1 litre of oxygen per minute, women generally less. This means the 3 litre cylinder filled to 200 bar contains 600 litres of oxygen and will last 10 hours!

The other incredibly significant benefit for the diver is that the amount of oxygen consumed is the same at all depths as shown in Table 1 overleaf.
### Table 1. Comparison of Gas Consumption between Open Circuit and Closed Circuit Apparatus

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Absolute Pressure (bar)</th>
<th>Gas consumption (litres/min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Open Circuit</td>
</tr>
<tr>
<td>0</td>
<td>1.0</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>2.0</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>3.0</td>
<td>75</td>
</tr>
<tr>
<td>30</td>
<td>4.0</td>
<td>100</td>
</tr>
<tr>
<td>40</td>
<td>5.0</td>
<td>125</td>
</tr>
<tr>
<td>50</td>
<td>6.0</td>
<td>150</td>
</tr>
<tr>
<td>60</td>
<td>7.0</td>
<td>175</td>
</tr>
<tr>
<td>70</td>
<td>8.0</td>
<td>200</td>
</tr>
<tr>
<td>80</td>
<td>9.0</td>
<td>225</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
<td>250</td>
</tr>
<tr>
<td>100</td>
<td>11</td>
<td>275</td>
</tr>
</tbody>
</table>

It is clear that the benefits to the diver in terms of gas carried are immense, but this is only part of the story.

### 3.3 Oxygen Benefits

**Background:**

Air at the surface is approximately 21% oxygen, 79% Nitrogen. The Absolute Pressure at the surface is approximately 1 bar. According to Dalton the partial pressure of oxygen \((ppO_2)\) is 0.21 bar and the partial pressure of the Nitrogen \((ppN_2)\) is 0.79 bar: \(0.21 + 0.79 = 1.0\) bar. Referring to Table 2 you can see the \(ppO_2\) and \(ppN_2\) at the different depths when breathing open circuit SCUBA. The \(ppN_2\) is simply derived from multiplying the \(ppN_2\) at the surface by the ambient pressure, i.e. at 10 m, the \(ppN_2 = 0.79 \times 2 = 1.58\). The \(ppO_2\) is calculated in exactly the same way, at 10 m the \(ppO_2 = 0.21 \times 2 = 0.42\).

The oxygen partial pressure in the INSPRIATION is monitored by three oxygen cells. As the diver is consuming the oxygen through metabolism, the partial pressure drops. Once it drops below a predetermined level, known as the setpoint, a solenoid valve is opened and oxygen is added.

By controlling the pressure of oxygen in the loop we have the opportunity to maintain higher \(ppO_2\) levels than that experienced on open circuit, decreasing the decompression obligations and giving us either increased no-stop time or an increased safety margin.

Table 2 shows a comparison between a diver on SCUBA, breathing air, and a diver on closed circuit rebreather with a setpoint of 0.70 bar on the surface and a setpoint of 1.3 bar for the dive. Comparing the \(ppN_2\) of open circuit AIR and the \(ppN_2\) when on closed circuit it can be seen that the closed circuit diver has a lower nitrogen loading at all depths down to 50m. But it can also be seen that the breathing mixture becomes richer in oxygen whilst ascending, reaching 100% oxygen at 3m. This has the positive effect of giving the diver oxygen-rich decompression on every dive, resulting in quicker off gassing of nitrogen.
### Table 2  Comparison of Open Circuit and Closed Circuit Apparatus

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Absolute Pressure (bar)</th>
<th>Open Circuit (AIR)</th>
<th>Closed Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ppO₂ (bar)</td>
<td>O₂ %</td>
</tr>
<tr>
<td>0</td>
<td>1.0</td>
<td>0.21</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>1.3</td>
<td>0.273</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>1.6</td>
<td>0.336</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>2.0</td>
<td>0.42</td>
<td>21</td>
</tr>
<tr>
<td>20</td>
<td>3.0</td>
<td>0.63</td>
<td>21</td>
</tr>
<tr>
<td>30</td>
<td>4.0</td>
<td>0.84</td>
<td>21</td>
</tr>
<tr>
<td>40</td>
<td>5.0</td>
<td>1.05</td>
<td>21</td>
</tr>
<tr>
<td>50</td>
<td>6.0</td>
<td>1.26</td>
<td>21</td>
</tr>
</tbody>
</table>

#### 3.4 Decompression

Constant ppO₂ decompression can be calculated using a software program such as Proplanner, DD-Plan or Z-Plan.

A set of tables, showing no-stop times, are at Appendix 4 of this manual. These have been calculated on Proplanner for the standard 1.3 bar setpoint. It can be seen that the no-stop time for 20m with a setpoint of 1.3 bar is 140 mins. This compares to 51 mins on AIR on a Buhlmann table.

Alternatively, a standard Nitrox dive computer can be adjusted to the oxygen percentage at the target depth with the planned setpoint. With a setpoint of 1.3 bar the oxygen percentage in the rebreather at 30m is 1.3 divided by 4 = 0.32, i.e. 32%. Setting the dive computer to 32% would be a very conservative way of calculating the decompression requirements because the dive computer would assume a constant gas percentage at every depth, whereas much higher oxygen percentages would be breathed during the shallower phases of the dive. In practical terms though this is a very easy method to achieve long duration dives with all the benefits of breathing Nitrox. Using a Nitrox dive computer is of most use when 3 or 4 dives are scheduled per day or multi-level dives are conducted.

Alternatively, a constant ppO₂ dive computer such as the Buddy Nexus can be used to take full advantage of the Inspiration’s reduced-deco potential.

#### 3.5 Oxygen Controller

The controller consists of three oxygen cells, two control units with their own displays and batteries and one solenoid valve for oxygen addition. Whichever control unit is switched on first becomes the Master control unit and the second unit becomes the Slave. The status of the control unit, whether it is a Master or Slave, is shown at the top of the display next to the setpoint. The Master unit controls the oxygen solenoid and hence the breathing mixture whilst the Slave purely acts as a secondary display but ready to take over if the Master controller’s power should fail. You can simulate this by switching off the Master controller - the Slave becomes the Master within 1 second.

#### 3.5.1 Accuracy of the Oxygen Controller

The oxygen controller displays the ppO₂ as measured by all three cells. The accuracy is ± 0.05 bar and this should be taken into consideration when dive planning. If the setpoint is 1.3 bar, assume 1.25 bar when calculating decompression and 1.35 bar when calculating oxygen toxicity time limits. See section 6 for further information.
3.5.2 Oxygen Cell Life

The cell life is not guaranteed by the manufacturer, Teledyne, as it varies with usage. It is expected to last for up to four years in air or 10 months in oxygen. In the INSPIRATION it is expected that the cells will last between 1 and 2 years. This largely depends on their treatment. Vibration, excess temperature, excess moisture and direct sunlight can adversely affect the cells. It is not recommended to store the oxygen cells in a sealed bag or in an inert gas. (When travelling to remote spots it is advised to take spare oxygen cells and batteries.)

3.5.3 Interpreting the ppO₂ Displays

On initial power up, the output from the cells is compared. If they are outside the expected range, cell failure warnings are displayed and the oxygen controller will not proceed to dive mode.

The oxygen controllers display the ppO₂ measured by all three oxygen cells and display in the range 0.0 to 2.55 bar. Remember that the ppO₂ level must remain between 0.16 and 2.0 bar to sustain life. If 2.55 bar is seen on the display - do not hesitate - perform a diluent flush immediately and consider reverting to open circuit. 2.55 bar on the display could indicate either a malfunction in the electronics or a very high ppO₂. In the latter case the ppO₂ level could be very high indeed e.g. 6 bar at 50m!

During the dive the oxygen controller controls the oxygen partial pressure in the breathing loop by averaging the nearest two cell output readings, i.e if you have one cell reading 1.28, another 1.29 and the other 1.31, the cell displaying 1.31 will be ignored and the ppO₂ assumed to be 1.285. As it is below the setpoint, the solenoid will open for a fraction of a second.

In this example the ppO₂ is assumed to be 1.34 bar, i.e above the setpoint, so the solenoid will not open.

In this example the ppO₂ is assumed to be 0.35 bar. Here it is a long way below the setpoint so the solenoid will open for a number of seconds.

The advantage of measuring the ppO₂ in this manner is that if one cell is faulty it is ignored, that is until the difference is greater than 0.2 bar in which case a cell error warning will be displayed and the buzzer sounded. The oxygen controller will continue to control the ppO₂ because it only needs two functioning cells to work properly. Because all three cells are displayed simultaneously you can assess the warning and see if it was just a pocket of oxygen affecting one sensor or the problem is ongoing. Although the controller will function normally with one faulty cell and continue to maintain the ppO₂, if the problem persists, the diver should abort the dive.

Warning Because the system averages the nearest two cells, it is important to be aware that in the unlikely event of two cells failing simultaneously then the only good cell will be ignored. Remember though, once one cell shows a difference greater than 0.2 bar a cell error warning will be displayed. See Sections 6.12 (Verification of ppO₂) and 9 (Warnings and Remedies) for more details.

By displaying all three cells simultaneously it allows you to instantly diagnose the problem. Any slow reacting cells can be spotted, along with any physical faults such as a faulty connection to a cell. If a cell reads 0.0 bar then a wire or connector has become disconnected. If a cell is inoperative abort the dive and consider manual operation or bailing out. Excess oxygen in the loop may be prevented by controlling the oxygen cylinder’s valve. If more oxygen is required, press the oxygen inflator. See Section 11 - Emergency Procedures.
3.5.4 Effect of Moisture on the Cells

In use the atmosphere in the scrubber is virtually always humid. When the scrubber lid is removed, after the dive, condensation and moisture will be evident. This cannot be avoided due to the moisture created by the Sofnolime reacting with and removing the CO\textsubscript{2} from the atmosphere in the loop. Humidity levels have been considered when determining the accuracy of the information provided to the diver, in the same way an allowance has been made for the effects of the inherent ± 1% accuracy of the cell outputs. The accuracy of the oxygen controller’s reading is ± 0.05 bar, allowing for all normal use errors.

However, large drops of water either on the front cell face or in the back of the cell may affect the readings. Water on the cell’s sensor face tends to slow down the reaction of the cell to changing ppO\textsubscript{2} and water in the back of the cell tends to push the ppO\textsubscript{2} read out higher. The cells used on the INSPIRATION have been modified to help eliminate both of these problems. When fitting replacements ensure only original parts are used.

3.5.5 Setpoint Selection

There are two setpoints. A low setpoint used when on the surface and for the descent and a high setpoint used when on the bottom and for most of the ascent. The switch from low to high and back again is done manually with the centre push button on the display (see Section 5 for details).

The setpoints are user selectable to match the type of diving planned. However, begin by using the default values: a low setpoint of 0.70 bar and a high setpoint of 1.3 bar. With a ppO\textsubscript{2} in the loop of 1.3 bar, the maximum duration of the set is 3 hours per exposure or 3.5 hours per day, when using the NOAA oxygen toxicity limits.

The Absolute Pressure at the surface is approximately 1.0 bar, if a higher setpoint than this is selected whilst still at the surface, the unit will continually inject oxygen, trying to reach the setpoint. Since this cannot be achieved the result would be a waste of oxygen and battery power. Look out for this and make sure a low setpoint is selected when at the surface.

In your Nitrox training you will have learnt about CNS oxygen toxicity and the NOAA exposure limits. When selecting setpoints be sure to consider the oxygen toxicity limits as this is the primary factor affecting the dive duration with the INSPIRATION, see Table 3.

<table>
<thead>
<tr>
<th>ppO\textsubscript{2} (bar)</th>
<th>Exposure Limit per Dive (mins)</th>
<th>Exposure Limit per Day (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6</td>
<td>45</td>
<td>150 (2 ½ hours)</td>
</tr>
<tr>
<td>1.5</td>
<td>120 (2 hours)</td>
<td>180 (3 hours)</td>
</tr>
<tr>
<td>1.4</td>
<td>150 (2 ½ hours)</td>
<td>180 (3 hours)</td>
</tr>
<tr>
<td>1.3</td>
<td>180 (3 hours)</td>
<td>210 (3 ½ hours)</td>
</tr>
<tr>
<td>1.2</td>
<td>210 (3 ½ hours)</td>
<td>240 (4 hours)</td>
</tr>
<tr>
<td>1.1</td>
<td>240 (4 hours)</td>
<td>270 (4 ½ hours)</td>
</tr>
<tr>
<td>1.0</td>
<td>300 (5 hours)</td>
<td>300 (5 hours)</td>
</tr>
<tr>
<td>0.9</td>
<td>360 (6 hours)</td>
<td>360 (6 hours)</td>
</tr>
<tr>
<td>0.7</td>
<td>570 (9 ½ hours)</td>
<td>570 (9 ½ hours)</td>
</tr>
</tbody>
</table>
3.5.6 Pulmonary Oxygen Toxicity

Prolonged exposure to oxygen in excess of 0.5 bar can lead to pulmonary toxicity which affects the whole body. Normally sport divers would never achieve such high exposures. However, with a rebreather such high levels may be achievable and it is necessary to ensure the limits are not exceeded. As a rough guide - if you stay within the NOAA CNS guidelines then pulmonary oxygen toxicity is only of concern during long duration dives over multiple days, e.g. 6 hours diving per day, every day, (using a ppO₂ of 0.9) for 14+ days. Check your dive times for risk of pulmonary oxygen toxicity by consulting one of the technical diving organisations’ (IANTD or TDI) work books. Using the higher ppO₂ levels of 1.35, 1.45 and 1.55 the CNS clock is the limiting factor in all cases.

3.6 Duration of the CO₂ Scrubber

Rule No 1 - Dive Planning
The Sofnolime must be replaced after 3 hours of use for CO₂ produced at a rate of 1.6 lpm.

Multiple Dives
The INSPRIATION’s scrubber can be used for multiple dives, providing the Sofnolime is not soaked during a dive, **bearing in mind the total timed used must not exceed 3 hours** (for CO₂ produced at 1.6 lpm).

Rule No 2 - For subsequent dives deeper than 20m, the diver must leave the bottom when the total time breathed from the unit reaches **140 minutes** (for CO₂ produced at 1.6 lpm), e.g. If dive 1 is for 100mins and the 2nd dive is deeper than 20m, the bottom time of the 2nd dive must not exceed 40 mins. Check the decompression times for the 2nd dive to ensure the dive durations, when added together, do not exceed 3 hours!

Rule No 3 - For subsequent dives deeper than 50m the diver must leave the bottom when the total time breathed from the unit reaches **100 minutes** (again this applies to CO₂ produced at 1.6 lpm), e.g. If dive 1 is for 90mins and the 2nd dive is deeper than 50m, the bottom time of the 2nd dive must not exceed 10 mins. Check the decompression times for the 2nd dive to ensure the dive durations, when added together, do not exceed 3 hours!

⚠️ Warning

1) This information is based on using the 1.0 - 2.5 mm diving grade Sofnolime and tested using a water temperature of 5°C and an average CO₂ production rate of 1.6 litres per minute.
2) Some people produce more than 1.6 litres per minute of CO₂ and usage times must be shortened. Conduct personal oxygen consumption trials at work and rest to determine your own CO₂ production before use. Calculate your approximate CO₂ production by multiplying your oxygen consumption by 0.9.
3) Never expect the Sofnolime to last longer because you are in warmer water but do expect it to last for a shorter period if used in colder temperatures than 5°C.
4) The design of the scrubber, not just the weight of Sofnolime, is a major factor in the duration, so these performance figures cannot be used for determining the duration of another make of scrubber.
5) If other scrubber materials are used, such as 2.5 - 5.0mm Sofnolime, then these duration figures are invalid.
6) The performance of the scrubber was tested by the Royal Navy’s DERA test centre on a fresh batch of material, taken straight from the manufacturer’s packaging.
7) Material that has been left exposed to the atmosphere can appear to be satisfactory but in reality may only work for a short period.
8) The efficiency of the material may vary slightly from batch to batch.
9) The information given applies to Air and Heliox diluents.
3.6.1 How do I know when the CO₂ absorbent can no longer absorb CO₂?

If fresh Sofnolime of the correct grade is used, then the time used can be recorded and compared to the three rules above. Recording the time used is most important! It is the only practical way of predicting the remaining absorbent life.

⚠️ Warning  DO NOT RELY ON COLOUR CHANGE

Some Sofnolime changes colour as it is used but this is only a guide as the material returns to the natural colour after a time and is also temperature dependent. In cold conditions it will not change colour at all.

Replace the Sofnolime if the material is soaked, do not attempt to dry it out.

3.6.2 Extra Considerations

Avoid leaving the absorbent open to the atmosphere or this will reduce its operational life. If you intend to use the absorbent again, once the scrubber is dried, seal up the scrubber using the convoluted hoses. Do not remove and repack partially used absorbent as CO₂ breakthrough will occur much earlier than expected. When absorbent is removed from the CO₂ cartridge, dispose of it immediately.

The CO₂ cartridge is easily refilled by the diver. The normal weight of Sofnolime required is 2.45 kg of 1 - 2.5mm (8-12 mesh) granule size, 797 diving grade, Sofnolime.

Some settling of Sofnolime will occur. A small amount of settling will be taken up by the spring loaded base plate. Care must be taken if a long car journey is undertaken between packing the cartridge and diving with it. Always inspect the cartridge before the dive.

⚠️ Warning  Hypercapnia, an excess of CO₂ at cellular level, can become a problem in any form of closed circuit rebreather diving. Reduced efficiency of the absorbent, channelling of breathing gas through the absorbent due to poor packing of the absorbent during refill or if the absorbent becomes wet, can lead to increased CO₂ levels which can result in Hypercapnia. Be aware of an increased breathing rate, symptoms of confusion or drowsiness. If the pCO₂ exceeds 0.15 bar - symptoms such as difficulty in breathing, rigidity and muscle spasms may become evident. Symptoms of Hypercapnia may be quickly reversed by flushing the breathing loop with diluent.

Maintenance of the apparatus, including disassembly of the scrubber, is detailed in Section 10.

3.7 Oxygen Limits for Diving Operations

<table>
<thead>
<tr>
<th>ppO₂ LEVEL</th>
<th>EFFECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.10</td>
<td>COMA OR DEATH</td>
</tr>
<tr>
<td>0.10</td>
<td>Unconsciousness</td>
</tr>
<tr>
<td>0.12</td>
<td>Serious signs of Hypoxia</td>
</tr>
<tr>
<td>0.16</td>
<td>Minor signs of Hypoxia</td>
</tr>
<tr>
<td>0.21</td>
<td>Normal air environment at the surface</td>
</tr>
<tr>
<td>0.40</td>
<td>INSPIRATION LOW OXYGEN warning</td>
</tr>
<tr>
<td>0.70</td>
<td>INSPIRATION Default Low Setpoint</td>
</tr>
<tr>
<td>1.30</td>
<td>INSPIRATION Default High Setpoint</td>
</tr>
<tr>
<td>1.40</td>
<td>Recommended recreation limit</td>
</tr>
<tr>
<td>1.60</td>
<td>INSPIRATION HIGH OXYGEN warning</td>
</tr>
</tbody>
</table>
3.8 Symptoms Associated with Low and High Oxygen Levels, High CO₂ Levels and Oxygen Toxicity.

The following is intended to be a brief overview. For further information we recommend studying the IANTD, or similar, training organisation manuals.

**Hypoxia Symptoms (Lack of oxygen)**

Hypoxia is extremely dangerous and is potentially fatal. The warning signs are very slight and hardly noticeable. Once the ppO₂ drops below 0.1 bar, the diver will become unconscious. It is, therefore, essential to monitor the oxygen controller at all times. Oxygen should be administered to a victim as soon as possible and may not always be successful.

**Hyperoxia Symptoms (excess ppO₂)**

Spastic Convulsions are not always preceded by warning symptoms. It is, therefore, essential to monitor the oxygen controller at all times.

**Hypercapnia Symptoms (excess CO₂)**

- Shortness of breath
- Headache
- Dizziness

**Central Nervous System (CNS) Oxygen Toxicity Symptoms**

- Visual problems (focus, tunnel, spotty etc.)
- Ears (ringing, abnormal)
- Nausea (spastic vomiting)
- Twitching (facial)
- Irritability
- Dizziness

**Whole Body Oxygen Toxicity Symptoms**

- Dry cough
- Shortness of breath
- Increased breathing resistance
- Discomfort in chest
4.1 Counterlungs

Two sizes of counterlungs are available: medium and large. Both have sufficient volume for breathing. Select the breathing bags/counterlungs according to your body size. When wearing trousers with a belt and a T-shirt, measure from the lower edge of the belt at the front over your shoulder and down to the lower edge of your belt at the back. Take the measurement on inhale.

Under 110cm - Medium Counterlungs

Over 110cm - Large Counterlungs

It is essential to keep the breathing bags/counterlungs down on your shoulders. They are prevented from floating upwards by the Fastex buckle located on the lower edge of each counterlung. These can be fastened to the special connection points on the INSPIRATION Harness. If these do not allow the counterlungs to remain on the shoulders then either a smaller breathing bag, or the use of crutch straps, must be considered.

4.2 Over-Pressure Exhaust Valve

This is a two position valve with an additional manual override. Fully closed (clockwise) is the high pressure setting, used for detecting leaks on the system and for providing positive buoyancy when at the surface with the mouthpiece closed. Fully open (anticlockwise) is the low pressure setting, used throughout the dive. On this setting the loop pressure is kept below the maximum lung overpressure of 60 mbar. During the ascent, this setting may be too high for comfortable exhalation so the valve has a pull cord exhaust fitted which can be either operated intermittently or continuously during the ascent. The latter option has the advantage of keeping the breathing loop volume at a minimum eliminating the possibility of the expanding gas in the loop from adversely increasing the buoyancy. The other alternative is to exhale around the outside of the mouthpiece during the ascent or to breathe out through your nose. If this hands free approach is preferred then it is best to exhale around the outside of the mouthpiece as this exhausts gas from your lungs and the counterlungs simultaneously.

Low Pressure Setting - DIVE

High Pressure Setting: for leak testing
4.3 Mouthpiece Valve

If the mouthpiece is removed while in the water, either underneath or at the surface, water may enter the loop. The INSPIRATION is tolerant of small quantities of water entering but excessive quantities should be avoided by closing the mouthpiece before removing it from the mouth. When re-inserting into the mouth, blow out to remove the water from the water vent and, while continuing to blow, open the mouthpiece valve. The opening and closing of this valve is very important and must be practised on the surface prior to diving. Unlike any other mouthpiece on the market, the central body section rotates and moves independently of the two outer sections which move together with the inner tube of the mouthpiece valve. It is easier to hold the mouthpiece still, as this is often in your mouth, and rotate the outer rings. They are prevented from unscrewing by the two cross-head screws located underneath. When servicing, do not attempt to unscrew the outer sections without first removing the screws. Attempting to do so may damage some components.

Located at each end of the inner tube is a non-return valve. These are keyed to prevent incorrect assembly. However, it is good practice to check the direction of gas flow and check the proper operation of the non-return valves prior to using the rebreather. This can be easily carried out by disconnecting the hose connectors from the T piece and gently blowing and sucking against the connector. The direction of gas flow for the INSPIRATION rebreather is clockwise when looking down on the unit, i.e. you exhale over your right shoulder. Therefore, when blowing into the right hand side hose connector the non return valve will close and it should open when air is sucked from the connector. The non return valve on the other end of the mouthpiece inner tube should close when air is sucked from the left hand connector and open when air is blown into the connector. After reassembling the hose to the unit check for correct operation by alternately squeezing the inhale and exhale tubes as you inhale and exhale. Gas must come from the left and go out to the right. You must not be able to inhale gas from the exhale side and exhale gas into the inhale tube.

4.4 Breathing Hose Connectors

The hose nuts are simply unscrewed. The connections to the scrubber and the T pieces are piston type seals and seal even when slightly loose. These connections should be hand tightened onto the shoulder to prevent accidental unscrewing. Ensure the O rings are lightly lubricated and not damaged before re-assembly.

Each hose nut is fastened to the convoluted hose using screw on connectors. These are larger versions of the connectors used to clamp the convoluted flexible rubber hose on the range of BUDDY Buoyancy Compensators. They allow easy removal for maintenance, they allow the hose to swivel at these joints and they provide an extremely secure connection.
4.5 Colour Coding of Convoluted Hose Connections

The blue rings all signify fresh oxygenated gas from the scrubber. The left shoulder T-piece located on the inhale counterlung has blue identification rings, as do the hoses connecting to it and the connection in the centre of the scrubber lid. The non-return valve in the inhalation side of the mouthpiece is also coloured blue.

4.6 Diluent and Oxygen Inflators

All inflators, oxygen, diluent and Buoyancy Compensator, are low pressure inflators, sometimes referred to as medium pressure inflators. They are designed to work with a maximum feed pressure of 15 bar. See the First Stage Interstage Pressures, Section 10.3. The inflator hoses connect to the low pressure ports on the first stages.

It is essential not to confuse the oxygen components with their diluent counterparts. See Section 10.7, Precautions When Using High Pressure Oxygen. Both the diluent and oxygen systems must be checked for leaks prior to the dive and this is best done by dipping the valve in a water bath.

The oxygen inflator has special lubrication and seals and has undergone special cleaning to make it suitable for use with oxygen. It must only be connected to a hose supplying oxygen. As the apparatus is worn the oxygen inflator must be on the right hand, on the exhale counterlung and the diluent inflator must be on the left hand, on the inhale counterlung.

Both inflators are secured into a base fitting with a large, hand tight, moulded ring. By unscrewing this ring slightly the inflator can be rotated to best align the feed hose. The identification badge can also be rotated clockwise to ensure the writing is up the right way. If these identification labels are lost over time, the type of inflator can be identified by the markings on the underside. After any adjustment, tighten the outer ring.

By unscrewing the outer ring completely the inflator valve can be removed. Care must be taken when removing it, as there is a large O ring seal underneath it.
Removing the inflator reveals a very useful drain valve which should be used after every dive to drain any water that has entered the counterlungs. This port can also be used to help with washing and disinfecting the inner bags of the counterlungs.

4.7 Weight Pocket

When swimming along horizontally on open circuit inhale fully, hold your breath, and lie still. You will notice that you are brought into an upright position. This is exactly what happens on a rebreather. As we breathe in and out of the counterlungs, the buoyancy at the chest area is constant which means you may find that you are constantly being brought into an upright position. To counteract this effect, up to 3kg of lead can be inserted in the weight pocket on the top of the rebreather. Normally, removing 2 kg from your weight belt and putting it on the top of the unit is sufficient.

4.8 Buoyancy Compensator and Harness

A Buoyancy Compensator must be used with this rebreather. Do not use the counterlungs to control your buoyancy.

The BUDDY wings 13, 16 and 22 have been developed specially for the INSPIRATION, in conjunction with the INSPIRATION harness. The harness has 25mm Fastex buckles located low down at the front which are used to hold the counterlungs down on the diver’s shoulders. Holding the counterlungs down is extremely important and care must always be taken to ensure they are not allowed to float above the diver’s shoulders. If this happens, breathing resistance will increase dramatically, probably causing the diver some discomfort - if not immediately, certainly after a time. Increased breathing resistance means increased CO₂ retention, which is believed to make the diver more susceptible to oxygen toxicity and nitrogen narcosis. If the counterlungs are floating off the shoulders, ensure the waist band of the harness is not riding up. This is usually cured by simply adjusting the waist band. If it cannot be secured, you may have to add a crutch strap or it may be necessary to change to a smaller size counterlung. See Section 4.1.

4.9 Audible Warning Device

The audible warning device or buzzer is located on the left shoulder T-piece and is directed towards the divers head. This is only a secondary device, the primary warning device being the ppO₂ displays, and is not to be used as the divers only warning system. All warnings: High O₂, Low O₂, Low Battery, Cell Warning have the same sequence - 1 second on, 1 second off and continue while the fault is occurring. The only exception to this is the Cell Warning is deactivated when the solenoid is open. When the buzzer is heard it is then the diver’s responsibility to assess the problem by interpreting the ppO₂ displays.