



ART – Rebreather Essentials – Key Skills

Overview

This document is designed to provide an overview of what skills an entry level Rebreather diver should clearly understand and be capable of executing in-water. The purpose of this document is to complement existing skills outlined by specific diver training agencies.

Notice:

All rights are reserved. No part of this outline may be reproduced or transmitted in any means, electronic, mechanical, photocopying without the permission of the publisher / author.

Disclaimer:

All diving activities have inherent risks. Each individual diver must accept responsibility for his or her own actions. The author / publisher and its members assume no responsibility to anyone for loss, damage, injury or death caused by errors or omissions in this work.

ART – Rebreather Essentials – Key Skills

All skills require demonstration by a certified Rebreather Instructor prior to students attempting the skills themselves.

Skills overview

General diving skills including, team signals, fining techniques, general equipment configuration and dive planning are not covered in this document.

The following skills are detailed with skill overview, skill breakdowns and instructional teaching notes to help assist trainers conduct basic Rebreather classes.

Additional wet cue prompts and Video Demonstrations of the skills are available online in the members area of www.association-rebreather-training.com

1. In water safety drill – decent check
2. Weight check / trim / buoyancy
3. Loop Volume Management
4. Descent techniques / ADV / manual diluents addition
5. Ascent techniques on CCR
6. Mask clear / removal
7. Bail out to open circuit including ascent
8. Delivery of gas to out of gas diver
9. Surface marker buoy deployment
10. Diluent flush at depth
11. Water in breathing hoses
12. Flooded Loop
13. In water sensor verification check for linearity
14. High level of inspired oxygen
15. Low oxygen / no oxygen
16. Low diluent / no diluent
17. Manual flight of the rebreather
18. Semi closed Circuit Rebreather Mode
19. Buoyancy Device Failure
20. Rebreather Rescue

ART – Rebreather Essentials – Key Skills

Skill Overview: **1. In Water Safety Drill - Descent Check.**

Description

The in-water safety drill is conducted on all dives when diving a Rebreather. It consists of several verification checks to ensure all equipment is fully functioning and gives the entire team an opportunity to check teammates prior to descent.

Recommended training steps

1. Head to tow check of all equipment to ensure function
2. S-Drill, have the diver switch to Bail Out Valve (BOV).
3. Verify Pressure on off-board, bailout supply gas.
4. Conduct an S-drill on all Bailout regulators.
5. Conduct a leak/bubble check on each team member.
6. Flush the unit with O₂ to insure sensors can read high PPO₂.
7. Diluent flush the loop gas back to a Low PPO₂ prior to descent.
8. Verify all monitoring systems are functioning.

Note: The checks can be conducted at either the surface if conditions allow or submerged at an appropriate shallow depth.

Instructor teaching notes:

When conducting the Oxygen flush it is essential the student has a fixed bottom or line to hold if they lose control of their buoyancy during this part of the skill. Instructors should personally verify that all students PPO₂ are breathable prior to descending.

ART – Rebreather Essentials – Key Skills

Skill Overview: 2. Weight Check & Trim.

Description In order to control a dive and manage depth it is essential all Rebreather divers conduct a weight check in full equipment and adjust the Rebreather for desired trim. If a diver is over or underweighted it could substantially increase the risk of failure to complete dives within the planned limits. Emergency skills will likely be hard to achieve if the diver is over or underweighted.

Recommended training steps

1. Have the diver at the surface vent all gas from the BCD and or dry suit and check if the diver needs to add or remove weight to make a comfortable descent. This check should be done in confined water with minimal depth.
The Rebreather diver should not be excessively over weighted at this part of the dive as at depth they will become negative requiring wing or suit gas to maintain natural buoyancy.
Things to consider are exposure suit thickness, steel vs. aluminium tanks and backplates as well as the type of bailout bottles; aluminium bailout bottles are preferred due to better buoyancy characteristics.
2. In shallow water, close to the bottom have the diver hold a minimum loop volume only adding minimum gas to avoid a dry suit squeeze if required. Add small amounts of gas to the divers BCD until the diver is neutrally buoyant and check to see if the diver has a head up or down position. It may be necessary to add trim weights to the diver to aid a better position in the water. Divers using an inverted cylinder may have a tendency to be butt heavy utilising a 360-donut style buoyancy device can combat this. Position of bailout tanks, variations in construction materials and size may also need adjustment. If Rebreather configuration allows positioning the tanks in an upright valve position usually aids in better trim, turning the valves inward aid in valve manipulation
3. Divers should conduct a shallow water buoyancy check with nearly empty bailout gas supplies to ensure they are able to hold decompression / safety stops in shallow water.
4. In the event a Rebreather fully floods with water a diver will become substantially negatively buoyant, the combination of suit / BCD and counter lungs should be ample to sustain positive buoyancy at depth and when back at the surface.

Note: The initial checks should be conducted in confined water in full equipment as worn in the planned diving environment.

Instructor teaching notes: Each individual must be given ample time to adjust and modify their equipment to ensure they are comfortable prior to open water dives. There are many variables affecting the divers buoyancy including style of exposure protection worn, material and construction of the Rebreather and additional components.

ART – Rebreather Essentials – Key Skills

Skill Overview: 3. Loop Volume Management.

Description

Rebreathers are dynamic breathing apparatus, meaning that volumes and gas additions vary through each phase of the dive. Divers should understand what is required to maintain a correct amount of breathing gas at each stage of the dive

Recommended training steps

1. The minimum loop volume concept refers to a divers counter lungs holding just enough gas for a diver to take one full deep breath without addition of gas.
2. To check this have the diver first practice on dry land breathing from the loop. Divers should not feel starved of gas and at the same time should feel minimal resistance whilst exhaling. MCCR /ECCR have individual diver adjustments. The position of the lungs and other Rebreather components as well as hydrostatics could also affect the divers work of breathing.
3. Having conducted a dry dive, Rebreather divers should conduct a loop volume check in confined water noting how additions of gases affect both buoyancy and PPO2. The diver must learn to balance both loop volume management with buoyancy control and PPO2 management.
4. If the Rebreather has an automatic diluent addition valve the diver must learn how to operate and isolate it in confined water.

Instructor teaching notes:

When a student has problems with buoyancy early on, it is often the loop volume changing that affects their position. Instructor should remind divers to monitor their loop volume, pre, during and after skills sets or ascents and decent on the Rebreather. It is recommended that early on in a divers training the diver maintain a fully functioning open ADV in case of buoyancy loss. If buoyancy loss occurs the Instructor should pay close attention to the divers gas volumes and loop PPO2.

ART – Rebreather Essentials – Key Skills

Skill Overview: 4. Descent Techniques

Description

The initial descent phase of a dive can be very task loading for the novice Rebreather diver, paying close attention to monitoring breathing gas supplies, paying attention to buoyancy, staying within the team, and maintain a breathing supply gas. Consider this with environmental challenges and you can have a challenging start to a dive.

Recommended training steps

1. Once divers have conducted all pre-dive checks and entered the water allow the diver time to relax, as this is a time a diver may experience a CO₂ build up in the lungs from carrying the heavy equipment. Once a diver is relaxed have them conduct a head to toe inspection for gear function prior to descent.
2. Always conduct initial descents using a fix line to aid with potential buoyancy loss.
3. The entire team should descend together in the event assistance is required.
4. It is recommended all divers level off in shallow water and conduct a safety check, if surface conditions allow have divers conduct s-drills at the surface.
5. Descent with a high set-point or ADV in the off position may cause an oxygen spike, divers should descend using a low set point until target depth and have ADV open to allow volume addition during descent.
6. Descent speed should be managed to allow the diver time to monitor breathing gases and control the addition of necessary gas.
7. It is recommended to level the team off several meters from the target depth to ensure maximum depth planned for the dive is not violated.
8. Upon reaching target depth divers should ensure they have a breathable PPO₂ for the bottom phase of the dive.
9. Team communication is essential to ensure all parties are diving to the plan and serve as back up brains.

Instructor teaching notes:

Initial descents should be conducted using a line to provide assistance in the event of a problem.

ART – Rebreather Essentials – Key Skills

Skill Overview: 5. Normal Ascent Techniques

Description

The ascent phase of a dive brings a host of challenges to the Rebreather diver. There are many dangers present during this phase of the dive. Running low or out of supply gas, buoyancy problems, surface marker deployment, maintaining a target PPO₂, staying together, runtime management and decompression / safety stop considerations.

Recommended training steps

1. Signal team it is end of dive.
2. Validate gas supplies are sufficient prior to ascent.
3. Deploy a surface marker if required (see skill 9. For more detail).
4. Use an ascent line if available.
5. Monitor PPO₂ through the ascent.
6. Open OPV if required on dry-suit and counter-lungs.
7. Vent expanding loop gas via the over pressure valve or the divers nose to allow expanding gas to escape.
8. Dump adequate gas from the divers BCD and dry-suit, thinking ahead prior to ascending.
9. Maintain a maximum ascent rate of 10m 33ft per min.
10. Conduct mandatory and or safety stops as required.
11. When arriving back in shallow water or back on the surface ensure adequate oxygen content and ensure PPO₂ is breathable.

Note: All Rebreathers have different functions when dumping gas, some allow for diver adjustment. Loss of oxygen supply at this stage of the dive could cause a hypoxic loop causing a diver to fall unconscious during the ascent or when arriving back at the surface. Divers should ensure all supply tanks remain open when arriving at the surface until back on dry land

Instructor teaching notes:

Instructors should have a means of slowing the ascent phase either by using an up line or personally deploy a surface marker. It is strongly recommended instructor checks divers gas supply pressures prior to ascent and personally validates the divers PPO₂ at intervals during the ascent. At no point should the Instructor leave student divers in the water. Upon reaching the surface the Instructor should be last to exit the water ensuring all the team are safely back on dry land.

ART – Rebreather Basics – Essential Skills

Skill Overview: **6. Mask Clear and Removal**

Description

This is a foundational skill that is mastered on basic scuba class. Every diver should be totally comfortable with doing this prior to moving on a Rebreather. This simple skill requires some additional considerations when diving a Rebreather

Recommended training steps

1. Inform the diver that when they exhale to vent the mask they will be venting loop volume from their breathing lungs. This will require them to consider the addition of a breathable gas supply.
2. Have the diver conduct this skill in shallow water.
3. Point out to the student the need to defog prior to gearing up to avoid continual venting and wasting gas during the dive clearing a mask
4. Have the Rebreather diver remove and replace the mask giving enough time to show them how difficult it would be to read their instruments without a mask. Inform the diver of the importance of carrying a spare to avoid this situation.
5. Touch contact should be made to provide communication as to the divers position. Are they going up or down? In this case you can communicate by gently pushing up or down on the divers arm. Maintaining touch contact when a diver is without a mask provides piece of mind there is someone there to assist if required.

ART – Rebreather Essentials – Key Skills

Skill Overview: 7. Open Circuit Bailout Drill.

Description

There are a number of reasons a Rebreather diver may choose to bailout the old saying “if in doubt bailout” still rings true today. Taking a sanity breath and keeping things simple is essential to staying alive when an emergency arises in the sub aquatic realm.

With this in mind and for any reason; suspect gas, breathing issue, or monitoring system failure or a rescue situation arises a diver should be confident to execute a bailout to open circuit gas supply and make a controlled ascent to the surface.

Recommended training steps

1. First have the diver switch to Bail Out Valve (BOV) it is strongly preferred this is a large volume breathable supply gas preventing the need to move to off-board gas creating task loading.
2. Validate cylinders content is breathable at depth
3. Ensure there is an open over pressure relief valve for expanding lung gas.
4. Switch dive computers to OC mode if available or follow open circuit bailout plan.
6. Consider switching to a low set point or closing/isolating the O₂ supply tanks for the ascent.
7. Locate buoyancy compensator and adjust dry suit dump if required and prepare for the ascent.
8. It is strongly advised divers use an ascent line or surface marker to help manage ascent.
9. The team should communicate the failure and stay close by to provide any assistance during the ascent.

Note: If the BOV is plugged to off board gas supply it is acceptable to remain breathing from the built in regulator without the need to switch to the open circuit regulator secured to a bail out bottle.

Instructor teaching notes: When teaching students to bailout it is essential all tanks are re-opened as well as ensure the loop PPO₂ is not toxic prior to switching back to the rebreather during a skill set.

ART – Rebreather Essentials – Key Skills

Skill Overview: 8. 'OOGD' – Out of Gas Diver

Description

In the event of Rebreather failure the diver could then encounter a problem with their bailout gas supply. With this in mind it is essential the diver understand how to deliver and receive gas from a fellow teammate. This skill may differ slightly if a buddy is also on a Rebreather or breathing from open circuit scuba.

Recommended training steps

1. Signal team mate that you need gas.
2. The donor immediately deploys his bailout regulator (preferable a longer hose approx 1m in length).
3. The OOG diver may or may not already be off the loop at this stage it is important the diver, having secured a breathing gas verifies their loop is closed.
4. The divers can now pass off the bailout bottle giving the team space and ease of exit.
5. The OOG diver must remember to switch decompression monitoring status to open circuit as they are no longer on a constant PPO2.
6. All over pressure valves must be open prior to ascent.
7. Divers may choose to initiate a low set point or close the oxygen supply tank to avoid excessive addition of oxygen causing buoyancy problems on ascent.
8. Follow ascent procedure (drill 5).
9. The team should communicate the failure and stay close by to provide any assistance during the ascent.
10. Upon reaching the surface divers may need to orally inflate their BCD.

Note: If the donor of gas is on an open circuit gas supply this will generally not allow the passing of gas and may require a longer hose to feed the OOG Rebreather diver. The ascent will be more challenging, as both divers will be required to stay together while maintain good buoyancy throughout the ascent.

This must be factored into the dive plan to ensure the open circuit diver carries adequate reserve gas for this eventuality.

Instructor teaching notes: This skill should first be practised in confined water, without an ascent, if possible students in training should have an opportunity to request gas from both a Rebreather diver and an open circuit team mate as both donor and receiver. It is strongly recommended the OOG diver actually making a bailout ascent uses a line or SMB to help manage the ascent.

ART – Rebreather Essentials – Key Skills

Skill Overview: 9. Surface Marker Deployment.

Description

Many dive situations require a diver to deploy a surface marker to note their position in the water or provide a visual reference.

Recommended training steps

1. Remove SMB and spool / reel from storage.
2. Fix together if not already.
3. Unlock or remove clip and stow.
4. Secure low-pressure hose from bailout supply.
5. Ensure gas supply is turned on.
6. Observe depth.
7. Ensure enough line on reel / spool for depth.
8. Check above for teammates and or surface traffic / hazards.
9. Connect low-pressure feed hose and control inflation.
10. Hold marker out in front to ensure its not tangled and then release.
11. Create drag to the line to ensure marker doesn't get pulled diagonal in possible current.
12. Once the marker stops spooling and arrives at the surface tug on the line and create tension.
13. Consider the environment and position relevant to any current and exit direction.
14. At any point the line snags let it go.

Note: It is recommended that the Rebreather diver use an oral inflation, closed circuit style SMB. Attaching a low pressure feed hose to the bailout first stage will allow for easy inflation of the SMB at depth it is also possible to switch to open circuit bailout valve and orally inflate the marker.

Instructor teaching notes:

When teaching students to deploy a surface marker it is essential the instructor have a good vantage point to see what is going on. It is recommended the instructor have a cutting tool ready in case of entanglement. It may be required to provide assistance to avoid buoyancy loss by the deploying diver. This skill should first be mastered in shallow water in a stationary position.

ART – Rebreather Essentials – Key Skills

Skill Overview: 10. Diluent Flush at Depth

Description

The diluent flush is a sub step of a number of other standard skills a safe Rebreather diver needs to master. If a divers is for any reason in doubt there may be toxic gas in the loop it is strongly advised they bailout. Hypoxia, hyperoxia and hypercapnia can lead to unresponsiveness without warning. Therefore the diluent flush should not be considered a skill used to deal with a compromised loop, as you may not have time. The diluent flush is intended to aid the diver in diagnostics or flushing water from a flooded loop.

Recommended training steps

1. Verify you have enough diluent pressure, at depth.
2. Open any over pressure valves to aid in buoyancy management.
3. Vent the loop and manually flush the loop with diluent.
4. Depending on the reason for the flush it may be required to isolate the oxygen supply to prevent injection of oxygen during the skill.
5. Priority to control buoyancy should be given during this skill.
6. Upon finishing flushing re-adjust any over pressure valve and activate any closed oxygen supply system.

Note: It is not an intended skill to manage high oxygen, low oxygen or carbon dioxide problems. A quick flush may provide a small amount of sanity breaths while a diver is bailing out.

ART – Rebreather Essentials – Key Skills

Skill Overview: **11. Water in Breathing Hoses**

Description

It is a common occurrence when diving a Rebreather that some water, saliva or moisture will enter the breathing hoses, this is not a major emergency but is annoying and generally resulting in a gurgling sound. The diver should be able to purge this into the exhale counter lung.

Recommended training steps

1. First have a teammate check the diver for leaks, as it may be a sign you have a broken hose, loose connection, mouthpiece failure or other.
2. Gently lean over in the direction of the exhaled lung and forcefully exhale gas into the loop. Ensure you have a firm grip on the diver supply valve so the loop doesn't come out of the divers mouth.
3. It is recommended that the diver concertina the loop to allow water to pass.
4. It is also possible to remove the loop and shake above the head but the risk here is that the diver fully floods the loop forgetting to close off the mouthpiece or pulling on a hose fitting. It is important the diver, having secured a breathing gas, verifies the loop is closed prior to executing this skill.
5. Having successfully flushed the breathing hose the diver should wait and check further water is not entering the breathing loop, which would suggest a unit failure and require a bailout from the compromised loop.

Instructor teaching notes:

This skill should first be practised in confined water. This skill can be combined with skill 12. Dealing with a flooded loop.

ART – Rebreather Essentials – Key Skills

Skill Overview: **12. Flooded Loop.**

Description

A fully flooded Rebreather is one of the reasons a Rebreather diver will have to come off the breathing loop. Either the Rebreather has failed and is considered an unknown failure or the diver has had the loop removed without closing the mouthpiece. Either way you cannot breath when the counter lungs or Rebreather hold a lot of water. Some Rebreather do allow for an attempted recovery of the loop by flushing water from the counter lungs, others do not allow this easily and require the diver to follow skill 7. Bailout.

Recommended training steps

1. Switch to bailout gas supply.
2. Have a team member inspect the Rebreather for any noticeable failure point.
3. If the Rebreather allows, open the OPV, and inject diluent gas supply to flush the Loop.
4. A team mate can hold the diver to aid with buoyancy control
5. Returning back to the loop should be done with caution, as it may not be possible to breath if the loop is still flooded.
6. The diver should maintain their bailout regulator incase the loop is still flooded.
7. If the divers are able to return to the loop the diver should remain in a slightly upright position to avoid any water sloshing and moving around the Rebreather.
8. The team should communicate the failure and stay close by to provide any assistance during the ascent.

Note: It must be mentioned that if a loop has been compromised with excessive water the scrubber may become wet causing it to fail. Having recovered a flooded loop the Rebreather diver must pay particular attention to their breathing pattern for the remaining portion of the dive. In some Rebreather it may be possible to suffer a caustic cocktail from wet absorbent material if the unit does not have built in water traps.

Instructor teaching notes:

When teaching students to recover a flooded loop it must be conducted in shallow water, it is recommended that the skill be conducted in fresh water.

ART – Rebreather Essentials – Key Skills

Skill Overview: 13. Sensor Verification.

Description

It is essential that all Rebreather divers are able to validate their breathing gas to avoid Hypoxic or hyperoxic breathing gas. All Rebreathers should be fitted with oxygen sensors that provide the divers with partial pressure readouts of inspired oxygen. With this in mind Rebreather are often required to validate the monitoring system and gauge the trueness of the sensor reading on the displays.

Recommended training Steps

1. Any discrepancy should indicate a potential problem.
2. If major discrepancy across cell readouts present have the diver switch to bailout gas (skill7.) this provides time to manage the problem. It may be possible to remain on the loop for minor discrepancy with life support range.
3. Ensure over pressure valves are in an open position.
4. Isolate the oxygen supply by a method suited to the specific Rebreather
5. Note the divers depth and calculate expected PPO2 when flushing.
6. Gradually flush the loop with diluent ensure buoyancy is not compromised.
7. Continue flushing, a diver would expect to see dynamic displays; reaction speed and expected target PPO2 should be noted.
8. The diver now moves into the diagnostic phase considering the movement of the sensors.
9. At this entry level it is recommended that the diver stays on bailout if in doubt of there readings
10. Discussion on how to validate the sensor readings, this takes time and requires a firm understanding to avoid the diver returning to a compromised loop.

Note: Even though it is often small changes in reading sensors may drift apart due to humidity, time and exposure we must consider that they could fail and put a Rebreather diver in a state of hypoxia or hyperoxia. With this in mind executing a bailout at the time of recognition may prevent the diver from becoming unresponsive.

Instructor teaching notes: It is recommended that the instructor have cue cards available to simulate PPO2 display reading on monitoring systems showing possible sensor failure. The divers can interpret this data; decisions to stay on bailout or return back to breathing loop can be made for each eventuality.

ART – Rebreather Essentials – Key Skills

Skill Overview: 14. High level of Inspired Oxygen

Description There are several reasons a Rebreather could display high levels of oxygen, they include supply feed failure via solenoids or flow orifice, manual injector could leak in to the loop, diver may descend too quickly causing oxygen levels to spike, electronic monitoring systems may have been incorrectly calibrated or not verified. With this in mind it is essential that Rebreather divers be trained to deal with high oxygen situations.

Recommended training steps

1. Identification by either readouts on monitoring systems or sudden loop volume changes may indicate a potential high oxygen situation.
2. Close the oxygen supply gases on the Rebreather this allows the diver the opportunity to validate which side of the Rebreather is failing.
3. Look at pressure gauges to note if the oxygen pressure gauge is dropping may indicate supply failure.
4. In a real situation where there is positive ingress of gas into the loop the diver would need to vent this to control position in the water.
5. If the Oxygen side is dropping pressure this would indicate a component failure possibly leaking gas into the loop the diver should bailout following (step 7).
6. Once off the loop the diver now has time to think through their actions.
7. Identification of the failure point may be possible at this stage and isolated either by disconnection or continuing to keep the valve closed.
8. The diver requires oxygen to maintain PPO₂ during ascent so it is advised the diver remain on open circuit bailout if the oxygen system fails' to avoid returning to a compromised breathing loop early on in training.

Note: This skill is often referred to as a BOOM drill where the Rebreather diver avoids diagnosing individual component failure and instead stops all supply to the loop. Unlike open circuit the diver is still able to breathe from the Rebreather. A drop in pressure shown on the pressure gauges will indicate the failure.

Instructor teaching notes: Signal to the diver they have an unknown gas leak, BOOM! They should then close the supply valve, they should validate using the units pressure gauges and look to the trainer for a signalled drop on the oxygen side. Upon completion of the skill it is essential the instructor ensure all supply tanks are re-open and desired set-point programmed.

ART – Rebreather Essentials – Key Skills

Skill Overview: 15. Low Oxygen / No Oxygen

Description A Rebreather diver could encounter low oxygen or no oxygen situation, this should not be to poor planning or gas management but could be due to a leaking or failed component. A leak could happen at the tank neck; valves assemble or first stage failure-leaking gas outside the loop. A team member would easily identify this by visually recognising continuous bubbles. It may or may be heard by the diver by means of a bang or sudden fizzing of gas. A drop in oxygen shown on a monitoring system due to a blockage or failed injection system may also identify it.

Recommended training steps:

1. Take a moment to listen if gas is escaping and or functionality of the injection into the breathing loop.
2. If the diver notes a sudden increase in loop volume this would indicate an internal leak from the diluent supply. Diluting the mix in the CCR. Having validated the leak is on the diluent supply the diver will most probably have to keep the diluent supply valve in the closed position or isolate any diluent addition.
3. The diver then needs to monitor Oxygen PPO2 stabilizes and the dive aborted.
4. The drop in PPO2 could also be due to a supply issue either the tank is empty, closed or feed supply failure. The diver should note contents and try to manually add oxygen to maintain PPO2.
5. If the diver confirms there is no Oxygen remaining and does not have additional supply of oxygen that can be connected to the Rebreather the diver should consider bailing out prior to ascending

Note: This skill also referred to as a BOOM drill where the Rebreather diver avoids diagnosing individual component failure and instead stops leaking gas by closing both supply valves. Unlike open circuit the diver is still able to breathe from the Rebreather. A drop in pressure shown on the pressure gauges will indicate validation of failure. If the oxygen gauge is reading stable yet the PPO2 has clearly dropped it's a no addition situation requiring manual addition of oxygen. If the diluent is leaking reducing the PPO2 then the Oxygen supply can be re-opened and the dive aborted

Instructor teaching notes:

This skill should be demonstrated as two scenarios positive external gas leak, BOOM drill and no gas leak, component failure manual flight.

ART – Rebreather Essentials – Key Skills

Skill Overview: 16. Low Diluent / No Diluent

Description A Rebreather diver could encounter low diluent or no diluent situation, this should not be due to poor planning or gas management during the dive but more due to a leaking or failed component. A leak could happen at the tank neck; valves assemble or first stage failure-leaking gas outside the loop. A team member would easily identify this by visually recognising continuous bubbles. It may or may not be heard by the diver by means of a bang or sudden fizzing of gas. Running low on diluent gas may also be due to poor buoyancy control requiring regular addition of diluent to maintain loop volume and manage oxygen PPO₂ as well as excessive inflation and deflation of the divers buoyancy devices.

Recommended training Steps

1. Take a moment to listen to hear gas escaping and or functionality of the diluent injection system.
2. If diagnosis suggests gas is escaping close both oxygen and diluents supply gases on the Rebreather this allows the diver the opportunity to validate which side of the Rebreather is failing.
3. Look at both pressure gauges to note which side is dropping.
4. If the diluent pressure gauge is dropping this would identify the leak is on diluent supply.
5. Having validated the leak is on the diluent side the diver will most probably have to keep the diluent supply valve in the closed position unless isolators are fitted to diluent feed hoses.
6. The diver does not requires diluent to maintain PPO₂ during an ascent therefore the diver can re-open the oxygen supply and monitor breathing gas.
7. The diver may have lost diluent supply feeding the divers BCD or suit and should pay particular attention to venting the loop and Buoyancy device during the ascent.
8. Upon reaching the surface the diver will be required to orally inflate the BCD.

Note: This skill is also referred to as a BOOM drill were the Rebreather diver avoids diagnosing individual component failure and instead stops leaking gas by closing both supply valves. Unlike open circuit the diver is still able to breathe from the Rebreather. A drop in pressure shown on the diluent gauge will indicate validation of the failure.

Instructor teaching notes:

It is recommended that an up line or surface marker be used to aid the ascent.

ART – Rebreather Essentials – Key Skills

Skill Overview: **17. Manual Flight of the Rebreather**

Description

A Rebreather diver could encounter a failed oxygen injection system or blocked orifice, this could lead to a diver having a hypoxic breathing loop. It is with this in mind that all Rebreather divers should know how to manually add oxygen to their Rebreathers to maintain the desired partial pressure of oxygen.

Recommended training steps

1. First validate you have not run out of oxygen by checking the oxygen pressure gauge and ensuring the supply is open.
2. Think to vent a little loop volume to allow for the addition of oxygen via the manual injection system.
3. Breathe the gas around the loop, as there is often a delay in the fresh gas reaching the oxygen sensors.
4. Continue the above cycle until the diver reaches the desired partial pressure of oxygen.
5. The diver will need to continue adding oxygen all the way back to the surface and may require substantially more addition during the ascent phase than swimming in a linear direction.
6. Upon arrival at the surface the diver should consider breathing bailout gas to avoid any risk of hypoxia during challenging exits.

Instructor teaching notes:

This skill should be first conducted while swimming at shallow depth allowing the diver time to see how much gas is needed to raise the PPO₂. Having mastered the skill at depth the Instructor may combine this skill with a low oxygen drill and have the diver maintain the PPO₂ manually for an ascent.

ART – Rebreather Essentials – Key Skills

Skill Overview: 18. Semi Closed Rebreather Mode

Description

A Rebreather diver could encounter low oxygen or no oxygen situation, or monitoring system failure. It may be that bailout gas supply has become limited during the dive. With this in mind the Rebreather can be used to extend the bailout gas supply by breathing the gas multiple cycles through the loop. Before we explain the steps below its important to state this should be considered an absolute last resort at this level diving in teams and carrying enough bailout gas is way simpler than executing a SCR mode ascent, especially if the dive has no way of monitoring the PPO2 of inspired oxygen.

Recommended training steps

1. Conduct a diluent flush as outlined in skill 10.
2. Breathe the loop for 3-5 cycles.
3. Repeat step 1
4. Pay particular attention to your buoyancy.
5. It is recommended if you have no ability to validate your PPO2 you should bailout and not use SCR mode for a blind ascent.

Note: This skill is particularly hazardous during ascent in the event the monitoring component is not functioning. If SCR mode is being conducted to extend gas with a functioning monitoring system the diver should periodically conduct a PPO2 comparison check to ambient pressure based on the O2 fraction of the diluent at that depth to ensure the breathing loop is not hypoxic, especially when close to the surface.

Instructor teaching notes:

This skill should be conducted at depth with working monitoring systems.

ART – Rebreather Essentials – Key Skills

Skill Overview: 19. Buoyancy Device Failure

Description

A Rebreather diver could encounter a failed buoyancy device during a dive; a diver excessively weighted would find it hard to control an ascent. It is recommended that Rebreather divers utilise a redundant buoyancy device either by means of a dual inflation system or dry suit as back up. The below training steps consider both failures positively and negatively.

Recommended training steps – Device unable to hold pressure

1. In shallow water have the diver vent all the gas from their BCD.
2. Using only fining power, have the diver swim up and hold a position in mid-water.
3. It may be possible to add small amounts of gas to the counter lungs to aid achievement of natural buoyancy.
4. A teammate may be able to provide support by making contact and adding gas to their BCD.
5. It is recommended divers dive with a redundant buoyancy device E.g. Dry suit.

Recommended training steps – Power Inflator injecting gas

1. Disconnect the Inflator.
2. It may be possible to disconnect a feed hose from a manual injector and connect it to the inflator (connection fitting needs consideration).
3. If step 2 is not an option the diver will need to orally add gas to the device in which case it may be a good idea to bailout opposed to closing and opening the breathing loop.
4. It is recommended to use a redundant buoyancy device E.g. Dry suit.

Note: If the divers are unable to hold position without assistance the diver should strongly consider an alternative method of controlling buoyancy in the event of primary failure.

ART – Rebreather Essentials – Key Skills

Skill Overview: 20. Rebreather Rescue

Description

Should you encounter a Rebreather diver who has become unresponsive underwater? Priority should be to get the victim back to the surface as safely as possible without risking your own safety. A number of reasons could have caused the diver to lose consciousness a brief check of the divers PPO2 display and gas content gauges may provide some ideas if the Rebreather diver is breathing toxic gas. In any event it is important to switch the diver to a bailout supply preferable via a built in bailout valve (BOV) and initiate a safe ascent to the surface.

Recommended training steps

1. The rescuer should consider switching to Bailout to reduce the need for active PPO2 monitoring.
2. Conduct a quick inspection of the victims PPO2 monitoring device and gas contents to ensure there is enough gas to switch the diver to the bailout valve or perform a diluent flush.
3. Ensure all overpressure valves including Rebreather & drysuit over pressure valves are open to allow expanding gas to escape during ascent.
4. Secure the victims gas supply and extend the divers airway prior to ascending.
5. Locate the victims buoyancy device to ensure a controlled ascent
6. Once the victim is brought back to the surface the breathing loop must be closed if not already.
7. Conduct an airway assessment and conduct rescue breaths if required
8. It may be beneficial to remove the scuba unit if in water rescue breathing is required.
9. Execute the diver EMS procedure and notify available rescue resources and medical support.

Note: The chance of a successful rescue will depend on many variables with this in mind divers must consider their own safety prior to assisting others. A team of three divers aids in assistance for the in water ascent. Insuring a good EMS plan and having surface support divers on stand by to aid in the rescue once back at the surface.

Follow recommended training agency standards regarding in water resuscitation and evacuation.