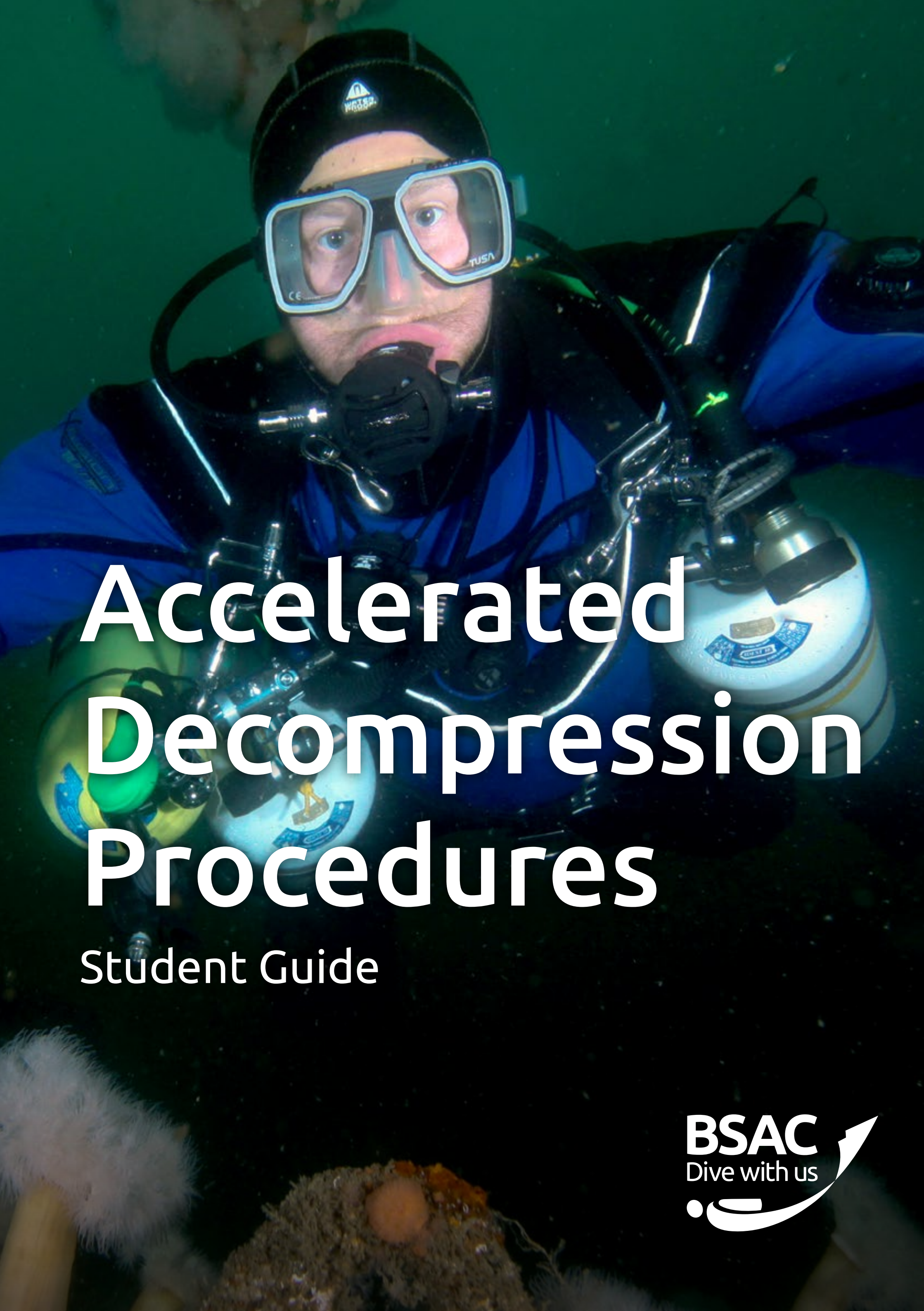

Accelerated Decompression Procedures

Student Guide

BSAC
Dive with us

Acknowledgements

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Check out your eLearning video

Introduction

Alex Warzynski is a BSAC National Instructor, he will take you through the first part of the video module.

Remember if you need to discuss any of the theory e-mail or call your instructor at your club or centre.

Video time length | 18:13 mins

Click the image below to start watching the video.

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ADPT1 Course Introduction

Module contents

This lesson sets the scene for the course overall. It briefly outlines the course content, domestics and timetable, and introduces some additional concepts.

- **This module covers the following**
- **Structure of the ADP course**
- **Qualification and how to progress**
- **Self-reliance in the buddy system**
- **Analysis**
- **Cylinder configurations**
- **Redundancy**
- **Problem solving**

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Course structure

The overall objective of the course is to teach how to accelerate decompression stops safely using rich nitrox decompression gas.

Safe use of a rich decompression gas requires not just the acquisition of the necessary skills but also an understanding of all the associated implications. While a basic level of diving knowledge and skills is assumed (because of the entry requirements), the course will utilise a mixture of theory lessons, dry practical lessons and dives to provide the necessary specific knowledge and skills.

- **Theory lessons**
- **Physics and physiology**
- **Decompression planning**
- **Gas planning and limiting factors**
- **Equipment and procedures**

Practical lessons

- **There is one dry practical lesson**
- **Equipment configuration and dry runs**
- **One sheltered water lesson**
- **One open water skills consolidation and asessment lesson**

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Assessment

Assessment on this course is ongoing and takes place throughout all lessons and dives. You must show that you understand the theory and can safely apply the skills in the water. Because these skills directly affect dive safety, reaching a satisfactory standard is essential. There is no formal written exam; instead, your instructor will continuously assess your knowledge, practical ability, and performance during the assessment dive as the course progresses.

BSAC ADP Diver

As a BSAC ADP diver, you gain extra knowledge and skills for using accelerated decompression procedures (ADP) safely.

Knowledge and Skills

- **Understand the risks**
  Using a gas beyond its maximum safe depth can be dangerous and may cause you to breathe a toxic mix. Always know exactly which gas you are using.

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- **Plan safe dives**
  Using a rich nitrox mix can make decompression stops shorter, but you must plan carefully for both gas use and your decompression profile.

- **Dive safely**
  Knowing the theory isn't enough - you must also be able to switch gases correctly and control your buoyancy while performing ADP skills.

Diving Limits

- **Depth**
  ADP does not let you dive deeper than your current qualification. You dive to the depth your existing certification allows.

- **Backgas**
  You must already be qualified to use the gas in your main cylinders (usually nitrox) that you will breathe on the dive.

- **Oxygen Limits**
  You can use gases with a maximum partial pressure of oxygen (PO_2) of 1.4 bar, or 1.6 bar if shallower than 10m. This is a UK legal limit.

- **Decompression gas**
  You can use up to 100% oxygen for decompression stops at a maximum of 6m. If conditions are likely to make 6m stops difficult, a mix of 80% may be safer and can be used for 9m stops too.

Equipment

- **Open circuit only**
  ADP is an open circuit only qualification. Rebreathers have their own training.

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The buddy system

Pre-dive

Before every dive, you must plan what you are going to do. The ADP course teaches simple tools that make planning quick and easy, helping you make sure nothing is forgotten and that the dive can be done safely and efficiently.

Once the plan is made, the dive leader will brief everyone using a structured system, such as SEEDS, to ensure all divers understand the objectives and procedures. Finally, a careful buddy check is carried out to make sure all equipment is working properly. This step is the last chance to spot any problems and should be done methodically to avoid simple mistakes, keeping everyone safe before entering the water.

During the dive

During ADP dives, good communication and positioning with your buddy are even more important than usual because of the increased risks. You should stay aware of each other so that help is available quickly if a problem arises.

Using torches effectively helps maintain visual contact; keeping the beam steady in your buddy's view means you don't have to keep looking around. Simple torch signals can be used: drawing a circle twice shows you are OK and can be acknowledged, a slow waggle signals attention is needed, and a fast waggle indicates an emergency. If a problem does occur, your buddy can assist, for example by helping you free an entanglement or reach a piece of equipment.

After the dive

After the dive, it's important to go through a debrief to review what happened. Using a structured format like REAP can help put the dive into context and highlight any lessons learned. The debrief doesn't need to be formal - it can be done in a relaxed way - but it should cover all the key points to make sure everyone understands how the dive went and what could be improved.

Self-reliance

This means being self-reliant, not solo diving. You should have a set of practiced skills that allow you to handle problems calmly and effectively if something goes wrong underwater.

Pre-dive

Before a dive, equipment must be carefully prepared. Taking the time to get everything ready ensures nothing is forgotten, everything is set up correctly, and all gear is working properly. A thorough equipment check should be done from head to toe - starting with the hood and finishing with the fins - to make sure all items are functional, correctly stowed, and ready for the dive.

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During dive

During the dive, it's important to keep checking your equipment and dive plan. Regularly check your gas supply, watch for bubbles during the descent, and monitor all your gear so any problems are noticed early. Any decisions made underwater should be done calmly and with clear communication with your buddy. Equipment issues are uncommon, but having a plan and following it helps prevent most problems. If something unexpected does happen, using your problem-solving skills will help you handle it smoothly and safely.

Quiz 1

What is the maximum depth for the course?

What is the minimum percentage of oxygen that can be used in the decompression breathing gas after this course?

Answers on page 123

Analysis

This session revisits what you learned in the nitrox course, emphasizing the importance of always checking the composition of your breathing gas. During the lesson, the theory will be paused so you can practice analysing the gas and correctly marking the cylinder.

Nitrox composition

Nitrox is made up of oxygen and nitrogen. Its composition is shown as the percentage of oxygen in the mix, for example, Nitrox 32 contains 32% oxygen.

Analyser

An oxygen analyser is a device that measures how much oxygen is in a gas mix using a special sensor, or cell. The process for analysing nitrox in the ADP course is the same as in the Ocean Diver, Sports Diver diver training programme and the nitrox workshops (Ocean Diver and Sports Diver levels).

Use

Before using the analyser, it must be calibrated against a known gas (normally air). The measurement records the partial pressure of oxygen and is affected by air pressure changes. To get an

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accurate measurement, let the gas flow slowly through the analyser. Some analysers have a built-in flow restrictor; if not, open the cylinder valve just enough to hear a gentle hiss. Opening the valve too much can give a wrong reading. Record the oxygen percentage to one decimal place.

Mark cylinder with analysis tape

The tape should stay on the cylinder until it is empty, or replaced with another gas and re-analysed.

- **Maximum operating depth**
  This should be the most prominent piece of information. The analysis tape should be positioned so the diver can read it underwater, and if possible, add an additional large numeral repeating the MOD on the cylinder body that can be read by the buddy.

- **Date**
  The date of the analysis.

- **Composition**
  The analysis to one decimal place.

- **Pressure**
  Cylinder pressure at the time of analysis.

- **Initials**
  Who carried out the analysis.

Analysis – demo

In this part of the lesson, you will get hands-on practice analysing the gas in a cylinder and correctly marking it with the results.

https://vimeo.com/410189281/983916dec1?share=copy&fl=sv&fe=ci

Cylinder configurations

Different cylinders

For ADP diving, you will use two sets of cylinders: one set for breathing during the main (bottom) part of the dive, and an additional cylinder carrying the richer mix for use during the decompression phase.

For the bottom phase of the dive, larger cylinders may be needed to give enough gas for the planned dive time. Twin-sets provide a larger backup supply and additional redundancy - if the main regulator fails, the diver can switch to the backup and continue safely. For deeper dives redundancy is essential. Small emergency cylinders, such as 3-litre cylinders, can also be carried, but careful planning is required to ensure they provide enough gas. These small cylinders are usually only useful at shallower depths and are unlikely to be sufficient below 30 metres.

Decompression cylinders

Decompression cylinders (also know as stage cylinders) are completely separate from your main breathing gas and must be clearly identified to avoid using them by mistake at depth. Aluminium cylinders are generally more neutral in the water, but are larger and become more buoyant as they empty. Steel cylinders stay negatively buoyant, as a result they can make it harder to maintain balance underwater.

Buoyancy

When carrying multiple cylinders, your BCD must have enough lift to support you at the surface with full tanks. Before diving deeper, do a shallow check dive to adjust your weights and trim, making sure you can just sink from the surface. Include the weight of the gas in your calculations so that you remain balanced as the cylinders empty. After the dive, or when cylinders are nearly empty, check your weighting again and adjust if needed to maintain proper buoyancy.

Redundancy

Because ADP diving involves higher risks, it's important to have backup systems for all critical equipment to ensure you can handle any problems safely.

Buoyancy

Your BCD must provide enough lift to support you at the surface with full cylinders. While drysuits

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can offer some backup buoyancy, they are not designed to handle large amounts of gas and should not be relied on as your main buoyancy source. The BCD, with its dump valves, is designed to safely vent large amounts of gas when needed.

If you run out of gas at the surface, you can still inflate your BCD manually. Using standard connectors on low-pressure hoses allows you to connect to any available gas source. Carrying an extra low-pressure hose on your decompression cylinder can also provide redundancy, by plugging it in to the BCD to inflate and maintain buoyancy.

Carrying a lot of weight on a weightbelt can be risky during a long decompression stop. To reduce this risk, some weights can be placed elsewhere, such as on the cylinders, while keeping a smaller weightbelt. This setup allows the diver to stay positively buoyant in an emergency without risking a rapid, uncontrolled ascent if the weightbelt is lost.

Gas

To prevent a diver losing access to their backgas (e.g. reg failure) on the bottom with a long decompression stop ahead, they should carry an additional backup method of breathing bottom gas.

Some cylinders in Europe have dual outlet valves, allowing two regulators to be attached for backup. However, this only provides redundancy for the regulators - it doesn't protect against total gas loss or a bad fill, since both regulators draw from the same cylinder.

An independent gas source, such as a small cylinder or a twin-set, gives the diver a separate supply of bottom gas. You must carefully calculate the volume needed to make sure it's enough for the planned depth and duration of the dive.

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Other equipment

Always carry a backup mask in a secure pocket. This allows you to continue the dive or make a safe ascent if your main mask is broken or lost.

Although dive computer failures are uncommon, you should carry a backup computer or a dive timer along with wet notes or a slate. In an emergency, if your buddy has similar gases, you can follow their dive profile. But add extra time to decompression stops to account for any differences.

Essential equipment like cutting tools, reels, torches, and DSMBs you should always have backups and be easily accessible. Cutting tools should be reachable with either hand, or duplicated if that's not possible. If a reel is needed, carry a small finger spool as a backup. Your main torch should have a smaller, long-burning spare in case it fails. If a DSMB is required for the ascent, both divers should carry one.

Problem solving

Out of dive gas

Running out of dive gas should be avoided. You can prevent this by regularly checking your pressure gauges throughout the dive.

Before the dive, plan exactly what you will do. This helps you understand how long you can safely stay underwater with the gas you have and ensures there's a clear contingency plan in case something goes wrong.

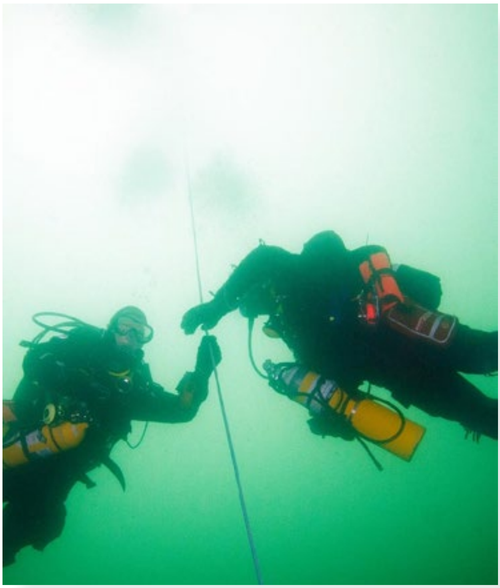
Out of decompression gas

Sometimes your decompression gas might not be available - this could be due to an empty cylinder, a faulty regulator, or a broken valve. Always plan your dive so that you can complete it using only your bottom gas. If the decompression gas is available, it's a helpful extra that can make your stops shorter, but your plan should never rely on it.

Controlled buoyant lift

A CBL may be needed to lift an incapacitated diver for a number of reasons - they may be unconscious, or panicking.

Lifting another diver while ascending is more difficult, especially if they have extra equipment. Controlling your ascent speed in this situation is challenging, so regular practice is important to handle it safely.



Deciding whether to skip decompression stops in an emergency ascent can be very difficult. You have to balance the risk of an unconscious diver near drowning against the risk of decompression illness (DCI). DCI can usually be treated and the diver is likely to survive, but near drowning is far more serious and may be fatal.

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Exceeding run time

Your dive plan should always include a backup plan in case you exceed the planned depth or dive time. This ensures you can manage unexpected situations safely.

An emergency gas cylinder can be prepared at the surface and lowered to you if needed, using a pre-arranged signal. At a decompression station, extra cylinders can also be set up so divers can access them safely.

Quiz 2

What is the most prominent information that should be marked on a cylinder?

Different cylinders may have an impact on buoyancy. What should a diver do before taking them on a deep dive?

Answers on page 123

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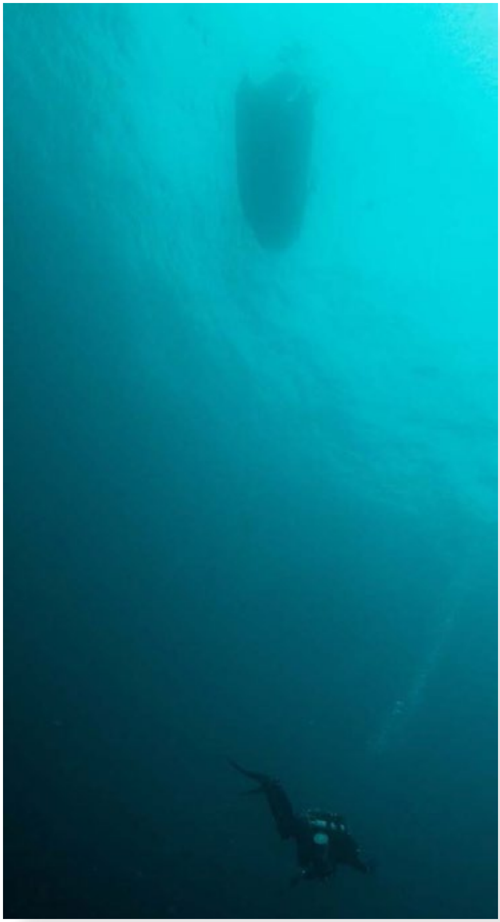
Summary



This module covered the following:

- ✔ Structure of the ADP course
- ✔ Qualification and how to progress
- ✔ Self-reliance in the buddy system
- ✔ Analysis
- ✔ Cylinder configurations
- ✔ Redundancy
- ✔ Problem solving

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End of module quiz

1. What is the main aim of the ADP course?
2. Does the ADP qualification allow you to dive deeper than your current qualification?
3. What type of diving equipment is permitted on the ADP course?
4. Why is knowing which gas you are breathing especially important on ADP dives?
5. What is the maximum oxygen partial pressure (PO_2) allowed on ADP dives?
6. Why must every dive be carefully planned before entering the water?
7. Why is gas analysis required before every nitrox or ADP dive?
8. What is the most important information that must be clearly marked on a cylinder?
9. Why is redundancy important on ADP dives?
10. What does self-reliance mean in ADP diving?

Answers on page 123

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Physiology

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Check out your eLearning video

Physiology

Alex Warzynski is a BSAC National Instructor, he will take you through the first part of the video module.

Remember if you need to discuss any of the theory e-mail or call your instructor at your club or centre.

Video time length | 29:13 mins

Click the image below to start watching the video.

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ADPT2 Physiology

Module objectives

This module is a revision session with theory taken from the nitrox course, updated with additional information about gas density, decompression theory and IPO.

Achievement targets

At the end of this module, you should understand:

- **Have reviewed previous learning on nitrogen narcosis**
- **Understand the effects of increasing breathing gas density**
- **Have reviewed previous learning on oxygen toxicity**
- **Reviewed previous learning on decompression illness**
- **Understand immersion pulmonary oedema**

Additional visual aids

The following visual aids will be required to support this lesson:

- Open circuit gas density tables – 1.4 bar PO_2

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Module content

This module builds on previous learning to ensure that students understand the physiology of ADP diving and how it will impact on them.

Much of the information has been covered in previous training, but the instructor should ensure you are refreshed and up to date.

- **This module covers the following**
- **Nitrogen narcosis**
- **Gas density**
- **Oxygen toxicity**
- **Decompression illness**
- **Immersion pulmonary oedema**

Nitrogen narcosis

Cause

At depth, the partial pressure of nitrogen increases, which means more nitrogen dissolves in the body. This is believed to interfere with the normal transmission of nerve signals, producing effects similar to alcohol or an anaesthetic, such as slowed reactions, poor judgement, and reduced coordination.

Although nitrogen narcosis affects divers at all depths, most people do not notice its effects until around 30 metres. The depth at which it becomes noticeable varies between individuals and can also be influenced by factors such as light levels, visibility, stress, and the diver's personal tolerance.

The effects of narcosis increase as depth increases. The deeper you go, the stronger the narcotic effect becomes. If you ascend to a shallower depth, the effects reduce again, often quite quickly.

Symptoms

At depths shallower than 30 metres, any narcosis is usually mild. Many divers do not notice it at all, and if they do, the effects are generally slight and easy to manage.

Between about 30 and 50 metres, nitrogen narcosis becomes much more noticeable. A diver's reasoning and judgement can be impaired in a way similar to alcohol intoxication. This may include dizziness, poor concentration, becoming fixated on a single task, feelings of anxiety or unease, reduced coordination, and difficulty reading or understanding gauges and dive computers.

Below about 50 metres, the effects of nitrogen narcosis can become dangerous. The symptoms experienced between 30 and 50 metres are intensified, which can quickly lead to poor decisions and loss of control. In some cases, these effects can become critical even before reaching 50 metres, depending on factors such as the diver's experience, stress levels, visibility, temperature, and workload.

Resolution – ascend!

The correct response to nitrogen narcosis is to ascend. Simply moving to a shallower depth will quickly reduce the narcotic effect. As

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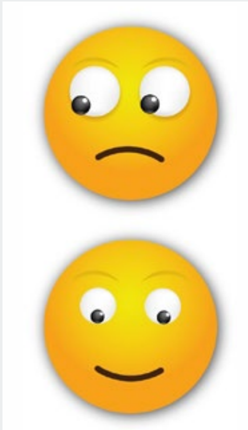
the depth decreases, the symptoms ease and the diver's thinking and coordination return to a more comfortable and manageable level.

Narcosis contributors

Personal factors



Anxiety, apprehension, and lack of experience can make the effects of narcosis feel much worse. If a diver is already nervous before the dive, narcosis can increase those feelings and reduce confidence. This can be managed by making sure the diver has suitable experience for the dive, receives a clear and thorough briefing, and dives with an appropriate buddy, all within their comfort and ability level.

Alcohol and some medications can make narcosis more likely and more severe. Divers should not drink alcohol before a dive, or dive if they are still feeling the effects from drinking the night before. If a diver is taking medication, they should check that it does not cause drowsiness or affect alertness, as this can increase the risks when diving.

Dive profile

A fast descent can cause narcosis to come on suddenly, making the effects much more noticeable and harder to manage. Descending in a slow, controlled way allows the narcotic effects to build gradually, giving the diver more time to recognise them and respond appropriately.

Physical exertion and fatigue can make narcosis worse. Higher levels of carbon dioxide in the body increase its effects. If a dive involves strenuous activity, taking time to rest, slow your breathing, and recover will help reduce the impact of narcosis.

Underwater conditions

Cold water can make the effects of narcosis stronger. Wearing appropriate thermal protection, such as a suitable wetsuit or drysuit, helps reduce this effect and keeps the diver more comfortable and alert.

Poor visibility can make narcosis worse because the diver loses visual reference points. Two dives to the same depth can feel very different: in clear water, narcosis may be mild, but in murky or low-visibility conditions, the diver may feel more disoriented or dizzy, increasing the impact of the narcotic effect.

Managing narcosis

The effects of narcosis cannot be completely avoided, but can be managed.

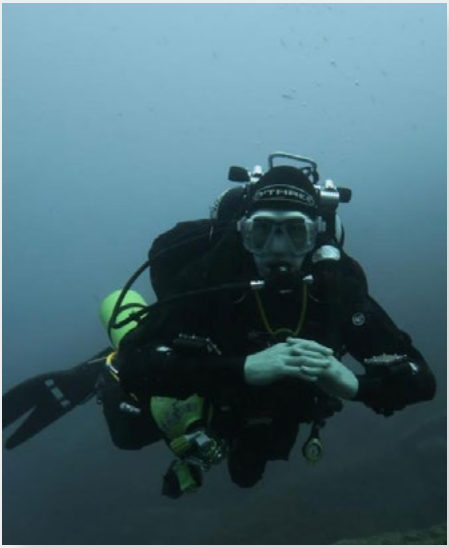
Preparation

If you are qualified, choosing a breathing gas that contains helium can help reduce the effects of narcosis. Helium is less narcotic than nitrogen, so using it in your gas mix makes deep dives safer and helps you stay clear-headed.

Being physically fit helps reduce narcosis because a fit diver produces less carbon dioxide, which is one of the factors that increases the narcotic effect. Regular exercise and good overall fitness can make diving safer and more comfortable.

Gradually increasing your dive depth and experience through “build-up” dives helps you get used to the effects of narcosis. By exposing yourself slowly to deeper dives and different conditions, you become familiar with how narcosis feels and learn how to manage it more effectively.

Gas density



Issue

As you dive deeper, the surrounding water pressure increases. Your scuba equipment delivers gas at this higher pressure, which means there are more gas molecules in each breath, making the gas denser the deeper you go.

As the gas gets denser at depth, it feels “thicker” and harder to breathe. Your lungs and regulator have to work harder to pull the gas in and push it out, making each breath require more effort.

Recommendations

Always use the right equipment for deep dives. EN250-rated regulators are tested to make sure they can deliver enough gas at

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depth. Regulators without this rating might not supply the denser gas fast enough for your breathing needs. Make sure all your equipment is serviced regularly according to the manufacturer's instructions.

Always breathe gas within the recommended limits - no denser than 6.3 g/L. While divers have occasionally breathed denser gas safely, studies show that higher densities can make breathing difficult, especially if you need to breathe faster.

Ideally, the gas you breathe should have a density below 5.2 g/L. At this level, it's much easier to breathe, and you're unlikely to experience any problems caused by the gas being too dense.

When planning a dive, use a risk-based approach. Consider your experience, the diver's condition, the dive environment, and the gas available to make safe and sensible decisions.

Gas selection

Calculating gas density

Gas Density Table (1.4 bar PO_2)

Depth (m)	Mix	Density ($g.L^{-1}$)	END (m)
35	31%	5.80	29
35	31/12	5.23	22
40	28%	6.42	36
40	28/23	5.20	21
45	25/15	6.16	32
45	25/31	5.23	20
50	23/23	6.19	31
50	23/39	5.17	19

Standard gases (1.4 bar PO_2)

Depth (m)	Mix	Density ($g.L^{-1}$)	END (m)
40	28/20	5.26	23
50	23/35	5.43	22

Calculating gas density the complex way means working out the density of each gas in the mix and then combining them based on their percentages. This method is more complicated and, like all calculations, mistakes can happen.

This course manual includes a detailed example showing how to calculate gas density, and additional resources are also available online for reference.

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Computer generated

If you enter your gas mix and depth into a dive computer, app, or software, it will calculate the gas density for you and give a warning if it goes above the recommended limits.

Gas density tables

You can also use online gas density tables to check your mix. BSAC has created recommended tables to avoid calculation errors, which are available on their website: .

bsac.com/advice-and-support/technical-diving/gas-density-tables/

For each dive depth, you should select a gas mix that stays within the safe limits. There are upper and recommended gas density values, and your chosen mix should not exceed these limits to ensure it's easy and safe to breathe.

The gas tables provide a list of standard gas mixes. Using these standard gases makes planning the dive and filling cylinders easier, especially when all divers are following the same plan.

Quiz 1

At what depth is the level of impairment caused by narcosis considered to be dangerous?

What is the maximum density recommended for breathing gas?

Answers on page 124

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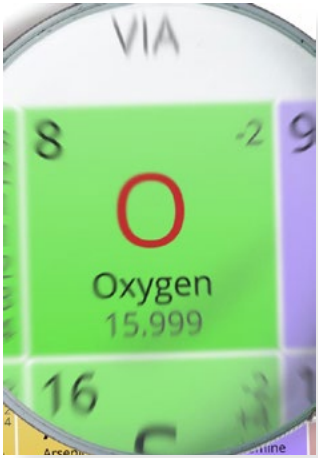
Review of oxygen exposure

Hyperoxia



Oxygen can be harmful if breathed at high pressures. For single-mix nitrox diving, this isn't usually a problem as long as the diver knows the gas they are using and stays shallower than the gas's Maximum Operating Depth (MOD).

Oxygen becomes toxic depending on how high its partial pressure is and how long you are exposed to it. A diver won't necessarily feel the effects immediately; symptoms usually develop after some time underwater. Different divers, or the same diver on different days, may react differently. In recreational diving, as long as you follow normal limits and avoid long, extreme dives, the risk of oxygen toxicity is very low.

Types of oxygen toxicity

Central nervous system (CNS) oxygen toxicity is the type most likely to affect divers. Studies show that keeping the oxygen partial pressure below 1.4 bar is generally safe for normal recreational dives. If the pressure rises above 1.6 bar, the risk of a CNS oxygen toxicity event increases sharply.

Whole body oxygen toxicity, also called pulmonary oxygen toxicity, is a long-term effect from breathing oxygen at elevated levels. It usually only becomes a concern during exposures longer than those in normal recreational diving. To track exposure, we use Units of Pulmonary Toxicity Dose (UPTD) or Oxygen Toxicity Units (OTUs).

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BSAC recommends not exceeding 300 UPTD/OTUs in a 24-hour period.

Symptoms of CNS toxicity

Symptoms

Until convulsions begin, minor symptoms can appear in any order or combination. They may not be recognised or remembered.

- **CONVENTID**

CONvulsions (cycles)

These are the most serious and damaging symptoms. They follow a given pattern:

- **Tonic phase**
  The tonic phase is the first stage of an oxygen toxicity seizure. During this phase, the diver's neck, body, and limbs become stiff and rigid. They will likely lose consciousness very quickly.

- **Clonic phase**
  The clonic phase happens about 30 seconds after the tonic phase. During this phase, all the diver's muscles spasm violently for around a minute. The contractions can be so strong that they could injure the body, but the spasms gradually calm down afterward.

- **Post convulsive depressive**
  The post-convulsive depressive phase happens after the clonic phase. During this time, the diver becomes limp and is usually unconscious. This is the critical moment to provide rescue and get the diver to safety.

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Vision

Narrowing of field of vision, possible brightly coloured spots before the eyes

Ears, hearing disturbances

Tinnitus, ringing

Nausea

Possible vomiting

Twitching

Facial twitching, particularly around the mouth

Irritability

Dizziness

Managing CNS O_2 toxicity

Avoid

Like most diving disorders, there are simple steps that can be taken to minimise the risk of oxygen toxicity and treatment is relatively straightforward

Always analyse your gas and check its MOD before diving. Oxygen toxicity happens when a diver breathes a gas at a depth beyond its safe limit. To avoid this, never exceed the planned Maximum Operating Depth (MOD) for your gas. This is why it's essential to

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analyse the gas, mark the cylinder correctly, and make sure you use the correct regulator for the cylinder with that MOD.

Always breathe normally and avoid strenuous exercise while diving. High levels of carbon dioxide increase the risk of oxygen toxicity, and these can build up if you breathe too quickly, too shallowly, or push yourself too hard physically underwater.

Keep track of your oxygen toxicity levels during the dive. You can do this using the tools and methods you learned in previous training, or with dive computers and software that calculate oxygen exposure. BSAC recommends keeping your Central Nervous System (CNS) oxygen toxicity level below 80% at all times.

Treatment

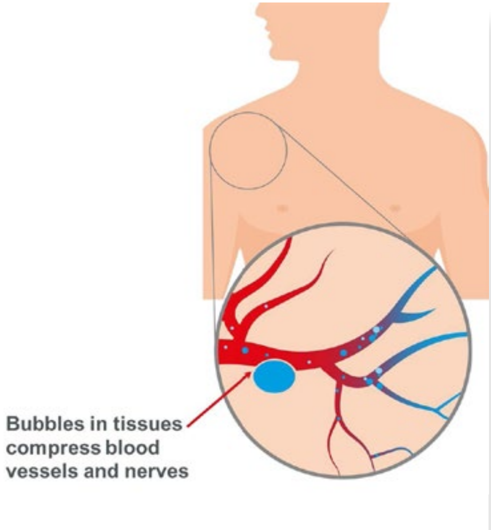
If a diver shows signs of CNS oxygen toxicity, they should be removed from the high-oxygen environment immediately, even if this means missing some decompression stops. Once at the surface, get them out of the water as quickly as possible and contact emergency services right away.

If a diver is convulsing or rigid, do not try to lift them to the surface. Their lungs cannot vent properly during convulsions, and ascending could cause a lung rupture. Wait until their body relaxes before attempting to move them.

Once the diver is on the surface, give them oxygen. Even though they had oxygen toxicity symptoms underwater, breathing oxygen at surface pressure is safe and will help increase their oxygen levels, aiding recovery.

Decompression illness (DCI)

Previous diver training will have introduced many of the concepts associated with decompression theory, including bubble formation, burst lungs and symptoms.



Causes/mechanism

The umbrella term decompression illness (DCI) is used to cover two different conditions which present in a similar manner.

During a dive, your body absorbs the inert gases (like nitrogen) from your breathing gas depending on the surrounding water pressure. While you stay at depth, this is fine. But if you ascend too quickly, the gas can come out of solution and form bubbles in your tissues and bloodstream (Henry's Law) This is what causes decompression sickness. Bubble formation usually happens when dive limits are exceeded or approached too closely, but it can also occur even if the dive follows accepted guidelines.

Lung injuries can happen if the air in your lungs expands during ascent and you can’t release it fast enough, according to Boyle’s law. This can occur even in shallow water or on short dives. The best way to prevent this is to breathe normally while ascending, or actively exhale if the ascent is faster than normal.

All dives require decompression

Regardless of the dive profile, there will be some form of decompression.

Surface decompression is the time spent on the surface after a dive while your body releases the inert gases absorbed during the dive, allowing your tissues to return safely to normal pressure.

Mandatory decompression stops, at different depths, are required for longer or deeper dives. It involves ascending slowly and making stops at different depths for set periods to allow your body to safely release the gases absorbed during the dive. Planning these stops has been covered in earlier training and will be explained further in the next lesson.

DCI symptoms

Any abnormality

Any abnormality after a dive should be treated as DCI, but the ones listed below are some of the more common ones.

- **Denial**
  Denial happens when a diver experiences a problem but insists it's caused by something else. They may not accept that there's a real issue and might need convincing before taking the correct action.

- **Itches, rashes on skin**
  Skin itches or rashes can appear as a marbled red and blue pattern. They may be itchy, but not always.

- **Numbness, tingling, joint pain**
  Numbness, tingling, or joint pain usually affects the limbs and joints and is often felt as a deep, bone-deep ache.

- **Vision disturbances**
  Vision disturbances can include tunnel vision, blurred vision, or difficulty focusing on objects.

- **Dizziness, nausea, headaches, confusion**

- **Weakness, paralysis of limbs, loss of bladder/bowel control**
  Weakness or paralysis can affect parts of a limb or an entire limb. Loss of bladder or bowel control is also a warning sign, especially if the diver hasn't urinated during the dive and suddenly cannot afterwards.

- **Shortness of breath, chest discomfort/pain**
  Shortness of breath or chest pain refers to any difficulty breathing or discomfort in the chest that begins after the diver has surfaced.

- **Shock, memory loss, unconsciousness**
  Shock, memory loss, or unconsciousness refers to the diver losing awareness or memory of events, whether short-term, medium-term, or long-term, which can be detected by asking questions or observing how they respond to people nearby.

May appear seconds to hours after diving

Occasionally signs and symptoms may start during the ascent to the surface and for up to 48 hours afterwards.

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Managing the risk of DCI

There are many techniques to minimise the risk of decompression illness.

Dive profile

“Plan the dive, dive the plan” means that when diving, especially to greater depths, you should carefully plan the dive ahead of time - including depth, timing, gas usage, and decompression stops - and then stick to that plan while underwater to reduce risks and stay safe.

It’s important to ascend at the right speed, usually around 8 - 10 m per minute for most dive computers. Going too slowly can cause some tissues to absorb more nitrogen while others off-gas more slowly, which can make decompression stops longer. Ascending too quickly doesn’t give nitrogen enough time to leave your body and, in extreme cases, can also cause lung injuries.

Behaviour

It’s important to stay well-hydrated before diving, starting gradually at least 12 hours beforehand. Check your urine - it should be clear and plentiful - which shows you’re properly hydrated. Avoid drinking too much at once, as overhydration can also be harmful.

Divers should stay warm, especially during decompression stops. Gentle finning during these stops helps maintain body heat, keeps

Go back

blood circulating, and supports the safe release of dissolved gases from the body.

After a decompression dive, divers should avoid strenuous exercise for as long as possible. They should also avoid pressure changes, such as driving over high hills or flying in planes - especially unpressurised aircraft - as these can increase the risk of decompression sickness.

Personal factors

Some people are more likely to get decompression illness (DCI) due to factors like age, fitness level, and any previous history of DCI. These personal factors can affect how the body handles nitrogen and decompression.

About 1 in 4 people have a Patent Foramen Ovale (PFO), which is a small flap covering a hole between the left and right upper chambers of the heart. Everyone has this hole before birth to allow blood to bypass the lungs and get oxygen from the mother. Usually, it closes naturally at birth, letting blood flow through the lungs. In some people, it doesn’t fully close, so blood can bypass the lungs even as an adult. This usually doesn’t affect daily life, but it can increase the risk of decompression illness (DCI) when diving.

Treatment of DCI

The treatment for DCI is very straightforward and forms a key part of the Oxygen Administration Skill Development Course (SDC), which is recommended for all divers.

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When to treat

If you notice any unusual symptoms after a dive, treat them as possible decompression illness (DCI) and provide or seek first aid immediately.

If a diver misses decompression stops or ascends too quickly, they might appear fine at first. Even without symptoms, it's safest to treat them as if they have decompression illness to prevent problems before they develop.

First Aid

- **Lie down**
  If the diver is conscious, have them lie on their back. If they are unconscious or likely to vomit, place them in the recovery position on their side to keep their airway clear.

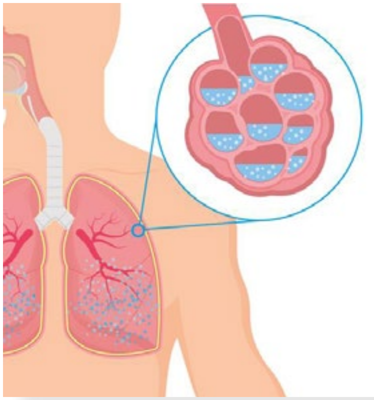
- **Keep calm**
  Stay calm and provide regular reassurance to the diver. The situation can be very stressful, so keeping them calm helps reduce anxiety and makes first aid more effective.

- **Administer 100% oxygen**
  Give the diver 100% oxygen if possible. This helps remove nitrogen from their body more quickly and supplies oxygen to tissues that need it most.

- **Give fluids by mouth**
  Give the diver small sips of fluids by mouth if they are conscious. This helps with hydration and supports recovery.

- **Evacuate**
  The diver should be taken to a recompression chamber as quickly as possible for proper treatment.

Immersion Pulmonary Oedema



Previously considered rare, Immersion Pulmonary Oedema (IPO) has been identified as a factor in a number of diving incidents.

What is it

IPO is a response to the body being immersed in water and can occur even in very fit people.

Immersion Pulmonary Oedema (IPO) happens when fluid from the body collects in the lungs. This can make breathing difficult and, if not treated, can be life-threatening.

Immersion in water causes your body's fluids to shift, especially in your circulation. This increases the amount of blood in your vessels. The body normally removes the extra fluid through the kidneys and into the bladder.

Immersion Pulmonary Oedema (IPO) can look similar to drowning because both conditions cause fluid to build up in the lungs, making it hard to breathe.

Risk factors

The risk of IPO is increased by the factors below.

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- **Cold water**
  Cold water is a recognised risk factor for getting IPO because constriction of blood vessels is greatest in the cold. Again the constricted blood vessels will need less blood in them, and excess fluid is moved out of the circulation.

- **High blood pressure**
  People with pre-existing heart disease and high blood pressure (hypertension) are also believed to be more susceptible to IPO. In both the previous scenarios, the excess of blood causes an initial rise in pressure.

- **Strenuous exercise**
  Exertion and stressful events during immersion increase blood pressure in the alveolar capillaries and their additive effects can be enough to cause IPO.

- **Overhydration**
  It has an additive effect on the increase in alveolar capillary pressure resulting from immersion. It is important to be adequately hydrated before a dive but not overhydrated. Post-dive rehydration is protective of DCI and not linked to IPO.

- **Negative inhalation pressure**
  Excessive negative pressure in the alveoli is encountered when a demand valve is poorly serviced or where the hydrostatic lung loading on a rebreather requires greater inhalation effort.

Go back

IPO symptoms (underwater)

A diver with IPO will find the symptoms extremely distressing and is unlikely to identify IPO as the issue. They may try increasingly extreme options to overcome their difficulties which will be increasingly apparent to their buddy.

Breathing disruption

As the diver has fluid in their lungs, they will experience disruption to their breathing.

A diver with IPO may have trouble breathing for no obvious reason. Their breathing may be rapid, uneven, heavy, or appear distressed. A common symptom of IPO is persistent coughing as the lungs try to expel the excess fluid.

Thinking equipment is faulty

Most divers will initially believe that their breathing problems are created by faulty equipment, which they will then try to address.

A diver with IPO may think their regulator isn't working properly, even if it is functioning correctly.

A diver experiencing IPO may switch to their alternative air supply (AS) or signal "out-of-gas," even if their own tank still has air, following standard emergency procedures.

The diver may reject other regulators, after finding out that switching doesn't help. This is a key sign that they may be experiencing IPO, not a regulator problem.

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Panic

Having exhausted all options to resolve their breathing issues, the diver with IPO is then likely to panic and may well rush to the surface.

First aid for IPO

Get casualty out of the water

As IPO is created by immersion, removing the casualty from the water should alleviate symptoms.

- **Surface safely as soon as possible**
  The diver will want to reach the surface as quickly as possible to relieve symptoms and get help.

- **Escort to the surface**
  Whenever possible, another diver should escort the casualty to the surface to ensure they stay safe during the ascent.

- **Get out of water without delay**
  This will take the load off their body systems and allow the vascular compartment to return to normal.

Surface treatment

The treatment for IPO is similar to many other diving illnesses, especially drowning, but it is key that the diver is not given fluids as this will exacerbate the condition.

- **Sit upright (if conscious)**

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Sit the casualty upright as this will enable them to breathe more easily.

- **Give 100% oxygen**
  Administering 100% oxygen by an appropriate means will help overcome the poor lung performance created by the fluid that they contain. It is also likely that the diver will have made a more rapid ascent than normal and potentially missed decompression stops, so this will assist with that.

- **Keep warm**
  The diver is likely to be suffering from shock, so keeping them warm is an important means of overcoming that. It will also help with circulation.

- **Do not give fluids!**
  Fluid overload is the problem, so giving them more will not help.

Seek medical attention urgently

As with any diving injury, it is important to evacuate the casualty to medical care as quickly as possible.

Quiz 2

How can CNS oxygen toxicity be avoided?

What are the two most obvious symptoms of immersion pulmonary oedema (IPO)?

Answers on page 125

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Summary

- ✔ This module covers the following
- ✔ Nitrogen narcosis
- ✔ Gas density
- ✔ Oxygen toxicity
- ✔ Decompression illness
- ✔ Immersion Pulmonary Oedema

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End of module quiz

1. What causes nitrogen narcosis?
2. At what depth does nitrogen narcosis usually become noticeable?
3. What is the simplest and most effective way to reduce nitrogen narcosis?
4. Why does gas become harder to breathe at depth?
5. What gas density limits are recommended for diving?
6. What are the two main types of oxygen toxicity?
7. What are some early warning symptoms of CNS oxygen toxicity?
8. What is decompression illness (DCI)?
9. When should a diver be treated for suspected DCI?
10. What is immersion pulmonary oedema (IPO)?

Answers on page 125

Gas planning and limiting factors

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Check out your eLearning video

Gas planning and limiting factors

Alex Warzynski is a BSAC National Instructor, he will take you through the first part of the video module.

Remember if you need to discuss any of the theory e-mail or call your instructor at your club or centre.

Video time length | 31:56 mins

Click the image below to start watching the video.

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ADPT3 Gas planning and limiting factors

Module objectives

This module reviews the gas planning taught in previous courses and introduces methods to calculate individual gas consumption. It also shows how gas reserves can be calculated for deeper dives.

Achievement targets

At the end of this lesson, you should:

- **Have reviewed gas consumption taught in previous courses**
- **Understand how to calculate individual gas consumption**
- **Know two methods to calculate the gas reserve for a dive**
- **Have considered other options to overcome limiting factors in deeper diving**

Module contents

This module covers the following:

- Review of gas consumption
- Calculating individual gas consumption
- Calculating the gas reserve for a dive
- Overcoming limiting factors for deeper diving
- Accelerating decompression

Review of gas consumption

As covered in previous training, breathing rates are not fixed and will vary, determined by many factors. Understanding how they will change and how to respond is important knowledge.

What increases consumption?

The factors below explain how consumption is increased. The converse is also true so changes in the opposite direction can be used to reduce gas consumption.

Factors such as cold, stress and exertion are particularly relevant for inexperienced divers who often have poorly fitting suits, may be nervous or haven’t grasped techniques that make things such as finning easy!

- **Depth**
  Gas consumption has a mathematical link to absolute pressure. An increase in depth will change gas consumption in proportion to the change of absolute pressure. As an example, going from the surface (1 bar) to 10 m (2 bar) will double the rate of gas consumption. The same thing happens going from 10 m (2 bar) to 30 m (4 bar), which means that the consumption at 30 m will be four times that on the surface.

- **Exertion**
  The body demands more oxygen during periods of physical exertion and the only way to achieve this is to increase the breathing rate, so it is faster and deeper.

- **Cold**
  The body reacts to cold in many ways and one thing that happens is for breathing rates to increase.

- **Stress**
  During periods of stress or anxiety, the body prepares to respond quickly, which means that the breathing rate will naturally increase.

- **Emergency situations**
  As well as the stress created by an emergency situation, it is also possible that two divers may be breathing from a single gas supply.

- **Max breathing rates**
  May double, triple or more.

Research and analysis of incidents have indicated that the breathing rates of divers can double, triple and more during periods of high work rate and stress.

So what?

Gas consumption should be considered before the dive and then monitored throughout.

When choosing a cylinder configuration for a dive, always plan for the worst-case scenario. This ensures you have enough flexibility and backup if something unexpected happens underwater.

If there's ever any doubt about having enough gas for the dive, it's important to end the dive early or modify one's actions to reduce gas use. Safety comes first.

Individual gas consumption

Gas consumption rates will vary significantly between individuals, so a cylinder appropriate for one diver on a given dive may not be adequate for another. That is why understanding how to calculate gas consumption rates is useful and can be used to assist in more accurate dive planning.

Surface air consumption

Another term for Surface Air Consumption (SAC) rate is Respiratory Minute Volume (RMV) rate.

The SAC rate (Surface Air Consumption rate) is unique to each diver, so it should be calculated individually. Keeping a record of gas consumption is very helpful, especially for new divers, those returning after a break, or anyone who dives in different equipment or conditions.

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Knowing your gas consumption rate helps you plan dives more accurately, which is especially important for deeper dives where careful gas management is critical.

A diver's gas consumption rate can vary from dive to dive due to different conditions and factors. The SAC rate is only a guide and should not replace regular gas checks during the dive.

Calculation methods

There are multiple different methods to calculate individual gas consumption rates. The first two will be considered in more detail later in this module.

- **Maximum depth**
  This method assumes the diver is at the maximum depth for the duration of the dive.

- **Constant depth**
  This method requires the diver to monitor their gas consumption over a specific time period while maintaining a constant depth.

- **Computer log**
  Many computers can have the dive profiles downloaded, and the gas consumption calculated automatically. Some gas integrated models will do this live.

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Calculating gas consumption rates

All methods of calculating gas consumption require the same information and use the
same formula.

Information required

- **Gas used (litres)**
  The gas used is found by multiplying the cylinder size (litres) by the cylinder contents used (bar).
- **Absolute pressure (bar)**
  Absolute pressure is a function of depth.
- **Duration(mins)**
  The duration is the time over which the gas was used.

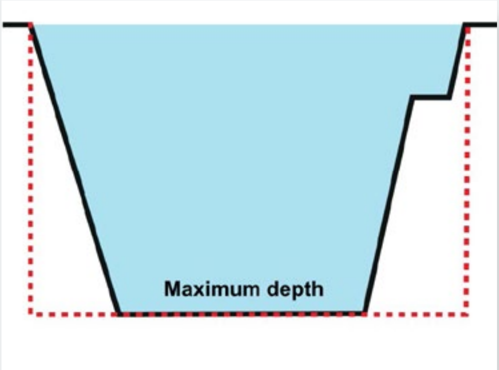
Formula

Gas consumption rate can be calculated using the formula below:

$$\textit{Surface gas consumption rate} = \frac{\textit{Gas used}}{\textit{Absolute pressure x Duration)}}$$

Method 1 – Maximum depth

This is the traditional method to calculate gas consumption. It assumes that the diver spends the entire dive at the maximum depth that was achieved.



Although inherently inaccurate, it is simple to calculate and be retrospectively applied to past dives

Requires

This calculation requires data from the whole dive, using the maximum depth to determine the absolute pressure for the SAC rate.

Disadvantages

One disadvantage of this method is that pressure changes during the dive can make the calculation inaccurate. Because divers move up and down, using the maximum depth may underestimate the actual surface air consumption. Some dive computers provide the average depth, which can be used instead to get a more accurate SAC rate.

Advantages

If a diver has recorded dive details in their logbook, SAC rates can be calculated from past dives. This data can help track trends, estimate average consumption, or provide guidance for specific equipment or conditions. Using multiple dives gives a range of likely rates, and for extra caution, the highest rate should be used when planning future dives.

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Method 1 – Example

This example assumes that a diver completed a dive to a maximum depth of 20 m with a surface-to-surface time of 30 mins. During this time, they breathed 150 bar from a 12 L cylinder.

Applying these figures to the formula results in a breathing rate of 20 litres per minute (L/min).

Calculation

$$= \frac{Gas\ used}{Absolute\ pressure\ x\ Duration}$$

$$= \frac{150\ bar\ x\ 12\ litres}{3\ bar\ x\ 30\ mins}$$

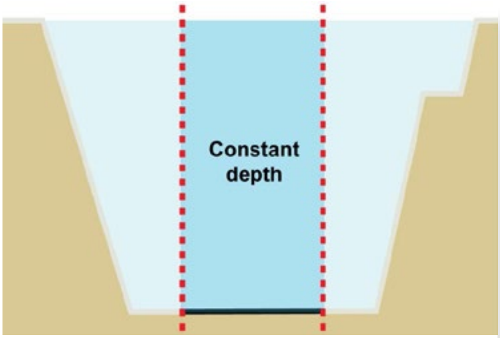
$$= 20\ litres\ per\ minute$$

Method 2 – Constant depth

This method is far more accurate but requires a dedicated period of the dive to acquire the relevant data.

Monitor

This method assumes that the diver uses a dedicated period of the dive to monitor their instruments.



To measure gas use at a constant depth and fixed time, the diver stays at the same depth and notes the cylinder pressure at the start and end of the period.

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Disadvantages

Pressure gauges can be hard to read accurately, often only showing changes in increments of 5 or 10 bar. This can make small gas use measurements less reliable, so this method is most accurate over longer monitoring periods.

This method cannot be used for past dives unless the diver previously recorded the same type of gas-use exercise during those dives.

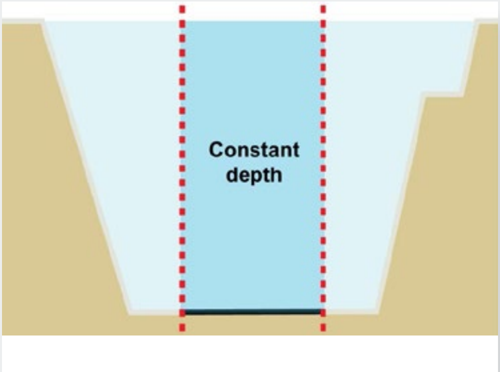
Advantages

If gauge inaccuracies are minimised - such as by using digital pressure devices - this method gives the most accurate SAC rate measurements.

Method 2 – Example

This example assumes that a diver remained at 30 m for 6 minutes, during which they breathed 40 bar from a 12 L cylinder.

Applying these figures to the formula results in a breathing rate of 20 litres per minute (L/min).



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Calculation

$$= \frac{Gas\ used}{Absolute\ pressure\ x\ Duration}$$

$$= \frac{40\ bar\ x\ 12\ litres}{4\ bar\ x\ 6\ mins}$$

$$= 20\ litres\ per\ minute$$

Method 3 - Computer log

Download the dive log

To download a dive log, follow the instructions for your specific dive computer. Some models connect with a cable, while others use Bluetooth, so always refer to the user manual for the correct method.

Input cylinder pressures and size

- **Start pressure**
- **End pressure**
- **Cylinder size**

Software calculates SAC

The software uses the dive profile recorded by your dive computer to accurately calculate your average depth. Entering in your air consuption figures will give you your SAC rate.

Very accurate

As the actual dive profile is used, this method is the most accurate as it does not require any assumptions on the profile.

Quiz 1

What factors increase the consumption of breathing gas?

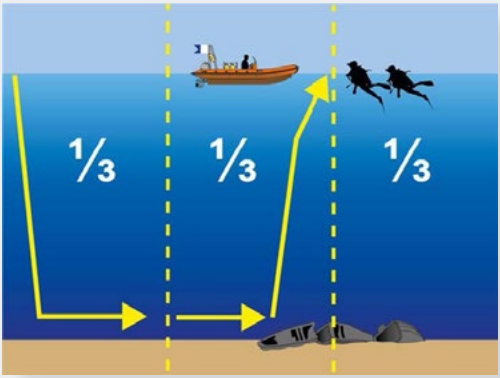
What does SAC stand for?

What is the formula to calculate SAC?

Answers on page 126

Reserve - rule of thirds

Gas planning using the rule of thirds was taught during previous training. The limit of decompression diving for Sports Divers (maximum of 10 minutes of stops on any dive and 20 minutes in any day) is well within the safe gas reserves the rule of thirds calculates.



Technique

- **One third out**

- **One third back**
- **One third reserve**

Calculation

To calculate the gas needed for a dive, multiply the absolute pressure at the planned depth by the planned bottom time.

To include a safety reserve, add 50% to the calculated gas (or multiply by 1.5). This is sometimes called the “1/3 reserve.”

After calculating the total gas needed for the dive, including the reserve, you can use this figure to determine the appropriate cylinder size, to have enough gas to safely carry out the planned dive.

The gas in a cylinder can be found by multiplying the volume in litres by the pressure. As an example, if a 12 litre cylinder is filled to 200 bar, then the total quantity of gas is 12 x 200 = 2400 litres.

Rule of thirds - example

Dive

- **Dive to 40 m for 15 mins**

The absolute pressure at 40 m is 5.0 bar.

- **SAC of 20 L/min**
- **5 (bar) x 15 x 20 = 1,500 litres**

This formula is based on the one for Surface Air Consumption but with the figures rearranged so that gas used is calculated.

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Absolute pressure x Duration x SAC rate=Gas Used

- **Reserve**
- **Including reserve (x 1.5) = 2,250 litres**

The 50% reserve required by the rule of thirds can be found by multiplying the planned consumption by 1.5.

Cylinder size

Having calculated the amount of gas required for the dive, this should be used to identify what size of cylinder is required.

- **10 L at 220 bar = 2,200 litres**
- **A 10 litre cylinder filled to 220 bar contains 10 x 220 = 2,200 litres of gas.**
- **12 L at 220 bar = 2,640 litres**
- **A 12 litre cylinder filled to 220 bar contains 12 x 220 = 2,640 litres of gas.**

Rule of thirds – student practice

Students should practise calculating the gas required under the rule of thirds method. Two examples are shown below, but others can be used.

The formula for gas used is:

Absolute pressure x Duration x SAC rate = Gas Used

Example 1

- **Dive to 45 m for 12 mins**
- **SAC of 20 L/min**

- **Total required is 1,980 litres**

The table shows how this is calculated:

Phase of dive	Duration (mins)	SAC (L/min)	Absolute pressure	Gas Used (litres)
Dive	12	20	5.5	1330
Reserve	+50%			660
			Total	1980

Example 2

- **Dive to 30 m for 15 mins**
- **SAC of 25 L/min**
- **Total required is 2,250 litres**

The table shows how this is calculated:

Phase of dive	Duration (mins)	SAC (L/min)	Absolute pressure	Gas Used (litres)
Dive	15	25	4	1500
Reserve	+50%			750
			Total	2250

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Reserve - minimum gas

For dives with extended decompression it is beneficial to have higher quantities of reserve gas than calculated using the rule of thirds method. The minimum gas method is one means of achieving this.

The decision on which method of calculating reserve to use should be based on factors such as amount of decompression, approach to risk, dive profile, availability of other gas and experience of divers.

Factors

The minimum gas method for calculating a reserve is more detailed and complex than the rule of thirds. It takes into account specific dive factors, which will be shown in the worked example.

The minimum gas method uses different breathing rates to allow for stress. After an incident, divers often breathe much faster than normal, especially if they are less experienced. Breathing rates are typically two to three times higher than usual and can be even higher in extreme situations. The breathing rate is usually highest at the start of the problem, then gradually reduces as the diver calms down and ascends to shallower depths.

Because it is based on worst-case scenarios, the minimum gas calculation produces a much larger reserve, especially for dives starting from greater depth, compared with the rule of thirds.

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Stages

During a real incident, SAC values are likely to start off high and then reduce over time.

The minimum gas method attempts to estimate what is required by breaking the ascent into three stages. At each stage an approximation of SAC is used to calculate the gas required and these are then added together to give a total.

It is important to appreciate that, like all gas calculations, the minimum gas method is simply an approximation and real gas usage is very likely to be different.

- **Settling time**
  This is the part of the dive where the gas usage will be the highest. The out-of-gas diver needs to access the buddy's alternate source and decisions made about the next step. This may include things such as deploying a DSMB or returning to a datum before commencing the ascent.

  Typically this takes at least 2-3 minutes, during which time the SAC for the out of gas diver should be planned to at least double, or possibly more.

- **Ascent**
  The out of gas diver will have an elevated breathing rate, and the ascent is likely to be faster than usual. The out-of-gas diver will not have access to any additional gas for buoyancy control, so the ascent rate may vary. Especially if they release too much gas and start to decend.

  The gas used during the ascent can be calculated using the absolute pressure at the depth of the mid-point of the ascent. For a no decompression dive, this is half the maximum depth but is a

Go back

bit more tricky to calculate for a decompression dive. The easiest way to find it is to add the maximum dive depth to the depth of the first decompression stop and then divide by two. For example, if the maximum depth is 45 m and the first decompression stop is at 9 m, then the mid-point of the ascent is (45 + 9) x 0.5 = 27 m which has an absolute pressure of 3.7 bar.

Gas consumption of the out of gas diver during the ascent should be calculated based on an SAC of at least double the normal rate.

- **Stops**
  If there are no mandatory decompression stops, the buddy pair need to make a decision whether a safety stop is required or whether the need to surface safely is more urgent, omitting the safety stop.

  If there are mandatory decompression stops and the divers are not carrying separate decompression cylinders, then both divers will have to complete their decompression stops using the same gas source. As they are shallow, the breathing rate is likely to reduce down to a more normal level than that experienced so far. They also need to add the post-decompression final ascent to the surface.

  During this phase, the normal SAC can be used for the calculation.

Minimum gas – example

This example shows the reserve calculated using the minimum gas method for a dive.

Dive

- **Dive to 40 m with a 3 min stop at 6m**
- **ISO stressed rate of 50 L/min**

- **Drops to 25 L/min at first deco stop**

Calculation of reserve

- **Total SAC is 75 L/min (50 + 25)**
- **The two divers are breathing 50 L/min and 25 L/min respectively, giving a total breathing rate of 75 L/min.**
- **10 m/min for ascent (4 mins)**
- **This is a no decompression dive, and it is assumed that no safety stop is carried out as there is an urgency to get to the surface that outweighs the potential risk of DCI.**
- **It will take 4 minutes for a diver to ascend at 10 m/min from 40 m to the surface.**
- **Mid-point of ascent is 20 m (3 bar)**
- **The gas used during the ascent can be calculated using the pressure of the mid-point. In this case this is 40 x 0.5 = 20 m. This depth has an absolute pressure of 3 bar.**
- **Deco stop at 6m for 3 mins**
- **At this point it is likely the divers will have calmed and a normal breathing rate can be used.**

Phase of dive	Duration (mins)	SAC (L/min)	Absolute pressure	Gas Used (litres)
Settling	3	75	5	1125
Ascent	4	75	3	900
Stop	3	50	1.6	240
			Total	2265

Cylinder pressure required

The pressure required for the reserve can be calculated by dividing the total gas by the cylinder size.

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- **15 L = 2265 ÷ 15 = 151 bar**
- **12 L twin-set = 2265 ÷24 = 94 bar**
- **A cylinder smaller than 12 L is unlikely to have an adequate reserve capacity.**

Complex calculation

Depth	Gas reqd	15m stop 1	15m stop 5	12m stop 1	12m stop 5	12m stop 10	9m stop 1	9m stop 5	9m stop 10	6m stop 1	6m stop 5	6m stop 10
20	975	125	625	110	550	1100	95	475	950	80	400	800
25	1209											
30	1463											
35	1734											
40	2025											
45	2334											
50	2663											
	Min gas (litres) = Direct ascent + deco stops											

Calculating minimum gas is relatively complex and can easily lead to calculation errors. A way to reduce these errors is to use a lookup table.

The BSAC Minimum Gas Lookup Table is used to help calculate a safe gas reserve. It is based on ISO breathing rates, assuming a higher rate of 50 litres per minute during the initial settling and ascent, when stress is likely to be highest, and a normal breathing rate during decompression stops. If a diver knows their own breathing rates, the table can be recalculated to better reflect their personal gas consumption.

BSAC Minimum Gas Lookup Tables

Minimum gas – example

Depth	Gas reqd	15m stop		12m stop			9m stop			6m stop		
		1	5	1	5	10	1	5	10	1	5	10
20	975	125	625	110	550	1100	95	475	950	80	400	800
25	1209											
30	1463											
35	1734											
40	2025											
45	2334											
50	2663											
	Min gas (litres) = Direct ascent + deco stops											

This example shows the reserve calculated using the lookup table.

- **Dive**
- **Dive to 45 m**
- **Decompression stops of 1 min at 9m and 6 min at 6m.**

Lookup values in the table

Select the value from the yellow depth column. If in between, use the next deeper value.

Select the values from the blue row for the gas used on the decompression stops.

- **Minimum gas calculation**
  Is the sum of all of the selected values, in this case 2334 + 95 + 80 + 400 = 2909 L

- **Calculate the value in bars in the cylinder used**
  Divide the reserve value by the cylinder capacity, in this case

  12 L twin-set = 2909 ÷ 24 = 121 bar

Use minimum gas to calculate dive limits

Dive planning using the rule of thirds is normally an iterative process as the diver tries to identify the dive time that will provide a reserve which is achievable with their cylinder capacity.

This iterative process is not required if reserve gas is calculated using the minimum gas method as we can take the minimum gas away from the total gas available to give us the amount of gas available for the dive, using our normal breathing rate.

- **Dive**
- **Known breathing rate of 15 L/min**
- **This should be measured using one of the previous methods**
- **Gas available for the dive**
- **From the previous calculation, the reserve is 121 bar.**
- **Gas for the dive is 220 - 121 = 99 bar.**

Dive limits

Using the formula below, the maximum bottom time can be calculated.

$$\frac{\textit{Cylinder pressure x capacity}}{\textit{SAC x Absolute Pressure}} = \textit{Bottom time}$$

For this example this gives:

$$\frac{\textit{99 bar x 24 L}}{\textit{15 LPM x 5.5 bar}} = \textit{28.8 minutes (round down to 28)}$$

Go back

The diver can use a decompression planning tool to plan a dive that has the maximum parameters above. As long as they plan a dive shorter than this, they will have enough reserve gas.

- No more than 28 mins bottom time
- Max 1 min at 9m and 6 min at 6m deco

Dive limits – student practice

Students should practise calculating dive limits building on the previous examples.

Example 1

- **Dive to 30 m**
- **Max 5 mins of deco at 6 m**
- **15 L cylinder at 220 bar**
- **SAC of 12 L/min**
- **1,863 L reserve (124 bar)**
- **Available gas for the dive = 220 - 124 = 96 bar**
- **Max bottom time = (96 x 15) ÷ (4 x 12) = 30 mins**

Example 2

- **Dive to 40 m**
- **Max 10 mins of deco at 6 m**
- **Max 5 mins deco at 9 m**
- **12L twin-set (24L) at 220 bar**
- **SAC of 15 L/min**
- **3,330 L reserve (137 bar)**
- **Available gas for the dive = 220 - 137 = 83 bar**

Go back

- **Max bottom time = (83 x 24) ÷ (5 x 15) = 26 mins**

Overcoming limiting factors

It should be clear that there are significant limitations to deeper diving which will restrict duration and depth.

There are well-established solutions to these limitations, but these require additional training outside the scope of this course.

Gas

Diving with a twin-set provides a much larger gas supply and improves safety by adding redundancy, as the diver can access an alternative regulator and a greater reserve of gas if a problem occurs.

Rebreathers use gas very differently from open-circuit scuba. Because the breathing gas is recycled rather than exhausted, rebreathers are much more efficient and can support much longer dive durations.

Decompression

Nitrox can be used as a breathing gas to reduce decompression requirements for a given dive profile. This concept should already be familiar to all students taking this course.

Accelerated decompression uses very high oxygen-percentage nitrox mixes, such as 50% or 80%, or 100% oxygen to significantly reduce decompression time. These gases are normally carried in a separate decompression cylinder, and the diver switches to them only at depths shallower than their Maximum Operating Depth (MOD).

A rebreather continually adjusts and mixes the breathing gas to provide an optimal gas composition at all depths, rather than the diver switching between different cylinders.

Depth

The use of trimix to reduce narcosis has already been highlighted, but this can also be used to go deeper than the limitations of this course.

- **Open circuit mixed gas**
- **Rebreather mixed gas**

Accelerated Decompression

We can reduce the length of decompression stops by switching to a different gas when ascending.

Switch to a rich gas for stops

- **Typically nitrox 50 or 80, or 100% oxygen**

Limited by the MOD

The richer gas will have a much shallower maximum operating depth than the gas used for the main part of the dive. It is important that the diver is aware of the MOD, and does not exceed this.

Reducing the PNN_2

Rather than changing the depth to change the partial pressure of inspired nitrogen to decompress, we switching to a decompression gas with even less nitrogen in it.

Decompression is sped up not because of higher oxygen levels, but because switching to a gas with much less nitrogen increases the difference between the nitrogen in the breathing gas and the nitrogen in the body's tissues. This larger gradient allows nitrogen to leave the body more quickly.

Using a decompression gas like Nitrox 80 greatly reduces the amount of nitrogen you are breathing in - by almost 60% compared to air. This creates a much larger difference, or gradient, between the nitrogen in your body and the gas you're breathing, which helps your body off-gas nitrogen faster during decompression.

Switching to a high-oxygen decompression gas increases the difference between the nitrogen in your body and the gas you're breathing. This pulls nitrogen out of your tissues faster, so your body can get rid of it more quickly than if you stayed on your main dive gas.

Because the nitrogen leaves your body faster when using a high-oxygen decompression gas, the decompression stops can be shorter, reducing the overall time needed to safely surface.

Go back

Quiz 2

What are two methods to calculate the gas reserve?

What are the three stages considered during the minimum gas method of calculating reserve gas?

Answers on page 127

Summary

This module covered the following:

- ✔ **Review of gas consumption**
- ✔ **Calculating individual gas consumption**
- ✔ **Calculating the gas reserve for a dive**
- ✔ **Overcoming limiting factors**
- ✔ **Accelerating decompression**

Go back

End of module quiz

1. Why is gas planning more important for deeper dives?
2. What factors increase a diver’s gas consumption?
3. How does depth affect gas consumption?
4. What does SAC stand for and what does it measure?
5. Why is SAC considered an individual value?
6. What information is needed to calculate SAC?
7. What is the rule of thirds?
8. Why might the minimum gas method be preferred over the rule of thirds?
9. What are the three stages used in the minimum gas calculation?
10. Why does switching to a rich decompression gas shorten decompression time?

Answers on page 127

Decompression planning

Go back

Check out your eLearning video

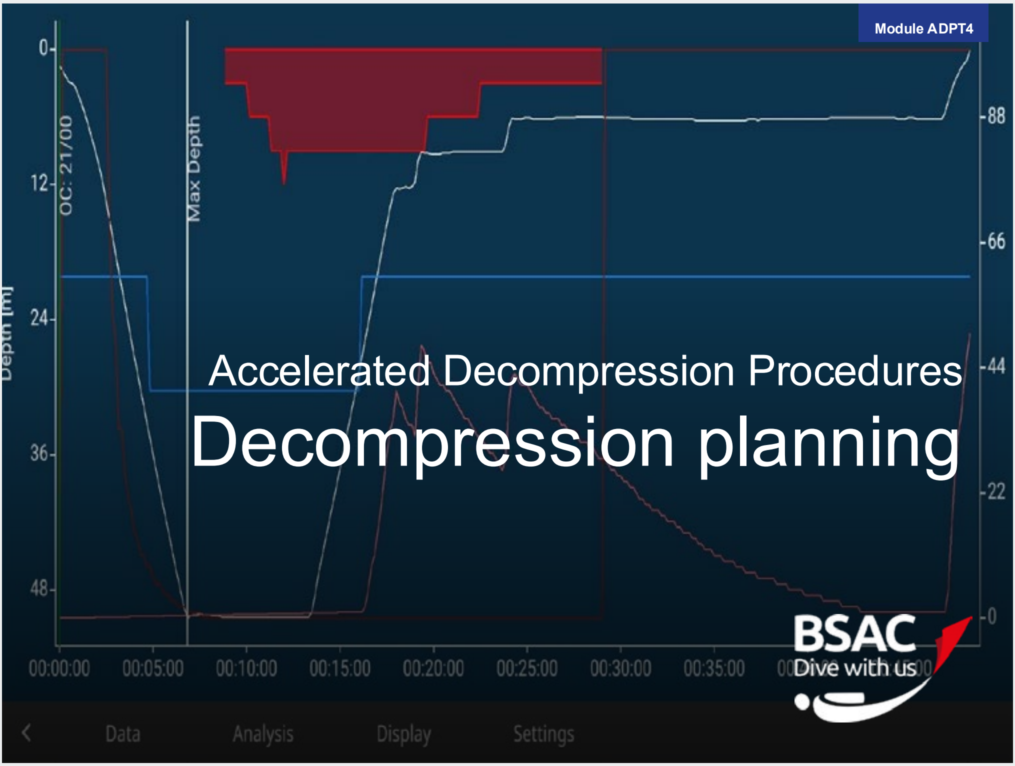
Decompression planning

Alex Warzynski is a BSAC National Instructor, he will take you through the first part of the video module.

Remember if you need to discuss any of the theory e-mail or call your instructor at your club or centre.

Video time length | 25:24 mins

Click the image below to start watching the video.



Go back

ADPT4 Decompression planning

Module objectives

This module builds on previous dive planning training to give you knowledge of other decompression planning tools and how to prepare run time slates.

Achievement targets

At the end of this lesson, students should:

- **Used the gas planning techniques from the previous lesson**
- **Have reviewed the use of BSAC 88 and nitrox tables**
- **Understand that there are many decompression models**
- **Know that gradient factors are a way of introducing additional conservatism**
- **Have experience of planning using dive computers and software tools**
- **Be capable of producing and reading run time slates**
- **Know how to use practical methods of oxygen exposure tracking**

Go back

Additional visual aids

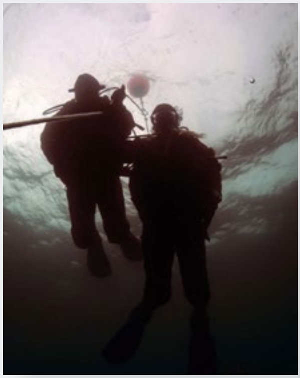
The following visual aids will be required to support this lesson:

- **BSAC 88, nitrox and ox-stop tables**
- **One or more dive computers with a planning function**
- **Dive planning software either on a computer or mobile device**
- **One or more run time slates**

Module contents

This module covers the following:

- **Using the dive limits from gas planning**
- **Planning with BSAC 88 and nitrox tables**
- **Decompression models and conservatism**
- **Alternative planning tools**
- **Run time slates**
- **Oxygen exposure**



Plan to gas limits

Instead of an iterative process of deciding the dive profile then finding out you don't have enough gas, the process is reversed. We work out the longest dive we can do on the gas available, then plan a shorter dive. This results in only one calculation.

Review available gas

First, work out the maximum dive time using back gas only. Use dive planning tools to calculate how long the dive can safely last based on the gas you are carrying, assuming you complete the entire dive on that single gas.

Next, calculate the maximum decompression time available from the decompression cylinder. Use dive planning tools to determine how long the decompression gas you are carrying can support decompression stops.

One plan iteration

Create a single planning iteration by choosing a dive profile that is slightly deeper and longer than the intended dive, but still within the limits of the available back gas. This provides a safety margin if the dive runs longer or deeper than planned.

Check that you have enough decompression gas by reviewing the amount of decompression required once you switch to the decompression mix. Make sure the cylinder you are carrying contains enough gas to complete all planned decompression stops safely.

Finally, generate the actual dive plan, making it slightly shallower and shorter than the earlier "deeper and longer" plan. This builds in an extra safety margin while keeping the dive within your gas limits.

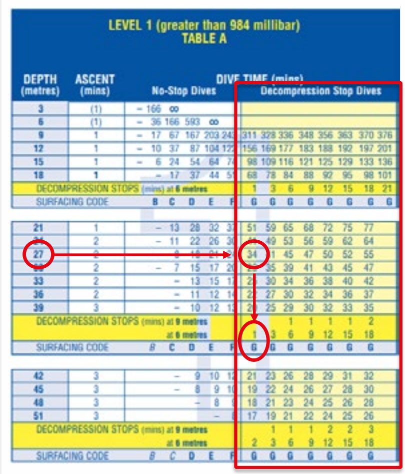
Go back

BSAC Table 88 revision

Divers should be familiar with the BSAC 88 and nitrox tables from previous training.

Using Level 1 tables work through the example below.

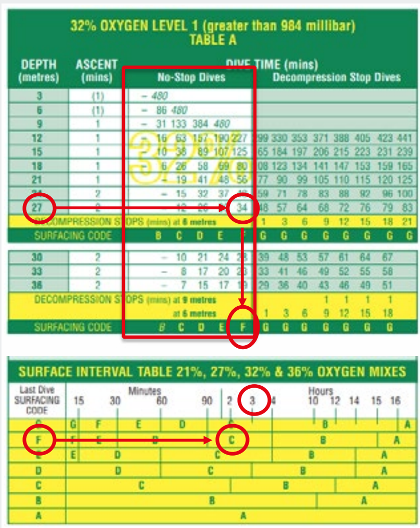
- **Example : Table A**
- **Depth 27 m**
- **Duration 34 mins**
- **Plan**
- **Stop required is 1 minute at 6m**
- **Surfacing Code is G**



BSAC Nitrox table revision

Using the Nitrox Decompression Tables, work through the example below. Ensure that the you clearly understand how to calculate Surfacing Codes and decompression stops.

The Surface Interval Table allows students to have practice in its application to calculate Current Tissue Codes for second dives.



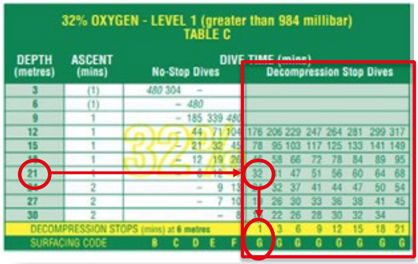
Go back

First Dive

- 26 m for 33 minutes using nitrox 32
- Surfacing Code is F
- Surface interval
- 3 hours
- Current Tissue Code is C

Second dive

- 20 m for 25 minutes using nitrox 32
- Stop required is
  1 minute at 6 m
- Surfacing Code is G



BSAC ox-stop tables

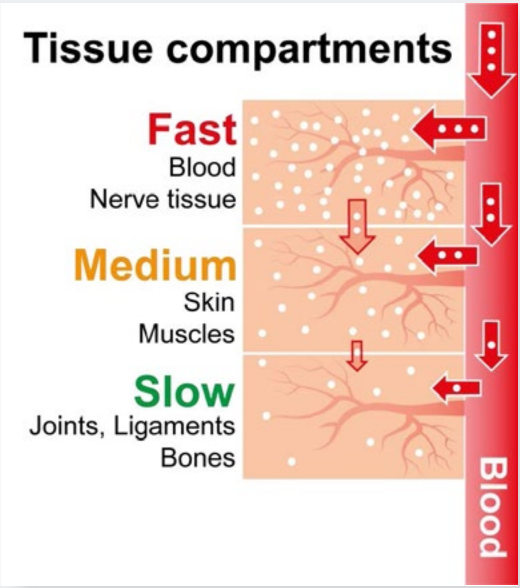
Identical format to nitrox tables

The ADP tables are laid out in the same format as standard nitrox tables, making them familiar and easy to use. The key difference is that each table includes an additional decompression gas, either 50% or 80% nitrox, to allow for accelerated decompression planning.

Like the nitrox tables the ox-stop tables are Level 1 only and there are no altitude transfer tables. Ox-stop tables are not included in this course but can be putchased from the BSAC shop.

Go back

Decompression models



All decompression planning uses mathematical models that are based on an imperfect understanding of how the body behaves while diving.

Perfusion models (Bühlmann)

Perfusion is the passage of blood through tissue, and other natural channels. Explanations for decompression based on gas transfer by perfusion were initially developed by John Scott Haldane in the early 20th century, and then refined by his successors. The most commonly used algorithms based on this model were created by Professor Albert Bühlmann.

Decompression models use multiple tissue compartments to represent how different types of body tissue absorb and release inert gas, such as muscle, fat, and the brain. Early models used only a few compartments, but modern models typically use 12 or 16, allowing for more accurate decompression calculations.

Different types of body tissue absorb and release gas at different rates. Each tissue compartment has a characteristic half-time, which is the time it takes to reach 50% saturation. These half-times range from just a few minutes for fast tissues to several days for slow tissues.

Go back

Decompression sickness (DCI) is thought to occur when the amount of inert gas in a tissue exceeds a safe limit, known as the M-value. Dive tables and computers that use perfusion models are designed to keep each tissue compartment below its M-value by requiring decompression stops at specific depths during the ascent.

Bubble models

Other theories that are used to explain and manage DCI can be grouped together and described as bubble models. Bubble theories form the basis of two well-known algorithms; the Variable Permeability Bubble Model (VPM) and Reduced Gradient Bubble Model (RGBM).

Studies have shown that larger bubbles forming in the body during or after a dive are linked to a higher risk of decompression illness (DCI). In general, bigger bubbles increase the chance of symptoms developing.

It is observed that bubbles grow when ambient pressure is reduced, but the additional squeeze from the bubble itself causes the gas to diffuse from inside the bubble into the solution in which they exist. This reduces their size.

Conservatism

Algorithm modifications allow different risk profiles to be applied to dives which allow divers to have their own approach to the risk of decompression illness. This approach may vary based on a diver's particular circumstances, which may include physiological factors, such as age and fitness, the nature of the dive or even the availability of post-dive medical treatment.

Some dive computers, generally the more basic or older models, offer levels of conservatism, set pre-dive by the diver.

Go back

Gradient factors (GF)

Gradient factors are one of the most common means of applying conservatism to the Buhlmann model. VPM and RGBM have their own methods to achieve the same result. If you are using a computer that supports gradient factors then you should use the following recommendations. An in-depth guide is available on the BSAC website.

Gradient factors are two numbers that help control your decompression stops. The first number (GF Low) decides how deep your first stop will be, and the second number (GF High) sets when it's safe to surface. As you ascend, the factor gradually increases from the first stop to the surface.

Gradient factors work together to shape your ascent. They adjust the maximum allowed tissue saturation (the M-value) at each depth, which in turn controls how your decompression stops are planned and how you safely reach the surface.

BSAC recommendations

BSAC Safe Diving contains recommendations for both the algorithm and gradient factors that should be used.

- **Bühlmann ZHL-16C algorithm**
- **85/95 for air/nitrox**
- **60/80 for trimix**
  The rationale for the differing GFs between trimix and air/nitrox is due to the types of diving undertaken using the respective gases. The rationale is that air/nitrox dives are generally shallower and shorter than those using trimix.

Simplified ADP planning

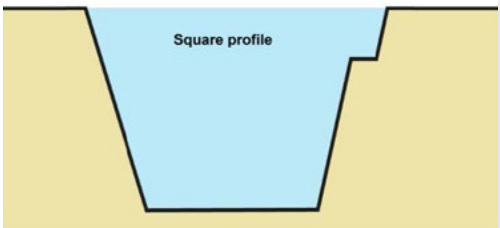
To ensure decompression dives are effectively planned, ADP planning is simplified to help divers plan the dives every time.

Always plan your dive assuming you will use only your backgas. This way, you'll be sure there's enough gas to complete the dive and get back to the surface safely. This covers the scenario whereby you do not have enough decompression gas to complete the dive using that.

Using a rich decompression gas can speed up your decompression stops, letting you finish the dive and get out of the water faster or be used as an additional safety margin.

Dive profiles

Square



Previous courses have used tables for dive planning. These assume that dives follow a 'square' profile.

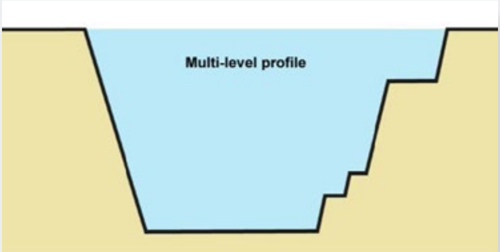
- **Single depth**

Square profile dives assume that the diver descends to the maximum depth of the dive and then remains there until they start the ascent. The diver then ascends at the maximum ascent rate until they reach any decompression or safety stops.

Square profile dives are easy to plan because the diver stays at a constant depth for most of the dive. Since divers usually don't stay at the maximum depth the whole time, planning this way naturally adds a safety margin for both decompression and gas consumption.

Go back

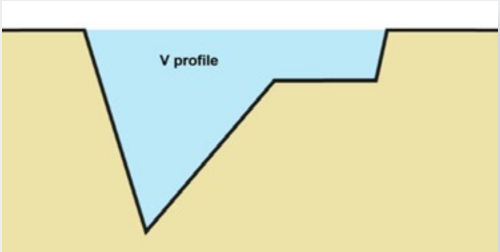
Multi-level



The alternative to square profiles are multi-level dives.

A multi-level dive means the diver starts at the maximum depth, then gradually ascends to shallower depths in steps, spending some time at each level before moving up again. This can be repeated as needed throughout the dive.

V (bounce)



A V (bounce) dive is an extreme type of multi-level dive where the diver quickly reaches the maximum depth and then ascends almost continuously. Such as on a reef. These dives are more complex to plan, so they usually need dive computers or software to help with planning.

Run time slates

Run time slates are used to record the dive plan and are then consulted during the dive to ensure it is progressing as planned.

Go back

Plans

Previous training emphasised the importance of having multiple plans to cover eventualities, such as exceeding the maximum planned depth. This is still important regardless of which planning tool is used.

It is normal to produce the plans listed below.

- **Deeper and longer no deco gas**
  Where the decompression gas is unavailable, then the dive can be planned to be completed on the backgas alone.

- **Deeper and longer**
  A single slate can be used to cover the three potential situations of a diver exceeding depth, exceeding time or exceeding both depth and time. The exact parameters on which the deeper and longer plan is based are chosen based on individual preferences and assessment of the risk. Two common options are 3 metres deeper/3 minutes longer or 2 metres deeper/2 minutes longer.

- **Dive plan**
  This is the plan for the dive.

Columns

The run time slate needs to be in a clear an unambiguous format.

- **Depth**
  The depth for each stage of the dive.

- **Stop time**
  The duration spent at each depth.

- **Run time**
  This is the time the diver needs to leave that particular depth.

- **Gas used**
  The slate should identify the breathing gas to be used. This becomes more important when dives with multiple gases are used.

Quiz 1

What is the BSAC recommended dive computer settings for an ADP dive?

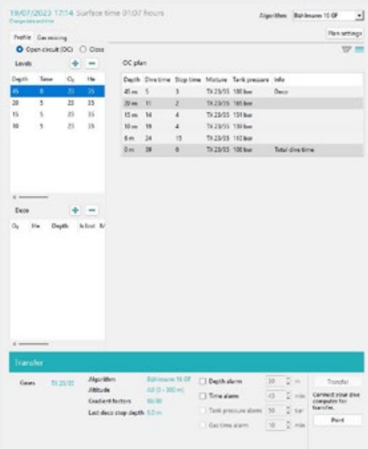
How do we make a simple plan for an ADP dive?

What does the run time column on a run time slate show?

Answers on page 128

Decompression planning

During previous training, dive planning has been carried out using tables, but there are many other options available. When selecting a tool to support dive planning, it is important that the underlying assumptions and settings are fully understood to ensure that it is compatible with the planned dive profile and any dive computer(s) being used.



Go back

Multiple planning tools

- **Tables**
  Previous training used the BSAC 88 and nitrox tables to plan dives and this was reviewed at the beginning of this lesson. Other agencies and organisations also produce diving tables, although relatively few provide the same level of detail.

- **Dive computers**
  Most dive computers offer a planning function, although the exact capabilities can vary considerably and are discussed more later in this lesson.

- **Software**
  There are many different programmes available across various platforms, including computers, tablets and mobile phones. The latter means that dive planning can easily be done on the dive site.

Settings and assumptions

All planning tools will have settings that are relevant to the dive. Sometimes these can be adjusted, but often they are fixed.

Not surprisingly, it is important to understand the underlying settings, as failure to follow these during the dive may create an unexpected and unpleasant surprise.

No matter which planning tool you use, it's important to understand the algorithm it relies on to calculate decompression requirements. It is best to use one that matches your dive computer, so you know what to expect. If you are going to use a slate to control your runtime, then matching your dive computer will prevent a potential lockout. For example, Suunto can lock out if a deeper stop is missed on trimix.

Go back

Ascent and descent rates can vary, but typically divers ascend at 8 - 18 metres per minute.

The final decompression stops are usually around 6 metres, but in some cases they may be as shallow as 3 metres.

Compatibility

Not all planning tools are compatible with each other or individual dive computers, so it is important to understand them before they are used. An excellent example is that BSAC dive tables assume an ascent rate of 15 metres per minute (to the first stop), whereas most modern dive computers use 10 metres per minute.

Taking time to ensure that the planning tool that you and your buddy use are compatible with each other will ensure you generate similar dive profiles.

Planning with dive computers

Most dive computers have some form of built-in planning tool.

Decompression plan

Some recreational dive computers, especially those designed for general use, only create no-decompression dive plans. They show the maximum time you can spend at a given depth before decompression stops would be required.

More advanced dive computers can create decompression dive plans. You enter the gases you'll use, the planned depth, and the dive time, and the computer calculates a plan showing all the decompression stops needed for that dive.

If your decompression gas becomes unavailable, some dive computers can create a backup plan showing the longer dive profile using only your main backgas.

Some dive computers have a "look forward" function, which lets you plan future dives by taking into account your current tissue gas loading, so the next dive is calculated safely.

Most modern dive computers can handle nitrox, but if you're diving with trimix, it's important to ensure your computer supports it as well.

Other information

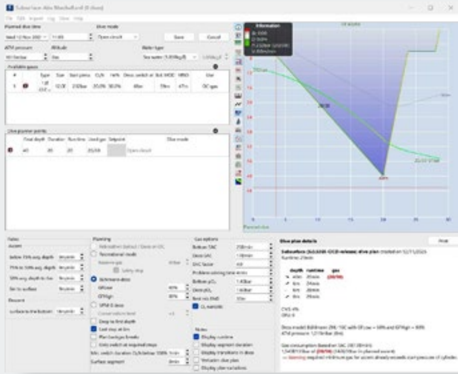
Dive computers can also be used to produce other information that may be useful.

Some dive computers can track oxygen toxicity levels, including CNS toxicity and UPTD/OTU values, and can even predict how these levels will change during or after a dive.

Some dive computers can estimate your gas consumption, helping you plan how much gas you will use during the dive.

Go back

Planning with software



Software tools suitable for dive planning are available for all types of devices, including phone, tablet and computer. Some of these are produced by dive computer manufacturers, so are guaranteed to be compatible with them.

Features

Dive planning software is often more capable than dive computers, offering extra features and flexibility. When run on handheld devices, it's easy to take to the dive site and use there, although weather conditions may sometimes limit its use.

Most dive planning software makes contingency planning straightforward. You can adjust many settings to create a plan tailored to the diver and quickly see how different scenarios or emergencies would affect the dive.

Very few dive tables or computers can handle multi-level dive planning, so using software tools is usually the easiest and most reliable way to plan these dives.

Considerations

Complexity: dive planning software often has many configuration options. While this allows for flexible and detailed planning, it can also make the software complicated to use.

Cost and support: Like any software, dive planning tools may require payment to purchase and for updates or technical support.

Additional considerations

Dive computer compatibility

Almost all divers will be using dive computers, and failure to check they are compatible with the plan can create lots of confusion underwater.

A good way to check dive computer compatibility is to use the dive planning facility on them to see if it produces similar plans to whatever other tool is used.

Before relying on a dive plan, check that it's compatible with your dive computer by confirming key settings, including the breathing gas, ascent rates, decompression algorithm, depth of decompression stops, and conservatism settings.

Within a buddy team, it's important that all divers' dive computers are compatible with each other to ensure everyone follows a consistent plan and avoids confusion underwater.

Ascent rates

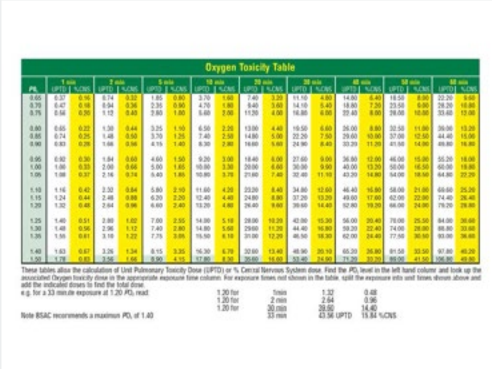
Every dive plan assumes a specific ascent rate. If a diver rises too slowly, they won't follow the planned schedule, which means their body will absorb more nitrogen than expected. This extra absorption increases the risk of decompression illness (DCI), so it's important to stick to the recommended ascent rate.

Divers need to ascend at the correct rate. Going up too quickly can be very dangerous, leading to an uncontrolled ascent or lung over-expansion injury. It's important to keep the ascent steady and controlled to stay safe.

Go back

Monitoring oxygen exposure

When diving with gases with an elevated fraction of oxygen, it is important to track our exposure.



Oxygen Toxicity Table

PO_2	1 min UPTD	1 min %CNS	2 min UPTD	2 min %CNS	5 min UPTD	5 min %CNS	10 min UPTD	10 min %CNS	20 min UPTD	20 min %CNS	30 min UPTD	30 min %CNS	40 min UPTD	40 min %CNS	50 min UPTD	50 min %CNS	60 min UPTD	60 min %CNS
0.65	0.37	0.16	0.74	0.32	1.85	0.80	3.70	1.60	7.40	3.20	11.10	4.80	14.80	6.40	18.50	8.00	22.20	9.60
0.70	0.47	0.18	0.94	0.36	2.35	0.90	4.70	1.80	9.40	3.60	14.10	5.40	18.80	7.20	23.50	9.00	28.20	10.80
0.75	0.56	0.20	1.12	0.40	2.80	1.00	5.60	2.00	11.20	4.00	16.80	6.00	22.40	8.00	28.00	10.00	33.60	12.00
0.80	0.65	0.22	1.30	0.44	3.25	1.10	6.50	2.20	13.00	4.40	19.50	6.60	26.00	8.80	32.50	11.00	39.00	13.20
0.85	0.74	0.25	1.48	0.50	3.70	1.25	7.40	2.50	14.80	5.00	22.20	7.50	29.60	10.00	37.00	12.50	44.40	15.00
0.90	0.83	0.28	1.66	0.56	4.15	1.40	8.30	2.80	16.60	5.60	24.90	8.40	33.20	11.20	41.50	14.00	49.80	16.80
0.95	0.92	0.30	1.84	0.60	4.60	1.50	9.20	3.00	18.40	6.00	27.60	9.00	36.80	12.00	46.00	15.00	55.20	18.00
1.00	1.00	0.33	2.00	0.66	5.00	1.65	10.00	3.30	20.00	6.60	30.00	9.90	40.00	13.20	50.00	16.50	60.00	19.80
1.05	1.08	0.37	2.16	0.74	5.40	1.85	10.80	3.70	21.60	7.40	32.40	11.10	43.20	14.80	54.00	18.50	64.80	22.20
1.10	1.16	0.42	2.32	0.84	5.80	2.10	11.60	4.20	23.20	8.40	34.80	12.60	46.40	16.80	58.00	21.00	69.60	25.20
1.15	1.24	0.44	2.48	0.88	6.20	2.20	12.40	4.40	24.80	8.80	37.20	13.20	49.60	17.60	62.00	22.00	74.40	26.40
1.20	1.32	0.48	2.64	0.96	6.60	2.40	13.20	4.80	26.40	9.60	39.60	14.40	52.80	19.20	66.00	24.00	79.20	28.80
1.25	1.40	0.51	2.80	1.02	7.00	2.55	14.00	5.10	28.00	10.20	42.00	15.30	56.00	20.40	70.00	25.50	84.00	30.60
1.30	1.48	0.56	2.96	1.12	7.40	2.80	14.80	5.60	29.60	11.20	44.40	16.80	59.20	22.40	74.00	28.00	88.80	33.60
1.35	1.55	0.61	3.10	1.22	7.75	3.05	15.50	6.10	31.00	12.20	46.50	18.30	62.00	24.40	77.50	30.50	93.00	36.60
1.40	1.63	0.67	3.26	1.34	8.15	3.35	16.30	6.70	32.60	13.40	48.90	20.10	65.20	26.80	81.50	33.50	97.80	40.20
1.50	1.78	0.83	3.56	1.66	8.90	4.15	17.80	8.30	35.60	16.60	53.40	24.90	71.20	33.20	89.00	41.50	106.80	49.80

These tables allow the calculation of Unit Pulmonary Toxicity Dose (UPTD) or % Central Nervous System dose. Find the PO_2 level in the left hand column and look up the associated Oxygen toxicity dose in the appropriate exposure time column. For exposure times not shown in the table, split the exposure into unit times shown above and add the indicated doses to find the total dose.

e.g. for a 33 minute exposure at 1.20 PO_2 read

1.20 for	1min	1.32	0.48
1.20 for	2 min	2.64	0.96
1.20 for	30 min	39.60	14.40
	33 min	43.56 UPTD	15.84 %CNS

Note BSAC recommends a maximum PO_2 of 1.40

CNS toxicity

The BSAC oxygen toxicity table can be used to track how long a diver has been exposed to high-oxygen partial pressure. By using the table, divers can calculate their oxygen exposure and make sure they stay within safe limits.

Generating plans on dive planning software and dive computers will show the expected oxygen exposure if the dive follows that plan. During the dive, dive computers track the actual oxygen exposure in real time.

Using the oxygen toxicity table

This is a revision of the technique taught in the nitrox course.

- **Find the PO_2 in the left hand column**
- **Find the time spent at that PO_2 along the top row**
- **Where lines bisect indicates CNS and UPTD uptake**

CNS% should not exceed 80%

UPTD should not exceed 300 in 24 hours

This is a rolling 24 hours – any UPTD accrued more than 24 hours ago can be disregarded

Go back

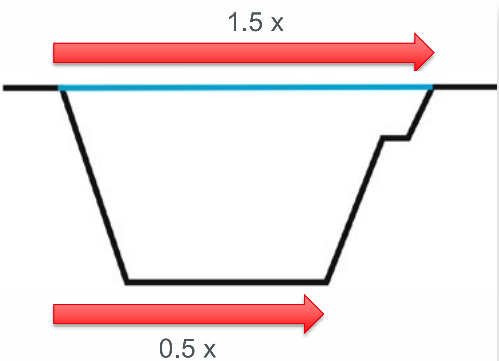
While at the surface

The CNS percentage drops by half every two hours. For example, if a diver's CNS is 30% when they surface, it will fall to 15% after two hours.

Any remaining CNS percentage from a previous dive should be added to the next dive. For example, if a diver has 15% leftover from a previous dive and the next dive adds 30%, the total CNS exposure for that dive is 45%.

Practical oxygen tracking

ADP diving unlikely to approach limits



For the exposures normally encountered on ADP type dives, it is unlikely that the limits will be breached

In practice, the CNS limits would only be reached during multiple long dives with high oxygen exposure carried out over several days.

A good rule of thumb for nitrox mixes assumes the diver has selected the ideal nitrox mix for the planned depth and also has a rich decompression gas available.

- **CNS = 0.5 x bottom time**
  The CNS percentage is half the time from leaving the surface to starting the ascent.
- **UPTD = 1.5 surface to surface time**
  The UPTD value is 1.5 times the whole dive time

Quiz 2

What are 3 settings/assumptions that should be checked when using a dive planning tool?

Using the rule of thumb, what would be the CNS and UPTD for a bottom time of 40 minutes and a total dive time of 50 minutes?

Answers on page 128

Summary

- ✔ This module covered the following:
- ✔ Using the dive limits from gas planning
- ✔ Planning with BSAC 88 and nitrox tables
- ✔ Decompression models and conservatism
- ✔ Alternative planning tools
- ✔ Run time slates
- ✔ Oxygen exposure

Go back

End of module quiz

1. What is meant by “planning to gas limits”?
2. Why should a dive always be planned so it can be finished on backgas?
3. What are BSAC 88 tables used for?
4. What is the difference between square profile dives and multi-level dives?
5. What is a decompression model?
6. What are gradient factors and why are they used?
7. When using a computer that uses gradient factors, what values does BSAC recommend for air nitrox dives?
8. What information is recorded on a run time slate?
9. Why is compatibility between dive planning tools and dive computers important?
10. How can oxygen exposure be monitored during ADP dives?

Answers on page 129

Go back

Equipment and procedures

Go back

Check out your eLearning video

Equipment and procedures

Alex Warzynski is a BSAC National Instructor, he will take you through the first part of the video module.

Remember if you need to discuss any of the theory e-mail or call your instructor at your club or centre.

Video time length | 21:04 mins

Click the image below to start watching the video.

Go back

ADPT5 Equipment and procedures

Module objectives

This module outlines the additional equipment and procedures required to carry out an ADP dive safely.

Achievement targets

At the end of this lesson, you should:

- **Understand they need to consider what happens if their main backgas supply fails**
- **Different types of decompression cylinders and how to carry them**
- **The Golder Rules of nitrox and ADP diving**
- **Procedures to safely carry and switch to a rich decompression gas**

Additional visual aids

While not essential, having a real decompression cylinder available would enhance the lesson.

Module contents

This module covers the following:

- **Backgas redundancy**
  If our main diving gas fails, we need a backup to breathe at depth. We cannot use our decompression cylinder as a redundant gas source.
- **Decompression cylinders**
  Different types of cylinders and how to rig and carry them.
- **Golden rules of nitrox and ADP diving**
  Simple rules to follow when carrying out ADP dives.
- **ADP procedures**
  Procedures to follow when carrying a potentially toxic gas at depth to ensure safe gas switching.

Back gas failure

Modern diving equipment means that a failure is less likely to happen, especially if equipment is well maintained and serviced according to the manufacturer's recommendations.

Primary regulator failure modes

- **Freeflows**
  A freeflow is when a regulator releases gas continuously, even when the diver is not breathing. While basic training teaches how to breathe from a freeflowing regulator, this is only a short-term solution because the gas supply will run out quickly. Freeflows can happen for two main reasons. In cold water, the regulator can freeze open due to gas expansion, so divers should use regulators rated for cold conditions and avoid heavy breathing on the surface. The second cause is a faulty regulator, which may result from a first stage failure that increases inter-stage pressure or a problem in the second stage mechanism.

- **Burst hose**
  Hoses in diving equipment have a limited service life and gradually wear out over time. If a hose bursts, it can cause a rapid loss of gas, putting the diver at risk of running out of air quickly. Regular inspection and maintenance are essential to prevent this from happening.

  Divers should also regularly check that all hoses are 'nipped up' into the first stage. Most manufacturers recommend a torque of 4.5Nm - 'nipped up' is tight enough and will not damage the first stage.

- **O-ring failure**
  O-rings are small, simple, and inexpensive components, but they need proper care. They sit in a groove and create a seal, and because they are made of soft rubber, they can wear out over time. If an O-ring fails, it can cause leaks in the equipment, so regular inspection and replacement are important.

  Extruded O-rings happen when the O-ring is pushed out of its groove and fails suddenly. This is more common on A-clamp regulator fittings and can also occur if a hose is loose or not fully tightened. To prevent this, make sure the A-clamp fitting fully covers the valve O-ring or use a DIN-style regulator.

Shredded O-rings happen when the material or hardness is unsuitable for the job. Using an O-ring that is too soft or made from the wrong material can cause it to become damaged or tear easily. Using an O-ring or O-ring grease that is not nitrox compatable could pose a fire risk.

- **Unseated first stage**
  A first stage can become unseated if a DIN fitting is accidentally unscrewed, or if an A-clamp first stage is knocked out of alignment.
- **First stage failure**
  First stages are designed to fail in the open position, as the interstage pressure normally keeps them closed. It is rare for a first stage to fail closed, but if it does, the gas supply will suddenly stop.
- **Bad fill**
  Pre-dive checks can help detect a bad fill, which is usually noticed by a taste test. If a diver begins to experience symptoms from a bad fill, often due to carbon monoxide contamination, the entire cylinder of gas must be considered unusable.

Immediate options

If the main breathing gas supply fails, then the priority is for the diver to obtain a backup supply immediately.

Use buddy's AS

All divers are already trained to use their buddy's alternative source. The buddy should set it up so that it is within easy reach, in the "triangle of access," and clearly identifiable.

Go back

If the buddy is not nearby when a diver runs out of gas, the diver will have to swim to them while under stress to reach the alternative source.

Switch to own independent backup

A pony cylinder is a small backup cylinder that provides only a limited supply of gas. For deeper dives, it may not contain enough gas to allow a full safe ascent.

A twinset gives the diver a lot more backup gas. The diver can switch to the backup regulator, and if the twinset is connected with a manifold, they can isolate one cylinder if needed. However, if the gas failure is due to a bad fill, both cylinders may be affected.

Cannot use deco cylinder

If a diver’s main gas fails while at depth, they must switch to a backup backgas source. They should not breathe the decompression gas at that depth because its oxygen level would be too high and could be toxic.

Regulator identification

As the diver is carrying a gas that may be toxic at depth, it is critical that the regulators are very well differentiated from each other. There have been several incidents where a diver has taken the incorrect regulator and breathed either a toxic gas below the MOD, or missed decompression stops as they have not switched to their deco gas.

Differentiate from backgas regulator

- **Location**

  The regulators for your main back gas and your decompression gas should be kept in separate locations. This prevents confusion and ensures you don't accidentally grab the wrong regulator during the dive.

  The alternative source (AS) should be stored in a prominent spot within the "triangle of access." This makes it easy for your buddy to grab quickly in an emergency and ensures it isn't confused with the decompression regulator.

  A bungee necklace can be used to keep the backup regulator close to the diver's neck, making it quick and easy to reach. Since the backup regulator is now with the diver, an out-of-gas buddy may need to use the donor's main regulator instead. This "primary donate" technique requires practice and is taught in the BSAC Primary Donate workshop.

  The decompression gas regulator must be clearly identified and easy to spot, so it is never confused with the main back gas regulator. This is important because the deco gas can be toxic if used below the MOD.

  If the decompression gas cylinder is carried at the diver's side, securing the regulator to the cylinder makes it easy to identify and prevents it from being confused with the back gas regulator.

  If the decompression gas is carried on a less accessible cylinder, the regulator should be stowed away from the back gas regulators so it is clearly separate and not easily confused with them.

  The decompression gas regulator can be made easy to identify and kept separate from the back gas regulator by using different features or markings.

Go back

- **Features**
  Using colour is one way to identify a decompression gas regulator. Different coloured bodies or faceplates can help show that it is for deco gas. However, colours can be hard to see underwater of the way light is absorbed, so this should not be the only method of identification.

  The shape of a regulator can help identify it as a decompression gas regulator. For example, using a different style, such as a non-handed regulator, makes it clear that it is for deco gas.

  A small snoopy loop can be added to the mouthpiece of the deco regulator. It doesn't affect airflow and can be easily removed with gloves. When the diver puts the regulator in their mouth, they can feel the loop and immediately know by touch that it is for decompression gas.

Decompression gas cylinders

Cylinders can be made from steel, aluminium or even carbon fibre. The way they are carried and used will affect the diver's buoyancy, trim and balance.

Rear mounted

Usually clamped to the side of the main breathing gas cylinder and may be inverted for access to the cylinder valve.

The decompression gas cylinder is carried as part of the diver's main kit, integrated with the rest of the equipment.

Carrying the decompression cylinder as part of the main unit adds extra weight and can make the diver unbalanced in the water. To compensate, additional weight may need to be added on the opposite side.

Having the decompression cylinder attached makes it harder to swap out the main cylinder between dives because the deco cylinder must be removed first, which can be inconvenient.

Regulators must be clearly and reliably identified. There have been several incidents where divers used the wrong regulator. Since the regulators are accessed from the rear of the diver, it is essential that each one can be unmistakably identified to ensure the correct gas is used.

Side mounted

A more common method is to have the decompression cylinder mounted to the side of the diver.

These regulators can be fitted separately from the main cylinder. Because they are not attached to the primary setup, they can be carried to the water and connected after entering, which makes handling much easier.

Aluminium cylinders are more neutral in the water, so they cause less imbalance for the diver. Steel cylinders are heavier and can make the diver feel unbalanced.

Stowing the regulators on the cylinder makes them easy to identify. The diver can follow the hose from the mouthpiece back to the first stage to make sure they are using the correct cylinder.

Go back

Valve types

ISO 12209-2 (DIN)

Commonly known as DIN connections, these are recommended for use due to the following:

- **Enclosed O-ring**
  The regulator has an O-ring seated in a machined groove. When the first stage is fully screwed in, the O-ring is completely enclosed, which reduces the chance of it being pushed out or leaking compared to an A-clamp (yoke) setup. If a leak does happen, it is usually slower and less serious. Since the O-ring is part of the regulator and not the cylinder, divers tend to take better care of it as it is on a more delicate part of the equipment.

- **Less vulnerable to impact**
  When the first stage is fitted directly to the cylinder, it forms a more secure and robust assembly that is less vulnerable to knocks and impacts. In contrast, an A-clamp valve can be pushed or knocked out of position on the cylinder valve, which may result in a sudden and catastrophic loss of gas.

- **Compact**
  DIN regulators are more compact than A-clamp designs. The clamping handle on an A-clamp regulator tends to protrude, which increases the risk of snagging and impact. It can also be easily confused with the cylinder valve handle when manipulating valves, particularly when the valve cannot be seen, increasing the chance of incorrect operation.

- **M26 Nitrox valves**
  M26 nitrox valves are defined by the BS EN 144-3 standard and are intended for use with oxygen-enriched gases. They can be found in use in some EU countries. In the UK, however, the M26 standard has not been widely adopted and most nitrox diving continues to use standard DIN fittings.

  Although an M26 valve looks similar to a DIN outlet, it uses a different thread form, meaning the two systems are not compatible. A standard DIN regulator will not fit an M26 valve, and vice versa. When diving abroad and renting cylinders, it is important to check the valve outlet type in advance to ensure it is compatible with the diver's regulators, or that suitable adaptors are available.

Handed valves

- **Left and right-handed versions**
- **Dedicated or blanked manifolded**

Handed valves are available in left- and right-handed versions, allowing regulators and hoses to be routed neatly and consistently. They can be manufactured as dedicated handed valves, or created from manifolded twin-set valves where the manifold has been removed and the exposed ports have been securely blanked off. This provides flexibility in configuration while maintaining correct hose routing and access.

Valve quality

When manipulating valves, ease of movement is important because it reduces the effort required to turn the valve handles. A good quality, well-maintained valve should be easy to operate with just the fingertips. In contrast, a poor quality or poorly maintained valve can be stiff and difficult to turn, increasing workload and stress, especially during an emergency.

Go back

Handle design also plays a significant role. Longer handles made from rubber are generally preferred because they are easier to grip when wet or when wearing gloves. Rubber handles are also more resistant to impact, whereas plastic handles can be slippery and may crack or break if struck. Most cylinder valves allow the handles to be changed, making it straightforward to upgrade to a more suitable design.

Labelling

When using any diving gas that is not air, analysis and cylinder labelling is extremely important. There have been incidents where divers have breathed gases from cylinders that have been either incorrectly labelled, or not at all.

MOD the most important

Make the Maximum Operating Depth the most prominent piece of information on the cylinder. When in the water, this needs to be easily read by the diver and their buddy.

The cylinder should be clearly labelled around the neck so that it can be read by the diver while wearing it. This allows the diver to easily confirm the gas mix before use, reducing the risk of breathing the wrong gas, particularly during gas switches or in low visibility conditions. For a cylinder carried on the diver’s side, the cylinder neck can be read. This should carry at least the MOD and gas mix.

The body of the cylinder should also be clearly labelled so it can be read by the buddy. This allows the buddy to easily confirm the maximum operating depth, helping to ensure that the gas about to be breathed is appropriate and safe for the depth, particularly during gas switches or when assisting another diver.

Large, prominent numbers should be used on cylinders so they can be read easily underwater and quickly identified on the surface among a group of cylinders. Clear, bold markings reduce the risk of confusion, especially in low visibility or stressful situations. Larger numbers also provide resilience, as they can still be recognised even if they are partially damaged or worn, ensuring the cylinder remains identifiable and safe to use.

Labels should be written in a way that prevents confusion. Numbers such as 6 and 9 can easily be mistaken for each other if the cylinder is rotated or viewed from an unusual angle. Adding an underscore beneath the number makes its orientation clear and removes any ambiguity. This simple step helps ensure the correct gas and MOD are identified, even when the cylinder is not in the same position as when the label was applied.

The MOD is the most important information on the cylinder and should be written in large, clear text so it can be easily read underwater. Other details such as the gas mix, date of analysis and the diver's name are still important but do not need to be readable at depth, so they can be written in smaller text without reducing safety.

Go back

Quiz 1

How can backgas and deco regulators be differentiated from each other?

Why are DIN valves preferred?

What is the most important marking on a decompression cylinder?

Answers on page 130

Golden rules

There are some simple rules to follow for every nitrox dive, and every ADP dive.

Apply to all nitrox dives

The following two rules should always be followed for a nitrox dive

- **Always analyse your gas**
  Every cylinder should be analysed before use. The gas should be checked when the cylinder is filled and again just before the dive to ensure it is correct and safe to breathe. Cylinder contents should be clearly labelled, and the label should remain in place until the cylinder is empty or has been refilled and reanalysed.

- **Never exceed the MOD**
  The gas can become potentially toxic if the Maximum Operating Depth (MOD) is exceeded, so the diver must take care not to go

deeper than this limit. The cylinder should be clearly marked with the MOD on the neck and repeated on the body in large text. Underwater, it should be easy for both the diver and buddy to see and confirm the MOD.

Apply to ADP dives

- **Always know what you are breathing**
  Because the diver is carrying a gas that can be toxic at depth, they must always be certain which cylinder they are breathing from. Following a robust, well-practiced gas switching procedure will help prevent accidentally using the wrong gas.
- **Plan assuming backgas only**
  Plan the dive assuming the worst case that only the backgas will be available. This ensures that if the decompression gas runs out or is unavailable, there will still be enough backgas to complete the dive safely. Using the rich decompression gas is an added benefit that can shorten the decompression stops.

  Simple gas planning makes the dive plan easy to create and ensures it is not overlooked. By keeping the planning straightforward, divers are more likely to follow it correctly and safely.

Switching gases

Signal to your buddy to double check the switch is safe. Use the mnemonic **DEPTHS.**

Ideally, we should use our buddy to confirm the gas switch to get an independent check that the gas is safe to breathe. You should signal that a gas switch is to take place. Your buddy should concentrate on staying still to provide a depth datum while you perform the gas switch.

- **Depth check**
  Use instrumentation to check the depth is shallower than the MOD of the deco gas.
- **Examine the cylinder**
  Read the MOD from the labelling, check you are shallower than this.
- **Permission from buddy**
  Show the cylinder to the buddy so they can read the MOD label and authorise the switch with a clear OK signal.
- **Turn on gas**
  Open the cylinder valve fully.
- **Hose route check**
  Deploy and route the hose, trace the hose from the second stage back to the cylinder valve to confirm it is the regulator connected to the deco cylinder.
- **Switch**
  Remove your backgas regulator and insert the deco regulator. Switch gas on your computer when all divers have switched gases.

Running out of deco gas

Plan the dive to use backgas only

If correctly planned by generating a Deeper and Longer plan without a deco gas, then doing an actual dive that is shallower and shorter using a deco gas, then there should be plenty of gas for the dive.

Go back

- **Monitor deco gas usage**
  While decompressing, regular gas checks should be made to monitor usage and predict if the gas will run out.
- **Inform buddy**
  If you need to switch back to your backgas, signal to your buddy that the switch needs to be made so they can authorise the switch and help if required.
- **Switch back to backgas when nearly exhausted**
  At around 40 bar or so, switch back to backgas. While gauges can indicate a lower pressure than this, they are unreliable at the extremities of the scale and may be indicating a pressure higher than the actual gas pressure. Exhausting a cylinder completely must be avoided as this will create a stressful out of gas situation, and may lead to flooding of the cylinder causing regulator and cylinder damage.
- **Switch computer to backgas**
  Once the switch has been made back to backgas, switch the dive computer back to the main backgas supply and tidy up the deco regulator back into stowage.
- **Complete dive on backgas**
  Complete the remainder of the decompression on the backgas as indicated by the dive computer.
- **Use buddy's deco gas?**
  This is a more complex procedure and needs good buoyancy control, practice, and the ability to program your dive computer with their gas details. In relatively benign conditions it may be possible, but it is simpler to finish the dive on your own gas.

Go back

If using tables

Simple gas planning makes the dive plan easy to create and ensures it is not overlooked. By keeping the planning straightforward, divers are more likely to follow it correctly and safely.

Quiz 2

What are the golden rules of nitrox diving?

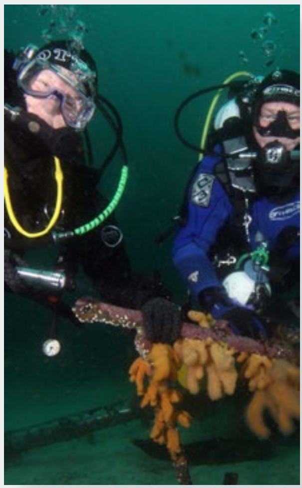
What are the golden rules of ADP diving?

When should you switch gases on your computer?

Answers on page 131

Summary

- ✔ **This module covered the following:**
- ✔ **Back gas redundancy**
- ✔ **Decompression cylinders**
- ✔ **Golden rules of nitrox and ADP diving**
- ✔ **ADP procedures**



End of module quiz

1. Why is backgas redundancy required for ADP dives?
2. Why must a decompression cylinder not be used as a backup gas at depth?
3. What are common causes of backgas regulator failure?
4. What are the immediate options if a diver loses their main gas supply?
5. Why is a twinset preferred over a pony cylinder for deeper diving?
6. Why must backgas and decompression regulators be clearly differentiated?
7. What are some methods used to identify a decompression regulator?
8. Why are DIN valves preferred for ADP diving?
9. What is the most important information that must be clearly marked on a decompression cylinder?
10. What does the mnemonic DEPTHS help divers remember?

Answers on page 131

Go back

End of module quiz answers

BSAC
Dive with us

Go back

ADPT1

Quiz 1 answers

1. Your existing qualification depth
2. A maximum of 100% oxygen

Quiz 2 answers

1. Maximum operating depth
2. You should:
   - Check there is adequate lift to support the diver at the surface
   - Confirm weight and trim with a shallow check dive
   - Check neutral buoyancy can be maintained with low gas

End of module quiz answers

1. The aim of the ADP course is to teach divers how to safely accelerate decompression using a rich nitrox decompression gas.
2. No. ADP does not increase your maximum depth. You may only dive to the depth allowed by your existing qualification.
3. Only open-circuit scuba equipment is allowed. Closed-circuit and semi-closed rebreathers are not permitted.
4. Because decompression gases can be toxic at depth. Breathing the wrong gas could cause serious injury or loss of consciousness.

Go back

5. A maximum of 1.4 bar PO_2, or up to 1.6 bar if the diver is shallower than 10 metres, in line with UK HSE regulations.
6. Planning ensures the dive can be completed safely with the available gas, covers contingencies, and reduces the chance of problems during the dive.
7. To confirm the actual oxygen content of the gas, ensure it matches the label, and calculate the correct Maximum Operating Depth.
8. The Maximum Operating Depth (MOD), so both the diver and their buddy know the deepest safe depth to breathe that gas.
9. ADP dives carry increased risk, so critical systems like gas supply, buoyancy, and instrumentation must have backups in case of failure.
10. It means being well prepared and having practiced skills to deal with problems independently, while still diving as part of a buddy team.

ADPT2

Quiz 1 answers

1. 50 m
2. The recomended is:
   - No greater than 6.3 g.L-1
   - Ideally less than 5.2 g.L-1

Go back

Quiz 2 answers

1. It can be avoided by:
   - Analyse gas and check MOD
   - Breathe normally and avoid hard physical exercise
   - Monitor oxygen toxicilty level
2. The symtoms are:
   - Breathing disruption
   - Thinking equipment is faulty

End of module quiz answers

1. IPO is a condition where fluid builds up in the lungs during immersion in water, causing breathing difficulties. It can occur even in very fit divers and requires urgent action.
2. Narcosis can affect divers at any depth, but it is not usually noticeable until around 30 metres. This can vary depending on conditions and the individual diver.
3. Ascending to a shallower depth will rapidly reduce the effects of nitrogen narcosis.
4. As depth increases, gas becomes denser. Denser gas is harder to move in and out of the lungs, increasing the work of breathing.
5. Gas density should not exceed 6.3 g/L, and ideally should be less than 5.2 g/L to reduce breathing difficulty.
6. The two types are Central Nervous System (CNS) oxygen toxicity and whole-body (pulmonary) oxygen toxicity.
7. Early symptoms can include visual disturbances, ringing in the ears, nausea, twitching (especially around the mouth), dizziness, irritability, and confusion.

Go back

8. DCI is an umbrella term covering injuries caused by gas bubbles forming in the body or lung injuries caused by expanding gas during ascent.
9. Any abnormal symptom after a dive should be treated as DCI, even if the diver feels well or symptoms are mild.
10. IPO is a condition where fluid builds up in the lungs during immersion in water, causing breathing difficulties. It can occur even in very fit divers and requires urgent action.

ADPT3

Quiz 1 answers

1. The factors that increase gas consumption are:
   - Depth
   - Exertion
   - Cold
   - Stress
   - Emergency situations
2. Surface Air Consumption
3.

$$\textit{Surface gas consumption rate} = \frac{\textit{Gas used}}{\textit{Absolute pressure x Duration}}$$

Quiz 2 answers

1. The two methods are:
    - Rule of thirds
    - Minimum gas
2. The three stages are:
    - Settling
    - Ascent
    - Decompression

End of module quiz answers

1. Gas consumption increases with depth and stress, and deeper dives often involve decompression. Careful gas planning ensures there is enough gas to complete the dive safely and deal with emergencies.
2. Gas consumption increases with depth, exertion, cold, stress, and emergency situations.
3. Gas consumption increases in direct proportion to absolute pressure. For example, at 10 m a diver uses twice as much gas as at the surface, and at 30 m they use four times as much.
4. SAC stands for Surface Air Consumption. It measures how much gas a diver breathes per minute at the surface.
5. Every diver breathes differently depending on fitness, experience, stress, and equipment. A cylinder that is sufficient for one diver may not be enough for another.
6. You need the amount of gas used, the absolute pressure (depth), and the duration of the dive or monitoring period.

7. The rule of thirds means using one third of the gas to go out, one third to return, and keeping one third as a reserve for emergencies.
8. The minimum gas method provides a larger and more realistic reserve for deeper or decompression dives, especially where stress and gas sharing are likely.
9. The three stages are settling, ascent, and decompression (including stops and final ascent).
10. Rich gases contain much less nitrogen, creating a larger gradient that allows nitrogen to leave the body faster, reducing the length of decompression stops.

ADPT4

Quiz 1 answers

1. BSAC recommends:
    - Bühlmann ZHL-16C algorithm
    - 85/95 for air/nitrox
2. Plan to finish the dive on our backgas
3. This is the time at which the diver needs to leave that depth

---

Quiz 2 answers

1. 3 settings/assumptions are:

- Algorithm
- Ascent rates
- Stop depths

End of module quiz answers

1. Instead of planning a dive first and then checking if there is enough gas, the diver calculates the maximum dive possible with the gas available and then plans a shorter, safer dive within that limit.
2. Planning to finish the dive on backgas ensures the diver can still surface safely if the decompression gas is unavailable or cannot be used.
3. BSAC 88 tables are used to plan air dives, calculate decompression stops, and determine surfacing codes based on depth and time.
4. Square profile dives stay at one depth for most of the dive and are easy to plan with tables. Multi-level dives involve changing depths during the dive and are more complex, usually requiring dive computers or software.
5. A decompression model is a mathematical way of predicting how inert gas is absorbed and released by the body during a dive, helping to reduce the risk of decompression illness.
6. Gradient factors are settings that add conservatism to decompression calculations. They control how deep the first stop is and how cautious the diver is when surfacing.

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7. BSAC recommends the Bühlmann ZHL-16C algorithm with gradient factors of 85/95 for air and nitrox dives.
8. A run time slate records depth, stop time, run time (when to leave each depth), and the gas being used.
9. If the tools use different algorithms, ascent rates, or stop depths, they may produce different decompression requirements, causing confusion and potential safety issues underwater.
10. Oxygen exposure can be tracked using BSAC oxygen toxicity tables, dive computers, or software, with limits of 80% CNS and 300 UPTD in a rolling 24-hour period.

ADPT5

Quiz 1 answers

1. Backgas and deco regulators be differentiated by:
    - Location
    - Features e.g., type, colour, mouthpiece
2. DIN valves are preferred because they are:
    - Compact
    - Less vulnerable to impact
    - Enclosed O ring
3. Maximum Operating Depth

Quiz 2 answers

1. The golden rules of nitrox diving are:
   - Always analyse your gas
   - Never exceed your MOD
2. The golden rules of ADP diving are:
   - Always know what you are breathing
   - Plan the dive using your backgas only
3. When all divers have finished changing gases

End of module quiz answers

1. If the main backgas supply fails at depth, the diver needs an immediate backup gas that is safe to breathe. Decompression gas cannot be used at depth because it may be toxic.
2. Decompression gases have a high oxygen content and can become toxic if breathed deeper than their Maximum Operating Depth (MOD).
3. Common causes include freeflow, burst hoses, O-ring failure, unseated first stages, first stage failure, and bad gas fills.
4. The diver can either use their buddy's alternate source or switch to their own independent backgas backup, such as a twinset or pony cylinder.
5. A twinset provides a much larger volume of backup gas and allows the diver to manage failures by switching regulators or isolating cylinders if required.
6. To prevent the diver from accidentally breathing a toxic gas at depth or missing decompression by failing to switch to the

correct gas.Identify trained personnel, plan and brief on key actions, check equipment is serviceable and accessible

7. Identification can be achieved by location, stowage on the cylinder, different regulator design, colour, or tactile features such as a snoopy loop on the mouthpiece.
8. DIN valves have an enclosed O-ring, are more resistant to impact, are more compact, and are less likely to suffer catastrophic gas loss.
9. The Maximum Operating Depth (MOD), which must be clearly visible to both the diver and their buddy.
10. **DEPTHS** is used to safely switch gases and stands for:
    - **D**epth check
    - **E**xamine the cylinder
    - **P**ermission from buddy
    - **T**urn on gas
    - **H**ose route check
    - **S**witch

Go back

Equipment and Dry Runs

Go back

ADPP1 Equipment and Dry Runs

Module objectives

This lesson builds on the equipment lesson and reviews individual's equipment configuration. Students should be encouraged to view their equipment holistically as a total system, the components of which must all work efficiently and in conjunction with each other.

This lesson is a hands-on workshop, led by the instructor. Its purpose is to work interactively with students to establish a safe, efficient, and workable configuration in readiness for the sheltered water lesson by adjusting and changing the assembly.

The instructor should supervise and work interactively with the students as they prepare their equipment.

The instructor should remember that what may work for them may not always work for the student and should strive to be flexible within the criteria of safe, efficient, and workable.

At the end of this lesson both the student and instructor should be happy that their equipment configuration produces a safe, efficient, and comfortable system.

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Achievement targets

At the end of this lesson, you should have a safe, efficient equipment configuration that:

- **Is comfortable**
- **Minimises drag**
- **Minimises snag potential**
- **Protects more vulnerable equipment**
- **Prioritises access to primary and redundant life support systems**
- **Is appropriate for the dive**
- **Fits the diver**
- **Has a logical, neat system of ancillary equipment stowage**
- **Supports self-sufficiency within the buddy system**
- **Is configured to support emergency and rescue actions**

You will also need to identify any equipment that needs to be sourced to finalise the configuration

Go back

Sheltered water training

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ADPS1 Sheltered water training

Depth no more than 10 m, duration no less than 30 minutes

While it is not mandatory to be able to perform various propulsion techniques for the in-water part of the course, students and instructors will find it easier to move during the skills if they can use small forward and reverse fin kicks for position adjustment.

The module must not have any skills in it that have not already been done as part of a dry run.

The module can be completed in a swimming pool but must be done in the students' normal protective clothing. Care must be taken not to overheat. For diving in open, sheltered water, as the lesson is quite static and does not include much swimming, care must be taken that the students do not get too cold as to become proficient, it may take some time to build up the skills to an acceptable level.

A suitable datum should be used as a reference point to control the lesson, and the ascent and descent to the lesson site.

Module objectives

The objective of the sheltered water module is to introduce the

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student to using a rich decompression mix, adjust their weighting and trim, and build up familiarity with the essential drills needed to use a rich decompression gas safely.

The instructor should be using a similar configuration to the students.

Achievement targets

At the end of this module, the student should:

- **Be able to perform pre-dive checks on the waterside under supervision**
- **Have adjusted their weight and trim to be neutral and flat in the water**
- **Have performed descent drills**
- **Be able to switch to their own backup dive gas (if carried)**
- **Be able to use an alternate source both as donor and recipient**
- **Perform an authorised switch to a decompression gas**
- **Perform a switch to a decompression gas without buddy authorisation**
- **Develop their buoyancy, aiming to be neutral during drills**
- **Position themselves for good buddy communication throughout the dive**
- **Deploy a DSMB from mid-water**
- **Know their breathing rate**

Open Water Assessment Dive

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ADPO1 Open Water Assessment Dive

The choice of site will vary due to location and circumstances but should not involve an overhead environment. Instructors should be aware that when performing ADP skills, the depth and conditions must be suitable so that they do not present additional risks and task loading. The depth must not exceed the students' qualifications or existing depth experience.

Duration no less than 40 minutes.

The students must complete at least 3 minutes of real accelerated decompression stops.

Module objectives

The objective of the assessment module is for the students to demonstrate they can plan and conduct an accelerated decompression dive using the skills developed in the previous modules.

Achievement targets

At the end of this module, the students should:

- **Analysed and marked their cylinders**
- **Have planned a suitable dive profile and dive plan**
- **Generated run-time slates to take into the water**

- **Top to toe self-check**
- **Buddy check**
- **Bubble check**
- **Regulator function check to backup dive gas**
- **Position themselves for good buddy communication throughout the dive**
- **Have developed their buoyancy and trim to a proficient level**
- **Followed the dive plan**
- **Made a controlled ascent deploying a DSMB mid-water as a buddy pair**
- **Switched to a rich decompression gas**
- **Performed a real accelerated decompression stop of at least 3 minutes with controlled slow ascent to the surface**

Qualification card

BSAC photo-ID qualification cards are a universally accepted and convenient proof of qualification.

Obtaining your QCard (qualification card)

Once you have successfully completed all the training your instructor will be able to apply for your qualification and digital card online.

Please be aware that you must supply the following information to them:

- Your full name
- Your BSAC membership number
- You should ensure your MyBSAC profile has a photo uploaded for your digital qcard.

Not able to download your digital qcard?

It can take time to process all qualifications so please allow 2 weeks from submission from instructor to viewing you qualification in your MyBSAC Profile.

Please contact qcards@bsac.com with the following if you cannot see your qualification on MyBSAC with:

- Your full name
- Your BSAC membership number
- The qcard you are expecting, i.e Dive Leader
- The name of the instructor who submitted the application
- The completion date of the training

After your course...

Go and use your newly acquired skills

Go diving... with the support of your club, you will be able to encounter a fascinating variety of wildlife and shipwrecks in seas, rivers, quarries, lochs and lakes. Plus, you will be able to dive anywhere in the world with your internationally-recognised qualification.

Progress your diver training...you can quickly move onto your next grade in BSAC's Diver Training Programme.

We recommend for your next course

Deeper Diving

To start the course, discuss your options with your Training Officer/ Diving Officer of your branch, your Regional Coach or local BSAC Partnership Centre...

Learn new specific skills...you could also develop specific skills such as safety and rescue, wreck diving or driving a dive boat.

Other courses you may like

Sidemount Diver
Twin-set Diver
Propulsion

To book and pay for your Skill Development Course simply click on the link to get going...

bsac.com/events

Diver benefits. . .

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. . . Don’t forget as a BSAC member, you get access to exclusive scuba and snorkelling -related benefits and prices.

www.bsac.com/member-benefits

BSAC Dive with us

Notes

Document change record

Date published	Document Version Number	Page(s) affected	Description of changes	Author
01/11/2025	v1.1	All	Course update	Alex Warzynski


Enjoy your diving...
BUDDY

Keep in touch

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