Module OT1

Ocean Diver

Adapting to the underwater world

Module objectives

This module provides a basic understanding of air and water pressure and the effects of the underwater environment on the diver. It also covers the purpose and function of diving equipment, and the other specialist kit that divers need, and introduces the concept of buoyancy. Heat loss from the body and how this can be reduced through the proper choice of protective clothing is considered.

Achievement targets

At the end of this module students should:

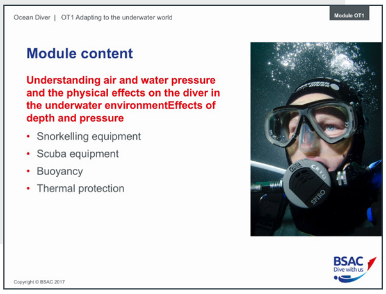
- Have a basic understanding of air and water pressure and the physical effects on the diver of the underwater environment
- Understand the purpose and function of basic equipment
- Understand the purpose and function of scuba equipment
- Understand buoyancy
- Understand heat loss, body temperature control and thermal protection options

Additional visual aids needed

- Mask, fins, snorkel, and weight systems
- Scuba equipment – cylinder, regulator with alternative supply, and buoyancy compensator
- Wetsuits and drysuits

Module content

This module considers the effects of depth and pressure underwater, basic equipment, scuba equipment, buoyancy and thermal protection.



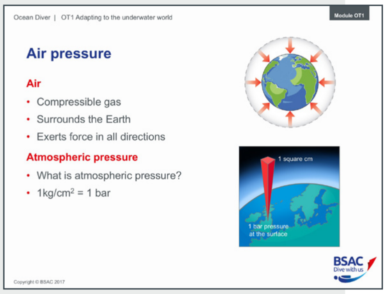
Understanding air and water pressure and the physical effects on the diver in the underwater environment

Explain that before discussing diving equipment, students need to have some understanding of the diving environment and its effects on divers and how equipment, both snorkelling and scuba, is designed with this in mind. There will also be an introduction to buoyancy control and heat loss. Finally explain how divers can reduce heat loss through thermal protection options.

The module covers the following topics:

- The effects of depth and pressure
  Divers need to have a basic understanding of the effects of depth and pressure on their bodies and equipment while diving. This knowledge will be the foundation of many of the topics introduced in future stages of their training and is required to ensure safety.
- Snorkelling equipment
  The sport of diving all starts with snorkelling equipment which allows us to see underwater, swim efficiently and breathe air while swimming on the surface face-down.
- Scuba equipment
  Self-contained underwater breathing apparatus (Scuba) has allowed millions of people to enjoy the underwater world. Ocean Divers need to know about the key features and functions of this equipment to be able to dive in comfort and safety.
- Buoyancy
  A key skill for Ocean Divers to master is that of buoyancy control. A basic knowledge of the principles which impact a diver's buoyancy are important in developing these skills.
- Thermal protection
  Keeping warm is a key consideration when diving. Even in warm tropical waters divers need to consider the impact of water temperature on their bodies.

Air pressure



It is important that students have a basic understanding of air and water pressure and the effects that this can have on our bodies. The bodies of land-dwelling animals are acclimatised to life on the Earth's surface and the need to breathe air to stay alive. When we venture underwater, the new environment will subject our bodies to unfamiliar stresses.

Air

- Compressible gas
  Air is a compressible gas. Students may have experienced this for themselves when inflating the tyres on a bicycle with a simple hand or foot pump, which compresses the air to make the tyres firm.

- Surrounds the Earth
  A layer of air approximately 10 to 12 kilometres deep surrounds the Earth and makes up the atmosphere in which we live. This layer of gas, under the influence of the Earth's gravity, exerts pressure.

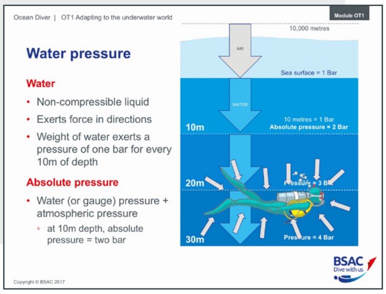
- Exerts force in all directions
  This air pressure acts in all directions, but generates an overall downward force on the surface of the Earth called atmospheric pressure.

Atmospheric pressure

- What is atmospheric pressure?
  The weight of the air in a column with a cross section of one square centimetre, stretching from the Earth's surface to the edge of the atmosphere is one kilogramme at sea level and this is atmospheric pressure. Students can visualise this as a column of air about the size of a fingernail stretching up about 10-12km and weighing about the same as a bag of sugar. The air gets thinner and weighs less the higher up in the column you go.
  The reason we do not sense the weight of the air above and around us is that the body, consisting of lots of water and some air, is in balance or 'equilibrium' with the surrounding air pressure. We know the air gets thinner and weighs less the higher up the column and beyond, that's why astronauts have to wear pressurised suits to keep their body in equilibrium to survive.

- $1kg/cm^2$ = 1 bar
  A pressure of 1kg per square cm is known as one atmosphere or one bar (barometric pressure). Although the actual air pressure at sea level varies a little due to weather conditions, we use one bar as a measurement of air pressure at sea level for diving purposes.

Water pressure



To understand the effects of the underwater environment on our bodies and our diving equipment, students should understand some basic properties of water.

Water

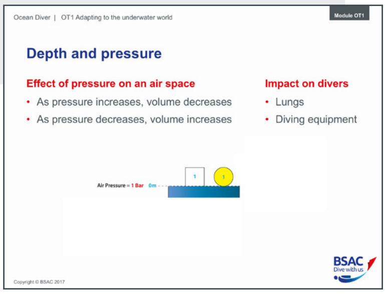
- Non-compressible liquid
  Water, unlike air, is a very dense medium and is not compressible.
- Exerts force in directions
  Like air, water exerts a force on things immersed in it.
- Weight of water exerts a pressure of one bar for every 10m of depth
  Water on its own, in a column with a cross section of one square centimetre, exerts a downward pressure of one bar for every 10m of depth.
  Divers use depth gauges – they measure the water pressure but the readout on the dial face is given in metres, as divers need to know how deep they are.

Absolute pressure

Understanding the term ‘absolute’ pressure is important. We have to combine the air pressure and the water pressure at any depth to give us the total or absolute pressure we will experience at that depth underwater.

- Water (or gauge) pressure + atmospheric pressure
  Absolute pressure = water pressure (gauge) + atmospheric pressure
  At 10m, we will experience one bar water pressure plus one bar atmospheric pressure; therefore, two bar absolute pressure.
  If we descend a further 10m to a depth of 20m, the water pressure increases to two bar, adding on the one bar for atmospheric pressure gives us an absolute pressure of three bar.

Depth and pressure



Effect of pressure on an air space

- As pressure increases, volume decreases
  If pressure is exerted on a body of air, remembering that air is compressible, it will be squeezed and the volume reduced. So if a body of air is taken underwater, say in an upturned, open, rigid container, the water pressure will ‘squeeze’ the air and reduce the volume the deeper the container is taken.

The compression of the air volume for every 10m water depth is easy to remember.

At 10m, at an absolute pressure of two bar, the volume of air reduces to half of its original surface volume.

At 20m, three bar, it reduces to one-third of its original volume.

At 30m, four bar, it reduces to one-quarter of its original volume, and so on.

- As pressure decreases, volume increases
  If the surrounding pressure decreases, such as on an ascent, then the volume of a body of air will increase.

Impact on divers

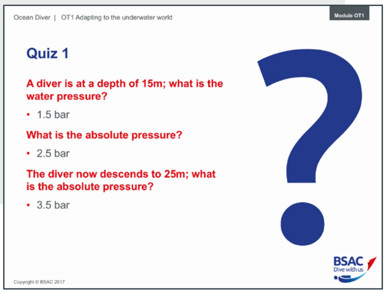
Fortunately, as human bodies have a high-water content of 70-85 per cent, our bodies can readily adapt to the increase in water pressure that recreational divers will normally experience. However, any air spaces within the body cannot adapt so readily. The most important of these are the lungs.

- Lungs
  The lungs are not a rigid air container like a bucket, but are a flexible air space more like two balloons. As we breathe in and out, the elasticity of the lungs allows expansion and contraction. If a swimmer takes a breath and dives down, immediately the water pressure squeezes the air volume in the lungs and they reduce in size. We do not feel this reduction unless we dive down deep.

- Diving equipment
  To survive underwater we need equipment that enables us to adapt to the underwater environment. This equipment is also subjected to the effects of depth and pressure. The following sections covering snorkelling and scuba equipment will explain the effects in more detail.

Quiz 1

Instructors should routinely check for transfer of knowledge to the students.



A diver is at a depth of 15m; what is the water pressure?

- 1.5 bar

What is the absolute pressure?

- 2.5 bar

The diver now descends to 25m; what is the absolute pressure?

- 3.5 bar

Snorkelling equipment – mask

To move easily through the water and see life below us from the surface, or to dive down to have a closer look, we need basic diving equipment; mask, fins, and snorkel.

Allows underwater vision

Divers need a mask to see underwater. The eye is designed to work in air not water – open your eyes underwater and everything is blurred. Putting an air space in front of your eyes allows you to see as normal.

Features

Features to look for in a mask are:

- Rigid frame
  A mask frame should be rigid to hold the glass.
- Tempered glass
  For safety reasons only use masks with tempered glass. Rather like older car windscreens, if it breaks it will form "pebbles" rather than "shards".
- Prescription lenses, if needed
  For divers who wear glasses, masks with prescription lenses or special frames that clip into mask are available.

- Flexible seal or 'skirt'
  The mask should have a flexible seal or 'skirt' that moulds easily to the face. Most are made of silicone rubber.

- Nose pocket
  The mask skirt must enclose the nose. Remembering that a volume of air will compress even in shallow water, being able to breathe into the mask will enable a diver to equalise the pressure inside with that of the surrounding water. If the pressure is not equalised, the mask will be squeezed onto the face and become uncomfortable. The seal inside the mask skirt under the nose pocket is designed so that if water enters the mask (generally seeping in because stray hairs have broken the seal) breathing out through the nose will displace the water from the mask.

- Adjustable strap
  To secure the mask comfortably, it should have an adjustable strap.

Fit

As masks come in a variety of sizes and designs, it is important that it fits the face comfortably. To test a mask for fit offer it up to your face, without using the strap, then inhale through your nose. A good-fitting mask should remain on the face until you exhale. It should even resist gentle pulling.

Care

- Rinse in fresh water
  A mask should be rinsed in fresh water after each dive.

- Dry before storing
  Avoid drying in direct sunlight as this could affect the flexibility of the silicone rubber and therefore the fit of the mask.

Snorkelling equipment – fins

Give underwater propulsion

Water provides considerable resistance to body movement. Using a fin to extend the diver's foot creates a higher surface area, which increases the propulsion the diver can generate with a minimal increase in effort.

Features

Fins come in a variety of shapes and sizes. Before buying a set of fins you need to consider whether the style of fin suits the type of diving being undertaken.

- Two basic styles
  There are two traditional, basic styles: the shoe fin and the strap fin. The shoe fin has a foot pocket with an enclosed heel and is generally used in warm water or in the pool, where extra foot protection is not worn. The strap fin has a foot pocket designed to fit over boots and an adjustable strap or spring fitting around the heel to hold the fin in place.
- Flexible blade
  The blade should allow some flexibility as the legs move up and down with the finning action.
- Stiffening ridges
  The basic design of a fin blade should include stiffening ridges to maintain the shape of the blade, the blade itself should decrease in stiffness towards the tip. Too rigid, too flexible or overlong fins will increase strain on the legs.
- Shaped to maximise efficiency
  Manufacturers have refined their fins over the years to increase finning efficiency. Most fins include slots, grooves or have shaped blades that assist the finning action.

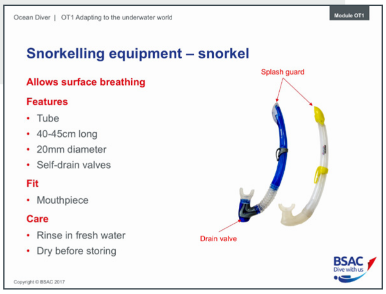
Fit

- Comfortable foot pocket
  The most important consideration is that the foot pocket is the correct size and a comfortable fit. If too big or too small, it will generally result in cramp and discomfort. The foot pocket should be foot size for shoe fins and boot size for strap fins.

Care

- Rinse in fresh water
  Fins should be rinsed in fresh water after each dive.
- Dry before storing
  Dry them standing up on the foot pocket end as standing fins up on their blades can distort their shape over a period of time.

Snorkelling equipment – snorkel



Allows surface breathing

The snorkel is a simple breathing tube to allow a diver to breathe while face down on the surface observing the underwater scenery or finning along. Snorkels can be worn under the mask strap or attached to the strap with a small clip.

Features

- Tube
  A rigid or semi-rigid open topped tube. May have a flexible corrugated section towards the mouthpiece end.

- 40-45cm long
  The tube usually forms a ‘J’ shape to fit close to the side of the head. Anything longer would require too much effort to breathe.

- 20mm diameter
  Anything narrower will require too much effort to breathe. Anything wider and it will be more difficult to blow clear of water following a surface dive.

- Self-drain valves
  Some snorkels have a self-drain valve at the lowest point to assist with clearing water out of the snorkel following a surface dive. Some designs also include splash protection at the top of the tube.

Fit

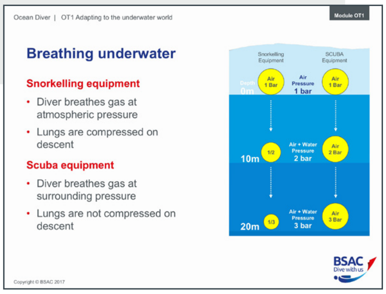
- Mouthpiece
  Mouthpieces come in different sizes, they should fit comfortably in the mouth gripped lightly by the teeth.

Care

- Rinse in fresh water
  Snorkels should be rinsed in fresh water after each dive.

- Dry before storing
  Snorkels should be allowed to dry before storing.

Breathing underwater



Snorkelling equipment

- Diver breathes gas at atmospheric pressure
  Using basic equipment, the diver breathes gas at atmospheric pressure on the surface and then breath holds during a surface dive.

- Lungs are compressed on descent
  The lungs react as a sealed balloon does; the air volume compresses but we do not feel this. The reason for returning to the surface is the urge to breathe.

Scuba equipment

To spend more time underwater, divers take their breathing supply with them.

- Diver breathes gas at surrounding pressure
  If the lungs are compressed the action of breathing becomes difficult. Divers need a gas supply that will maintain, as near as possible, their normal lung volume. Scuba equipment does this by delivering breathing gas at the same pressure as the surrounding water. A higher pressure of gas is needed the deeper a diver goes and this is incorporated into the design of scuba equipment.

- Lungs are not compressed on descent
  When diving with scuba equipment the lungs are not compressed on descent.

Scuba equipment

Scuba

Scuba gear is also known as the aqualung.

- Self
- Contained
- Underwater
- Breathing
- Apparatus

Components

Scuba equipment comprises a

- Cylinder
- Buoyancy compensator
- Regulator

The cylinder

The cylinder holds the diver’s supply of breathing gas.

Features

- Contains breathing gas at high pressure
  Dive cylinders are usually filled to either 232 bar or 300 bar pressure, from a suitable compressor. The cross flow or pillar valve in the cylinder neck is used to prevent or allow gas flow into or out of the cylinder.

- Steel or aluminium
  Typically, cylinders are made of steel or aluminium. The base of the cylinder is often protected by a rubber or plastic boot.

- BS/EN standard; CE mark
  Diving cylinders contain large amounts of stored energy. They are made to a very robust design, manufactured to strict safety standards. These standards are marked on the shoulder of the cylinder. It is vital that there are appropriate standards and that cylinders are used and maintained to ensure the safety of both the divers who use them and the people who fill them. In the EU, a cylinder used with diving apparatus cannot be put on the market unless it conforms to the Pressure Equipment Directive (PED), which is implemented in UK legislation by the Pressure Equipment Regulations 1999, as amended.
  All diving cylinders manufactured to the PED will bear the CE mark. Cylinders made before the application of the PED will not bear the CE mark but may continue to be used as long as they have been manufactured in accordance with an appropriate standard and are maintained in serviceable condition.
  Applicable standards include BS EN ISO 0909-2:2010 for steel cylinders and BS EN ISO 7866:2012 for aluminium cylinders. Older cylinders with older specifications are still valid subject to Periodic Inspection and Testing.
  Outside the EU, instructors should describe the corresponding local requirements.

Testing

Diving cylinders should be subject to a suitable inspection and test regime to ensure they are safe.

- **Hydrostatic test every 5 years**
  Scuba cylinders require a hydrostatic test every five years. On successful completion, the date (year/month) of the test is stamped on the cylinder shoulder.

- **Visual inspection every 2.5 years**
  Scuba cylinders also require a visual inspection test every two and a half years in line with the five-year cycle of hydrostatic tests. The date a hydrostatic test is due is not affected by the date of the last visual inspection. If a cylinder is unused for a period of time such that it has a visual inspection four years after its hydrostatic test (rather than at the two-and-a-half--year mark) the cylinder will only then be ‘in test’ for a further one year before the next hydrostatic test is due.

  Cylinder testing regulations and the required periods between test are changed periodically, so please check the BSAC web site for the latest information and advice.

Care

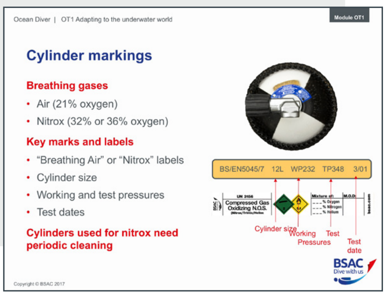
- **Rinse in fresh water**
  Cylinders should be rinsed in fresh water after each dive and the boot (if fitted) removed periodically to clean the base of the cylinder.

- **Dry before storing**
  Cylinders should be stored dry. If possible store upright, but ensure cylinder cannot fall over.

- **Do not store empty**
  Storing cylinders completely empty should be avoided; rather store them with a small amount of residual gas pressure to prevent ingress of contaminants.

Cylinder markings

In addition to the manufacturing standard there is other important information marked on the cylinder and some labels that divers should understand.



Breathing gases

Gases used by Ocean Divers are air and some nitrox mixes.

- Air (21% oxygen)
  Standard air from the environment is compressed and filtered into scuba cylinders. Air has an oxygen content of 21% and contains 79% nitrogen.

- Nitrox (32% or 36% oxygen)
  A nitrox mix has extra oxygen in it in place of some of the nitrogen. Nitrox 32 has 32% oxygen and 68% nitrogen whereas nitrox 36 has 36% oxygen and 64% nitrogen. The reasons that these nitrox mixes might be chosen are covered later in the course.

Key marks and labels

Several of the additional markings contain essential information about the cylinder.

- "Breathing Air" or "Nitrox" labels
  Scuba cylinders should be labelled to indicate whether the contents are air or nitrox. This could be a large sticker around the whole cylinder.

- Cylinder size
  Cylinders can have different capacities. Capacity is measured in litres, or put another way, how much water the cylinder could hold if you took the valve off and poured water in. Hence, the term water capacity (WC)

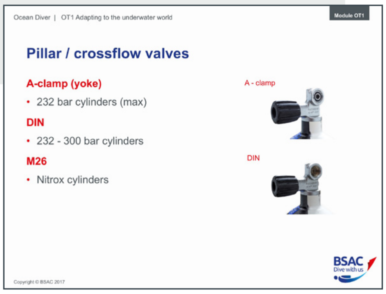
- Working and test pressures
  The working pressure, labelled WP, indicates the maximum operating pressure of the cylinder. Usually this is 232 bar or 300 bar. Some cylinders may have this value marked as CP, charging pressure.
  There is another mark, TP, which stands for test pressure. This is a value higher than the WP and is used during the hydrostatic test.

- Test dates
  The manufacturer tests the cylinder and stamps it with the date of this test. Subsequent test dates are also stamped on the cylinder and these are looked at by compressor operators to ensure the cylinder is 'in test' before being filled. If a cylinder is not 'in test', it should not be filled. Test dates may be of the format YYYY/MM or since 2013 just YY/MM. Where the date refers to a visual inspection then there will be a 'V' stamped next to the date.

Cylinders used for nitrox need periodic cleaning

Cylinders used for nitrox mixes that are produced using partial pressure mixing techniques need to be in oxygen service. which means they need to have oxygen compatible parts in the valves and need to be oxygen clean to ensure no hydrocarbons are present in them. Nitrox mixes below 40 per cent produced by continuous blending or by using premixed gas do not need such cleaning. Cleaning is recommended every 15 months.

Pillar/cross-flow valves



A-clamp

The A-clamp or international fitting cylinder valve has an O-ring set into the valve outlet and the regulator clamps around it. Sometimes this is referred to as a yoke fitting.

- 232 bar cylinders (max)
  The A-clamp type of cylinder valve can only be used on cylinders with a working pressure up to 232 bar.

DIN

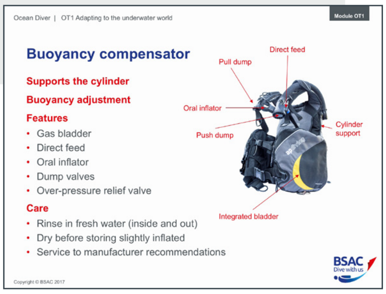
The DIN cylinder valve has an internal 5/8-inch BSP thread and no sealing O-ring as this is on the diving regulator instead.

- 232 -300 bar cylinders
  DIN valves can be fitted on cylinders up to 300 bar. A 232 bar DIN cylinder valve has five thread rotations within the valve whereas a 300 bar DIN valve has seven thread rotations. This means that it is not possible to attach 232-bar-rated equipment to a 300 bar cylinder supply. It is possible to screw an A-clamp insert into some 232 bar DIN valves to convert them to allow use of regulators equipped with A-clamp fittings.

M26

- Nitrox cylinders
  In 2008, an EU directive came into force requiring an M26 fitting to be used on equipment where the gas being used has an oxygen content above 22 per cent. This fitting appears similar to a DIN fitting but is a 26mm fitting rather than a 5/8”. However, this valve type has not been generally adopted in the UK.

Buoyancy compensator



Supports the cylinder

The buoyancy compensator or BC carries the cylinder. It is a jacket or harness system. They are manufactured in various styles but have many important common features.

Buoyancy adjustment

Gas is added to or dumped from the BC to assist the diver with their buoyancy control. Students will learn in the pool/sheltered water how the BC is used to adjust a diver's buoyancy.

Features

- Gas bladder
  An integrated gas bladder gives support to the diver and equipment on the surface when inflated. It also allows the diver to adjust buoyancy underwater.

  Note: Point out that breathing in from the bladder of a BC should be avoided due to risk of lung/chest infection.

- Direct feed
  A direct feed uses gas from the cylinder to inflate the BC. An intermediate pressure hose connects the direct feed to the first stage of the regulator. A simple 'push button' is used to inflate the BC.

- Oral inflator
  BCs also have a back-up oral-inflation mouthpiece. The oral inflator also has a push dump. Some have an alternative method of inflation, such as a small cylinder.

  Note: Point out that filling of emergency BC cylinders with nitrox should be avoided unless oxygen clean.

- Dump valve
  A manually operated "dump" mechanism allows easy venting from the bladder so the diver can descend. This is a pull dump.

- Over-pressure relief valve
  This prevents the bladder from bursting if gas is continually added.

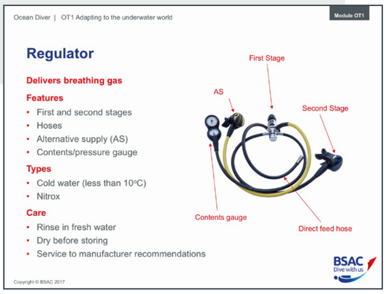
Care

- Rinse in fresh water (inside and out)
  The BC should be rinsed with fresh water. Mild disinfectant solutions can also be used inside the bladder. Do not breathe the gas from the BC bladder. The bladder can build up bacteria and breathing from it may cause serious respiratory problems.

- Dry before storing slightly inflated
  The BC should be dry before storing and should be stored slightly inflated.

- Service to manufacturer recommendations
  The BC should be serviced according to the manufacturer's recommendations.

Regulator



Delivers breathing gas

The gas in a diving cylinder is at high pressure, anything up to 300 bar. It would be impossible to breathe directly from the cylinder so the regulator has been designed to reduce the pressure of the gas leaving the cylinder and deliver it to the diver at ambient pressure so that it is easy to breathe whenever the diver wants to. The regulator is also referred to as a demand valve, or DV, for this reason.

Features

- First and second stages
  The regulator first stage fits to the cylinder valve with either with an A-clamp or DIN fitting (5/8” BSP or possibly M26).

  When the cylinder valve is opened the first stage reduces the pressure in the cylinder to an intermediate pressure around 10 bar above the local absolute (or ambient as it is also known) pressure.

  The gas at this inter-stage pressure is passed down an intermediate pressure hose to the regulator second stage.

  The second stage further reduces the gas pressure from inter-stage pressure to equal ambient pressure and delivers gas to the diver when they breathe in.

  When the diver breathes out the exhalation is expelled via the exhaust valve into the water.

  If water enters the second stage it can be easily cleared by either breathing out or by pressing the purge button located on the front face of the regulator.

  The fail-safe design of regulators usually means that they will ‘free-flow’, continuously delivering gas if a mechanical fault occurs. Training includes how to breathe from a free-flowing second stage.

- Hoses
  As well as the inter-stage, intermediate pressure hose, a regulator set will probably have further intermediate pressure hoses for connection to a buoyancy compensator direct feed and a dry suit direct feed.

- Alternative supply
  The alternative supply is an additional second-stage regulator connected to the first stage via its own intermediate pressure hose to provide a backup system. This additional second stage is commonly known as an octopus rig and, as a backup system should be easily identifiable. Yellow marked hoses and second

stages are a common method of identifying this backup system. Regulator first stages manufactured after 2014 will be stamped with an “A” if they are compatible to be fitted with an alternative supply.

As a backup system, an alternative supply second stage should be of equal standard to the primary second stage. This alternative supply is for use in an emergency, usually by the diver’s buddy.

Note: The latest version of the regulator standard EN250 (2014) advises that an octopus rig is not a preferred option if the depth is greater than 30m or the water temperature is less than 10°C, instead an alternative fully independent gas supply is advised.

- Contents/pressure gauge
  Divers need to know how much gas is in their cylinder at all times throughout their dive, so a contents gauge is connected via a hose to the first stage. This has to be a high-pressure hose as it delivers high-pressure gas for the gauge to “read”. This contents gauge is sometimes mounted in a console that also includes a depth gauge and possibly a compass.

Types

- Cold water (less than 10°C)
  Many entry-level regulators are designed for water at a temperature above 10°C. EN250 (2014) compliant regulator first stages which are not designed for cold-water performance are marked with “>10°C”. Regulator first stages may be marked with a lower working temperature if specified by the manufacturer.

- Nitrox
  Regulators used with nitrox should be in oxygen service. A regulator is in oxygen service when all its internal components are compatible with high oxygen levels and have been cleansed of hydrocarbons.

Care

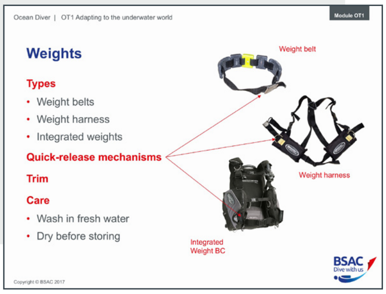
- Rinse in fresh water
  Regulators should be rinsed in fresh water after use. It is good practice to rinse regulators while still attached to a cylinder and pressurised.
  Warn about not pressing the purge button while rinsing a regulator that is not under pressure, as water can enter the hoses and first stage. Also the first stage should not be submerged in water unless sealed with an adequate cover; some first stage covers are only dustproof and not watertight.

- Dry before storing
  Regulators should be dry before storing and should be stored without placing strain on the hoses.

- Service to manufacturer recommendations
  Regulators should be professionally serviced at least once a year according to the manufacturer's recommendations. Remember they are a diver's 'life line'. Problems with the gas supply, or a lack of it, are not conducive to happy diving.

Weights

The weights that divers need to take with them to maintain control of buoyancy can be of several types/configurations.



Types

- Weight belts
  A simple belt with quick release buckle onto which cast weights are threaded. Weight blocks come in various sizes and can be plastic coated. Straightforward to release and drop/dump in an emergency

- Weight harness
  Where a diver has a problem with a simple weight belt; perhaps due to it slipping from the waist past the hips or where the weight on the hips is uncomfortable a harness system may be used instead. This harness is usually donned first so is harder to jettison in an emergency unless the weights are secured in pockets/sleeves that can be removed from the harness.

- Integrated weights
  Some BCs have weight pockets integrated into the harness/sides of the device. These can be removed for emergency jettison. Integrated-weight BCs often do not have sufficient capacity to take the amount of lead needed for drysuit diving.

Quick-release mechanisms

All weight systems must have a way to easily jettison weights in an emergency. However, it is also important that weight is not lost unintentionally as this would create a dangerous positive-buoyancy situation. Release mechanisms vary between a simple fold-over buckle, through Velcro sealed pockets to release clips.

Trim

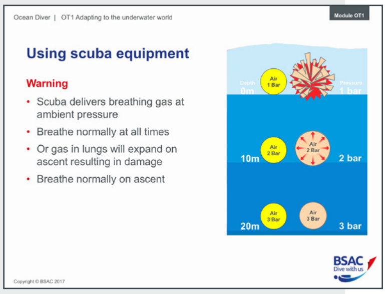
Weight can be placed at different places on a diver to help improve their trim in the water. For example, weights may be stowed in small pockets towards the top of a BC or threaded on the cam-band attaching the BC to the cylinder.

Care

- Wash in fresh water
  Weight belts, harnesses and pockets should be washed in fresh water after the dive.

- Dry before storing
  As with all equipment, they should be allowed to dry before being stored.

Using scuba equipment

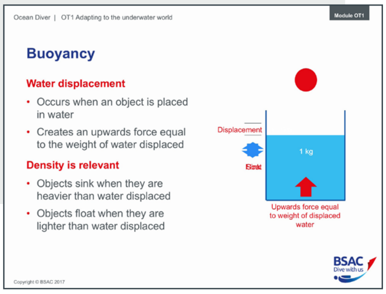


As scuba equipment delivers breathing gas at ambient pressure, when divers ascend, regardless of depth, they must never hold their breath. To do so would mean that the breathing gas volume increases in the lungs and, unless they breathe out, could cause serious lung damage. It is very important that divers breathe normally on ascent to equalise pressure in the lungs with that of the surrounding water. If snorkellers were to dive down and take breathing gas from a diver, they would increase their lung volume and would need to breathe out on ascent to avoid lung damage.

Warning

- Scuba delivers breathing gas at ambient pressure
- Breathe normally at all times
- Or gas in lungs will expand on ascent resulting in damage
- Breathe normally on ascent

Buoyancy



It was a Greek philosopher, Archimedes, who worked out the basic principle that allows things to float or sink.

Water displacement

- Occurs when an object is placed in water
  When an object is placed in water, its weight pushes down moving the water out of the way.

- Creates an upwards force equal to the weight of water displaced
  The water pushes back in an upward force (upthrust) equal to the weight of water displaced by the object. Any object immersed in water therefore apparently loses weight. Lifting someone out of a swimming pool is easy while most of their body is still in the water; the more they are lifted out of the water the heavier they become.

- Density is relevant

- Objects sink when they are heavier than water displaced
  An object will sink if it weighs more than the upthrust - it is heavier than the water it displaces

- Objects float when they are lighter than water displaced
  An object will float if it weighs less than the upthrust – it is lighter than the water it displaces.

  As an example: A solid ball of modelling clay will sink in a bowl of water – it is heavier than the water it displaces. (The water displacement makes the level of water rise.)

  If the ball is reshaped into a boat, the volume of the object has increased. The boat and the air that it contains displace a greater volume of water so the upthrust has been increased and the boat floats. (With the greater displacement, the level of water in the bowl is higher than with the submerged ball.)

  Steel ships weighing thousands of tonnes float because of their large ‘displacement’ and they contain a large volume of air.

Buoyancy and divers

The only times divers want to be able to float on the surface are at the beginning and at the end of the dive. It is underwater where we need to control our buoyancy.

Neutral buoyancy

This is a state when a diver is in equilibrium with the surrounding water.

- Weightless state
  It is a weightless state, which reduces physical effort. A diver’s buoyancy needs adjustment throughout the dive to maintain neutral buoyancy – to be able to hover above, below or to the side of interesting marine features.

- Reduces physical effort
  Happiness is neutral buoyancy.

Positive buoyancy

- Too light
- Physically tiring
  Positive buoyancy makes you too light and the ensuing struggle to remain below the water is physically tiring.
- Uncontrolled upward movement
  More importantly, being too light risks an uncontrolled ascent and possible over-expansion of the lungs as ambient pressure reduces quickly.

Negative buoyancy

- Too heavy
  Negative buoyancy makes you too heavy and is also physically tiring
- Physically tiring
  Negative buoyancy makes you too heavy and the ensuing struggle to remain above the seabed or at the planned depth for your dive are physically tiring
- Risk of going too deep
  There is a risk of descending below safe diving depths.
- Damage to self or marine life
  Bouncing off the seabed can damage marine life and the diver's equipment.
- Sinking if on surface
  Being too heavy might make it harder to stay securely at the surface.

Buoyancy in practice

A diver with no equipment will float on the surface. Each piece of added diving equipment has a weight and a volume, some will increase the diver's buoyancy and others will decrease it.

Descent

- Diving suits + scuba kit normally cause positive buoyancy at the surface
  The combined effect of the diver's body, their suit and scuba equipment will normally result in positive buoyancy.
- Add weight to achieve neutral buoyancy
  This buoyancy is compensated for by adding weight to a weight system to allow the diver to descend.

During a dive

- Compensate with BC or drysuit
  Having left the surface, the increasing ambient pressure during descent will compress the bubbles in the wet/semi-dry suit material or the gas held within the drysuit resulting in buoyancy loss.
  To balance this loss of buoyancy, gas is introduced to either the BC if wearing a wet/semi-dry suit, or the drysuit.

- Fine tuning with lungs
  Moving around or over underwater features can be affected by using the lungs to fine tune neutral buoyancy.

Ascent

- Gas will expand
  Gas introduced at depth into a BC or drysuit will expand as the diver ascends and the ambient pressure reduces.

- Controlled dumping of gas equalises diver's buoyancy
  Removing or dumping the gas in a controlled manner will equalise the diver's buoyancy as they ascend.

Buoyancy check – correct weighting

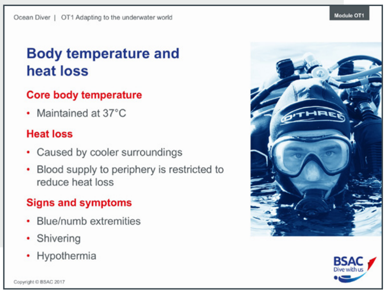
Divers need to set the amount of additional weight they wear not just to assist the descent, but for the control that will be required on an ascent.

Gas in the cylinder has weight and as it is used during the dive, both the cylinder contents and its weight will reduce. Buoyancy checks before diving should take account of this by adding one to two kilos to allow for gas consumed during a dive so that neutral buoyancy can be maintained at the end of the dive.

The salt content, or salinity, of water can also vary and affect a diver's buoyancy. Divers weighted for fresh-water diving in quarries or lakes will need to add additional weight for sea-water diving. Conversely, divers weighted for sea diving will need to remove some weight for diving in fresh water.

Body temperature control and heat loss

Humans give off heat naturally due to the heat generated in the cells by the body's metabolism.



Core body temperature

The core consists of the important body areas – brain, spinal cord, chest organs, abdomen and pelvis. These are surrounded by a peripheral 'shell', consisting of the limbs, muscles and skin.

- Maintained at 37°C
  The body has temperature sensors to maintain the 'core' body temperature at 37°C.

  The core temperature is controlled within very narrow limits, plus or minus 2°, while the peripheral shell is subject to greater variation. For example, if the body gets too hot, the sensors trigger sweating and thus evaporation on the skin surface draws heat from the body cooling it down.

Heat loss

Heat loss from the body depends on many factors but the main one is a cooler temperature around the body drawing heat away.

- Caused by cooler surroundings
  In cooler surroundings the greatest heat loss in humans, around two-fifths, is from the head and face. Other main heat-loss areas are the front of the chest and under the armpits.

- Blood supply to periphery is restricted to reduce heat loss
  With insufficient insulation in peripheral areas, the body begins to protect its core temperature by narrowing the blood vessels and therefore reducing blood supply to the peripheral shell. As the blood flow is less, the heat loss is reduced. The initial peripheral areas affected are the hands, feet, nose and ears.

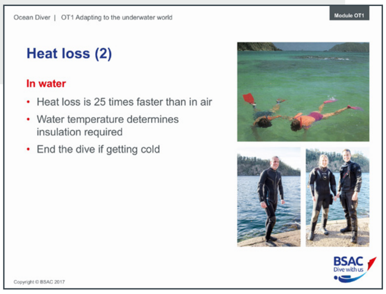
Signs and symptoms

- Blue/numb extremities
  Peripheral areas look bluish in colour due to the reduced blood supply. They may also begin to feel numb.

- Shivering
  If the peripheral cooling continues, the muscles begin contracting and relaxing quickly to generate body heat - the "shivering mechanism". This is a clear indication that the body needs to increase its temperature by either moving to a warmer environment or adding additional clothing for insulation.

- Hypothermia
  If nothing is done to remedy the situation and shivering stops, the body is sinking into a state called hypothermia, which can become a very serious condition as the body slowly shuts down.

Heat loss (2)



In water

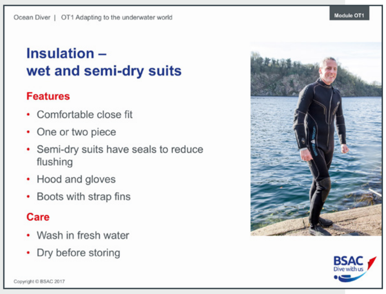
- Heat loss is 25 times faster than in air
  Water is an excellent conductor of heat; 25 times better than air. A human body immersed in cold water loses heat far more quickly than in air.

- Water temperature determines insulation required
  Divers need to consider wearing thermal insulation to protect against heat loss. The rate of heat loss in water for divers depends on the water temperature, the amount of energy heat the body creates by swimming or finning and the time in the water, but as a general guideline:

  - Diving in water not less than 21°C the body is generally comfortable with minimal insulation.
  - Between 20°C and 10°C, a minimum of a wet or semi-dry suit is required.
  - Below 10°C, a drysuit is strongly recommended.

- End the dive if getting cold
  Common sense dictates that feeling cold on a dive is an indication to leave the water to prevent further heat loss.

Insulation – wet & semi-dry suits



Many suits are made of neoprene that has been foamed and expanded. The gas bubbles are sealed in the neoprene fabric, so the suit does not act like a sponge. This provides effective insulation combined with elasticity to allow movement and for this reason neoprene suits can be a close fit. This does not prevent water entering the suit, but this has an advantage. A relatively stable amount of water directly in contact with the body is warmed by the body's heat but protected by the suit from the surrounding cooler water. Therefore, the wetsuit and warmed layer of water act as thermal insulation.

Features

- Comfortable close fit
  The fit should be reasonably close but allow movement. Too loose and more water will flush through the suit drawing more heat from the body and leading to more rapid heat loss.

- One or two piece
  Variation in styles means divers can choose between one or two-piece suits. Some designs have an integrated hood.

- Semi-dry suits have seals to reduce flushing
  The semi-dry suit uses the same principle, but they generally have thicker neoprene than wet suits, and tighter seals at wrists and feet to reduce the water ingress even more. Less water = semi dry.

- Hood and gloves
  Divers can choose whether to wear a hood or not with these suits depending on the water temperature. Hoods should be worn in cooler water to prevent heat loss through the head. Gloves are another option in cooler water.

- Boots with strap fins
  Shoe fins can be worn but where a diver chooses to wear neoprene boots to protect or keep feet warmer, strap fins will be needed.

Care

- Wash in fresh water
  Maintenance for wetsuits is to wash the suit with fresh water after every dive. A mild disinfectant wash can also be used.

- Dry before storing
  Make sure the suit is dry before storing, hanging it on a padded hanger is a sensible approach.

Insulation – drysuits

The body warms the air within the suit providing insulation. Depending on the suit fabric and the water temperature, clothing or undersuits need to be worn to increase the insulation. To allow equalisation of air within the suit during a dive, air is introduced via a direct feed from the regulator and excess air can be expelled via a dump valve – both similar mechanisms to those on a BC.

Types

- Neoprene
  Drysuits can be made from neoprene or crushed/compressed neoprene.

- Membrane
  Membrane drysuits are made of other waterproof materials, such as rubberised fabric or a laminate constructed of hardwearing outer surfaces and waterproof rubber inner layers.

Features

- Comfortable fit
  Fit needs to allow for movement.

- Seals to prevent water entering
  Drysuits do not allow water entry because of seals around the neck and wrists and come with either integrated boots or ankle seals. The seals can be latex, neoprene or silicone.

- Waterproof entry zip
  Drysuits have a waterproof entry zip, often across the back of the shoulders but also available in a 'self-donning' diagonal arrangement across the front of the body.

- Undersuits
  Depending on the type of drysuit and its inherent insulation characteristics, under garments are worn underneath. These might range from a single onesie-type thermal suit or a build up of layers of garments made from technical fabrics.

- Hood and gloves
  A hood and gloves would normally be worn with a drysuit.

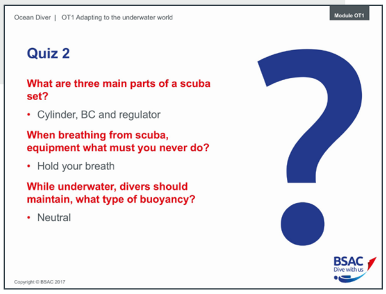
Care

- Rinse in fresh water
  Suits should be rinsed with fresh water after every dive and dried thoroughly. A mild disinfectant wash inside the suit is recommended from time to time.

- Dry before storing
  Make sure the suit is dry inside and out before storing; storing on a padded hanger is a good idea. Or you can hang a drysuit up by its boots.

- Dust seals, lubricate zip
  French chalk on seals helps to prolong their life and wax or proprietary lubricating products on zips will protect them. Generally, zips are left open for storage.

Quiz 2



What are three main parts of a scuba set?

- Cylinder, BC and regulator

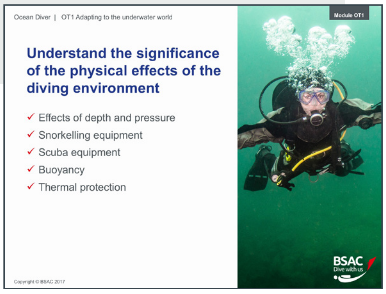
When breathing from scuba equipment; what must you never do?

- Hold your breath

While underwater, divers should maintain what type of buoyancy?

- Neutral

Summary



Understand the significance of the physical effects of the diving environment

- Effects of depth and pressure
- Snorkelling equipment
- Scuba equipment
- Buoyancy
- Thermal protection