DEEPER DIVING

Lesson Objectives

This lesson develops previous knowledge gained from the Ocean Diver Course and covers how nitrogen affects divers from two aspects, nitrogen narcosis and decompression, and considerations when undertaking deeper diving. This lesson includes decompression stop dive planning, using the BSAC tables and computers. An understanding of the working knowledge of tables will assist in understanding how computers, using their algorithms, can also be used for planning and tracking decompression requirements

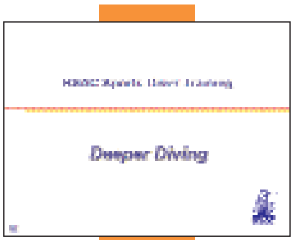
Achievement Targets

At the end of this lesson students will:

- Understand that managing the effects of nitrogen covers two areas: nitrogen narcosis and decompression
- Understand that an increase in ambient pressure increases the partial pressures of gases breathed and the effects on the body
- Understand the effects, signs and symptoms of nitrogen narcosis and how they increase with depth
- Understand the effects, signs and symptoms of oxygen toxicity
- Review nitrogen and decompression and why decompression stops may be required
- Understand how to plan decompression stop dives using the BSAC tables
- Understand how to use computers and how, in being able to constantly update nitrogen tracking on a dive, they can give up to the minute information regarding decompression stop requirements but dive planning is still required
- Understand that in broadening diving experience and travelling to different sites or countries, there is a need to plan diving by using the altitude/atmospheric pressure chart and Transfer tables
- Understand effects of travelling on computers
- Consider safety margins for using either tables or computers when diving

The following items will be needed

Copies of the BSAC 88 Tables and BSAC Nitrox Tables to allow students to work with the Instructor on decompression stop dive planning exercises and use of the Atmospheric/Pressure Chart and Transfer Table. A dive computer to demonstrate read out display information



PLANNING FOR DEEPER DIVING

Students have already been introduced to nitrogen narcosis and no stop dive planning using decompression tables in Ocean Diver training. This lesson is going to cover deeper diving because, upon qualifying as Sports Divers, they can progressively dive to deeper depths and will experience the increased effects of nitrogen.

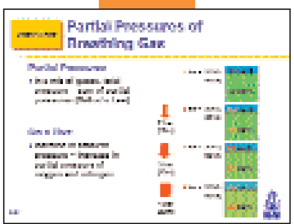
Management of the effects of nitrogen will be covered in two areas

- Its narcotic effect, Nitrogen Narcosis
- Dive planning for deeper dives including decompression stops
  - Using BSAC Decompression Tables
  - Understanding the working of tables will assist in understanding how computers can also be used for planning and tracking decompression requirements

Diving and travelling

Because students will be broadening their diving experience, visiting more varied sites or holidaying in different countries, they need to:

- Understand how changes in atmospheric pressure will affect them when travelling or flying. This will include how to use the BSAC Tables Altitude/Atmospheric Pressure Chart and Transfer tables as part of dive and travel planning



PARTIAL PRESSURES OF GAS

As a diver goes deeper, the increasing ambient pressure increases the uptake of nitrogen by the body. Looking at what happens to the partial pressures of the individual gases, mainly oxygen and nitrogen in the case of air, helps to understand the effects on divers.

Partial Pressures

- The gases in the body are in equilibrium with the surrounding air. Sea level pressures are generally equal to 1 bar and the air mainly consists of approximately 21% oxygen and 79% nitrogen

  In a mixture of gases the total pressure is equal to the sum of the contributions, or partial pressures, from each individual gas in the mixture. This is known as Dalton's Law

On a Dive

- Partial pressures increase in direct proportion to the absolute pressure. The overall percentage remains the same, i.e. approximately 21% oxygen and 79% nitrogen, but the partial pressures will increase. At double the surface pressure, 2 bar, the partial pressure of oxygen has increased to 0.42 bar and nitrogen to 1.58 bar. The sum of both partial pressures is 2 bar

  Increasing the pressure to three times that at the surface, 3 bar (20m) increases the partial pressures threefold. Oxygen partial pressure is now 0.63 bar and nitrogen 2.37 bar. Add them together and they equal 3 bar but the percentage overall is still 21% : 79%

  Even deeper at 30m, the partial pressures have increased to four times that at the surface, oxygen partial pressure is 0.84 bar and nitrogen 3.16 bar giving a total of 4 bar

OXYGEN PARTIAL PRESSURES

Oxygen becomes increasingly toxic as the partial pressure of oxygen increases, and the BSAC has set a limit on the partial pressure of oxygen breathed. That limit is 1.4 bar, and this should be further reduced if exertion is planned during the dive.

How to calculate the for a given depth

Fraction O_2 = O_2% divided by 100

Multiply the oxygen percentage by the absolute pressure at depth.

Examples:

	Fraction	x	Pressure	=	
1. pO_2 for Air at 36 metres:	0.21	x	4.6 bar	=	0.97 bar
2. pO_2 for Nitrox 32 at 30 metres:	0.32	x	4.0 bar	=	1.28 bar
3. pO_2 for Nitrox 36 at 27 metres:	0.36	x	3.7 bar	=	1.28 bar

How to look up the pO_2 for a given depth

The BSAC Nitrox Decompression Tables contain a Partial Pressure Table.

To use the table, select the column containing the percentage of oxygen in the mix, and then select the row containing the depth in metres. Where these two intersect, read off the partial pressure of oxygen.

Example:

1. pO_2 for Nitrox 27 at 30 metres: = 1.08 bar

The tables contain depths at 3 metre intervals, matching the depths in the decompression tables.

If you wish to find the pO_2 for an intermediate depth (for example 25 metres) then either:

Use the calculation method above, rather than the lookup table.

Use the next greater depth (27 metres in this example).

MAXIMUM OPERATING DEPTHS

The Maximum Operating Depth (MOD) of a Nitrox mix is the depth at which the pO_2 limit is reached. The BSAC pO_2 limit is 1.4 bar, but this may be further reduced if exertion is planned during the dive.

It is very important NOT to exceed the MOD. Bear this in mind when planning your "just deeper" alternative option.

How to calculate the MOD for a given Nitrox Mix

Divide the pO_2 limit by the oxygen percentage in the mix. This will give an absolute pressure which can be simply converted into a depth.

Examples:

	Limit	/	Fraction	=	Pressure	(Metres)
1. MOD for Air (21%)	1.4	/	0.21	=	6.66b	(56.6m)
1. MOD for Nitrox 32	1.4	/	0.32	=	4.37b	(33.7m)
1. MOD for Nitrox 36	1.4	/	0.36	=	3.88b	(28.8m)

For safety, round the depth down - e.g. 33.7 metres rounds down to 33 metres.

How to look up the MOD for a given Nitrox Mix

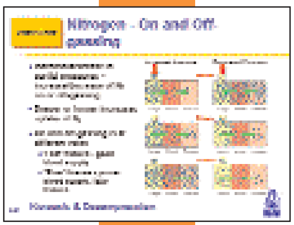
The BSAC Nitrox Decompression Tables contain a Partial Pressure Table.

The table does not contain entries for partial pressures greater than 1.4, therefore the bottom entry in each column represents the MOD for that Nitrox mix.

Example:

1. MOD for Air:	=	51 Metres
2. MOD for Nitrox 32:	=	33 Metres
3. MOD for Nitrox 36:	=	27 Metres

The tables contain depths at 3 metre intervals, matching the depths in the decompression tables, and may therefore indicate an MOD that is slightly shallower than the MOD that would be obtained by the calculation method above. Compare the examples in each method to see the differences.



NITROGEN - ON AND OFF-GASSING

On a Dive

- Increasing or decreasing the pressure of gas produces a corresponding increase or decrease in the partial pressure of Nitrogen, hence more nitrogen will be absorbed into or released from the body tissues - on and off-gassing
- Going deeper or longer increases the body's uptake of nitrogen
- Nitrogen on and off-gassing is at different rates in different tissues
  - Fast tissues, those that have a good blood supply such as the brain or heart, will on or off-gas quickly
  - Slow tissues, those with poorer blood supply such as bones or those that contain a high fat content, will on or off-gas more slowly

  The ascent phase of a dive is a relatively short period of time for the tissues to release nitrogen compared to the preceding part of the dive when the body has been absorbing nitrogen. So even after completing a dive and when back on the surface, nitrogen continues to off-gas. It continues for some considerable time until it reaches a state of equilibrium with the atmospheric pressure - the body's 'normal' state

The Nitrogen affects divers in two areas

- Nitrogen Narcosis and Decompression planning

NITROGEN NARCOSIS

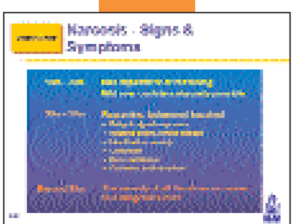
Affects all divers

- Although commencing earlier, narcosis is not generally noticed until about 30m
- Some divers may notice effects at shallower depths but others may not do so until deeper
- The deeper the diver goes, the more the effect increases

Cause

There are various theories as to what causes narcosis, but it is generally believed that:

- Nitrogen, which is very soluble in fat, enters the highly fatty nerve cells
- Nitrogen impairs the transmission of nerve impulses which control conscious and unconscious body actions and responses
- With the raised partial pressure of nitrogen proportionate to the increase in depth, the "impairment of transmissions" is greater
- Effects are similar to those of anaesthetics or alcohol



NARCOSIS - SIGNS & SYMPTOMS

It is important to remember that onset of symptoms, their severity and the exact depth, varies greatly between individuals and the underwater conditions

Between 10m-30m

- At shallower depths, brain function such as memory, concentration, reasoning and judgment are the first affected by narcosis. If a diver is feeling happy in their surroundings a sense of over confidence may be felt, but if the conditions are dark or challenging then anxiety may be experienced

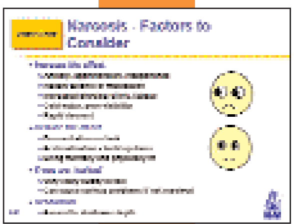
Between 30m-50m

- As the diver goes deeper, reasoning and judgment become more impaired, co-ordination can become poorer and a simple task may be difficult to perform. The indications are:

- Delays in responding to buddy signals
- Reading errors or wrong choices - mistaking the contents gauge for the depth gauge or vice versa
- Confusion - maybe about the dive plan, direction, maximum depth or time monitoring
- Going deeper than the dive plan due to over confidence
- For some divers, feeling dizzy, seeing stars or not seeing things as they are, hallucinations

Beyond 50m

- The severity and intensity of all the above increases - these depths are not a place to be with narcosis. It is for this reason that the BSAC recommends 50m as the absolute limit for air diving. In the UK, this is also the legal limit for commercial air diving operations



NARCOSIS - FACTORS TO CONSIDER

Some divers will claim they have never been 'narked' - it is important to realise that all divers suffer from narcosis to some degree when diving, particularly below 30m. Because a diver is suffering from narcosis it is difficult for them to realise that they are in fact 'narked', as the ability to monitor their own performance is one of the first things to be affected - this is similar to a drunk driver who feels perfectly capable of driving safely.

- Certain factors will increase the effects of nitrogen narcosis
  - Anxiety, apprehension or inexperience
  - Recent drinking or some medications such as sedatives or some antihistamines - if taking any medication a diver should check they are OK to dive. If in doubt contact BSAC HQ or a medical referee.
  - Increased physical effort, getting tired or fatigued will increase breathing rate and the possible build up of carbon dioxide which predispose divers to nitrogen narcosis
  - Cold water or poor visibility
  - Rapid descents
- In developing more experience and awareness, there are also factors that can reduce the effect of narcosis
  - Although reflexes and thought processes may be 'slowed down', most problems can be sorted out provided the diver remains calm, has sufficient time to resolve a problem safely by concentrating carefully. The important thing is not to become 'task fixated' or forget other normal dive monitoring checks, such as gas, depth, buoyancy or the buddy
  - Acclimatisation to depth should be done by progressively building depth experience so that a diver's awareness of conditions and their own signs of narcosis can be recognised and coped with
  - It is also important that a diver is both mentally and physically fit, as this will improve their ability in recognising and coping with narcosis
- **If you are 'narked'**
  - It is very likely that your buddy is too. Monitoring between the buddy pair is even more important at depth by regularly checking breathing gas and maximum depth
  - Errors caused by narcosis can have severe consequences
- **Resolution**
  - The safest action to take if the diver feels anxious, or their buddy does not appear alert in responses, is to ascend to a shallower depth.

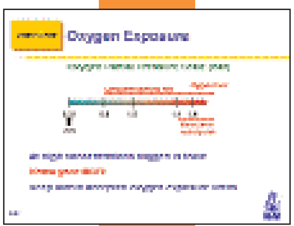
Fortunately narcosis resolves itself very quickly in shallower and therefore safer water.

NITROGEN - DECOMPRESSION

As was learned in Ocean Diver, managing nitrogen on a dive is one of the most important elements of dive planning, whether using tables or computers.

On Ascent

- Nitrogen off-gasses from the tissues in the body at different rates and continues when a diver returns to the surface
- The body can tolerate a certain excess of nitrogen
- Beyond certain combinations of dive time and depth, there will be a level of excess nitrogen where a direct ascent to the surface risks the onset of decompression illness (DCI)
- Under these circumstances, dive tables or computers will indicate the need to carry out decompression stops on the ascent
- Decompression stops on an ascent allow the excess of nitrogen in the body to be reduced to a tolerable level before continuing to the surface



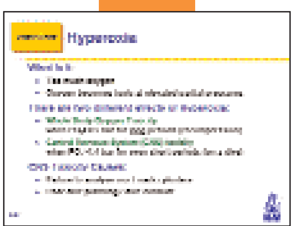
OXYGEN EXPOSURE

Oxygen Toxicity is the main concern when Nitrox diving and is the limiting factor for achievable depth.

CNS toxicity is caused by exposure to high pO_2 levels and the length of time a person is exposed to these increased levels.

Tolerance to CNS toxicity varies from individual to individual, and from day to day for the same person.

It is essential that we measure the uptake of oxygen into the body, ensuring that we never exceed a pO_2 of 1.4 b. Stay within the acceptable exposure times; these can be found in the NOAA Oxygen Exposure Limits Table (see page 24 in the Nitrox tables).



HYPEROXIA

In a Nitrox mix, where the oxygen content exceeds 21% O_2 (typically 32% O_2 or 36% O_2), the partial pressure of oxygen will increase proportionally faster than when diving on air.

It is essential therefore that the increase in exposure of the body to oxygen is monitored, since above a certain pO_2 level; or after a certain time at a given pO_2 level, oxygen becomes toxic to the human body.

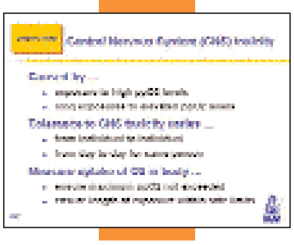
There are two forms of oxygen toxicity (hyperoxia) that the sports diver should be aware of:

- Whole Body Oxygen Toxicity and
- Central Nervous System (CNS) toxicity.

Whole body toxicity occurs with long exposures of oxygen partial pressures above 0.5b. Often the dive parameters and scope of the diving experienced by recreational divers fall well outside danger levels where problems could occur.

CNS toxicity is by far the most important form for divers using Nitrox mixes typically of 32% O_2 and 36% O_2.

The maximum safe depth limit will be considerably shallower than that for air (21% O_2), and falls well within the depth ranges of sports divers.

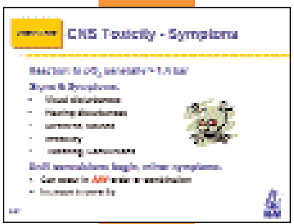


CENTRAL NERVOUS SYSTEM (CNS) TOXICITY

Oxygen Toxicity is the main concern when Nitrox diving and is the limiting factor for achievable depth.

- CNS toxicity is caused by exposure to high pO_2 levels and the length of time a person is exposed to these increased levels.

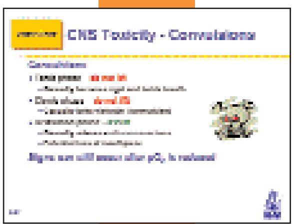
- Tolerance to CNS toxicity varies from individual to individual, and from day to day for the same person.
- It is essential that we measure the uptake of oxygen into the body, ensuring that we never exceed a pO_2 of 1.4 bar; and that we stay within the acceptable exposure times found in the NOAA Oxygen Exposure Limits Table.



CNS TOXICITY - SIGNS

The following signs do not necessarily occur in this order and some may not happen at all.

- Visual or Auditory Disturbances, including dizziness or nausea
- Muscular twitching of the face, lips, or fingers
- Fatigue or general tiredness
- Convulsions



CNS TOXICITY - CONVULSIONS

If convulsions occur in water, the casualty will probably loose their regulator, swallow water and drown

- Convulsions occur in different phases.
- Phases can occur in any order and one or more may be omitted.
  - Tonic phase - casualty becomes rigid and holds breath
  - Clonic phase - casualty jerks violently (convulsion)
  - Relaxed phase - casualty relaxes and is unconscious

CNS TOXICITY - ACCIDENT MANAGEMENT

If a diver suffers from CNS toxicity, make a Controlled Buoyant Lift to the surface even if decompression stops have to be omitted.

- Do not attempt to lift the casualty until the casualty has relaxed (is in the depressive phase) as there is a risk of embolism in the other phases, when the casualty is usually holding their breath.
- Remove casualty from the water, monitor respiration and circulation and call for medical assistance to evacuate casualty.
- Do give casualty oxygen therapy.

CNS TOXICITY - AVOIDANCE

- Do not exceed the MOD of your gas mix - preferably stay well within the MOD.
- Do not over exercise during the dive. Build up of carbon dioxide increases the risk of oxygen toxicity.
- Track the uptake of oxygen (covered next)

MONITORING OXYGEN EXPOSURE

How to track CNS oxygen uptake

- During dive planning, use the NOAA Oxygen Exposure Limits table in the BSAC Nitrox Decompression Tables to check the Maximum Single Exposure, and Maximum 24 hour exposure.
- Oxygen uptake is measured, by the minute, at the maximum pO_2 the diver experiences.

Using the Oxygen Toxicity Table in the BSAC Nitrox Decompression Tables:

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.

Example: pO_2 1.4 bar for 32 minutes

1.4 pO_2 for 30 minutes = 20.10

1.4 pO_2 for 2 minutes = 1.34

Total CNS% = 21.44

CNS % must be tracked for each gas when multiple gases are used.

If CNS % reaches 80% (this is the maximum BSAC limit), a two hour surface break must be taken, breathing air.

For every two hours on the surface breathing air, the CNS % is reduced by half.

Whatever CNS % remains at the end of the surface interval must be added to the next dive CNS % uptake.

BSAC DECOMPRESSION TABLES - DEFINITIONS

Students may already be using dive computers. However, as both computers and dive tables are mathematical "models" with inbuilt parameters that should not be ignored nor over-ridden, understanding the principles of the BSAC tables will help with understanding computers.

BSAC decompression table definitions are

Decompression Stop Dive

- Where tables indicate the need for pauses in the ascent (stops) at specified depths to allow sufficient off-gassing of excess nitrogen to enable the ascent to be continued
- Decompression stop dives will result in Surface Code G

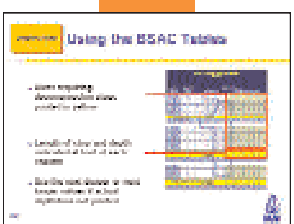
Decompression Stop

- Time actually spent at decompression stop depth
  - In the BSAC Tables, these are mainly at 9m and 6m

  (For divers using computers they may also indicate stops at 3m. It is worth explaining here that BSAC Decompression Tables were designed to take into account waves and swell conditions, where maintaining a 3m stop may be very difficult)

Dive Time

- The time from the start of the descent to reaching the decompression stop depth



USING THE BSAC DECOMPRESSION TABLES

- Dives requiring decompression stops are printed in yellow
- The length of the stop and its depth are indicated at the foot of each column
- If the actual depth/time are not shown, use the next deeper depth or next longer time values

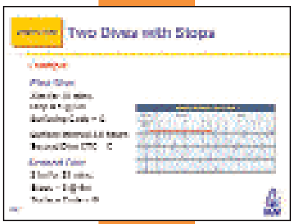
SINGLE DIVE WITH STOPS

Using Level 1 Tables, work through the following example with students

- Depth 27m and wanting to do a dive time of 34 minutes
- What decompression stops will be required

- 1 minute at 6m and surfacing code is G

  Give another example to ensure students have understood how to calculate decompression stops



TWO DIVES WITH STOPS

Using Level 1 Tables, working the following example with students not only checks that students have understood how to calculate decompression stops using the tables but also acts as a revision on use of Surface Interval Table

Example

First Dive

33m for 20 minutes

Stops required are 1 minute @ 6m

The Surfacing Code is G

The Surface Interval before the next dive is 3.5 hours

The Current Tissue Code (CTC) for the second dive is C.

Second Dive

21m for 25 minutes

Stops required are 3 minutes @ 6m

The Surfacing Code is G

Students may need another example from the instructor but when they are happy with calculating stops on 2 dives, they can move onto the next example, which should be done without instructor assistance

PLANNING TWO DIVES

Set the scene for a two-dive plan using Level 1 Tables. Starting Tissue code is 'A'

Dive One - Starting at 0930

27m for 30 minutes

What stops if any will be required?

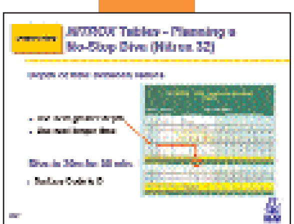
What time will divers surface? - *Remind students the dive time ends on reaching the decompression stop but time at the stop and 1min. to the surface need to be added to give a surfacing time*

Dive Two - Starting at 1430

25m for 25 minutes

What stops if any will be required?

What time will divers surface?



NITROX TABLES - PLANNING A NO-STOP DIVE (NITROX 32)

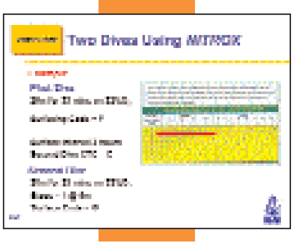
Using the BSAC Nitrox tables, work through the example on the slide by stepping through the processes involved to look up the surfacing code. Emphasise that the procedures for using both BSAC 88 and BSAC Nitrox tables are the same.

Example

What is the surfacing code following a dive to 20m for a dive time of 30 minutes?

Lookup next greater depth, and next longer time.

The surfacing code is 'D' (this following the arrows on the slide)



TWO DIVES USING NITROX

Using the Nitrox decompression tables, work through the following example with the students; ensuring that they 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.

Example

First Dive

26m for 33 minutes using Nitrox 32 breathing gas.

The surfacing code is F

The surface interval prior to the next dive is 3 hours

Current Tissue Code (CTC) for second dive is C.

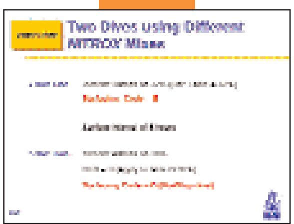
Second Dive *(using 32% table C)*

20m for 25 minutes using the same breathing gas

Stop required is 1 minute at 6m

The surfacing code is G

Further examples from the instructor would benefit students, giving them sufficient practice, hence confidence to work with NITROX tables. When satisfied with students' performances in the use of these tables, move on to the next example



TWO DIVES USING DIFFERENT NITROX MIXES

It's possible for divers to use different NITROX mixes in a series of dives. Here the instructor should focus on two dives only, and to apply the good practice of increasing the Oxygen fraction for the second dive (for reasons of being more effective decompression).

Example

First Dive

25m for 33 minutes using Nitrox 32 breathing gas

Using Table A 32%, the surfacing code is E

The surface interval prior to the next dive is 5 hours

Current Tissue Code (CTC) for second dive is B

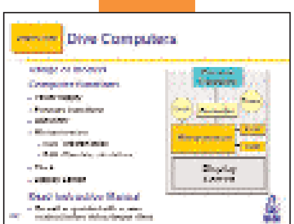
(The procedure for calculating the CTC for dive two is to input the surfacing code from dive one together with the time interval to the Surface Interval Table and to apply this to the table appropriate to the mixture chosen for the next dive).

Second Dive

18m for 40 minutes using a Nitrox 36 breathing gas

Using Table B 36%, the surfacing code is D (no stops required)

Again, further examples from the instructor would give students more practice in the application of these procedures.



DIVE COMPUTERS

Range of models

As there are various models on the market, it is important that if buying a computer you consider the type of diving you may be planning to do in the future. Some models cater only for air diving whereas others will cater for air and other diving gases.

Computer Functions

All computers can be broken down into eight main components

- **Power supply**

  Batteries provide the power for all the components of a computer. They vary according to the power requirements of the particular model and, as with all batteries, their 'life' is dependent on use. Most computers will give a 'low battery' warning indicating a change in battery is needed

- **Pressure Transducer**

  Once the computer is powered up, the pressure transducer measures ambient pressure. This is transmitted via a converter which sends its readings to the microprocessor
- **Microprocessor**

Using two types of memory

  - ROM (Read Only Memory) is the permanent memory that contains all the programme steps including the tissue simulation programme, that are used to calculate decompression status (dive 'tables' equivalent)
  - RAM (Random Access Memory) holds the information where the dive data and calculation results are stored

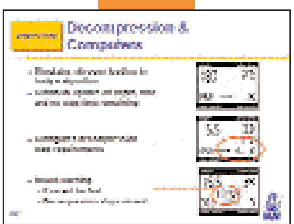
- **Clock**

  The internal clock determines parameters such as dive time, decompression time and surface interval time
- **Display Screen**

  Depending on the computer model, there is a variety of display formats. The screen shows the diver's current decompression status and other dive related information such as maximum depth achieved, current depth, dive time, time to decompression stops. Some computers also include the facility to read water temperature and some have cylinder pressure readouts via a transducer in the gas supply

Read the Instruction manual

With the variety of computers available, it is obviously important that divers fully understand the information the computer delivers. Reading the manufacturer's instruction manual is important as is getting used to the screen display. Initial dives in shallow water are also recommended so the diver becomes fully acquainted with the computer's operation before progressing to deeper dives.



DECOMPRESSION & COMPUTERS

Computers:

- Using their algorithms, mathematical models, simulate the nitrogen loading of the diver
- Continually calculate nitrogen loading throughout the dive, displaying the maximum depth achieved, current depth, time and no stop time remaining
- Display when decompression stops are required
- Display 'flashing' warnings (some issue audible warnings too)
  - If ascents are too fast
  - If decompression stops are missed

In case of computer failure, use a dive slate as a back-up plan - with information for the next longer time and next depth to that planned

DIVING WITH COMPUTERS

Using computers does not replace dive planning

As computers continually update depth, time and decompression requirements throughout the dive, there is a temptation to use them "on the hoof". However, using a computer this way can result in incurring a decompression penalty without having sufficient breathing gas available.

- Use the computer's pre-dive function as part of dive planning

  Computers have a pre-dive function that will scroll through depth increments and give information on maximum no stops times for each depth. Some computers have an additional facility that enables decompression requirements for dives in excess of no stop times to be determined

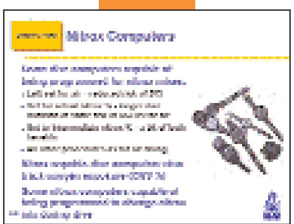
For second dives, the surface interval from the first dive will be included in the computer's calculation. The indication that this calculation has been done is the reduced no stop times for the second dive on the pre-dive scrolling information and these should be used for planning the second dive

- Agree timing signals with buddy

  Whether it is a no stop or decompression stop dive, agree with the buddy the signals to indicate how much time is left before either the end of a no stop dive or, if decompression stops are planned, when they will start and what their timings/depth are as displayed on the computer

  The 'timing' signals must be agreed prior to each dive to avoid any confusion.

- Ensure you have sufficient breathing gas for the planned dive
- As computers are battery operated - they can fail or the computer can develop a fault. Have a back up plan for the dive being undertaken in case of computer failure. This can be done either by noting the pre dive scroll information or referring back to tables and noting dive times/deco requirements, on a slate or pad
- Do not share your computer with other divers as it reflects the owner's decompression profile, including surface intervals, it should only be worn by its owner
- If the buddy pair are a 'mix', one diver using tables and the other a computer, plan and run the dive to the tables - they are the more punitive. However, the computer diver should still monitor their computer for depth and time according to the joint plan



NITROX COMPUTERS

Some dive computers capable of being programmed for nitrox mixes:

Many of the new dive computers or wrist watches can be programmed for up to 10 nitrox gas switches. Before using the nitrox functions, it is essential that the user has practiced and become familiar with the use of their own dive computer.

- Left set for air – reduced risk of DCI

  As per the Ocean Diver course, leaving the dive computer configured with an air mathematical model minimises the risk of the diver experiencing DCI.

- Set for actual nitrox % - longer dive duration at same risk of DCI as for air

  Programming the dive computer for the exact nitrox percentage enables the computer to adapt to the actual percentage of nitrogen in the mix. This extends the no-stop times over an air mathematical model, but if the diver extends their dive time beyond the no-stop time of the air mathematical model, they are placing themselves at a similar risk of DCI.

- Set to intermediate nitrox % - a bit of both benefits

  Half way house. The user is reducing the probability of DCI while benefiting slightly from extended no-stop dive times over an air mathematical model.

- All other procedures as for air diving

  Other than programming for nitrox, the computer will still behave operationally and functionally as when it is configured to use an air mathematical model. Dive planning based on the computer should produce the adjusted times for nitrox. All other dive parameters and processes willremain unchanged.

Nitrox capable dive computers also track oxygen exposure (CNS %)

During the dive, the majority of nitrox enabled computers will display the actual CNS%.

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- Set for actual nitrox % - longer dive duration at same risk of DCI as for air. Programming the dive computer for the exact nitrox percentage enables the computer to adapt to the actual percentage of nitrogen in the mix. This extends the no-stop times over an air mathematical model, but if the diver extends their dive time beyond the no-stop time of the air mathematical model, they are placing themselves at a similar risk of DCI.
- Set to intermediate nitrox % - a bit of both benefits. Half way house. The user is reducing the probability of DCI while benefiting slightly from extended no-stop dive times over an air mathematical model.
- All other procedures as for air diving. Other than programming for nitrox, the computer will still behave operationally and functionally as when it is configured to use an air mathematical model. Dive planning based on the computer should produce the adjusted times for nitrox. All other dive parameters and processes will remain unchanged.

Nitrox capable dive computers also track oxygen exposure (CNS %)

During the dive, the majority of nitrox enabled computers will display the actual CNS%. Some nitrox computers capable of being programmed to change nitrox mix during dive. As new computers and updated models enter the sport diving market, new features are being added, including the facility for multiple gas switches. This is beyond the scope of this course.

TRAVELLING AND DIVING - DECOMPRESSION TABLES

There are also other implications when planning dives. Some divers may have to travel to and from dive sites overland, some may dive lakes at altitude and many travel by plane to dive sites around the world on diving holidays. Travel upwards from sea level and the atmospheric pressure reduces (e.g. students may have heard the term 'thin air' used by mountaineers). Another reduction in atmospheric pressure is from the ever-changing weather patterns moving high and low pressure weather systems over the earth. (Low pressure generally indicates bad weather).

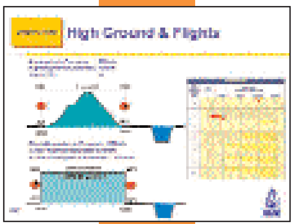
Any changes in local atmospheric pressure (either due to altitude or weather systems) affect the gas saturation of body tissues.

- It is this saturation that determines which Level set of BSAC Decompression Tables should be used
- Weather forecasts usually provide atmospheric pressure at sea level

Using the Altitude/Atmospheric Pressure Chart give as an example

- The sea level atmospheric pressure is around 1000 mbar, the planned dive is in a lake 750m above sea level. Trace the sea level atmospheric pressure vertically and known altitude level horizontally
- Where the values meet it indicates the Level of table to use - in this example Level 2 Tables

- If the value lines meet on a borderline, choose the more punitive option, the lower atmospheric pressure level



HIGH GROUND & FLIGHTS

To establish what the diver's current tissue code is when experiencing changes in atmospheric pressure, the Altitude/Atmospheric Pressure Chart and the Transfer Table are used.

As an example, travelling to a dive site over high ground

- The atmospheric pressure is 995 mbar

  The highest point of the journey is 1000m

  The start CTC is A at Level 1 (A/1)
- The start of the journey is 0700 and will take 3 hours
- Looking at the Altitude/Atmospheric Pressure Chart, the pressure of 995 mbar and the highest point of the journey being 1000m, the level reached will be Level 3
- On the Transfer Table, look at the 'Last Level Column'; this indicates the CTC, in this case it is A/1
- The code to transfer for the journey is indicated by moving along the dotted line across the table to the Level 3 column and code 'B' is indicated. So on transfer, A/1 CTC alters to B/3
- Travelling up and down will subject the diver to various pressure changes that cannot be clearly defined, so the whole journey over the high ground and back to sea level remains as a CTC of B/3
- Having completed the journey and back at sea level, the diver's body has experienced pressure changes and this needs to be taken into account by using the Transfer Table again. Using the Transfer Table, CTC is B/3, use the 'Last Level CTC column' - B/3, follow across the dotted line to Level 1 column (the atmospheric pressure at sea level has not changed) and B/3 transfers to B Level 1 - B/1
- For planning any dives following this journey the CTC is B/1 and it would need a surface interval of at least 10 hours to go back to A/1

As an example when flying

When flying, pressurised aircraft are assumed to maintain a cabin pressure equivalent to Level 4, which should be used to cover such flights. At this level, the appropriate Surface Interval Table should be used. *(Using the Transfer Table and Surface Interval Table for Levels 2,3,4, work through with students).*

- Starting from a CTC of A/1 on take-off, the Transfer Table shows that the ascent alters the CTC to C/4
- Because the pressure will remain relatively constant in flight, the level 4 Surface Interval Table can be used to determine the change in CTC as the flight progresses
- For flight durations of less than 90 minutes, the descent will commence with a CTC still remaining at C/4, resulting in a code of B/1 once back on the ground. Inspection of the Level 1 Surface interval Table shows that it will take a further 10 hours after flying for the CTC to return to A/1
- For flight durations of longer than 90 minutes, the CTC will reduce to B or even A at the start of the descent, resulting in a CTC of A/1 immediately on landing

Note: Some travelling may involve short flights in unpressurised aircraft, i.e. island hopping planes or helicopters - the height and atmospheric pressure chart should be used.

If the branch is involved in dives at altitude, the instructor can include examples typical to the type of diving undertaken at this point.

DIVING - TRAVELLING - FLYING

Implications of travelling after diving need to be considered.

Work through following example with students

- Divers decide to grab a morning dive before flying home at the end of a holiday. The atmospheric pressure is 1010 mbar and the height of the hills they will travel over on the way to the airport is 1095metres. The flight leaves at 2000
- The divers surface at 1200 with a code of F/1
- They plan to be picked up and begin their three hour journey to the airport over the hills at 1315, leaving time to go to the duty free in the airport before the flight in a pressurised aircraft

Students should

- Note that the CTC after the dive is F and that 1010 mbar at sea level is Table 1.
- Going over the hills is Level 3
- A surface interval of an hour and a quarter up to when the journey is planned to start, gives D/1
- On the Transfer Table, D/1 transfers to 'X' on Level 3 - the journey cannot be made
- With the students, determine from the tables what code is acceptable for the journey and work back to give appropriate timings
- From inspection of the Transfer Table, the maximum code at Level 1 that will allow an ascent to Level 3 is C. This will result in a CTC of F/3. In order to allow the CTC at the end of the dive of F/1 to reduce to C/1, the surface interval required is at least 90 minutes. The journey must therefore not be commenced before 1330 hours
- Their CTC changes from F/3 to D/1 when they arrive at the airport at sea level at 1630
- Remaining at sea level and shopping in the duty free until the flight leaves involves no change in atmospheric pressure so the Surface Interval Table can be used, resulting in a CTC of B/1 which transfers to D/4 for the flight

The examples that have just been worked on are obviously extreme but not only do they allow students to understand how to use the Altitude and Atmospheric Pressure Chart and the Transfer Table, but also demonstrate that travelling before or after diving needs careful planning particularly if it involves journeys to heights above sea level or flying.

TRAVELLING AND COMPUTERS

Adjust for altitude diving

- Computers will compensate for diving at altitude but how they do so varies from model to model. It is necessary to read the manufacturer's instructions to determine the level of compensation

Travelling/flying then diving

- Pressure changes before diving may not be accurately reflected by some computers due to their being inactive (turned off)

Diving then flying

- Computers will indicate the surface interval required following a dive before it is safe to fly

TRAVELLING & SURFACE INTERVALS

Travelling can be very tiring and stressful at the best of times.

- If travelling before diving

  - A good surface interval before the first dive is strongly advised
  - Then keep the first dive within conservative limits
- If travelling after diving
  - A good surface interval before flying is strongly advised

TABLES & COMPUTERS

Tables or Computers are not infallible

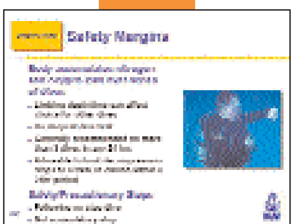
- They are just planning tools to minimise the risk of DCI. Remember that both tables and computers are a "model" of body tissues; they do not imitate exactly what is happening in the owner's body
- For the above reason, do not push the limits of tables or computers, it is pushing the limits of the diver's body too

Divers are not infallible

They need to be fit to dive. They should avoid:

- Smoking
- Alcohol
- Dehydration
- Tiredness
- Getting cold
- Excessive exercise during or after diving

All are factors that could predispose to DCI



SAFETY MARGINS

The body accumulates a nitrogen and oxygen load over a series of dives whether diving tables or computers.

There are a number of safety margins that divers should consider:

- Limiting the depth or time by a small margin or extending surface intervals can benefit decompression requirements for other dives
- Plan the deepest dive first - this maximises repetitive dive times and minimises the decompression requirements on subsequent dives
- It is generally recommended that divers, do no more than 3 dives in any 24 hours. Repeat diving carries a cumulative amount of nitrogen for the next dive, it makes sense to be careful as other effects on the body are not reflected by tables or computers
- It is advisable to limit decompression stops to a total of 20 minutes within a 24 hour period

Safety Stops

- When planning and diving no-stop dives, many divers will do safety or precautionary stops (1 - 5 minutes) after reaching 6m (the end of dive time) and before commencing the final part of the ascent to the surface
- This is an extra safety margin and is not a mandatory decompression stop. However, it should be included in the dive plan and be communicated to the Dive Manager so they know when you will be back on the surface

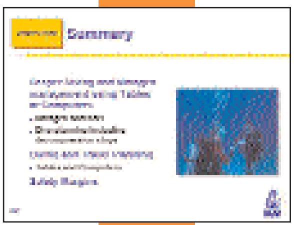
USE OF NITROX IN DEEPER DIVING

When planning for deeper dives, the use of Nitrox mixes reduces the partial pressure of Nitrogen at any given depth, resulting in:

- Reduced nitrogen narcosis
- Longer no-stop times using Nitrox tables or Nitrox computers

Even when air is used as the main breathing gas, the use of Nitrox mixtures for decompression will result in:

- Nitrogen being eliminated faster
- An added safety margin



SUMMARY

This session has looked at deeper diving and managing nitrogen in relation to:

- Nitrogen narcosis
- Dive planning including decompression stops using tables or computers

Also, when extending experience the implications of travelling to more varied sites have been explained together with considerations for increasing safety margins involved, looking at how atmospheric pressure can impact on

Diving and travel planning

- Using tables and computers

Safety Margins

Considerations for safer diving