The Sports Diver Nitrox Workshop

Student Workbook

The British Sub Aqua Club

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The British Sub-Aqua Club, Telford's Quay, South Pier Road, Ellesmere Port, Cheshire CH65 4FL

Telephone: 0151-350 6200 Fax: 0151-350 6215 www.bsac.org

Sports Diver Supplementary Training

Nitrox Workshop

The workshop presents the nitrox-related elements contained within the 2007 Diver Training Programme BSAC Sports Diver course. Divers who have not received any basic nitrox training should attend the 'Ocean Diver Nitrox Workshop' before attending this workshop.

Aim

The key objectives of this workshop are:

To further the learning of qualified divers

The workshop extends the your knowledge by expanding on the implications of nitrox diving as the maximum operating depth is increased to 35 metres.

To enable BSAC Sports Divers (or similar) to plan and execute nitrox dives for gas mixes up to 36% using computers/tables controlled by the MOD of the selected gas

You will be enabled to plan and execute decompression dives using an appropriately calculated nitrox mix up to a maximum oxygen percentage of 36%.

Sports Diver

The Sports Diver qualification enables you to:

Dive within maximum operating depth (MOD) of the gas carried

You must observe the maximum operating depth of the chosen gas. If you plan to dive to 35 metres, you must chose an appropriate nitrox mix that enables you to achieve your planned decompression profile safely.

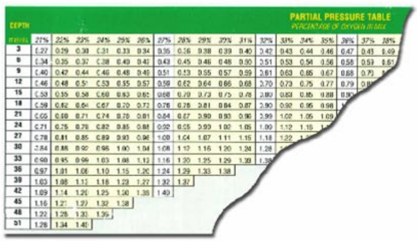
Plan decompression dives on nitrox tables or nitrox computers

You can take advantage of the reduced nitrogen content of an enriched nitrox mix, allowing you to benefit from longer no stop times than when breathing air (Nitrox 21).

Dive within the depth limit of the diver's experience or qualification

A diver's experience should always be progressive in terms of depth or type of dive. If you have crossed over from an alternative agency you may have certification constraints until further training is conducted. Your Diving Officer should be able to advise on this.

Oxygen Partial Pressures



This section covers some of the basic definitions for managing oxygen when diving at depth. It is aimed at providing an understanding of the rudimentary calculations that allow for safe diving with enriched nitrox.

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.

Fraction of oxygen (FO_2) in mix

The fraction of oxygen in the mix is defined by a decimal representation of the final mix percentage for calculation requirements.

- **FO_2 = % divided by 100**
- **e.g. FO_2 of Nitrox 36 = 0.36**

Oxygen partial pressure (PO_2)

The notation for oxygen partial pressure varies between documents and agencies. Sometimes ppO_2 or ppO2 are used. Both are incorrect. Oxygen partial pressure is simply defined as:

- **PO_2 = FO_2 x absolute pressure**

  Oxygen partial pressure = Fraction of oxygen times absolute pressure.

Example - Nitrox 32 at 30 m

Given this information, you can calculate the oxygen partial pressure:

- **PO_2 = 0.32 x 4.0 bar = 1.28 bar**

Safety limit

Oxygen becomes toxic (poisonous) at high partial pressures. To reduce the risk of oxygen toxicity, there is a defined safe diving limit for decompression diving:

- **Maximum recommended PO_2 is 1.4 bar**

  This rule is relaxed for two standard mixes of Nitrox 32 and Nitrox 36 when executing a **no stop dive**. The maximum PO_2 of 1.44 bar is allowed.

Maximum Operating Depth (MOD)

The depth at which the PO_2 of the mix reaches 1.4 bar

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 for Sports Divers, but this may be further reduced if exertion is expected during the dive.

Example

You can calculate the maximum operating depth using the following formula:

- **(PO_2)max ÷ oxygen fraction = MOD**

  The result of the calculation is an absolute pressure. To convert this into a depth it needs to be converted into a gauge pressure by subtracting 1 bar; and then multiplied by 10 to convert to metres.

  Assuming the same gas, Nitrox 32, as the previous example and substituting numbers for the words:

- **1.40 bar ÷ 0.32 bar = 4.38 bar (33.8 m)**

Do not exceed your MOD

To avoid oxygen toxicity, BSAC Safe Diving recommends that divers should not exceed the MOD of their chosen gas. Bear this in mind when planning your “just deeper” alternative option.

Select a mix with an MOD greater than your “just deeper” planned depth

On the day, even the best laid plans sometimes go wrong and some degree of flexibility is required. For example, the planned dive turns out to be marginally deeper than expected. Selecting an MOD greater than the planned depth provides some additional flexibility if, for example, a diver is uncomfortable in the water and their buoyancy is not quite what it should be. The allowance enables them to safely complete the dive without fear of oxygen toxicity.

Limits of 36%=30m and 32%=35m still OK for No-Stop dives only

The standard mixes of Nitrox 32 and Nitrox 36, for no-stop diving, provide a calculated PO_2 of 1.44 bar. Although this exceeds the recommendation for decompression diving, i.e., 1.40 bar, this is allowable due to the no-stop diving constraint, which minimises the risk of encountering oxygen toxicity by limiting the time of exposure.

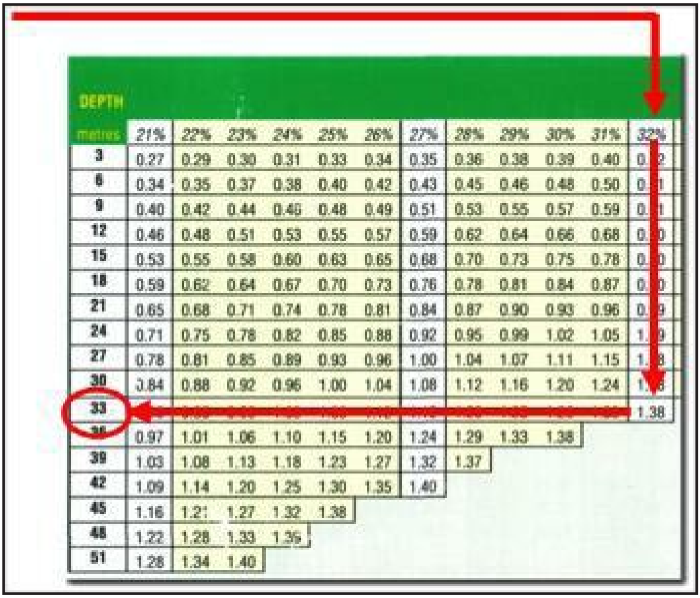
Partial Pressure table

To simplify and reduce the probability of a calculation error, the BSAC has provided a partial pressure look-up table in the back of the BSAC Nitrox Tables. The 'x' axis shows the percentage of oxygen in the mix in 1% increments starting with air (21%). The 'y' axis shows the depth in 3 metre intervals starting at 3 metres and aligns with the BSAC '88 and Nitrox tables.

The following example illustrates the advantages of a table versus mathematical calculations.

What is the maximum MOD for nitrox 32%?

Identify 32% on the 'x' axis. The PO_2 at the MOD should never exceed 1.4 bar. Move down the column looking for the number 1.40. The table stops at 1.38 bar, because the next incremental depth increment of 3 metres would cause the PO_2 to exceed the maximum allowable of 1.40 bar. Move across until the 'y' axis is intercepted, where the following answer is obtained.



DEPTH metres	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%	31%	32%
3	0.27	0.29	0.30	0.31	0.33	0.34	0.35	0.36	0.38	0.39	0.40	[illegible]
6	0.34	0.35	0.37	0.38	0.40	0.42	0.43	0.45	0.46	0.48	0.50	[illegible]
9	0.40	0.42	0.44	0.46	0.48	0.49	0.51	0.53	0.55	0.57	0.59	[illegible]
12	0.46	0.48	0.51	0.53	0.55	0.57	0.59	0.62	0.64	0.66	0.68	[illegible]
15	0.53	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	[illegible]
18	0.59	0.62	0.64	0.67	0.70	0.73	0.76	0.78	0.81	0.84	0.87	[illegible]
21	0.65	0.68	0.71	0.74	0.78	0.81	0.84	0.87	0.90	0.93	0.96	[illegible]
24	0.71	0.75	0.78	0.82	0.85	0.88	0.92	0.95	0.99	1.02	1.05	[illegible]
27	0.78	0.81	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.11	1.15	[illegible]
30	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24	[illegible]
33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.38
[illegible]	0.97	1.01	1.06	1.10	1.15	1.20	1.24	1.29	1.33	1.38		
39	1.03	1.08	1.13	1.18	1.23	1.27	1.32	1.37				
42	1.09	1.14	1.20	1.25	1.30	1.35	1.40					
45	1.16	1.21	1.27	1.32	1.38							
48	1.22	1.28	1.33	1.36								
51	1.28	1.34	1.40									

Answer: 33 metres

The calculated answer from the previous slide was 33.8 metres for an exact PO_2 of 1.40 bar. The table rounds down introducing a further safety factor, but above all keeps the process simple and less prone to mathematical errors. Using the waterproof 'BSAC Nitrox Tables' at a dive site, allows you to simply and quickly look up the MOD on the day.

For no-stop dives only:

If performing a no-stop dive on Nitrox 32, you may plan to a deeper maximum operating depth of 35 metres.

Max depth is 35 metres

Remember that Nitrox 36 has a maximum operating depth of 30 metres for a no stop dive.

Partial Pressure table

This next example explains how you can obtain the partial pressure of oxygen at the target depth for a given mix from the partial pressure table.

What is the PO_2 of nitrox 32% at 30 metres?

Along the 'x' axis, locate the 32% oxygen fraction column. On the 'y' axis, locate the depth of 30 metres. Locate in the table where the two columns intersect. This provides you with the required PO_2 in bar.

DEPTH metres	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%	31%	32%
3	0.27	0.29	0.30	0.31	0.33	0.34	0.35	0.36	0.38	0.39	0.40	[illegible]
6	0.34	0.35	0.37	0.38	0.40	0.42	0.43	0.45	0.46	0.48	0.50	[illegible]
9	0.40	0.42	0.44	0.46	0.48	0.49	0.51	0.53	0.55	0.57	0.59	[illegible]
12	0.46	0.48	0.51	0.53	0.55	0.57	0.59	0.62	0.64	0.66	0.68	[illegible]
15	0.53	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	[illegible]
18	0.59	0.62	0.64	0.67	0.70	0.73	0.76	0.78	0.81	0.84	0.87	[illegible]
21	0.65	0.68	0.71	0.74	0.78	0.81	0.84	0.87	0.90	0.93	0.96	[illegible]
24	0.71	0.75	0.78	0.82	0.85	0.88	0.92	0.95	0.99	1.02	1.05	[illegible]
27	0.78	0.81	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.11	1.15	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.28
33	0.90	0.95	0.99	1.03	1.08	1.12	1.16	1.20	1.25	1.29	1.33	1.38
36	0.97	1.01	1.06	1.10	1.15	1.20	1.24	1.29	1.33	1.38		
39	1.03	1.08	1.13	1.18	1.23	1.27	1.32	1.37				
42	1.09	1.14	1.20	1.25	1.30	1.35	1.40					
45	1.16	1.21	1.27	1.32	1.38							
48	1.22	1.28	1.33	1.36								
51	1.28	1.34	1.40									

Answer: 1.28 bar

This answer is identical to the previously calculated value.

Partial Pressure Table reduces calculation errors.

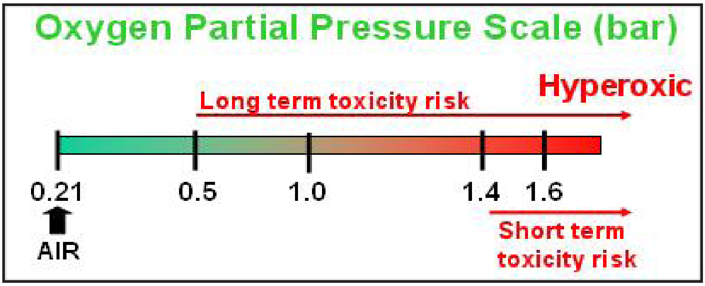
Overall, this is a very good way of finding PO_2. Knowing the PO_2 at the target depth beforehand helps you avoid accidentally exceeding the critical limit of 1.40 bar for your dive gas.

Oxygen Exposure

Oxygen has been discussed as being toxic in general terms. The next section goes into more detail, highlighting just how much oxygen is too much.

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

Oxygen Partial Pressure Scale (bar)



The bar on the graphic moves from normoxic oxygen levels to hyperoxic conditions. Hyperoxic conditions can be fatal.

At high concentrations oxygen is toxic

For safe diving the PO_2 is limited to 1.40 bar avoiding the more extreme exposures.

Know and observe your MOD to control the PO_2!

Exceeding the limits of human tolerance of oxygen can be life threatening. By planning properly and not exceeding the MOD the risk of oxygen toxicity can be managed. You need to understand what actions to take should you approach or exceed limits.

Keep within accepted oxygen exposure limits

Some consequences of elevated PO_2 are time dependent. Oxygen exposure tracking is therefore as important as planning decompression. Tolerance to CNS toxicity varies from individual to individual, and from day to day for the same person.

It is essential that divers measure the uptake of oxygen into the body, ensuring that they never exceed a PO_2 of 1.40 bar. 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 (Overview)

This section focuses on hyperoxia and specifically the practical situations that could lead to it when diving.

What is it?

- **Too much oxygen**

  Although any gas mixture containing a PO_2 in excess of 0.21 bar could be termed a hyperoxic mix, the effects do not become significant until the PO_2 approaches 0.5 bar.

- **Oxygen becomes toxic at elevated partial pressures**

  Basically, you can have too much of a good thing. The richer the mix the shallower the depth at which it becomes toxic.

  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 different effects of hyperoxia:

- **Whole Body Oxygen Toxicity when PO_2 > 0.5 bar for long periods (recompression)**

  Whole body oxygen toxicity is also known as 'pulmonary toxicity dose' as it affects the lungs before other body parts. This is the long term effect of oxygen toxicity and the extent of exposure required for whole body toxicity to appear is longer than would be experienced during Sports Diving.

- **Central Nervous System (CNS) toxicity can occur when PO_2 > 1.4 bar for even short periods (on a dive)**

  You will be at a high risk of experiencing CNS toxicity if you exceed the Safe Diving recommendation of 1.40 bar. The maximum safe depth limit is considerably shallower than for air (21% O_2), and falls within the depth range of Sports Divers.

Hyperoxia (Causes)

The following is a list of reasons why divers might breathe a hyperoxic mixture.

Causes:

- **Inaccurate dive planning**

  Safe diving should always start with accurate dive planning. Nitrox only slightly increases the complexity of the dive plan, by requiring the diver to choose a suitable dive gas for the proposed dive; and then to work out the decompression requirements.

- **Failure to analyse gas**

  There are many examples where the gas blender has failed to blend the gas accurately. One documented incident resulted in a diver entering the water with a pure oxygen mix. It is essential that divers witness an analysis of their own cylinder gas content.

- **Incorrect marking or fitting of cylinders**

  Divers can be very lazy and trust to memory or others that they have chosen or labelled a cylinder correctly. On many occasions, divers have dived on the wrong mixture or used inappropriate regulators. If unsure, perform or ask for an analysis and then correctly mark on the cylinder its contents and MOD.

- **Failure to observe MOD!**

  The MOD is there to protect the diver. Failure to observe the MOD could lead to CNS toxicity and a potential fatality.

Hyperoxia (Practicalities)

Aggravating factors

- **Actual PO_2**

  The higher the PO_2, the greater the effect.

- **Duration of exposure**

  The longer the exposure, the more likely the onset of symptoms.

- **Level of exertion**

  The greater the diver's level of exertion, and hence carbon dioxide (CO_2) production, the greater the impact of a high PO_2. Evidence shows that a high PCO_2 predisposes towards oxygen toxicity.

- **Cumulative O_2 exposure**

  The oxygen exposure from any dive will be additive to any residual exposure from previous dives.

Long term (whole body) toxicity risk not an issue at this level

The short dive durations experienced by Sports Divers preclude this from being a significant risk.

Short term (CNS) toxicity risk needs to be understood

CNS toxicity is a real risk for Sports Divers so you need to understand its effects and how to manage it.

CNS Toxicity

Also known as acute oxygen toxicity

Reaction to PO_2 generally > 1.4 bar

While a PO_2 of 1.4 bar is generally accepted as a level below which the effects of CNS toxicity are unlikely to be experienced, as with many physiological effects of diving, it is not a precise threshold. An individual's tolerance will also vary day to day.

Symptoms:

The following is a useful mnemonic to remember the symptoms of CNS toxicity.

CON - Convulsions

V - Vision

E - Ears, hearing disturbances

N - Nausea

T - Twitching

I - Irritability

D - Dizziness

Until convulsions begin, minor symptoms:

There is no set progression through the more minor symptoms. They:

- **Can occur in *ANY* order or combination**
- **Increase in severity**

These minor symptoms are ones that only the diver affected may notice and some are similar to those experienced with other diving related conditions (e.g., narcosis). If you or your buddy feels that something is wrong, then it could be! The dive should be aborted: it may save a life! Particular symptoms which have alerted some divers to a potential oxygen toxicity attack are narrow / tunnel vision and bright coloured spots appearing before the eyes. Facial twitching, particularly around the lips, is the one sign that buddies may observe.

Once convulsions begin however, a more recognisable pattern is seen.

CNS Toxicity – Convulsions

CNS convulsions are experienced at high partial pressures generally greater than 1.4 bar; but evidence has shown episodes to occur as low as 1.28 bar; and they can be experienced after long exposure to elevated partial pressure. Although the cause in human physiology is not fully understood the effects have been categorized as shown below:

Three phases *may* be apparent:

- **Tonic phase – do not lift**
    - **Casualty becomes rigid and holds breath**

      As the casualty will be holding their breath, an ascent could cause lung damage.

- **Clonic phase – do not lift**
    - **Casualty jerks violently (convulsion)**

      The casualty's movements can be extremely violent, therefore rescuers should, if practicable, remain clear of the casualty to avoid prejudicing their own safety.

- **Relaxation phase - assist**
    - **Casualty relaxes and is unconscious**

      Once the casualty has entered this phase is the time to act and bring them to the surface, as rescuers can assist without prejudicing their own safety or risking injury to the casualty during the ascent.

- **Note: loss of regulator**

  As the casualty is unconscious there is a high probability that he/she will lose their mouthpiece.

While the above description gives the ‘classic’ progression of signs and symptoms, the reality is that not all phases may be observed by a buddy or subsequently remembered by the casualty. Underwater, even if they do occur, the first phase may go unnoticed by buddies.

Evidence indicates that once they begin, convulsions progress through the above sequence of phases, which is subsequently repeated with increasing frequency.

Signs can still occur after PO_2 is reduced

Sometimes convulsions can continue after the casualty has been removed from breathing a high PO_2. This may be due to the casualty having been brought to the surface or after a dive, recognising the more minor symptoms, has bailed out to a lower PO_2 on open circuit.

The mechanism is not understood but divers, particularly rescuers, need to be aware that it can happen and be prepared to deal with it.

CNS Toxicity - Incident Management

If a diver suffers from CNS toxicity:

Provided the casualty is in the relaxation phase, perform a

- **CBL to surface even if deco stops omitted**

  Missing a few minutes has a low risk of DCI, especially when diving on nitrox. Discuss options during the planning phase, if you or your buddy does not wish to lift a casualty directly to the surface.

If casualty is rigid, holding breath or convulsing ...

If the casualty is in either the tonic or clonic phase,

- **Do NOT attempt to lift**
- **Risk of embolism**
- **Wait until the casualty has relaxed**

On reaching the surface,

Remove casualty from water

Use any additional resources to help with this exercise.

Do administer oxygen therapy if suspect DCI or barotrauma

If the casualty convulses, remove from the oxygen source, and then reapply when the convulsion has finished.

Hyperoxia (Avoidance)

Avoidance:

While the effects of oxygen toxicity can be quite dramatic, there are a few simple procedures that can effectively reduce the likelihood of them occurring:

- **Plan the dive; dive the plan**

  Always ensure that the fundamentals of good dive practices are performed.

- **Max PO_2 of 1.4 bar**

  Calculate the MOD using a PO_2 of 1.40 bar or less.

- **Do not exceed MOD**

  Monitor depth at all times.

- **High PCO_2 predisposes to oxygen toxicity**

  A high level of PCO_2 in the blood is known to reduce tolerance to high PO_2. Measures to counteract the impact of CO_2 are:

  - **Breathe normally throughout the dive**

    Ensure that the lungs are properly ventilated by breathing normally at all times.

  - **Reduce PO_2 for high exercise dives**

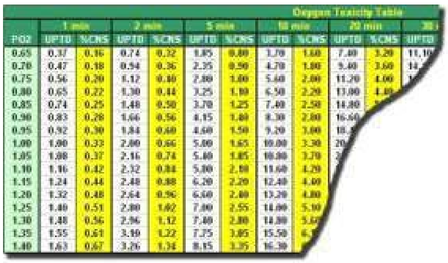
    Where high levels of exercise are expected – such as swimming against a current – reduce depth if possible.

- **Accurately track your oxygen exposure**

  Monitor your CNS exposures for each dive and take them into account when planning the next dive.

Monitoring Oxygen Exposure

CNS toxicity needs to be monitored



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.

A number of different systems are available to calculate the uptake of CNS:

- **BSAC Oxygen Toxicity Table**

  The BSAC Oxygen Toxicity Table provides data for the tracking of CNS toxicity uptake.

- **Dive planning software / nitrox computers**

  Computer based dive planning software will normally automatically compute CNS for each dive and, where appropriate, take account of previous dives.

CNS% should not exceed 80%

If a planned dive's CNS% reaches 80%, then take a two hour break breathing air on the surface.

While at the surface

- **CNS% is reduced by half every two hours**

  For every two hours spent at the surface breathing air there is a reduction in the previous dive's CNS total of 50%.

- **Add outstanding CNS% to next dive**

  Residual CNS% is cumulative. The CNS% from the last dive should be added to the next dive taking into account the two hour decay model, unless 24 hours has elapsed between the dives.

Oxygen Toxicity Table

Using the Oxygen Toxicity Table

The oxygen toxicity table is a simple look-up table for calculating total CNS% for a dive.

- **Find PO_2 in left hand column (round-up)**

  Identify the PO_2 or the closest higher value from the left hand column.

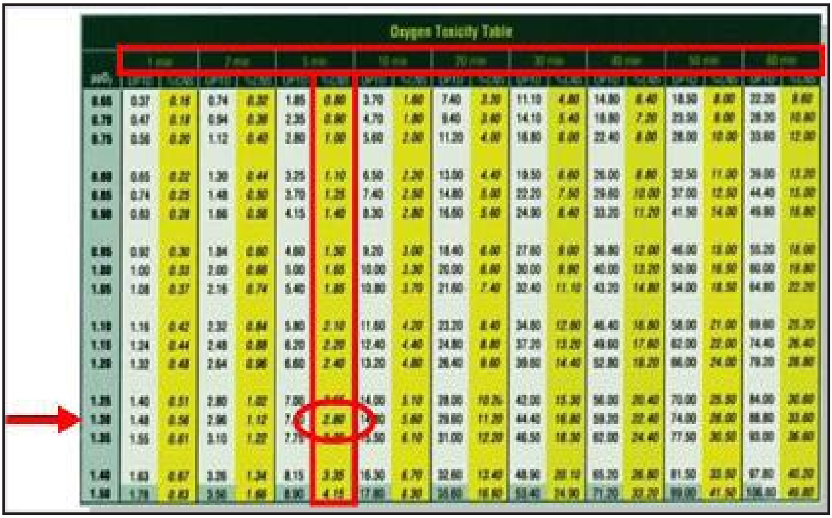
  - **e.g., $PO_{2Actual}$ = 1.28 bar; PO_2 Table = 1.30 bar**

- **Find time spent at PO_2 along the top row**

  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.

- **Where lines intersect (yellow column) indicates CNS% uptake**

  For example a 5 minute exposure gives a CNS% value of 2.80%.



Dive 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 you practice and become familiar with the use of your 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 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 you extend your dive time beyond the no-stop time of the air mathematical model, you are placing yourself at a similar risk of DCI.

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

  Half way house. You are 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 workshop.

Practice - Oxygen Toxicity Table

The following example illustrates working with the BSAC Oxygen Toxicity Table.

What is the accumulated CNS% for a total dive time of 27 minutes at a PO_2 of 1.38 bar?

There are two different methods of using the table:

Method one

Using the oxygen toxicity table, split the total dive time of 27 minutes into manageable portions, for example, 2, 5 and 20 minutes then add together the resultant CNS% values.

- **CNS% = 1.34 (2 mins) + 3.35 (5 mins) + 13.40 (20 mins)**
  = 18.09 %

Method two

Identify 1 minute of CNS% at a PO_2 of 1.38 bar (rounding up to 1.4 bar) and then multiply by the total time.

- **CNS% = 27 mins × 0.67 (1 min) = 18.09 %**

2 hours later the divers plan a second dive, what is the residual CNS% at the start of the dive?

CNS% halves every 2 hours,

- **CNS% = 18.09 ÷ 2 = 9.045 %**

This value should then be added to the calculated CNS% for the next dive.

Note: dive computers may use a different method for calculating residual CNS%

The CNS% calculation varies depending on how the mathematical model has been implemented, so you may observe subtle discrepancies in the calculated CNS%.

Nitrox Tables - planning a dive using *Nitrox 32*

The rules, procedures and definitions utilised in the BSAC NITROX decompression tables are identical to those used for the BSAC '88 Tables.

- No-stop diving.
- Decompression diving.
- Ascent rates.
- Dive profiles.
- Table procedures and usage.
- Altitude diving above level 1 is not catered for in the BSAC Nitrox Tables. However, the considerations regarding decompression and flying in aircraft before or after a dive remain the same.
- Recommended safe diving.

You must understand the basic definitions when using the tables.

Dive to 20 metres for 30 minutes

The dive is to be performed on Nitrox 32. No previous dive history in the past 24 hours, so the CTC is A.

Depth and/or time is 'in between' values

The table increments in 3 metre intervals. If the exact planned depth or time is not shown always err on the side of caution:

- **Use next greater depth**

  21 metres is the closest incremental depth for dive planning purposes.

- **Use next longer time**

  41 minutes is the closest and safest option to the dive plan of 30 minutes.

32% OXYGEN - LEVEL 1 (greater than 984 millibar)
TABLE A

DEPTH (metres)	ASCENT (mins)	DIVE TIME (mins) No-Stop Dives						Decompression Stop Dives							
3	(1)	-	480												
6	(1)	-	96	480											
9	1	-	31	133	384	480									
12	1	-	18	63	157	190	277	299	330	353	371	388	405	423	441
15	1	-	15	38	89	107	126	165	184	197	208	215	223	231	239
18	1	-	6	28	58	69	80	108	123	134	141	147	153	159	165
21					41	48	56	77	90	99	105	110	115	120	125
24	2		-	15		37	43	59	71	78	83	88	92	96	100
27	2		-	12		30	34	48	57	64	68	72	76	79	83
DECOMPRESSION STOPS (mins) at 6 metres								1	3	6	9	12	15	18	21
SURFACING CODE			B	C	D	E	F	G	G	G	G	G	G	G	G
30	2		-	10	21	24	28	39	48	53	57	61	64	67	
33	2		-	8	17	20	23	33	41	46	49	52	55	58	
36	2		-	7	15	17	19	29	36	40	43	46	49	51	
DECOMPRESSION STOPS (mins) at 9 metres											1	1	1	1	
at 6 metres								1	3	6	9	12	15	18	
SURFACING CODE			B	C	D	E	F	G	G	G	G	G	G	G	

Surface Code is D

The intersection of 21 metres at 41 minutes then identifies the surfacing code as D.

Planning - dive one *Nitrox 32*

First Dive

There is no previous dive history in the past 24 hours, so the CTC is A.

- **Nitrox 32**

  The divers preferred nitrox mix.

- **26 metres**

  The principle of next greater depth of 27 metres applies.

- **33 min**

  The next longest time of 34 minutes needs to be applied to identify the correct surfacing code.

32% OXYGEN - LEVEL 1 (greater than 984 millibar)
TABLE A

DEPTH (metres)	ASCENT (mins)	DIVE TIME (mins) No-Stop Dives						Decompression Stop Dives							
3	(1)	-	480												
6	(1)	-	96	480											
9	1	-	31	133	304	480									
12	1	-	18	63	157	190	227	299	330	353	371	388	405	423	441
15	1	-	10	38	89	107	125	165	184	197	206	215	223	231	239
18	1	-	6	26	58	69	80	108	123	134	141	147	153	159	165
21	1		-	19	41	48	56	77	90	99	105	110	115	120	125
24	2		-	15	32	37	43	59	71	78	83	88	92	96	100
27	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	34	49	57	64	68	72	76	79	83
DECOMPRESSION STOPS (mins) at 6 metres								1	3	6	9	12	15	18	21
SURFACING CODE			B	C	D	E	F	G	G	G	G	G	G	G	G
30	2		-	10	21	24	28	39	48	53	57	61	64	67	
33	2		-	8	17	20	23	33	41	46	49	52	55	58	
36	2		-	7	15	17	19	29	36	40	43	46	49	51	
DECOMPRESSION STOPS (mins) at 9 metres											1	1	1	1	
at 6 metres								1	3	6	9	12	15	18	
SURFACING CODE			B	C	D	E	F	G	G	G	G	G	G	G	

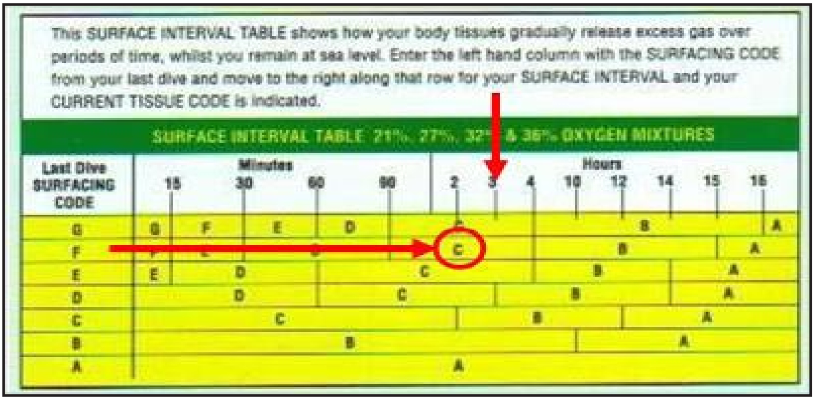
Surface code = F

Surface Interval Table

The example continues. The next step is to work out the current tissue code

Surface interval 3 hours

The divers had a surfacing code of F. The Surface Interval Table is used to find the new surface code in preparation for dive two.



Second dive CTC = C

Planning - dive two *Nitrox* 36

Dive two in the sequence is planned to be executed on Nitrox 36.

Second Dive

- **Nitrox 36% Table C**

  The mix is 36% and the CTC is C which means that you must use the 36% Oxygen – Level 1 Table C.

- **20 metres**

  This is the planned maximum depth for the second dive. The next greater entry on the table is 21m.

- **25 min**

  This is the planned maximum dive time for the second dive. The next greater entry on the table for 21 metres is 40 minutes.

- **Stops = 1 min @ 6m**

  This is identified as a decompression dive requiring a mandatory decompression stop of 1 minute at 6 metres.

36% OXYGEN - LEVEL 1 (greater than 984 millibar)
TABLE C

DEPTH (metres)	ASCENT (mins)	DIVE TIME (mins) No-Stop Dives					Decompression Stop Dives							
3	(1)	480	163	-										
6	(1)	-	480											
9	1		-	480										
12	1		-	71	116	177	311	382	450	480				
15	1		-	29	45	64	112	137	155	170	183	196	209	223
18	1		-	16	25	34	61	77	89	97	106	114	122	129
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	51	60	66	72	78	84	89
24	2		-	8	12	16	30	39	46	50	55	59	64	68
DECOMPRESSION STOPS (mins) at 6 metres							1	3	6	9	12	15	18	21
SURFACING CODE		B	C	D	E	F	G	G	G	G	G	G	G	G
27	2			-	9	12	23	31	36	40	44	47	51	55
30	2			-	7	9	19	26	30	33	36	39	43	46
DECOMPRESSION STOPS (mins) at 9 metres													1	1
at 6 metres							1	3	6	9	12	15	18	21
SURFACING CODE		B	C	D	E	F	G	G	G	G	G	G	G	G

- **Surface Code = G**

The higher the percentage of oxygen in the nitrox mix, the lower the probability of a diver experiencing a DCI incident.

Practice - planning two dives using different *nitrox* mixes

Good practice to increase oxygen % for second dive

It is good practice to increase the oxygen in the mix for subsequent dives as this will help to reduce the risk of DCI:

- by minimising the cumulative effect of nitrogen diffusing into the already preloaded tissues
- and by maximising the pressure differential between the lungs and alveoli thereby increasing the rate of nitrogen off-gassing during the ascent phase.

Dive one

There is no previous dive history in the past 24 hours so the CTC is A.

- **25 m for 30 min on nitrox 32 (Use Table A 32%)**
- **Surfacing code = E**

Surface interval of 5 hours

Use the surface interval to find the CTC for dive two from the 'Surface Interval Table'.

Dive two

- **18 m for 40 min on nitrox 36**

  The second dive requires you to change nitrox tables and use the 36% Oxygen tables.

- **CTC = B (apply to Table B 36%)**

  Now use the planned dive time and maximum depth to find the surfacing code for dive two from Table B 36%.

- **Surfacing code = D (no-stop dive)●**

Dive Management

Divers using different mixes

In an ideal world, the Dive Manager (formerly 'Dive Marshal') would pair divers using similar gas mixes. When this is inconvenient or impractical then the divers and Dive Manager need to consider the following:

Dive plan limited by:

- **MOD of highest % oxygen mix**

  The diver with the shallower MOD dictates the maximum depth of the dive.

and

- **Decompression requirements for the lowest % oxygen mix**

  The diver with the most nitrogen in their cylinder mix drives the overall decompression plan. This diver has a higher susceptibility to DCI.

Dive Manager should additionally ensure recording of percentage mix and MOD of each diver.

Dive Manager on the day is responsible for the percentage mix and MOD being recorded on the Dive Manager's Slate. You should be pre-prepared to provide these specific details in addition to the agreed dive plan.

Summary

Sports Diver

- **Max PO_2 of 1.4 bar**

Partial Pressure Table

Oxygen Exposure

- **Hyperoxia**

CNS Toxicity

- **Convulsions**

- **Incident Management**

Oxygen Toxicity Table

BSAC Nitrox Tables

- **Dive planning**

Dive Management

- **% Mix**
- **MOD**