American Dive Center

Nitrox Diver
Home Study Workbook

N is for Ni-trox

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Nitrox Diver Independent Learning Course

Course Outline

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What Is Nitrox?

Nitrox is any mixture of **Oxygen** and **Nitrogen**. As such, the air we breathe fits this definition. In diving, and in this course, we will limit our consideration to those mixtures that have a greater percentage of Oxygen than the air we breathe. These mixtures are referred to as **Enriched Air Nitrox** or, the abbreviation, **EANx**.

Nitrox I (**NI**) and **Nitrox II** (**NII**) are popular mixtures for diving. The modern terms for these mixtures are **EANx32** and **EANx36**.

Definitions					
	Air	NI or EANx32	NII or EANx36	EANx40	Pure Oxygen
Oxygen %	21%	32%	36%	40%	100%
Nitrogen %	79%	68%	64%	60%	0%

The tolerance on NI and NII is + or - 1%. Thus EANx31 to EANx33 is considered to be NI and EANx35 to EANx37 is considered to be NII.

All **Nitrox** mixtures are **odorless** and **tasteless**. This is good, because it means that you will not have to get used to new odors or tastes. The downside is that you can not use your senses of smell and taste to tell one mixture from another. To your senses, they all seem the same.

Note: While the focus in this course is on the amount of Oxygen in the mixture, the real benefits of Nitrox come from the reduced Nitrogen content of the mixture. Thus, you might do better to think of Nitrox, not as Oxygen enriched air, but rather, as Nitrogen reduced air.

What is Nitrox? Self Test	
What is the Oxygen % in Nitrox I?	
What is the Oxygen % in Nitrox II?	
What is the Oxygen content tolerance for Nitrox I and Nitrox II?	

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Nitrox History

In the beginning, there was a need for a Nitrox history to help justify that diving Nitrox was an ok thing to do. Now, with the experience of the many people diving Nitrox, this history is much less important. But, for completeness, here it is.

1959 USN	1979 NOAA	1989 IANTD	1996 PADI

In 1959 the United States Navy (USN) documented it's procedures for the military use of Nitrox in the USN Diving Manual.

In 1979 the National Oceanic and Atmospheric Administration (NOAA) followed suit and published it's procedures for the scientific use of Nitrox in the NOAA Diving Manual.

In 1989 Dick Rutkowski, a former NOAA diving safety officer, started teaching Nitrox use to the recreational diving community.

In the early 1990's, the agencies to teach Nitrox to the recreational community were not the main line scuba agencies. Instead, new organizations like Dick Rutkowski's IANTD (International Association of Nitrox and Technical Divers), and later Ed Betts' ANDI (American Nitrox Divers International), and still later Bret Gilliam's TDI (Technical Divers International) put Nitrox into the recreational lexicon.

In 1996 the Professional Association of Diving Instructors (PADI) announced full educational support for Nitrox. While other main line scuba organizations had announced their support of Nitrox earlier, it was PADI's endorsement that was needed. With PADI committed, the history of recreational Nitrox was complete.

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Advantages of Nitrox

The advantages of Nitrox? Three words --- more bottom time.

On a 60 foot dive on air the allowable bottom time is 55 minutes. With a 40% Nitrox mixture the allowable bottom time is 2 hours and 34 minutes.

In addition, Nitrox is a **safer mix** to dive than air, and many divers report **less fatigue** after diving with Nitrox.

More Bottom Time	Safer Mix	Less Fatigue

Note: Contrary to popular opinion, Nitrox is not used for deep diving. Instead, the optimum depth range for Nitrox is from 50 feet to 130 feet.

Note: Reduced narcosis at depth is not one of the claims for Nitrox. Logic suggests that with less Nitrogen in the mix, there would be a reduced narcotic experience at depth. However, Oxygen is also a narcotic gas. The net effect is that the Narcotic experience does not change when diving Nitrox.

Advantages of Nitrox Self Test	
What is the primary advantage derived from diving Nitrox?	

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Disadvantages of Nitrox

If there were only advantages to diving Nitrox there would be no need for a course. We would just have our tanks filled with Nitrox and go diving. So let's take a good look at the disadvantages.

First we must remember that Nitrox is a gas and thus we still have to equalize while descending and breathe continuously while ascending. And since Nitrox still has Nitrogen in it, it is still possible to get decompression sickness when diving Nitrox.

However, the real disadvantages of Nitrox are a result of the additional Oxygen in the mix. Specifically, the risks due to increased Oxygen concentrations in the mix are **Oxygen Toxicity**, **Wrong Mix**, and **Trauma**.

Oxygen Toxicity	Wrong Mix	Trauma

Oxygen Toxicity is, with out a doubt, the number one risk associated with diving Nitrox.

The more Oxygen in a mix, the less deep the mix can be dived. Each mix has it's own **Maximum Operating Depth** (**MOD**). The National Oceanic and Atmospheric Administration (NOAA) MOD's for various mixes are shown in the table below.

NOAA Maximum Operating Depths					
	Air	NI or EANx32	NII or EANx36	EANx40	Pure Oxygen
Oxygen %	21%	32%	36%	40%	100%
Nitrogen %	79%	68%	64%	60%	0%
MOD	218 Feet	**132 Feet**	**113 Feet**	**99 Feet**	20 Feet

Warning
Exceeding the Maximum Operating Depth of the mix will result in death by drowning.

The high Oxygen concentration will cause the diver to have a gran mal seizure similar to an epileptic fit. On the surface, such an occurrence would result in unconsciousness but not death. Underwater, the diver will become unconscious, probably spit their regulator out, and drown. This event is essentially non rescueable. Attempts to replace the regulator and get the diver to breathe will not be successful. The only possible rescue would be to surface the diver immediately and treat for near drowning Clearly, the proper course of action regarding Oxygen toxicity is prevention.

Warning
Never exceed the Maximum Operating Depth of the mix.

Wrong Mix is the term applied to diving the wrong Nitrox mix for a particular dive. Some examples follow.

- Failure to measure the mix or properly mark the tank contents label with the Oxygen % and/or MOD can obviously result in using the wrong mix. If you aren't sure of the tank contents, you can't be sure of the safe use of the tank.

- Misuse could be deliberate. You have two EANx40 tanks (MOD 99 feet). You plan to dive two 60 foot reef dives but the dive plan is changed to a 132 foot deep wreck dive followed by a 60 foot reef dive --- you decide to do both dives anyway.

- Misuse could be accidental. You have two tanks one EANx32 (MOD 132 feet) and one EANx40 (MOD 99 feet). You plan to use the first tank on a 132 foot deep wreck dive and the second tank on a 60 foot reef dive --- but you don't pay attention when setting up your equipment and you dive the EANx40 mix on the deep wreck dive.

The result of diving a wrong mix can be diving a mix with more or less Oxygen than planned. If there is more Oxygen in the mix the result could be Oxygen toxicity and death. If there is less Oxygen in the mix the result could be decompression sickness. Either way, you loose.

Trauma or the injury from fires and/or explosions is always a possibility when working with Oxygen. Due to the relatively low concentrations used by recreational divers i.e. 40% maximum Oxygen, there is little risk to the diver. The risk is greater in dive stores that blend 100% Oxygen with air to make Nitrox. Fortunately, this is a controlled setting, and to date, dive stores vending Nitrox have a perfect safety record.

Two other disadvantages of diving Nitrox are **limited availability** and **increased cost**. While availability is getting much better, there are still places in the world, and even the United States, where only air is available. As to cost, Nitrox fills will always cost more than air fills due to the increased labor, material, and capital costs required to make Nitrox. Typical fill costs in south east Florida are $4.50 to $5.50 for air fills and $7.50 to $9.50 for Nitrox fills.

Note: To date, there has not been a single death due to use of Nitrox in a recreational setting. This is a direct result of recreational divers being properly trained in, and respectful of, the use of Nitrox for recreational diving.

Disadvantages of Nitrox Self Test	
What is the primary disadvantage to consider when diving Nitrox?	
What is the maximum safe depth for diving Nitrox I?	
What is the maximum safe depth for diving Nitrox II?	

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Physics of Nitrox
Depth and Pressure

In this module we will explore the relationship between **depth** and **pressure**. This understanding is needed as a tool in subsequent modules.

As divers we are interested in depth, here measured in feet of sea water (FSW).

But our bodies, from a physiological standpoint, react to pressure, here measured as atmospheres absolute (AtA).

Using these terms, we see in Table 4 that, at the surface, the pressure on our bodies is one atmosphere. This is the pressure that results from the weight of the air in space pressing down on us. As we descend in the water, this pressure increases e.g. at 33 FSW the pressure is 2 AtA, etc.

Table 4
Depth and Pressure

Depth	Pressure
Feet of Sea Water (FSW)	Atmospheres Absolute (AtA)
00	1
33	2
66	3
99	4

In the modules that follow it will be necessary to convert FSW to AtA and visa versa. The formulas below will be used for that purpose.

Given FSW find AtA: (FSW/33) + 1 = AtA

Example: Given a dive to 130 feet of sea water (FSW), find the pressure in atmospheres absolute (AtA).
Answer: (130/33) + 1 = 4.94 AtA

Or

Given AtA find FSW: (AtA-1) X 33 = FSW

Example: Given a pressure of 7 atmospheres absolute (AtA), find the depth in feet of seawater (FSW).
Answer: (7 - 1) X 33 = 198 FSW

Physics of Nitrox Depth and Pressure Self Test	
For a dive to 85 feet of seawater (FSW), find the pressure in atmospheres absolute (AtA). Show Me!	
For a pressure of 2.82 Atmospheres Absolute (AtA), find the depth in feet of seawater (FSW). Show Me!	

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Physics of Nitrox
Depth and Pressure
Show Me Answers

--- Depth and Pressure ---

Find AtA: For a dive to **85 FSW** (feet of seawater), find the pressure in atmospheres absolute (AtA).

AtA = (FSW / 33) + 1 = (85 / 33) + 1 = 3.58 AtA

Or, for Dummies ...

Nitrox Calculations for Dummies			
Depth and Pressure Given Depth in FSW find Pressure in AtA			
Line	**Item or Calculation**	**Example Data**	**Your Data**
A	Enter the depth in feet	**85 feet**	
B	Divide Line A by 33	2.58 AtA	
C	Add 1 to Line B	3.58 AtA	

Find FSW: For a pressure of **2.82 AtA** (Atmospheres Absolute), find the depth in feet of seawater (FSW).

FSW = (AtA - 1) X 33 = (2.82 - 1) X 33 = 60 FSW

Or, for Dummies ...

Nitrox Calculations for Dummies			
Depth and Pressure Given Pressure in AtA find Depth in FSW			
Line	**Item or Calculation**	**Example Data**	**Your Data**
A	Enter the pressure in AtA	**2.82 AtA**	
B	Subtract 1 from Line A	1.82 AtA	
C	Multiply Line B by 33	60 feet	