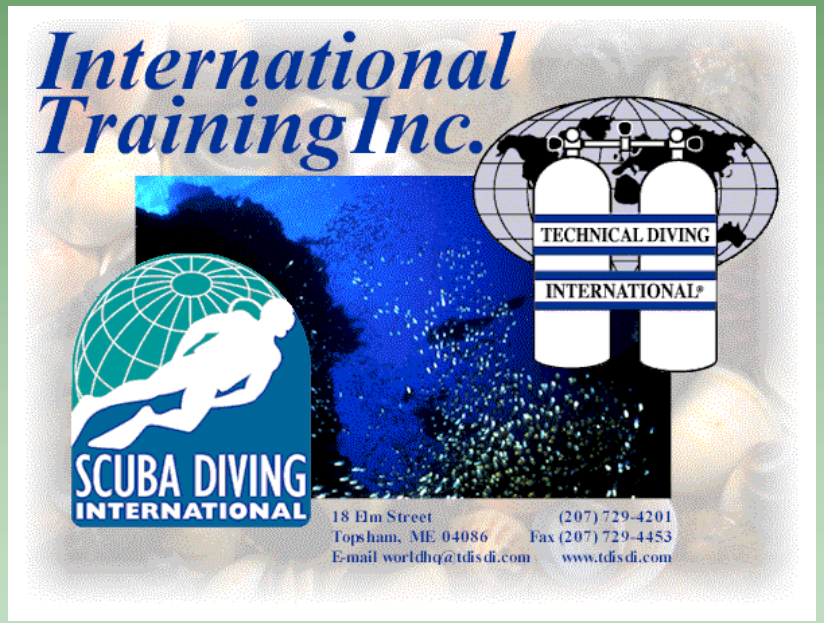
TDI Nitrox

Diving With Oxygen Enriched Air



Technical Diving International
http://www.tdisdi.com/

Enriched Air Nitrox Diver

- Overview
  - **TDI Nitrox** is the entry - level certification course for recreational divers wishing to utilize enriched Air Nitrox (EAN) as a breathing gas. The objective of this course is to train divers in the benefits, hazards and proper procedures for using Nitrox mixes from twenty two (22) to forty (40) percent oxygen content.

The program is presented in 5 Chapters:

- Dive Theory
- A Brief History
- Diving Physics Made Easy
- Equivalent Air Depth Concept
- Considerations For O_2 Use and Handling

Qualifications of Graduates

Upon successful completion of this course:

1. Graduates may engage in diving activities utilizing EAN 22 to EAN 40 without direct supervision.

Graduates would be qualified to enroll in:

1. TDI Advanced Nitrox Course.
2. TDI Decompression Procedures Course.
3. TDI Semi-closed Rebreather Course.

Course Policies

- Dives shall not exceed 130 fsw
  or 1.6 atm PO_2
  (1.4 atm PO_2 maximum recommended).
- All dives to be no-stop dives.

Open Water Requirements

- Two dives with oxygen enriched air
  - one of which is to be a repetitive dive
- Students analyze their own gases
- Plan and safely execute each dive
- Instructor will provide u/w activities

Academic Modules

1. Introduction
2. Dive Theory
3. A Brief History
4. Diving Physics Made Easy
5. Equivalent Air Depth Concept
6. Considerations For O2 Use And Handling
7. Conclusion

Introduction

- Misconceptions about Nitrox
- Reality

Misconceptions of Nitrox

- This course is extensive
- Nitrox is for deep diving
- You can’t get decompression sickness
- Narcosis is eliminated
- Using enriched air nitrox is difficult
- You need to be a cave or technical diver first
- Nitrox is not safe for recreational divers
- It’s too expensive

Reality

- Most use nitrox fo safety dive less than 130fsw / 39.6msw.
- The math consists of only 2 formulas

  (Fg = Pg / P & Equivalent Air Depth)
- The course costs about the same as a new cylinder and you don't need new equipment.
- Nitrox divers perform the same underwater dive activities as air divers.
- Safety is proven by many thousands of recreational nitrox divers since 1985 (Must be smart divers!)

Conclusion

- You don’t have to be a millionaire, professor, deep diver, or cave explorer to become a certified Nitrox diver.
- Nitrox is for everyone, and the training can be fun.

Chapter 1 – Dive Theory

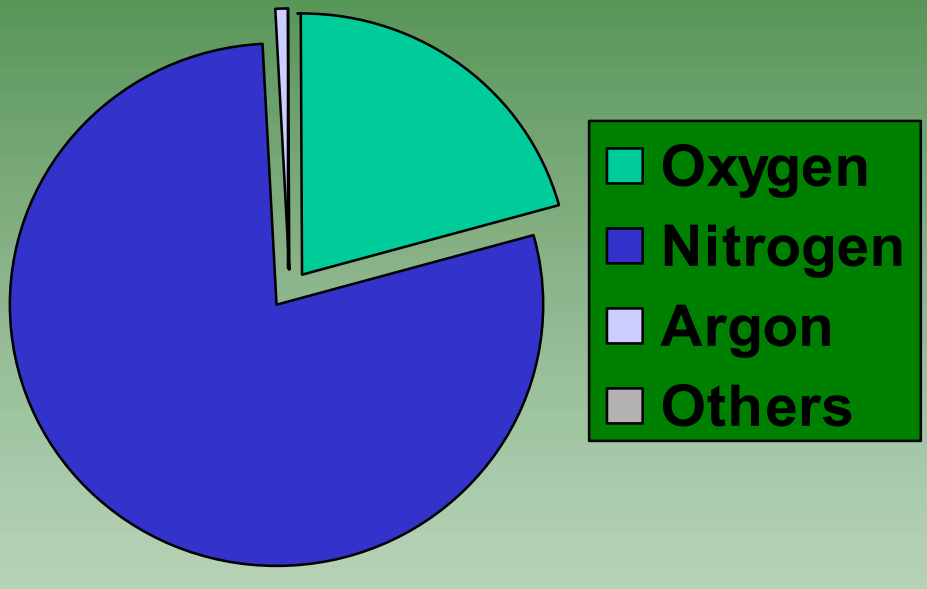
What is Air?

- Air is comprised of 21% oxygen (O_2) and 79% nitrogen (N_2).
- O_2 is necessary for life. It's transported in our blood as oxyhemoglobin and is metabolized to provide fuel for cellular function.
- N_2 is inert and is not metabolized, but is diffused into our blood and tissues.

Composition of Air

- Oxygen 0.2095
- Nitrogen 0.7808
- Argon 0.00934
- Others

- Total 1.0000



Composition of air

- Oxygen, O_2 20.95%
  - essential component of all breathing mixes
- Nitrogen, N_2 78.08%
  - inert gas in air and nitrox mixtures
  - narcotic properties are main disadvantage
- Argon, Ar 0.934 %
  - makes up about 1% of air and is considered with the nitrogen component.
- Trace gases include
  - CO_2, neon, helium, methane, nitrogen oxides

Basic Principles

- A scuba regulator delivers air to our lungs equal to the surrounding (ambient) pressure.
- On descent a pressure gradient develops between the N_2 coming into our lungs and the N_2 already absorbed into our blood & tissues.
- During ascent the pressure gradient is reversed, N_2 off-gassing occurs. Excess N_2 is eliminated during exhalation.

Henry's Law

- Nitrogen moves from areas of high concentration in his lungs to the lower concentrations in the rest of his body. During his ascent this process is reversed.
- This is a simple explanation of decompression theory which is based on Henry's Law.
- The amount of gas that will dissolve in a liquid is relative to the partial pressure of that gas in contact with the liquid.

What is Nitrox?

- Nitrox has the same component gases as Air. Air is also Nitrox.

- Enriched Air Nitrox (EANx) refers to Nitrox with a higher O_2 content than air.
  - The “x” in the EANx is O_2 content in decimal form.
  - Nitrox is also an N_2/O_2 mix with less than 21% O_2 for diving deeper than about 200fsw / 61msw.

Two common Mixes.

- EAN_{32}
- NOAA Nitrox I
- NNI
  - 32% oxygen
  - 130fsw

- EAN_{36}
- NOAA Nitrox II
- NNII
  - 36 % oxygen
  - 110fsw

We will use from 22% to 40% O_2 mixes.

Benefits of Enriched Air

- Longer no-stop dive times.
- Shorter surface intervals.
- Longer repetitive dives.
- Less nitrogen absorbed.
- Lower risk of decompression illness.
- Less post dive fatigue and narcosis.

No-Stop Dive Times			
Depth fsw	21% Air	32% EAN32	36% EAN36
60	55	100	100
70	45	60	60
80	35	50	60
90	25	40	50
100	22	30	[40]
110	15	25	[30]
120	12	[25]	
130	8	[20]	

Justification for Enriched Air

- The lower nitrogen content in oxygen enriched air allows for longer no-stop dive times.
- Some are almost 100% longer.

No-Stop Dive Times			
Depth fsw	21% Air	32% EAN32	36% EAN36
60	55	100	100
70	45	60	60
80	35	50	60
90	25	40	50
100	22	30	[40]
110	15	25	[30]
120	12	[25]	
130	8	[20]	

Two sides of every coin

- There s a down side to the increased O_2 in EANx.
  - EANx diving imposes both O_2 depth and O_2 Time Limits.
- Diving is all about limits.
  - N_2 time limits for NDL's.
  - N_2 depth limits to avoid narcosis.
  - Now O_2 Time and Depth Limits.

Oxygen Depth Limits fsw / msw

- Air = 218 / 66.4
- EAN32 = 130 / 39.6
- EAN36 = 110 / 33.5
- 100% O_2 = 20 / 6.1

As the O_2 content in a mixture increases, maximum O_2 Depth and O_2 Time decreases.

Physiological Factors

- If you have any physiological factors that change N_2 on-gassing or off-gassing, dive EANx as air for safety.
- Factors for increased Risks:
  - Older age, obesity, dehydratation, poor circulation, illness, injury, alcohol consumption, fatigue, strenuous exercise and history of DCS.
- If this factors don't apply, use EANx to increase your safety.

Chapter 2 – A Brief History

- Priestly discovers oxygen in 1774.
- Bert publishes his results with hyperbaric oxygen in 1878.
- Fleuss documents first nitrox dive in 1879.
- US NAVY publishes nitrox dive tables in 1955.
- NOAA publishes nitrox tables in 1965 and the Equivalent Air Depth Formulas in 1979 NOAA Manual.
- The first Nitrox training agency for recreational divers was started in 1985.

Many Industry Changes

- Training:
  - Nitrox training agencies; Technical Diving International (TDI), International Association of Nitrox and Technical Divers (IANTD), American Nitrox Divers Inc (ANDI).
- Terminology:
  - Tech' talk in books, magazines and everyday language.
- Equipment:
  - Programmable EANx computers and rebreathers.
- Compressed Air Quality:
  - Oil-free compressors & higher quality filtration systems.

Chapter 3 – Diving Physics

By the end of the lesson the student will be able to:

- List the pressure units.
- Explain the concept of partial pressure.
- Convert depth units.
- Explain Dalton's Diamond.
- Be able to calculate partial pressures of a gas in a mix.
- Explain fractions and percentages of gases.
- Understand O_2 Time & Depth Limits.

Pressure units

- Absolute pressure of air at sea level

  14.7 psig (Pounds Square Inch Gauge)
- Absolute pressure (P) is the sum of atmospheric pressure and hydrostatic pressure.
  - Atmospheres Absolute (ATA) is the combination of pressures exerted by the surrounding atmosphere and water (also P).
  - At 33 fsw P = 2 ATA

    1 ATA (air) + 1 ATA (water) = 2 ATA
  - ATA is the unit of pressure used for most gas law calculations.
  - An “a” added to the end of a unit pressure denotes absolute pressure (P).

Equivalent to 1 atm

- 14.7 pounds per square inch (psi)
  - Common scale for supply gauges
- 33 feet salt water (fsw)
  - (33fsw) / (.455 psi /fsw) = 14.7psi
- 34 feet fresh water (ffw)
  - (34ffw) / (.432 psi / ffw) = 14.7psi
- 10.07 meters salt water (msw)
- 10.33 meters fresh water (mfw)
- 1.013 bar

To Convert Depth (fsw) to P (ATA)

$$Pata = (Dfsw \div 33\ fsw) + 1\ ATA$$

or

$$Pata = (Dfsw + 33\ fsw) \div 33\ fsw$$

For a depth of 100 fsw

$$\frac{100\ fsw + 33\ fsw}{33\ fsw / atm} = 4.03\ ATA$$

Depth divide by 33 then plus 1

To Convert Depth (msw) to P (ATA)

$$Pata = (Dmsw \div 10\ msw) + 1\ ATA$$

or

$$Pata = (Dmsw + 10\ msw) \div 10\ msw$$

For a depth of 30 msw

$$\frac{30\ msw + 10\ msw}{10\ msw / atm} = 4\ ATA$$

Depth divide by 10 then plus 1

Converting Pata to Dfsw

Dfsw = (Pata – 1 ATA) 33 fsw

or

Dfsw = (Pata x 33 fsw / atm) - 33 fsw

For a pressure of 7 ATA

(7 ATA x 33 fsw) - 33 fsw = 198fsw / 60.4msw

ATA times 33 then minus 33 = Dfsw

Dalton's Law

- In a mixture of gases, the total pressure is made up of the sum of the pressures of the individual components.

$$P = P1 + P2 + P3 + \ldots + P_n$$

- Dalton's formula for air or any EANx mix.

$$P = PO_2 + PN_2$$

The Total is equal to the sum of the parts

Partial Pressure of Gases in a Mix

- When the partial pressure of a gas is divided by the total pressure, the fraction of that gas or decimal equivalent is found.

$$P_g \div P = F_g$$

- The partial pressure of a gas, is the product of the fraction of that gas times the total pressure.

$$P_g = F_g \times P_{total}$$

Calculating Partial Pressures

$$Pg = P \times Fg$$

Pg = partial pressure

P = absolute pressure

Fg = fraction of the gas

Partial Pressure

- The fraction of the component gas multiplied by the total pressure.
- When added, all of the partial pressures of the component gases become the total pressure.

Air at 1 atm

Percentage		Partial Pressure
79% N_2	=	0.79 atm
21% O_2	=	0.21 atm
100%	=	1.00 atm

Partial Pressure

- Ambient pressure is the total pressure surrounding a diver.
- The gas content remains the same.
- The partial pressure of each gas increases and decreases in your lungs proportionally with the ambient pressure.
- Partial pressure over time is the gas dosage delivered during a scuba dive.

Three Equations – Three Answers

- $PO_2 = FO_2 \times P$

  What's the max O_2 dose?

  To find the O_2 Time Limit

- $P = PO_2 \div FO_2$

  How Deep?

  To determine maximum O_2 Depth Limit

  Called MOD (Maximum Operating Depth)

- $FO_2 = PO_2 \div P$

  Best mix is?

  To extend bottom time by dividing the N_2%

MOD – Maximum Operating Depth

- Maximum Operating Depth
- Contingency Operating Depth
- These are recommended and contingency limits

Maximum and Contingency Operating Depths		
	EAN32	**EAN 36**
PO_2 Maximum	**1.39** **110 fsw** **33 msw**	**1.34** **90 fsw** **27 msw**
PO_2 Contingency	**1.58** **130 fsw** **40 msw**	**1.56** **110 fsw** **33 msw**

Calculating: Maximum Operation Depth (fsw)

$$MOD, \text{fsw} = \left(\frac{(PO_2\ limit, \text{ATA})}{(FO_2\ mix, \text{ATA})} - 1\,\text{atm} \right) \times 33\ \text{fsw}$$

To calculate the MOD for 32% oxygen, which has an FO_2 of 0.32, at a limit of 1.4 atm:

$$MOD, \text{fsw} = \left(\frac{(1.4\ \text{ATA})}{(0.32\ \text{ATA})} - 1\,\text{atm} \right) \times 33\ \text{fsw} = 111\ \text{fsw}$$

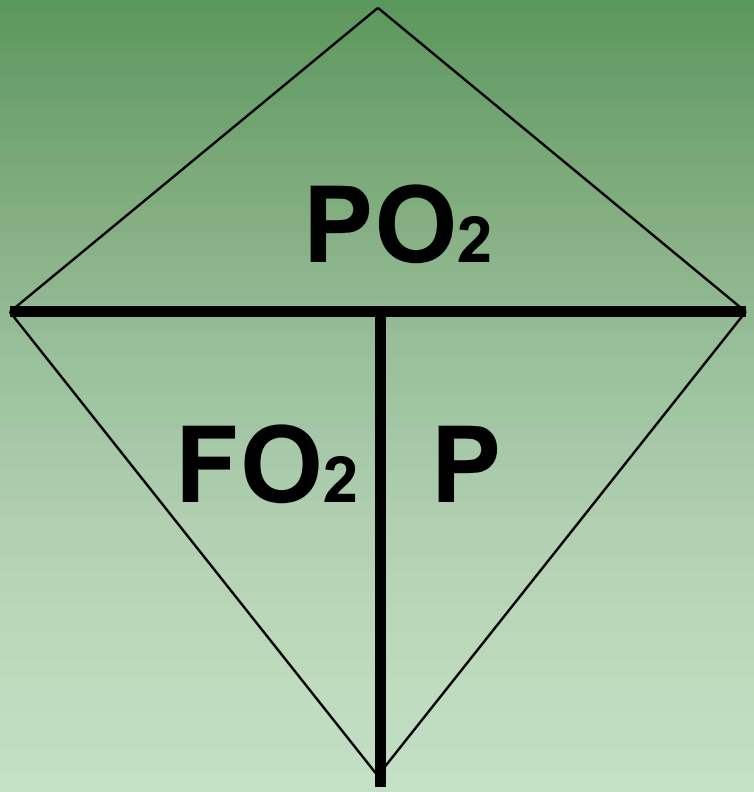
Calculating: Maximum Operation Depth (msw)

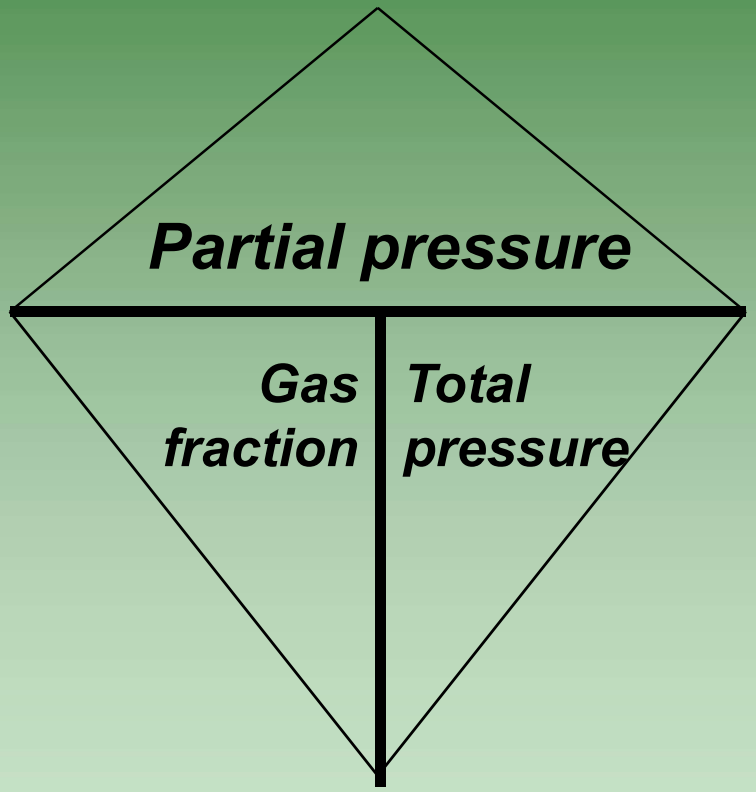
$$MOD, \text{msw} = \left(\frac{(PO_2\ limit, \text{ATA})}{(FO_2\ mix, \text{ATA})} - 1\,\text{atm} \right) \times 10\,\text{msw}$$

To calculate the MOD for 32% oxygen, which has an FO_2 of 0.32, at a limit of 1.4 atm:

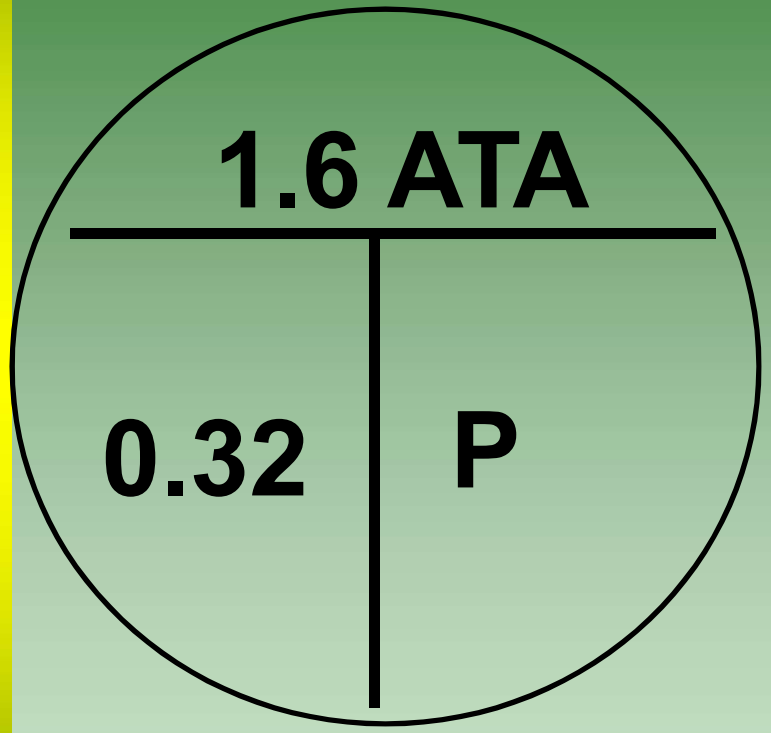
$$MOD, \text{msw} = \left(\frac{(1.4\,\text{ATA})}{(0.32\,\text{ATA})} - 1\,\text{atm} \right) \times 10\,\text{msw} = 33\,\text{msw}$$

Dalton's Diamond





Maximum depth for EAN_{32} ?



P = 1.6 ATA / 0.32

P = 5 ATA

Dfsw = (5 ata - 1atm) x 33 fsw

or

Dmsw = (5 ata - 1atm) x 10 msw

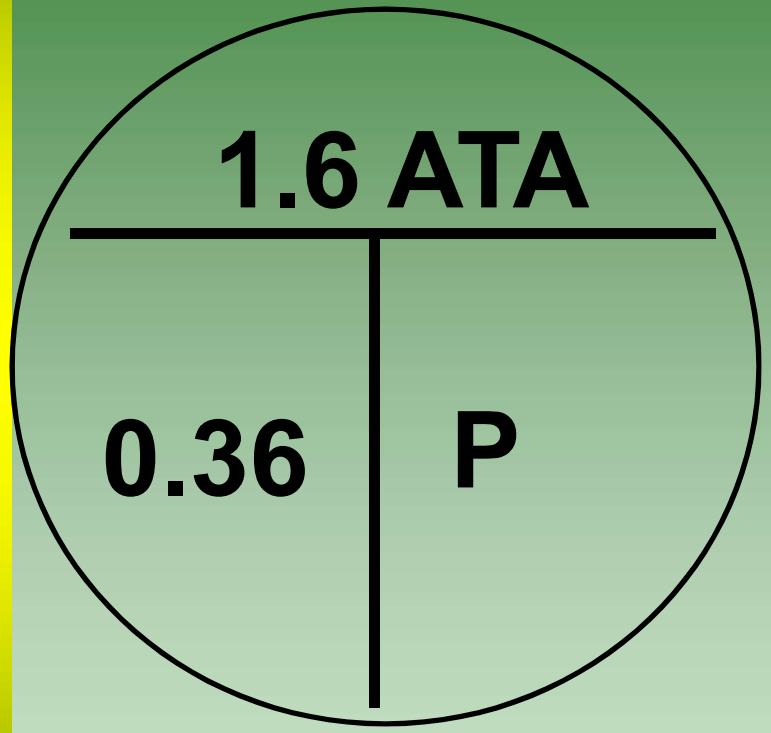
D fsw = 132

D msw = 40

132 fsw is maximum operating depth

40 msw is maximum operating depth

Maximum depth for EAN_{36} ?



P = 1.6 ATA / 0.36

P = 4.44 ATA

Dfsw = (4.44 ata - 1atm) x 33 fsw

or

Dmsw = (4.44 ata - 1atm) x 10 msw

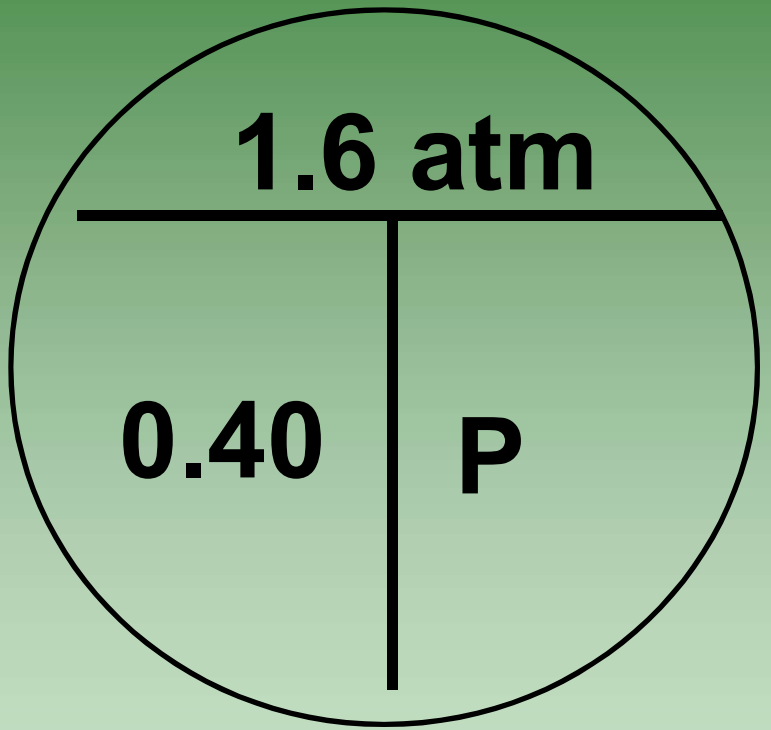
D fsw = 113

D msw = 34.4

113 fsw is maximum operating depth

34 msw is maximum operating depth

Maximum depth for EAN_{40} ?



P = 1.6 ATA / 0.40

P = 4 ATA

Dfsw = (4 ata - 1atm) x 33 fsw

Dmsw = (4 ata - 1atm) x 10 msw

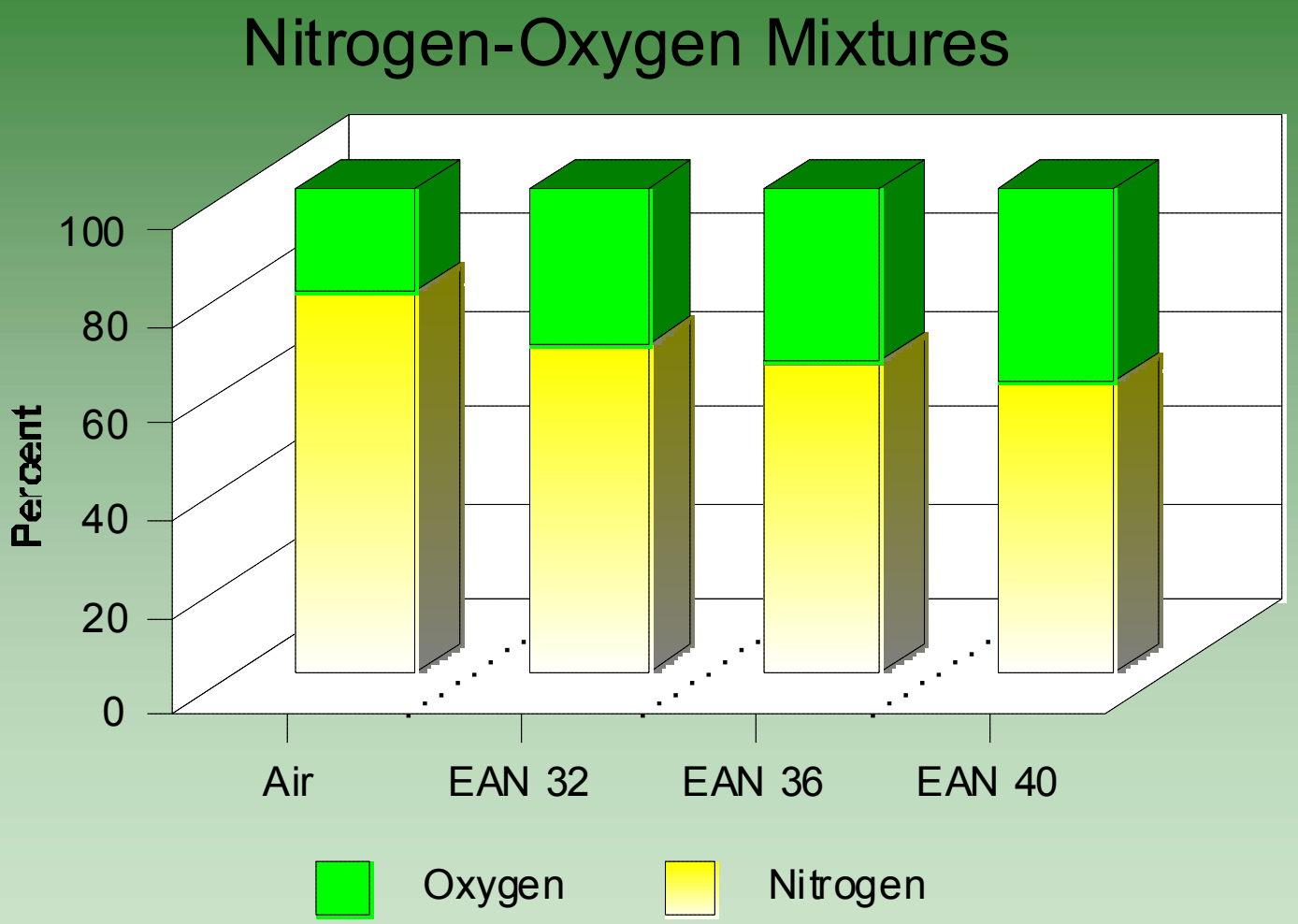
D fsw = 99

D msw = 30

99 fsw is maximum operating depth

30 msw is maximum operating depth

The Nitrox Mixes



NOAA O_2 Limits

- NOAA has established a maximum PO_2 of 1.6 ATA for 45 minutes.
- Use a 1.5 ATA PO_2 for bottom times longer than 45 minutes but less than 120 minutes.
- Use a 1.5 ATA PO_2 or less for particular hard or cold dives to increase safety regarding O_2 toxicity.
- Exceeding O_2 limits can produce seizure under water, possibly resulting in death. (Chapter 5)

O_2 Tolerance

- O_2 tolerance is decreased by elevated carbon dioxide (CO_2).
- Causes of CO_2 build up
  - Labored breathing
  - Inefficient breathing
  - Poor regulator performance
- The onset and magnitude of O_2 Toxicity is dose dependent or relative to O_2 pressure and exposure time

Single Dive Oxygen Exposure Limits	
PO_2 atm	Minutes
1.60	45
1.55	83
1.50	120
1.45	135
1.40	150
1.35	165
1.30	180
1.25	195
1.20	210

Concerns of the mix

- 2 hour surface interval recommended on air if a single exposure limit is reached.
- 12 hour surface interval on air is required whenever a 24 hour limit is reached.

NOAA Oxygen Exposure Limits		
PO_2 atm	Maximum Single Limit	Maximum 24-Hour Limit
1.60	45	150
1.55	83	165
1.50	120	180
1.45	135	180
1.40	150	180
1.35	165	195
1.30	180	210
1.25	195	225
1.20	210	240

Examples

1. What is the PO_2 for an air dive to 99fsw / 30.2msw so I can find my O_2 Time Limit?
2. How deep can I go with EAN36 on a normal dive?
3. What's the best mix to use that will give me the most bottom time for a particularly hard spearfishing dive to 95fsw / 28.9msw?

Chapter 4 – EAD Concept

- EAD – Equivalent Air Depth Concept.
- EAD concept means that on an EANx dive, less N_2 will be absorbed than on an air dive of the same depth and duration.
- The EAD formula converts our maximum planned depth to de N_2 Equivalent Air Depth.
- We will use an EAD to compute our N_2 time limits from the Navy Air Tables.

EAD Formula *(fsw)*

$$EAD\ fsw = \left(\frac{(D\ fsw + 33\ fsw)(1 - FO_2)}{0.79} \right) - 33\ fsw$$

$$57.9\ fsw = 58\ fsw = \left(\frac{(81 + 33)(1 - 0.37)}{0.79} \right) - 33$$

- **This is a dive to 81 fsw using 37% oxygen EAN.**
- **The EAD computes to 57.9 rounds to 58.**
- **A 60 fsw air schedule would be used.**

EAD Formula *(msw)*

$$EAD\ msw = \left(\frac{(D\ msw + 10\ msw)(1 - FO_2)}{0.79} \right) - 10\ msw$$

$$17.9\ msw = 18\ msw = \left(\frac{(25 + 10)(1 - 0.37)}{0.79} \right) - 10$$

- **This is a dive to 25 msw using 37% oxygen EAN.**
- **The EAD computes to 17.9 rounds to 18.**
- **A 20 msw air schedule would be used.**

Additional methods for EAN diving

- Equivalent Air Depth principle
  - convert air table to use lower nitrogen mix
  - can be done with formula or chart.
- Custom Tables
  - "Table makers"
  - Desktop Software
    - Abyss, Voyager, Decom, etc.
  - Enriched Air Dive Computers.

NOAA Nitrox Tables

- NOAA has published Nitrox tables for NNI & NNII which are converted Navy Air Tables.
- Your Nitrox mix should have an FO_2 of .32 (+/- 1%) to use NNI Dive Tables.
- Your Nitrox mix should have an FO_2 of .36 (+/- 1%) to use NNII Dive Tables.
- Use either the NOAA Nitrox Tables, the EAD formula with the Navy Air Tables or a programmable Nitrox dive computer.

Dive Computers

- Air
- Enriched Air
- Multi-level diving
- Repetitive diving

Using an air computer

- OK to use
- Show “air” limits
- Monitor depth
- Observe O_2 limit
- Watch MOD
- Make a safety stop

Write MOD on computer

Important

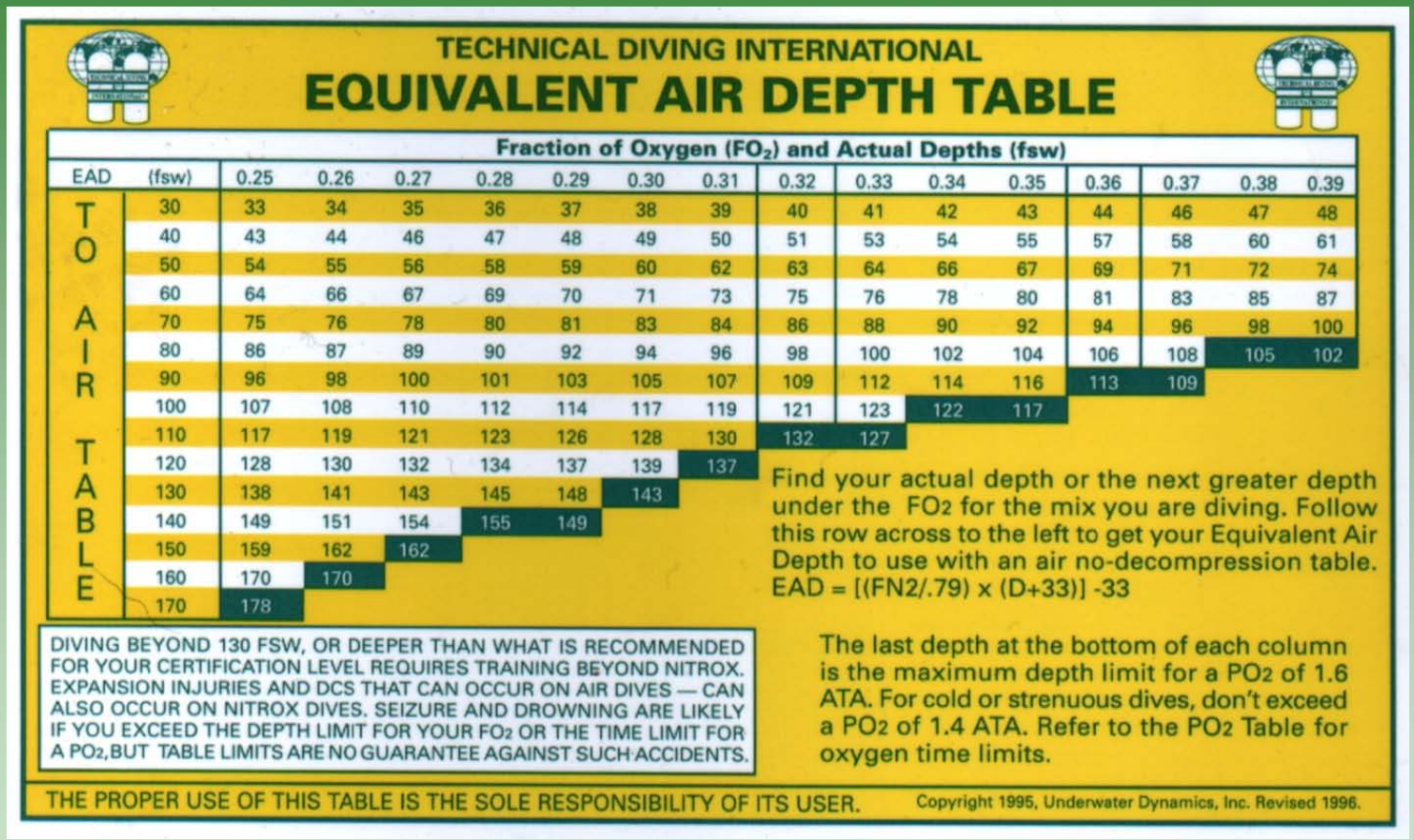
- Don’t change between procedures for repetitive dive calculations.
- The dive calculations may not be equal in all cases due to rounding.
- Diving to the No-decompression limits with EANx poses the same risks as diving to the limit with air,whether you use an EAD, converted tables or a Nitrox computer.
- Dive conservatively to reduce these risks.

Three Options when using EAD with EANx

1. Increase safety regarding DCS by diving EANx as Air.
2. Extend bottom time by using the EAD Formula with an air table.
3. Shorten surface interval time by using the EAD Formula with an air table.

- Note: For each option you must always know your oxygen and nitrogen time and depth limits.

Equivalent Air Depth Table



TECHNICAL DIVING INTERNATIONAL

EQUIVALENT AIR DEPTH TABLE

		Fraction of Oxygen (FO_2) and Actual Depths (fsw)														
EAD	(fsw)	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39
TO AIR TABLE	30	33	34	35	36	37	38	39	40	41	42	43	44	46	47	48
	40	43	44	46	47	48	49	50	51	53	54	55	57	58	60	61
	50	54	55	56	58	59	60	62	63	64	66	67	69	71	72	74
	60	64	66	67	69	70	71	73	75	76	78	80	81	83	85	87
	70	75	76	78	80	81	83	84	86	88	90	92	94	96	98	100
	80	86	87	89	90	92	94	96	98	100	102	104	106	108	105	102
	90	96	98	100	101	103	105	107	109	112	114	116	113	109		
	100	107	108	110	112	114	117	119	121	123	122	117				
	110	117	119	121	123	126	128	130	132	127						
	120	128	130	132	134	137	139	137								
	130	138	141	143	145	148	143									
	140	149	151	154	155	149										
	150	159	162	162												
	160	170	170													
	170	178														

Find your actual depth or the next greater depth under the FO_2 for the mix you are diving. Follow this row across to the left to get your Equivalent Air Depth to use with an air no-decompression table.
EAD = [(FN2/.79) x (D+33)] -33

DIVING BEYOND 130 FSW, OR DEEPER THAN WHAT IS RECOMMENDED FOR YOUR CERTIFICATION LEVEL REQUIRES TRAINING BEYOND NITROX. EXPANSION INJURIES AND DCS THAT CAN OCCUR ON AIR DIVES — CAN ALSO OCCUR ON NITROX DIVES. SEIZURE AND DROWNING ARE LIKELY IF YOU EXCEED THE DEPTH LIMIT FOR YOUR FO_2 OR THE TIME LIMIT FOR A PO_2, BUT TABLE LIMITS ARE NO GUARANTEE AGAINST SUCH ACCIDENTS.

The last depth at the bottom of each column is the maximum depth limit for a PO_2 of 1.6 ATA. For cold or strenuous dives, don't exceed a PO_2 of 1.4 ATA. Refer to the PO_2 Table for oxygen time limits.

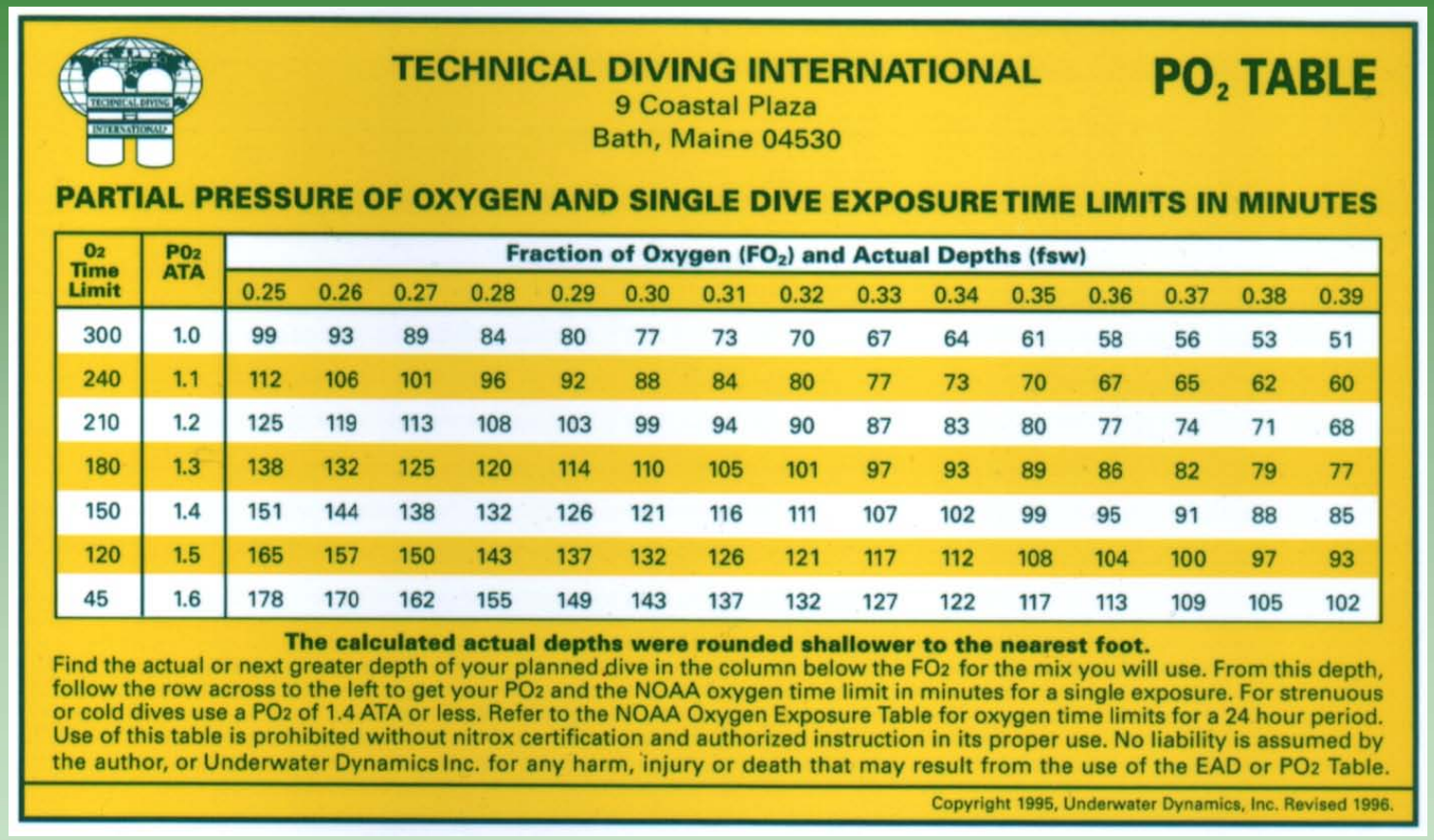
THE PROPER USE OF THIS TABLE IS THE SOLE RESPONSIBILITY OF ITS USER.

Equivalent Air Depth Table

- The EAD / PO_2 Table allows us to find and EAD, PO_2, and O_2 Time Limit without any math.

1. Locate your FO_2 at the top of the table.
2. Follow that column down until you find your exact actual depth or the next grater.
3. From this depht, follow that row across to the left to get your EAD. Use this EAD depth to compute your nitrogen time limits from an air table.

Partial Pressure of Oxygen Table



TECHNICAL DIVING INTERNATIONAL
9 Coastal Plaza
Bath, Maine 04530

PO_2 TABLE

PARTIAL PRESSURE OF OXYGEN AND SINGLE DIVE EXPOSURE TIME LIMITS IN MINUTES

O2 Time Limit	PO2 ATA	Fraction of Oxygen (FO_2) and Actual Depths (fsw)														
		0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39
300	1.0	99	93	89	84	80	77	73	70	67	64	61	58	56	53	51
240	1.1	112	106	101	96	92	88	84	80	77	73	70	67	65	62	60
210	1.2	125	119	113	108	103	99	94	90	87	83	80	77	74	71	68
180	1.3	138	132	125	120	114	110	105	101	97	93	89	86	82	79	77
150	1.4	151	144	138	132	126	121	116	111	107	102	99	95	91	88	85
120	1.5	165	157	150	143	137	132	126	121	117	112	108	104	100	97	93
45	1.6	178	170	162	155	149	143	137	132	127	122	117	113	109	105	102

The calculated actual depths were rounded shallower to the nearest foot.

Find the actual or next greater depth of your planned dive in the column below the FO_2 for the mix you will use. From this depth, follow the row across to the left to get your PO_2 and the NOAA oxygen time limit in minutes for a single exposure. For strenuous or cold dives use a PO_2 of 1.4 ATA or less. Refer to the NOAA Oxygen Exposure Table for oxygen time limits for a 24 hour period. Use of this table is prohibited without nitrox certification and authorized instruction in its proper use. No liability is assumed by the author, or Underwater Dynamics Inc. for any harm, injury or death that may result from the use of the EAD or PO_2 Table.

Partial Pressure of Oxygen Table

- The PO_2 Table follows the same direction of flow as the EAD Table when determining your PO_2 and O_2 Time Limit in minutes.
- For both tables, when the exact depth or time is not listed, round up rules apply.

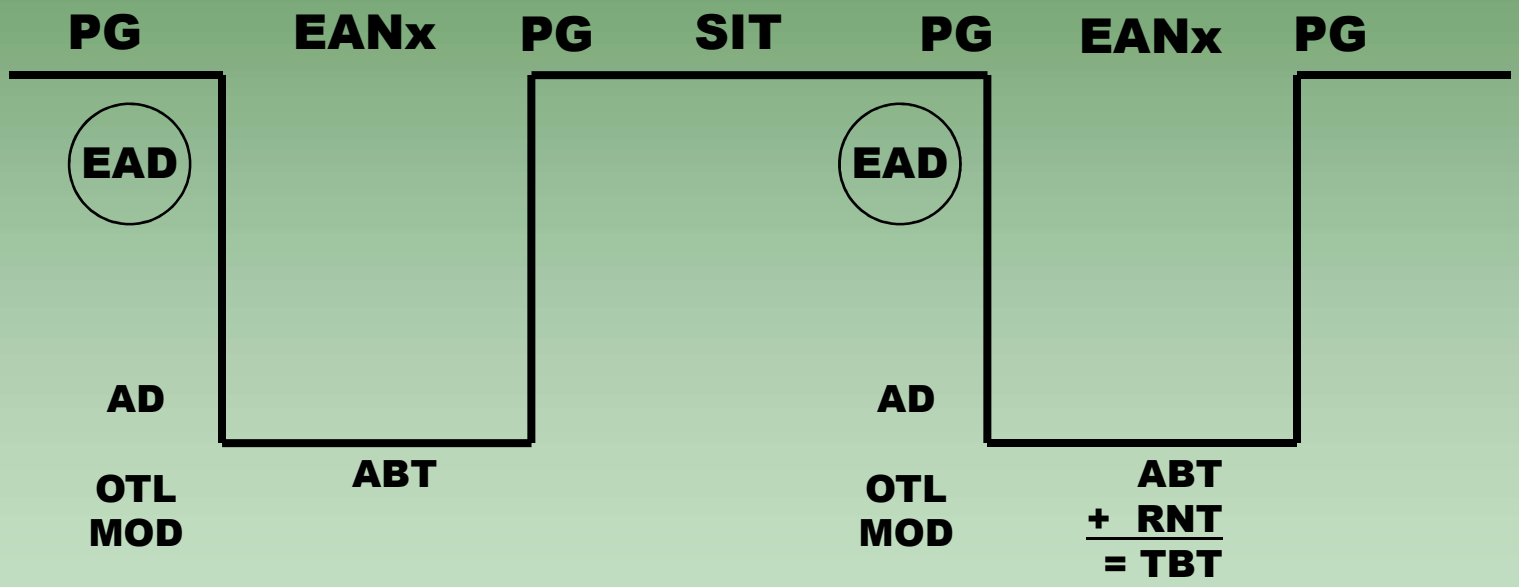
Examples

- What is the EAD for a dive to 100fsw / 30.5msw on EAN36?
- What is the oxygen dose for a 100fsw / 30.5msw dive using EAN36?

Graphic Dive Profile

- Is a record of your O_2 and N_2 limits for each dive you make.
- A graphic dive profile completed with information from an air table and the EAD / PO_2 Table avoids both confusion and omissions.
- Write your EAD above or near your actual depth.
- Write your O_2 Depth Limit under or near your actual depth.
- Review the nitrox dive profile abbreviations.

Graphic Dive Profile

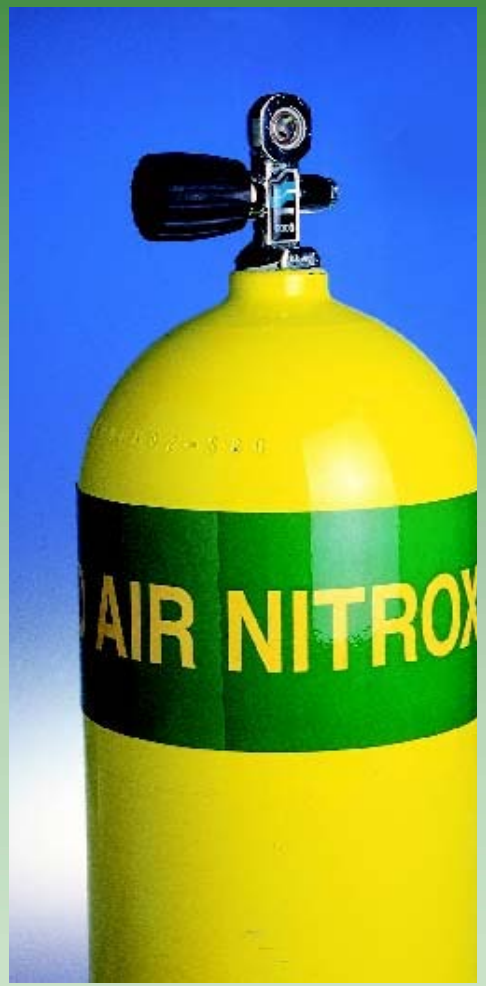


Chapter 5 – Considerations for O_2 Use and Handling

- All Nitrox cylinders must be properly identified and labeled to avoid diving an air cylinder for nitrox or a nitrox cylinder for air.
- DCS is probable if you extend your bottom time while diving air because you assume you're diving nitrox.
- Central Nervous System (CNS) O2 Toxicity is probable if you dive too deep while using nitrox because you assume you're diving air.

Standard EANx cylinder ID

- 4 inch green band on yellow tank.
- NITROX or Enriched Air stenciled in 2 inch high letters.
- Non-yellow cylinders have an additional 1 inch yellow band above and below the green.

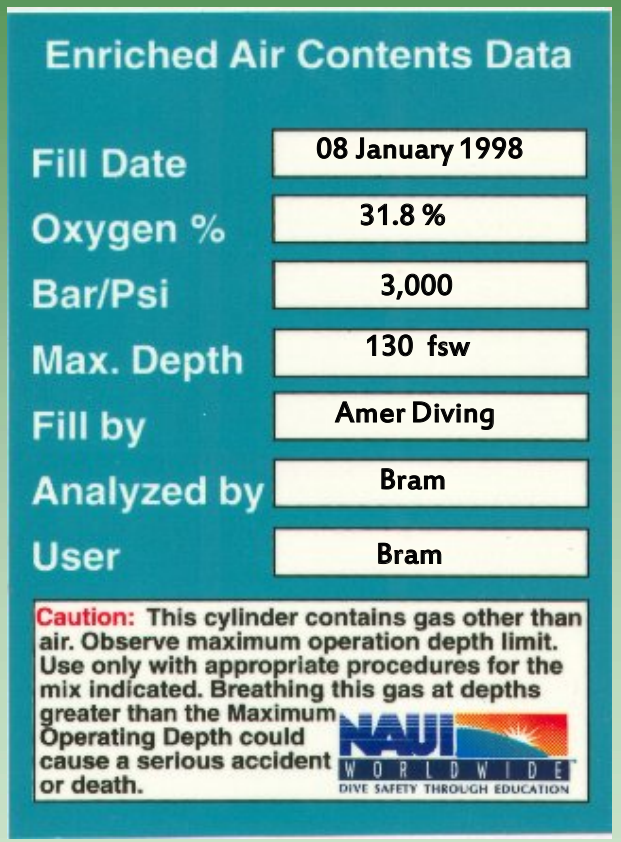


Obtaining Nitrox Fills

- Certification required
- Rental cylinders
  - Usually pre-mixed
  - 32% and 36% most popular
- Filling a cylinder
  - Qualified technician only

Contents tag or sticker

- Must be attached to an EANx cylinder
  - Use permanent marker
  - FO_2
  - MOD
  - PSI (pressure)
  - Date
  - Divers initials
  - Analyzed by
  - Cylinder Serial Number



ALWAYS ANALYZE ! ! !

- Before you take it out, check it out!
- You should analize each cylinder of nitrox before diving the gas or supervise it's analysis by a nitrox technicician.
- The only sure way to know what mix you will be diving is to analyze each cylinder!

Facility Fill Log

- Name
- Certification number
- Date
- Fill pressure
- Oxygen percentage
- Maximum depth limit
- Cylinder serial number
- Signature

Oxygen Analyzers

- Digital
- Analog
- 0.1% accuracy is desirable
- Electrochemical oxygen sensor
  - Has limited life span

The Need for Calibration

- Sets analyzer at a known value.
- Allows for adjustment of sensor deterioration.
- Affected by flow rate.
- Calibrate new analyzer to 100% O_2 and when replacing batteries.
- Calibrate to atmospheric air at 20.9% (21%).
- Open valve for at least 30 seconds and the reading has stabilized.

Analyzing the Gas

- Flow Rate
  - Affects reading
  - 1-2 lpm for 30 seconds
  - Calibrated at same flow
- Acceptable range
  - desired mix +/- 1%
  - 36% tables ok for 35-37%
  - 32% tables ok for 31-33%

The EAN Cylinder

- Calibrate analyzer
- Analyze cylinder
- Check for accuracy
- If not right
  - check again
  - have gas re-mixed
- Write information
  - contents label or tag

Human Compatibility

- The O_2 in EANx is medical or aviator grade.
- In some places O_2 is considered a drug or tool.
- In medicine O_2 is administered in dosage.
- In EANx diving O_2 dose is measured in PO_2 and exposure time.
- O_2 tolerance is different from person to person and day to day.
- Use limits as guidelines for safety and dive well within established limits.

Oxygen Toxicity

- Breathing oxygen in doses higher than a PO_2 of 1.6 ATA for even a short time can cause central nervous system oxygen toxicity.
- CNS O_2 Toxicity results in a (grand mal type):
  - Seizure which can cause drowning and death if the scuba regulator is lost and not recovered when breathing resumes.
  - It can also lead to arterial gas embolism if an ascent is made while breathing is stopped. Dead may result.

CONVENTID

- A CNS Oxygen seizure can occur without any of these warning signs.
- Keep PO_2 levels below 1.6 ATA
- If symptoms appear ascend at a normal ascent rate.
- Swicth to breathing Air as soon as possible.

- Convulsions
- Visual disturbances
- Euphoria & Ears ringing
- Nausea
- Tingles, Twitching
- Irritability
- Dizziness

CNS Oxygen Toxicity Signs and Symptoms

- Convulsion
- Visual disturbances, tunnel vision
- Ear ringing
- Nausea
- Tingling, twitching (facial or muscle spasms)
- Irritability, restlessness, euphoria, anxiety
- Dizziness, dyspnea

Pulmonary Oxygen Toxicity

- Is low dose / long term exposure.
- The primary symptoms involve the lungs (burning sensation and dry cought), and the primary effect is a reduction in vital capacity (VC).
- VC is measured by the amount of air that can be expelled following a full breath.
- Pulmonary O_2 toxicity is not a problem within recreational scuba diving limits.

Toxicity Prevention

- Always Analyze!
- Keep PO_2 levels at 1.6 ATA or less.
- Don't exceed the O_2 Depth & Time limits.
- If signs of toxicity appear
  - Ascend to a shallower depth
  - Diver should be taken to surface
  - Do not delay ascent

Hardware Compatibility

- High pressure O_2 is not compatible with petroleum based products.
- The risk is O_2 fire.
- Only a certified Nitrox technicician should convert a cylinder for EANx use.
- It's necessary that all EANx scuba cylinders be O_2 cleaned, converted, labeled with a Nitrox ID band & contents tag, and have a current EANx visual inspection sticker.

Cleanliness

- Items that come in contact with 40% or more oxygen must be prepared for oxygen service.
- Equipment that will only come in contact with less than 40% oxygen does not need special preparation, though it is prudent.

Equipment Cleaning List

- Must be cleaned for enriched air service
  - Cylinder valves
  - Scuba cylinders

- Not necessary
  - Buoyancy compensators
  - Low pressure inflator
  - Dry suit inflator

- Recommended to be cleaned
  - Regulator first stage
  - Regulator second stage
  - High pressure hoses
  - Submersible pressure gauges

Conversion to EAN service

- Cleaned of all:
  - Lubricants, dirt, filings,oil, and grease using a series of cleaning baths.
- Soft goods replaced
  - O-rings.
- Oxygen compatible lubricants
  - Krytox, Christolube, Halocarbon, *not* silicone.

Filling Nitrox

- Nitrox cylinders should only be filled by a certified Nitrox Blender trained in proper blending and the hazards of handling 100% O_2.
- Every Nitrox diver should personally analyze each EANx cylinder they will use or supervise the analysis by a certified nitrox technician, even if it has already been analyzed.

Preparing Enriched Air Nitrox

- Commercial pre-mix
  - simplest method
- Partial pressure mixing
  - most popular method
  - requires ultra clean air
- Continuous flow mixing
  - requires “oil free” compressor
- Pressure swing absorption
- Membrane separation

Conclusion

- **Always follow the ABC's of Safe Nitrox Diving.**