Answers to EAN$_x$ Review
By
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Myths

1. NOAA I is **32** % oxygen. It can also be written as **EAN$_{32}$**.

2. NOAA II is **36** % oxygen. It can also be written as **EAN$_{36}$**.

3. OEA is abbreviation for **Oxygen Enriched Air.**

4. True or **False**: Nitrox is safer than air.

5. True or **False**: Nitrox is for deeper diving.

6. True or **False**: Nitrox eliminates all risk of DCS in diving.

7. True or **False**: Using nitrox prevents hyperbaric treatment for DCS.

8. True or **False**: Using nitrox prevents narcosis.

9. True or **False**: Using nitrox is too complicated for sport divers.

EAN$_x$ Advantages

1. EAN$_x$ provides a (**longer**, shorter) no-decompression required bottom time than the same dive on air.

2. EAN$_x$ provides a (**longer**, shorter) repetitive dives without deco obligation than the same dives on air.

3. EAN$_x$ provides a (longer, **shorter**) surface intervals between dives than the same dives on air.

4. EANx no-deco times compared to air is termed the "(**Decompression,** Physiological) Advantage."

5. Diving EAN$_x$ on air is equivalent to diving air at a **(shallower**, deeper) depth.

6. Using EANx while diving with air tables/computers is the "(Decompression, **Physiological**) Advantage."

7. For most non-working dives, divers report being (more, **less**) fatigued than the same dive on air.

8. In addition to monitoring time and depth , EAN$_x$ dive planning adds concerns about **oxygen** exposure

Medical Matters

1. Air is primarily a mix of **78 or 79** % nitrogen and **21** % oxygen.

2. Two major maladies associated with too much on-board nitrogen are **DCS** and **narcosis**.

3. Martini's Law is considered (valid, **not valid**) by the hyperbaric medical community.

4. Meyer-Overton suggests anesthesia effects can be explained by gasses dissolving in **lipid layer** of nerves.

5. Oxygen has a diminished narcotic effect because it is **consumed** in metabolism.

6. Signs and symptoms of narcosis in warm water include:

   Tendency to giggle
   Tunnel vision (syncope)
   Idea fixation (repetitive behaviors)
   Shortened attention span
   Declining neuro-muscular coordination
   Numb lips
   Inability to concentrate

7. Signs and symptoms of narcosis in cold water include:

   Sense of being stalked ("It" is out there … somewhere)
   Loss of confidence (sense of helplessness)
   Intense anxiety

8. Narcosis problems are exacerbated by:

   cold
   work load (CO_2)
   anxiety
   fatigue
   drugs
   alcohol
   menses (?)

9. Narcosis impairment can be relieved by (**ascending,** descending) in the water column.

10. High CO_2 loads are a (**major**, minor) problem in diving.

11. Sources of excess CO_2 include:

    Contaminated Gas (very rare)
    Work load exceeding ventilation
    "Skip Breathing"
    Poor ventilation (equipment dead space)
    snorkel
    poor regulator
    full face mask

12. You are a bit winded and getting ready to dive. Your regulator does not seem to be working. You should:

    Rest (imagine STOP sign) and breathe slowly to vent excess carbon dioxide

13. Two primary symptoms of excess carbon dioxide:

    Respiratory starvation
    Headache in center of forehead

14. At depth, the pN_2 is (**much larger**, the same, or much smaller) than pO_2.

15. Gases move into / out of tissues until the partial pressures of all gases are ($<$, **=** . $>$) ambient.

16. Symptoms of DCS depend on the **number of bubbles** and their **location.**

17. The primary symptom of DCS is **joint pain.**

18. The majority of DCS cases show symptoms within **3** hours.

19. Symptoms of DCS type I (Pain Only) include:

Musculoskeletal Insult
limb or joint pain
Itching
Skin Rash
Localized swelling

20. Symptoms of DCS type II (CNS) include:

Spinal Involvement

numbness / tingling	**Inner ear (staggers)**
bi-lateral paralysis	**Lungs (Chokes)**
no bladder function	**Cardiac arrest**
loss of sexual response	**Type I on ascent**

21. The heart condition in ~ 25% of the population that appear implicated in serious CNS lesions is the **PFO.**

22.DCS Risk factors include:

older age	**strenuous exercise**
obesity	**cold**
dehydration	**repetitive dives**
poor circulation (tight clothing)	**multiple ascents / descents on same dive**
illness	**multi day diving**
scar tissue	**history of DCS**
alcohol	**being female (?)**
fatigue	**misuse of dive tables / dive computers**

23. The best prevention of swimmer's ear is a post dive rinse with **vinegar.**

Physics

1. Pressure in physics is defined as a **force** per unit area.

2. An atmosphere is the total **weight** of an air column directly above point of measurement**.**

3. One atmosphere equals:

760	**mm Hg**
14.7	**psi**
1.01325	**bar**
33	**fsw**
34	**ffw**

4. Convert the US cylinder pressure below (psi) to rest of the world pressure (bar)

$$3000\text{ psi} \times \frac{1\text{ atm}}{14.7\text{ psi}} \times \frac{1.01325\text{ bar}}{1\text{ atm}} = 207\text{ bar}$$

$$2000\text{ psi} \times \frac{1\text{ atm}}{14.7\text{ psi}} \times \frac{1.01325\text{ bar}}{1\text{ atm}} = 149\text{ bar}$$

$$1000\text{ psi} \times \frac{1\text{ atm}}{14.7\text{ psi}} \times \frac{1.01325\text{ bar}}{1\text{ atm}} = 69\text{ bar}$$

$$500\text{ psi} \times \frac{1\text{ atm}}{14.7\text{ psi}} \times \frac{1.01325\text{ bar}}{1\text{ atm}} = 34\text{ bar}$$

5. Convert European cylinder pressure (bar) to US equivalent (psig):

$$100\text{ bar} \times \frac{1\text{ atm}}{1.01325\text{ bar}} \times \frac{14.7\text{ psig}}{1\text{ atm}} = 1451\text{ psig}$$

$$200\text{ bar} \times \frac{1\text{ atm}}{1.01325\text{ bar}} \times \frac{14.7\text{ psig}}{1\text{ atm}} = 2902\text{ psig}$$

6. Convert the following depths to atmospheres absolute (ata):

$$101\text{ fsw} = \frac{101\text{ fsw}}{33\text{ fsw / atm}} = 3.1\text{ atm} + 1\text{ atm} = 4.1\text{ ata}$$

$$56\text{ ffw} = \frac{56\text{ ffw}}{34\text{ ffw / atm}} = 1.6\text{ atm} + 1\text{ atm} = 2.6\text{ ata}$$

7. Total pressure in a gas mix is the **sum** of the pressures of all components in a mix.

8. Boyle's Law is important for understanding changes in volume as the diver changes **depth.**

9. Charles' Law is important for understanding changes in volume as diver changes **water temperature.**

10. Guy-Lussac's Law is important for understanding changes in cylinder pressure with **temperature.**

11. Henry's Law is important for understanding **decompression** obligation.

12. The amount of gas dissolved in a tissue is a function of **the partial pressure** of each individual gas.

13. In cold water, **(more**, less) gas dissolves in tissues.

Oxygen Toxicity

1. Hypoxia generally results when the pO_2 **is less than 0.16** ata.

2. Hyperoxia generally results when the pO_2 **is greater than 1.6** ata.

3. Symptoms of hypoxia include:

R = Restlessness
A = Anxiety
T = Tachycardia
B = Bradycardia
E = Extreme Restlessness
D = Dyspnea

4. Hyperoxia is a function of **pO_2** and **exposure** time.

5. Hyperoxia symptoms are remembered by the pneumonic:

V = Vision
E = Ears
N = Nausea
T = Twitching
I = Irritability
D = Dizziness
C = Convulsions

6. Hyperoxia effects are exacerbated by:

Heavy exercise
Breathing dense gas
Breathing against resistance
Increased carbon dioxide buildup
Chilling or hypothermia
Water immersion (as opposed to "chamber diving")

7. Major concern of CNS toxicity involves an **underwater seizure.**

8. An inexpensive protection of tissues from oxidative damage is eating **chocolate** just before diving

9. Whole Body (pulmonary) toxicity is of concern when **breathing high pO2 (> 0.5 ata) for hours.**

10. Symptoms of whole body oxygen toxicity include:

Pulmonary	**Skin numbness and itching**
Chest pain or discomfort	**Headache**
Coughing	**Dizziness**
Chest tightness	**Nausea**
Fluid in the lungs	**Visual disturbances**
Reduction in vital capacity	**Diminished aerobic capacity**

11. The oxygen toxicity unit (OTU) is based on **decreased lung vital capacity.**

12. 1 OTU is defined as **Breathing 100% O_2 for 1 minute.**

13. OTU's are best tracked by **computer.**

14. For diving EAN_x more shallow than 130 fsw, it is (necessary, **not necessary**) to track OTU accumulation.

Dive Planning

1. The optimum EAN_x mix minimizes $\mathbf{N_2}$ (limit deco obligation) while keeping $\mathbf{pO_2}$ below toxic levels.

2. The pO_2 scientific standard for extended diving is a maximum**1.6** ata.

3. The current NOAA and recreational diving pO_2 standard maximum is **1.4 ata.**

4. The NOAA single dive time limit for a pO_2 of 1.4 ata is **150 minutes**

5. The NOAA single dive time limit for a pO_2 of 1.6 ata is **45 minutes**

6. Increasing pO_2 in the breathing mix (increases, **decreases**) bottom time.

7. a. The pO_2 for EAN_{32} at 94 fsw is

$$pO_2 = 0.32\ [(94\ \text{fsw} / 33\ \text{fsw/atm}) + 1\ \text{atm}]$$
$$pO_2 = 1.23\ \text{ata}$$

b. The oxygen single dive exposure limit for this dive is

pO_2 of 1.25 ata ➔ 195 minutes

8. a. You dive for 40 minutes at a pO_2 of 1.4 ata. The % CNS exposure for this dive is

$$\frac{40\ \text{minutes dive}}{150\ \text{minute limit}} \times 100 = 27\ \%$$

b. You have a surface interval of two hours and 10 minutes. Your % CNS exposure is now

Start @ 30 % ➔ - 12 % ➔ 18 %

c. You now dive for 27 minutes at a pO_2 of 1.6 ata. Your % CNS for this dive is

$$\frac{27\ \text{minute dive}}{45\ \text{minute limit}} \times 100 = 60\ \%$$

d. The total oxygen exposure for this dive is

18 % + 60 % = 78 %

9. The MOD for EAN_{34} for a pO_2 of 1.4 ata is

$$\text{MOD} = \left[\left(\frac{1.4\ \text{ata}}{0.34} \right) - 1 \right]\ 33\ \text{fsw} = 103\ \text{fsw}$$

10. The pO_2 of EAN_{32} at 110 fsw:

$$pO_2 = 0.32 \left[\left(\frac{110\ \text{fsw}}{33\ \text{fsw/ atm}} \right) + 1\ \text{atm} \right] = 1.39\ \text{ata} \rightarrow 1.4\ \text{ata}$$

11. The best mix for 85 fsw at a pO_2 exposure of 1.4 ata is

$$FO_2 = \frac{1.4\ \text{ata}}{(85\ \text{fsw/ } 33\ \text{fsw/atm} + 1\ \text{atm})} = 0.39$$

Dive Planning Tools

1. The NOAA EAN_x Dive Tables are based on **US Navy Air Tables** using the **EAD** concept.

2. EAD is based on (**nitrogen**, oxygen) content and not on the actual physical depth.

3. Using EAD, the diver is assumed to be (**more shallow**, deeper) than actual physical depth.

4. EAD is the basis for the (**physiological**, decompression) advantage of EAN_x.

5. a. The EAD for EAN_{32} at 82 fsw is

$$\mathbf{EAD = \left[\frac{(82\ fsw + 33\ fsw)(1 - 0.32)}{0.79} \right] - 33\ fsw = 66\ fsw}$$

   b. For this dive, you can use US Navy or NOAA air tables entering at **70 fsw.**

6. Dive computers are most useful for (**multi-level**, constant depth) diving.

7. The two options for using a dive computer:

   Use a computer designed for EANx
   Use EANx while monitoring dive with an air based dive computer

8. Desirable computer features:

   Allow for a variety of nitrox mixes
   Compute the deco profile based on user entered % O_2
   Provide MOD limits based on the mix and pO_2
   Track Oxygen and Nitrogen
   Allow extended dive time by adjusting pO_2 on ascent

9. When diving EANx with an air computer, the diver must know

   MOD of mix
   Maximum oxygen exposure time

10. Air computers (will, **will not**) alert the diver when MOD has been exceeded.

11. DCS hits have been associated with (increasing, **decreasing**) ambient pressure.

Dive Tables
Problems use the NOAA (2015) Nitrox Tables

1. Dive tables assume a **+/- 1** % tolerance of oxygen concentration.

2. When using EAD, always use **on-site analyzed** cylinder oxygen concentration.

3. Always use next (**greatest**, smallest) values for depth and time.

4. a. The rep group for an air dive to 56 fsw for 38 minutes is:

   Enter table at 60 fsw for 39 minutes ➔ G

   b. After a SIT of 2 hours, the rep group is **E**

   c. The available bottom time for 80 fsw is **17 minutes**.

   d. After 14 minutes at 80 fsw, the rep group is **(14 + 22) = 36 minutes at 80 fsw ➔ I**

   e. After a 3:20 SIT, the rep group is **F**

5. a. The rep group for an EAN_{32} dive to 56 fsw for 38 minutes is:

   Enter table at 60 fsw for 41 minutes ➔ F

   b. After a SIT of 2 hours, the rep group is **D.**

   c. The available bottom time for 80 fsw is **28 minutes**

   d. After 14 minutes at 80 fsw, the rep group is **(14 + 20) = 34 minutes at 80 fsw ➔ H**

   e. After a 3:20 SIT, the rep group is **E.**

6. a. The rep group for an EAN_{36} dive to 56 fsw for 38 minutes is:

   Enter table at 60 fsw for 39 minutes ➔ E

   b. After a SIT of 2 hours, the rep group is **C.**

   c. The available bottom time for 80 fsw is **41 minutes**

   d. After 14 minutes at 80 fsw, the rep group is **(14 + 19) = 33 minutes at 80 fsw ➔ F**

   e. After a 3:20 SIT, the rep group is **C.**

7. You dive EAN_{32} to 88 fsw for 44 minutes. Your emergency deco obligation is **10 minutes at 20 fsw**

8. Your gas analysis indicates 30.9 % oxygen. The time allowed at 52 fsw is

   $$\text{EAD} = \left[\frac{(52\text{ fsw} + 33\text{ fsw})}{0.79} (1.000 - 0.309) \right] - 33\text{ fsw} \Rightarrow \text{EAD} = 41\text{ fsw}$$

   Air table for 50 fsw allows 92 minutes

9. NOAA Tables assume a descent rate of **75 fsw / min** and an ascent rate of **30 fsw / min.**

10. NOAA tables assume the dive site of less than **1000 feet** altitude.

11. a. The rep group for an air dive to 56 fsw for 38 minutes is:

Enter table at 60 fsw for 39 minutes ➔ G

b. After a SIT of 2 hours, the rep group is **E**

c. The available bottom time for 80 fsw is **17 minutes**.

d. After 14 minutes at 80 fsw, the rep group is **(14 + 22) = 36 minutes at 80 fsw ➔ I**

e. After a 3:20 SIT, the rep group is **F**

f. As an F air diver, how much maximum no-deco time is available on EAN_{36} for a dive to 54 fsw?

Enter EAN_{36} table 3 as an F ➔ 108 minutes maximum

g. As an F air diver, you dive EAN_{36} to 54 fsw for 45 minutes. Your rep group is now:

Enter EAN_{36} table 3 as an F ➔ (45 minutes + 55 minutes) ➔ 100 minutes @ 55 fsw ➔ K

h. After 4:30, your rep group is **F**

i. You now want to dive on EAN 32 to 43 fsw. Your maximum no deco time is **168 minutes.**

j. You dive to 43 fsw for 45 minutes, your rep group is now:

Enter EAN_{32} table 3 as a F diver: (64 minutes + 45 minutes) ➔ 109 minutes @ 45 fsw ➔ J

Handling Gases

1. Oxygen (burns, **does not burn**).

2. Oxygen (**increases**, decreases) the ability of other chemicals to burn.

3. Adiabatic compression is a concern because this process (**heats,** cools) gases.

4. Always open gas valves (**slowly**, quickly).

5. a. Compressed air contains two undesirable components for preparing EAN_x:

   Water
   Oil

   b. The concerns of these components are:

   water: can condense, freeze, mechanically jam regulator
   oil; with oxygen, explosive hazard

6. The preferred CGA grade of air is **J**.

7. Most recreational scuba uses a **"modified E"** standard.

8. The preferred grade of oxygen for EAN_x blending is **aviation** grade.

9. An industry term for air used in EANx blending is **Oxygen Compatible Air (OCA).**

10. A measure of water in a breathing mix is the **dew point.**

11. A high dew point in a breathing gas can result in **ice formation from adiabatic expansion.**

12. Partial pressure blending is (**most**, least hazardous) method of preparing EANx.

13. For partial pressure blending the cylinder and valve need to be **oxygen cleaned.**

14. Membrane / Stik methods typically are used for EAN_x mixtures having less than **40** % oxygen.

15. **Continuous blending** can be used for concentrations up to 95 % oxygen.

16. Medical oxygen cylinders should be filled at an **FDA licensed facility.**

17. EAN_x cylinders must be clearly marked with the word **"Nitrox" on a 4" green and yellow label.**

18. Non-yellow cylinders have an additional **1" yellow band above and below the Nitrox label.**

19. The data on an EAN_x tag includes:

   Date filled
   % Oxygen
   Cylinder pressure
   MOD
   Analyzer
   User

20. A **ball** valve should never be used on oxygen line.

Oxygen Cleaning

1. NOAA standards allow EANx mixes of **< 40** % to be treated as air.

2. Equipment used with oxygen mixes > 40 % must be
   a. oxygen compatible
   b. oxygen clean

3. The two types of oxygen cleaning are:
   a. formal
   b. informal

4. Scuba equipment is cleaned to (formal, **informal**) protocols.

5. Oxygen cleaning removes
   Particulates
   Oils
   Organics

6. Visual inspection for oxygen cleaning uses (ordinary white light, **UV light**.)

7. Any scuba gear used with > 40% must **be oxygen clean.**

8. A cylinder certified as oxygen clean is used for ordinary air. Before using with EAN$_x$, it should be
   Recleaned
   Recertified

9. The color of O-rings (is, **is not**) a reliable indicator of acceptability for use with EAN$_x$ mixes.

Gas Analysis

1. Typical scuba oxygen analyzers use (polarographic, **electrochemical**) detection.

2. Every oxygen analysis (**degrades**, has no effect, improves) oxygen electrode response.

3. The standard is the community is to replace the electrode at a max of (**one,** two, five) years.

4. Meter sensitivity should be + / - **0.1** %

5. Factors which can degrade analyzer performance include:

Humidity / Moisture
Too high a flow rate (Should be ~ 1 L / min)
Physical abuse
Major temperature fluctuations
Mechanical connection to analyzer
Sensor degradation with time
Expense
Sensor Obsolescence

6. a. Your analyzer indicates a 30.4 % oxygen for a purchased NOAA I cylinder. Your pO_2 1.40 ata MOD is

$$\mathbf{MOD = \left[\frac{1.40\ ata}{0.304} - 1\ atm \right]\ 33\ fsw / atm = 118\ fsw}$$

b. Your extended exposure pO_2 1.60 ata MOD is

$$\mathbf{MOD = \left[\frac{1.60\ ata}{0.304} - 1\ atm \right]\ 33\ fsw / atm = 141\ fsw}$$

7. Your analyzer indicates a 37.4 % oxygen for a purchased NOAA II cylinder. Your pO_2 1.40 ata MOD is

$$\mathbf{MOD = \left[\frac{1.40\ ata}{0.374} - 1\ atm \right]\ 33\ fsw / atm = 91\ fsw}$$

b. Your extended exposure pO_2 1.60 ata MOD is

$$\mathbf{MOD = \left[\frac{1.60\ ata}{0.374} - 1\ atm \right]\ 33\ fsw / atm = 108\ fsw}$$

8. Your calibration using air reads 19.6 % oxygen. You should (continue to use, **replace**) the oxygen sensor.

9. Two on-site analyzers report a NOAA I cylinder as having 30.5 and 33.8 % oxygen.

a. your deco obligation is dictated by the **30.5** % value.

Use NOAA 31 % Table, or EAD calculation for FN_2 of 0.695

b. your MOD is tracked using the **33.8** % value. For a pO2 of 1.4 ata, this is

$$\mathbf{MOD = \left[\frac{1.40\ ata}{0.338} - 1\ atm \right]\ 33\ fsw\ atm = 104\ fsw}$$

10. Every EAN_x cylinder should be analyzed:

On filling
On pick-up
At the site