American Dive Center

Deep Diver
Home Study Workbook

D is for Deep

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Deep Diver Independent Learning Course

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Physics Review 1.1
Depth and Pressure

In this module you will review the relationship between **depth** and **pressure**. This understanding is needed as a tool in subsequent pages.

As a diver you are interested in **depth**, here measured in feet of sea water (**FSW**). But your body, from a physiological standpoint, reacts to **pressure**, here measured in atmospheres absolute (**AtA**).

Using these terms, you see in this table that, at the surface, the pressure on your body is one atmosphere. This is the pressure that results from the weight of the air in space pressing down on you. As you descend in the water, this pressure increases e.g. at 33 FSW the pressure is 2 AtA, etc.

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

In the pages 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

Note: When converting depth in fresh water (FFW) to pressure (AtA) and visa versa, use the constant 34 feet/AtA instead of the 33 feet/AtA used for sea water. This change will account for the fact that fresh water is 3% less dense than sea water.

Physics Review Depth and Pressure Self Test	
Show Me! 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).	

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Physics Review 1.1
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

--- Depth and Pressure ---

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

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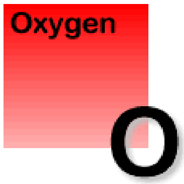
Physiology of Diving Gasses 2.2
Oxygen



Oxygen is the necessary, life supporting, part of air. Without Oxygen you die. However, too much oxygen in your tank can also cause problems, because oxygen becomes toxic at depth.

As divers, there are two types of Oxygen toxicity that we must consider --- **Central Nervous System Oxygen Toxicity** and **Pulmonary Oxygen Toxicity**.

- **Central Nervous System (CNS) Oxygen Toxicity** is the toxic effect on the **brain** of breathing high Oxygen concentration mixtures for too long a time period.

  Signs and symptoms of CNS Oxygen Toxicity may be any of the following --- visual disturbances, ringing in the ears, nausea, muscular twitching, irritability, dizziness, and convulsions. It is important to note that these signs and symptoms do not proceed in any particular order i.e. convulsions and subsequently death by drowning, can occur without warning.

  Clearly, the proper course of action regarding CNS Oxygen Toxicity is prevention. Never exceed the Maximum Operating Depth of the mix.

  Warning

  In no case should your planned or actual dive ever exceed the maximum Oxygen pressure of 1.6 AtA.

  For prolonged, or strenuous, or cold water dives, limit the maximum Oxygen pressure to 1.4 AtA.

- **Pulmonary Oxygen Toxicity** is the toxic effect on the **lungs** of breathing high Oxygen concentration mixtures for too long a time period.

  Signs and symptoms of Pulmonary Oxygen Toxicity may be any of the following --- shortness of breath, dry coughing, lung irritation, a burning sensation in the breathing cycle, and a reduction in lung vital capacity. Complete recovery usually occurs within a few days.

  Pulmonary Oxygen Toxicity is normally not a problem for technical divers because the dose/time levels required are much higher than those experienced on technical dives.

For additional information on Oxygen Toxicity see the Appendix - NOAA Diving Manual Excerpts on Oxygen Poisoning.

Physiology of Diving Gasses Oxygen Self Test	
What are the signs and symptoms of CNS Oxygen Toxicity?	
In no case should your planned or actual dive ever exceed the maximum Oxygen pressure of ____ .	
For prolonged, or strenuous, or cold water dives, limit the maximum Oxygen pressure to ____ .	
What are the signs and symptoms of Pulmonary Oxygen Toxicity?	
Why is Pulmonary Oxygen Toxicity normally not a problem for technical divers?	

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Dive Tables 5.1
Published Tables

The risk of decompression sickness can be reduced by the conservative use of dive tables.

Note: Most tech divers still dive tables on deep dives because these dives are Trimix dives and there are no dive computers that currently work for Trimix dives. And, even when Trimix dive computers are available, tables will still be used to plan deep dives and as a backup to a failed Trimix dive computer. So, settle down and get comfortable with dive tables.

Begin with the selection of dive tables that are inherently safe. A good choice is tables derived from the Buhlmann model. Both the original Buhlmann tables and the DECOM computer generated Buhlmann tables are good choices. Use of the original USN tables is not recommended.

Note: The DECOM table below was generated using the DECOM 6.61 dive planning program. The "conservatism settings" for both Nitrogen and Helium were set at 7%.

US Navy Dive Tables (Air)				
FSW	Bottom Time and Deco Stops			
130	15	20	25	30
40				
30				
20				3
10	1	4	10	18

Buhlmann Dive Tables (Air)				
FSW	Bottom Time and Deco Stops			
130	15	20	25	30
40				
30			2	3
20		3	4	7
10	4	7	12	18

DECOM Dive Tables (Air)				
FSW	Bottom Time and Deco Stops			
130	15	20	25	30
40				2
30		1	4	6
20	3	7	9	11
10	6	9	14	19

Using the DECOM dive table as an example, the interpretation of the table for a 130 FSW dive for 25 minutes is that you; dive to 130 FSW for 25 minutes, then ascend to your first stop at 30 FSW. There you stop for 4 minutes. Then you ascend to 20 FSW and stop for 9 minutes, etc., etc.

Note: Compare the difference between the US Navy table and either of the two Buhlmann tables and you will see that the US Navy stops are shallower and shorter. It is for this reason that the US Navy tables got the reputation for being the fastest to get you out of the water and the fastest to get you into a chamber. It is also for this reason that the use of the original USN tables is not recommended. In fact, even the US Navy has discontinued the use of these tables.

To add safety to the use of the selected tables, apply one or more of the approaches listed below. Remember, even the safest tables have some risk in them, so it’s not a good idea to "push" the tables.

Parameter	Approach	Actual Dive	Dive Table Plan
Maximum Depth	Use Next Deepest Depth	130 FSW Maximum Depth	140 FSW Table Depth
Bottom Time	Use Next Longest Time	25 minutes Bottom Time	30 minutes Table Time
Bottom Mix	Use More Oxygen	32% Bottom Mix	21% Table Plan
Deco Stops	Extend Shallowest Time	xx + 5 Minutes @ 10 FSW	xx Minutes @ 10 FSW
Deco Mix	Use More Oxygen	80 % Deco Mix	21 % Deco Mix

For example, to make the 130 FSW dive for 25 minutes, you could use the 140 foot air tables for 30 minutes of bottom time. Then, instead of doing the dive on air you could use EANx32 for the bottom mix and EANx80 for the decompression mix. And finally, you could extend the time spent on the shallowest decompression stop.

Employing all of these approaches on one dive would be overly conservative. However, every dive plan should have some additional safety built into it to avoid "pushing" the tables.

Note: Controlled ascent rates are crucial to proper off gassing. Most modern dive tables assume an ascent rate of 30 feet per minute. It is important that you do not ascend faster or slower than this rate. If you ascend faster you will off gas too rapidly and risk decompression sickness. If you ascend slower you will be at depth for a longer time than planned and again risk decompression sickness.

Warning

Ascend from every tech dive at 30 feet per minute.

Dive Tables Published Tables Self Test	
Buhlmann model based dive tables are ___ than US Navy dive tables.	
Name five things can you do to add conservatism to a dive.	
The proper ascent rate for tech diving is ____ feet per minute.	

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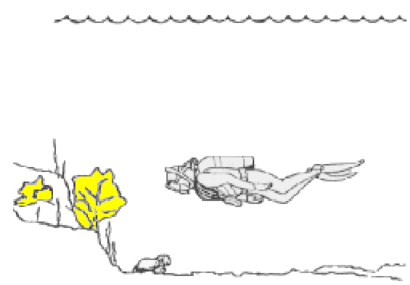
Gas Supply Planning 7.2
Consumption vs. Depth

"*How long can you stay down there?*" ... "*It depends on how deep I am diving. The deeper I dive the less bottom time I have.*"

The deeper you dive, the more air you consume in a given period of time.

Your scuba regulator is designed to adjust the pressure of the air supplied to you, to match the pressure of the surrounding water.



As you dive deeper, the surrounding water pressure and the pressure of the air supplied to you increases.

As the pressure of the air supplied to you increases, the density of this air also increases.

Since you still breathe in the same lung full amounts of air, each lung full you breathe has more molecules of air from the tank, and thus the tank does not last as long.

The table below, shows the depth, pressure, density, and time relationships for dives to 33', 66', and 99' assuming that a tank of air would last 120 minutes at the surface.

Depth - Pressure - Density - Time Relationships			
Depth Feet	**Pressure** Atmospheres Absolute	**Density** Relative to Surface	Time Tank Lasts (Minutes)
00	**1x**	**1x**	120
33	**2x**	**2x**	60
66	**3x**	**3x**	40
99	**4x**	**4x**	30

From the table above, you can see that the deeper you go, the less time you have to dive.

The amount of time you have at depth is simply the amount of time you have at the surface, divided by the pressure in Atmospheres Absolute at the depth you are diving.

For example; how long will a tank of air last at 172 FSW (6.21 AtA) if it would last 120 minutes at the surface?

The answer is 120 minutes divided by 6.21 AtA or 19.32 minutes. Then the tank will be EMPTY.

Gas Supply Planning Consumption vs. Depth Self Test	
The deeper you dive, the ____ air you consume in a given period of time.	
Show Me! A scuba tank that lasts you 120 minutes at the surface will last ____ minutes at 66 feet.	

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Gas Supply Planning 7.2
Consumption vs. Depth
Show Me Answers

--- Consumption vs. Depth ---

A scuba tank that lasts you **120 minutes** at the surface will last how many minutes at **66 feet** i.e. (**3 AtA**).

The answer is **120 minutes** divided by **3 AtA** or **40 minutes**. Then the tank will be EMPTY.

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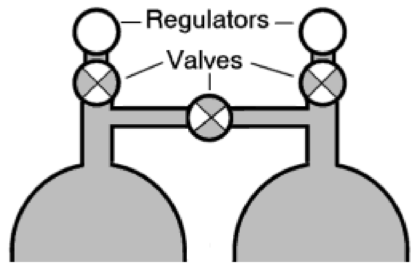
Deep Diving Equipment 8.2.1
Special Equipment
Double Tank Rig

Two tanks, connected with a manifold, is the most common rig used for the bottom mix.

This tank configuration allows you to use two separate regulators, each with it's own on/off tank valve. Thus, in the event of a regulator failure, you can turn off the failing regulator and still have a working regulator to breathe from.

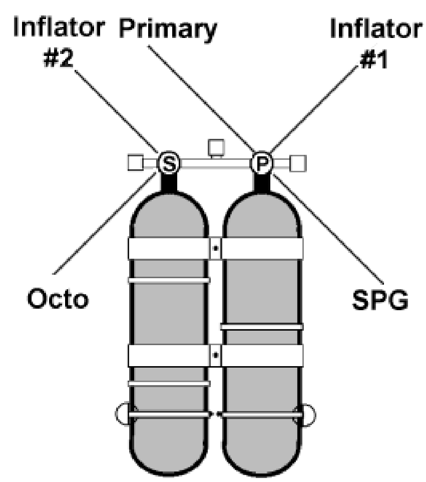


Because, the tanks are connected with a manifold, each regulator has access to all the gas in both tanks. As a refinement, some manifolds have an isolator valve in the center. This valve can be used to isolate one tank from the other in the event of a catastopic failure of one of the tanks e.g. a blown burst disk, or a blown main tank "o" ring.

Using two tanks, without a manifold, is not a safe way to dive doubles.

Absent a manifold, you must periodically switch your breathing from one tank to the other to insure that each tank maintains an adequate reserve for emergency use. Given the other tasks that require your attention during the dive, the task of periodically switching breathing from one tank to the other is a distraction to be avoided.

Setting up doubles properly for tech diving is both a science and an art.



Facing the front of the doubles, the primary first stage should be mounted on the right post since this is the post most likely to be turned off in an overhead environment. The gauges and primary inflator hose should also be mounted to this first stage to minimize hose congestion behind your head.

The secondary first stage should be mounted on the left post. The secondary inflator hose or dry suit inflator hose should also be mounted to this post.

The choice of which regulator hose should be the seven foot hose is a matter of personal choice.

It can on the primary regulator and worn tucked in the BCD belt and wrapped once around your neck. Or, the seven foot hose can be on the secondary regulator with the hose tucked in surgical tubing on the tank.

Note: Creativity is needed to get clean layouts with different types of regulators. Try rotating the first stages 90 degrees from their normal position. When properly laid out, all of the hoses should be within the silhouette of the diver.

Finish the assembly by putting mounting hardware on the tanks as needed to provide attachment points for your decompression tanks and accessories and surgical tubing to keep your seven foot regulator hose from dangling.

Note: If you fasten all of your decompression tanks and accessories to your harness, there is no need for any mounting hardware on the tanks. And, if you dive with the long hose as your primary, there is no need for surgical tubing on the tanks.

For additional information on which hose to use for your primary regulator, see the Appendix - Other Articles On Deep Diving - Short Hose - Long Hose by Karl Shreeves.

Deep Diving Equipment Special Equipment Double Tank Rig Self Test	
Two tanks, connected with a ____, is the most common rig used for the bottom mix.	
True or False - Two tanks, without a manifold, is not a safe way to rig double tanks.	