Open Water Diver

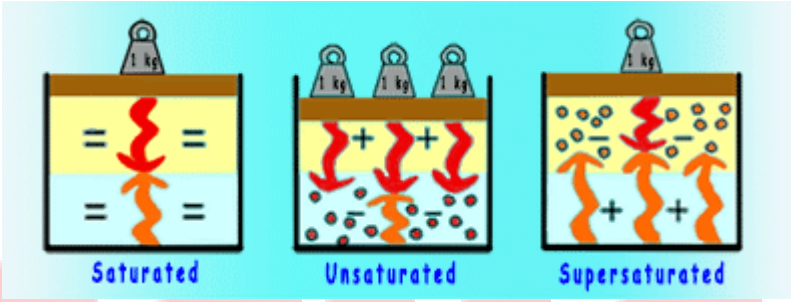
Part 6 (I)

Henry’s law

6.1 Henry's law

Of enormous interest for diving, Henry's law tells us: "*At a constant temperature, the amount of a given gas that dissolves in a liquid is directly proportional to the pressure exerted by the gas on the surface of the liquid*."

In short, because our internal temperature is constant, the more pressure the more gas that dissolves. This does affect our body as we breathe gases under pressure (the air) that comes into contact with our liquids (the blood). Nitrogen is the one that interests us for these effects, since oxygen is used by our metabolism, so it is barely freely dissolved in the blood. Nitrogen is an inert gas (does not participate in the metabolism), being simply a diluent of oxygen, so it dissolves in the blood and circulates dissolved in the plasma.



Under normal conditions we are saturated, our blood has the nitrogen corresponding to the atmospheric pressure to which we are at, so it does not dissolve anymore. However, when diving, as we are under more pressure, we breathe air at more pressure, and then more nitrogen is dissolved in the blood, which is distributed throughout our body. Therefore, the total amount of nitrogen that dissolves in our body depends on the depth (pressure) and time of exposure. The deeper we dive the more nitrogen that dissolves and the longer we dive, the greater the amount as well.

As all along our dive we have been dissolving nitrogen because of the higher pressure, we find that when ascending, our blood contains more nitrogen than its initial load, so we go into supersaturation and now the flow goes the other way, the blood has to get rid of the excess of nitrogen, which we have to expel through our breathing. But attention! Nitrogen is in our whole body and can only come out through the lungs, so we have to make the ascent at a speed that allows this exit, that is, we have to go up slowly enough to give our blood time to reach the lungs and lose supersaturation. Even, depending on the duration of the dive and the depth reached, we may need to do mandatory decompression stops before reaching the surface.

If we do not respect the ascent speed or the deco stops, nitrogen can form bubbles in our veins (embolisms), causing circulatory blockages (ischemia), thus developing what is known as decompression sickness (DS). An accident certainly serious (can be deadly) but, like all the others, very easy to avoid. The only thing we must do is to respect the ascent speed required in the dive. If such an accident occurs, the rescue action consists of the urgent transfer to the nearest hyperbaric chamber, keeping the victim hydrated by giving him water and breathing pure oxygen.

So, the next question we can ask ourselves is how to know the right ascent speed. Well, that's what decompression tables and dive computers are for. Both are explained in this course, but first let's calm down a bit:

Almost all recreational dives in the world, are made by using the services of a diving centre, which transport divers to places of interest for diving and with professional people aboard. The places chosen for the dives meet the conditions of offering a lot of attractiveness and being on a route in which the dives are not deep, so that nitrogen is not dissolved so much that it forces mandatory decompression stops. In such dives, it is enough to ascend slowly, 10 meters per minute is a maximum speed accepted and incorporated even in the alarms of dive computers, and doing a safety stop of 3 minutes at 5 meters, then using 2 minutes to go up to the surface from 5 meters. It may seem complicated, but certainly in practices you will see how simple it

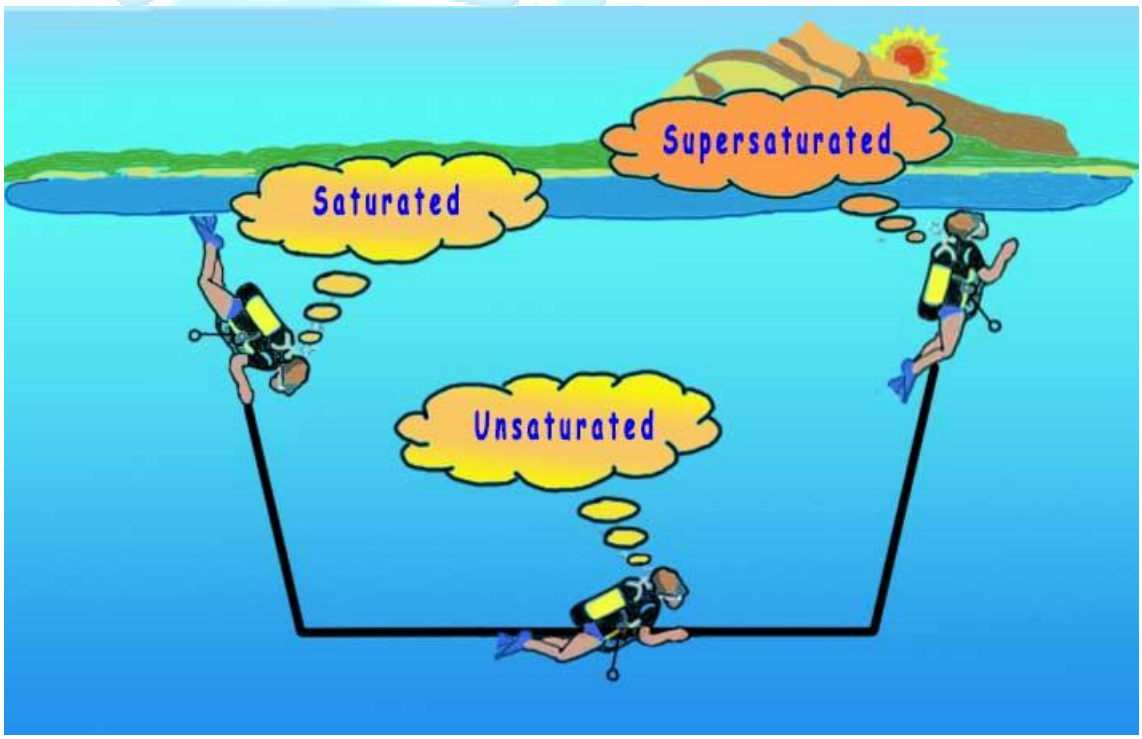
is and you will learn to regulate your ascent speed. By observing these simple safety rules, we will be more than reasonably safe from decompression sickness.

As a part of the theory training, you have to learn how to handle the decompression tables (there are several models of tables). ACUC uses its own decompression tables based on the Canadian DCIEM (Defence and Civil Institute of Environmental Medicine) tables, considered one of the safest. The tables offer you a correspondence of depths and times of dive that do not require mandatory underwater decompression stops and, if those times are exceeded, the depths at which you have to do the decompression stop(s) and the time to remain at such depths. As you can see, using tables to regulate our dive requires the using of a watch and a depth gauge, besides checking and consulting tables. In the next topic we will learn how to use these tables.

Knowing how to handle decompression tables is necessary for your safety and allows you to dive even if you do not have a computer. It is the basis for you to understand about decompression and also you must answer questions in the exam that require using the tables; but nowadays, tables, watch and depth gauge have been widely replaced by dive computers, which give us all the necessary data to regulate our safety regarding decompression. They even tell us if our ascent speed is adequate and if we need to do decompression stops, they indicate the depth of the stop and the time, triggering alarms if we inadvertently surpass the stop depth.

The “no decompression” dive does not exist. From the moment we breathe under water, since we breathe at higher pressure, nitrogen is dissolved in our organism as we have explained, so we are always going to exit supersaturated and, therefore, we have to decompress.

As we have indicated, the total amount of nitrogen that will dissolve in our organism also depends on the length of time. If our dives take place within the safety curve (green area of the table), It is assumed that we have not dissolved enough nitrogen to have to stop underwater, but on the surface, we are really doing the equivalent of a decompression stop, so we should keep some precautions that we will indicate at the end of this chapter; therefore, there is **always** decompression. In the text, we differentiate mandatory underwater decompression stops, before reaching the surface, from surface decompression, calling them "mandatory stops" or "stops in the water".



To summarize, let's say that we are talking about the decompression sickness, a very serious accident that can even be fatal, but its prevention is as simple as:

Never dive to depths and for times that require mandatory deco stops and always **ascend slowly at a maximum speed of 10 meters per minute**, being very advisable to always do a **safety stop, of 3 minutes at 5 meters**, then using **2 minutes to go up from 5 meters to surface**.

At ACUC the tables based on the DCIEM are used, the depth in these tables was originally calculated in feet; the depth of the safety stop was set at 15 feet; in the ACUC tables we indicate the depth of 4.5 meters for the safety stop, which is the equivalent to 15 feet, but the rest of the recommendations are the same. The use of these tables allows a maximum speed of ascent of up to 15 meters per minute, with some margin, but we, in all calculations and theory, will use 10 meters per minute to be safer.

We must understand the concept of successive dives and continuous dives. The described processes allow us to reach the surface without suffering a decompression accident, but that does not mean that we are in equilibrium of nitrogen saturation. Our body admits a certain level of supersaturation without the accident occurring, so we exit to the surface with an excess of nitrogen, which takes between 12 and 24 hours to dissolve. If before that time we do another dive, for example a dive in the morning and another in the afternoon, we will start the second dive with more nitrogen load than the one contemplated in the calculations in the tables and computers, then other different calculations are required. We will learn those modifications when handling the tables.

The computers do it automatically, since the data remains saved, and that is the reason why a computer cannot be lent to another diver in a period of less than 24 hours after the last dive and, if we lend it after that term, we cannot use it until 24 hours after the last dive. There are computers that have a reset system (set to 0), which is used to rent equipment, but if we are going to use it in successive dives, we must keep it with us until we finish that succession of dives, usually during the whole dive trip.

Simple or single dives are those that we start after a period of 24 hours or more without diving. We start the dive saturated as there is no accumulation of nitrogen due to a previous dive.

Continuous dives are those that we start in a maximum period of 10 to 15 minutes after having reached the surface in the previous dive, according to the calculation model used. As the time period is so short, decompression calculations are done as if the second dive was part of the first one, that is, when calculating the decompression data, the maximum depth reached in both dives will be taken as depth, and the time of the dive will be the sum of the times of the 2 dives. **Attention**, we can do a continuous dive inadvertently if, for example, after leaving a dive, we go back down to look for something. We must take this fact into account to avoid accidents, which unfortunately have occurred by these causes.

Successive or repetitive dives, are those that start in a period exceeding 10 or 15 minutes, depending on the calculation model used, and less than 12 to 24 hours after the previous dive has been completed. To calculate it, we must obtain the letter with which we exit the previous dive (we see it in the tables) and, depending on the time spent on the surface until we start the next dive, called the SIT (Surface Interval Time) in the tables, apply a factor of correction of time to this second dive, which we take from the table for successive dives. This correction factor is usually expressed in minutes to be added to the second dive, which is why it is also called Residual Nitrogen Time (RNT) or Nitrogen Penalty Time (NPT). These dives are very frequent in diving trips or excursions in which you dive in the morning and in the afternoon.

IMPORTANT. The second dive should always be shallower than the first. Any successive dive must be done to a shallower depth than the previous one. This safety measure is established to prevent the possibility of a decompression accident.

It is very important that we are clear about the fact that we will exit oversaturated. We have already said it but it is worth repeating it. Although we have not needed water decompression stops, on the surface we are doing a decompression that will last between 12 and 24 hours, depending on the previous dives, as we have already indicated when explaining continued dives and successive dives. This means that we must not

place ourselves in situations in which our environment pressure or our circulatory system varies. Let's see the recommendations (must do's).

- Do not fly or climb a mountain pass until 12 to 24 hours after the last dive. The tables indicate the term and the computers as well
- Do not do intense physical exercise
- Do not sunbath or take a sauna
- Avoid copious or flatulent meals, as well as soft drinks, but stay well hydrated
- Drink water, start the dive well hydrated. Diving causes dehydration, since we breathe a very dry air, which adversely affects decompression. We must also drink water after the dive.

We should know that the decompression information that is offered in this course is mainly focused on sea level dives (up to 300 meters of altitude). If the dive is going to be done at higher altitudes, you have to make adjustments in the depths of the dives, depth of the stops and speed of ascent, since the pressure ratio changes. These dives have special characteristics (Altitude Diving) that are not studied or trained in this diving course.

Finally, next we indicate some rules that we will repeat in the section where we teach how to use decompression tables:

- The dive time, also called **Bottom Time**, begins to count from the moment we start the dive, until the moment in which we begin the direct ascent to the surface. The ascent time and decompression time or safety stop are not dive times but they are ascent times.
- The depth of the dive for any calculation, is always the maximum depth reached during the same, regardless of the time spent at that depth, that is, if in our dive we have reached 20 meters of depth but most of the dive has been done at a lesser depth, we will understand as the dive depth the 20 meters depth.
- The surface interval in the case of successive dives, begins to count from the moment we reach the surface in the first dive, until the moment in which we begin the descent in the second dive.
- In the case of dives that will be done at different depths (multilevel dives), we must first reach the maximum depth and then go losing altitude to lower depths. Never the other way around.
- Never change depths going up and down continuously in a dive (saw blade profile).

Although we have already said it several times, it is very important to respect the ascent speed. We must always ascend slowly to prevent any unexpected accident, but above all to prevent the onset of the decompression accident.

Keep in mind that the decompression accident can have very serious consequences for the person affected, but it is very easy to avoid following the recommendations we offer. The most important recommendation for this or other accidents is to always carry out a responsible dive. Do not undertake dives for which you are not trained and make sure you have a first aid protocol prepared, because in case of any accident, an early intervention is very important.