# INSTRUMENTS

## PANORAMIC TABLE OF CONTENTS

(2021 edition)

## DIVE COMPUTERS



## NAVIGATION INSTRUMENTS



## HIGH PRESSURE INSTRUMENTS



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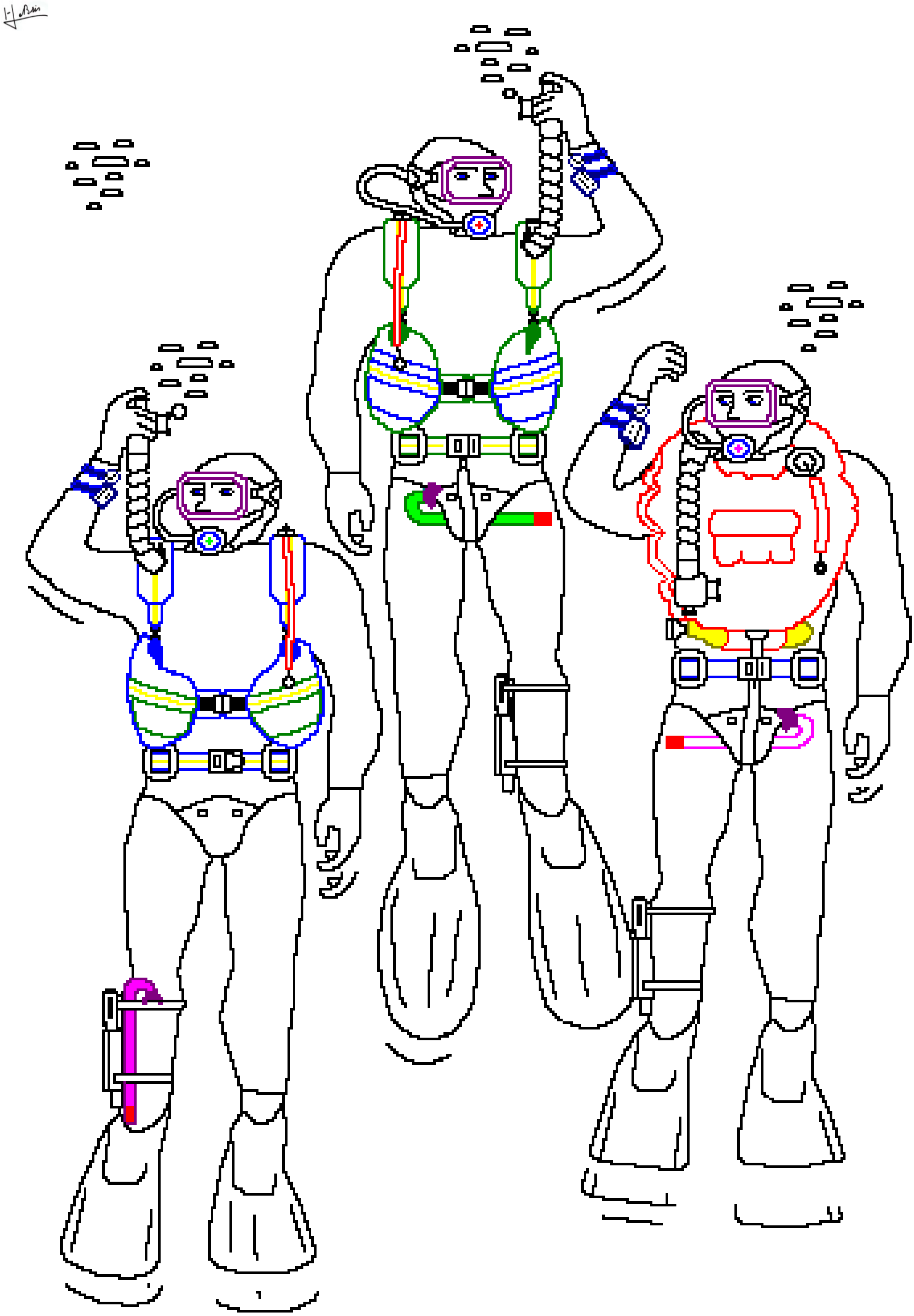
## ANNEX



## *GUESTBOOK*



***Three divers on the ascen***

**SELF-PUBLISHED AUTHOR**


(By the same author)

**JACKET 2021**

**DIVING INSTRUMENTS 2021**

**COMPRESSORS AND INFLATION STATIONS 2021**

**DIVING CYLINDERS 2021**

**PRINCIPLES OF REGULATORS 2021**

**LIGHTING**

**REBREATHERS**

**Back to home**

**Warnings:**

- The information and indications given in this publication are not exhaustive. They are given for information purposes only and cannot be the responsibility of the author. It shall not be liable for any error, omission or deficiency which may have occurred therein or for any consequences whatsoever resulting from their use.



**I thank in advance the visitors who will send me the remarks**

**and corrections they deem useful.**

# - INTRODUCTION -

*It was on my return from a dive that I realized that the gauge of the outboard pilot's depth was moving between 30 and 40 metres under the effect of the engine vibrations.*

*I decided to study the precision of these devices and in 1986 I wrote an article in the magazine Subaqua to mobilize the community of divers on the dangers they ran.*

*From that time on these devices slowly disappeared to be replaced by diving computers.*

*The first work on this subject was in the form of a handout and was distributed by the college of instructors of the Ile de France committee from 1993. I would like to thank all those who helped me with their review and their advice, in particular Jean-Pierre Montagnon, who chaired the committee at the time.*

*In this version, we have retained a large part of the original elements. The updates only touch on essential points. We kept some photographs or references to old cameras.*
*We added the other instruments: compasses, depth gauges and HP pressure gauges.*

*This will allow the reader to see the evolution of all these materials and the research that the manufacturers have devoted themselves to improving them over the years.*

*In order to be useful to visitors preparing a diving level, we have introduced a TRAINING chapter at the end of which we propose some questions whose answers are found in the different other chapters.*

*This year, 2020, we moved the chapters "Choosing a Computer" and "Physiology and Risk" to the end of the chapters on computers. This makes it possible to better read them in full knowledge of the facts.*

***GUESTBOOK***

# ***GENERAL PRINCIPLES***

# ***OF DIVING COMPUTERS***

*If you think that the detailed study of computers is too complex, simply consult the attached simplified document:*

**Introduction to diving computers**

## **Detailed table of contents**



## **Mathématical simulation**

It is difficult to measure what is happening inside our body. It is for this reason that we are forced to carry out, externally, a mathematical simulation of internal physiological phenomena.

The necessary operations are carried out using a small electronic computer called a microprocessor but which the divers ended up calling "Computer". It is of the same kind as those found in most pocket scientific calculators.

To do this, the researchers drew inspiration from the different models. (We will see them later)

**Simplified diagram** (See figure 2)
The following drawing, easy to remember, gives a general idea of how a diving computer works. The microcontroller receives, on its inputs, the information of the sensors of pressure, temperature, time, as well as the mathematical constants and the program of calculation.

It carries out high-speed operations and thus provides, in real time, through a display and a sound transducer, the necessary information to the diver.

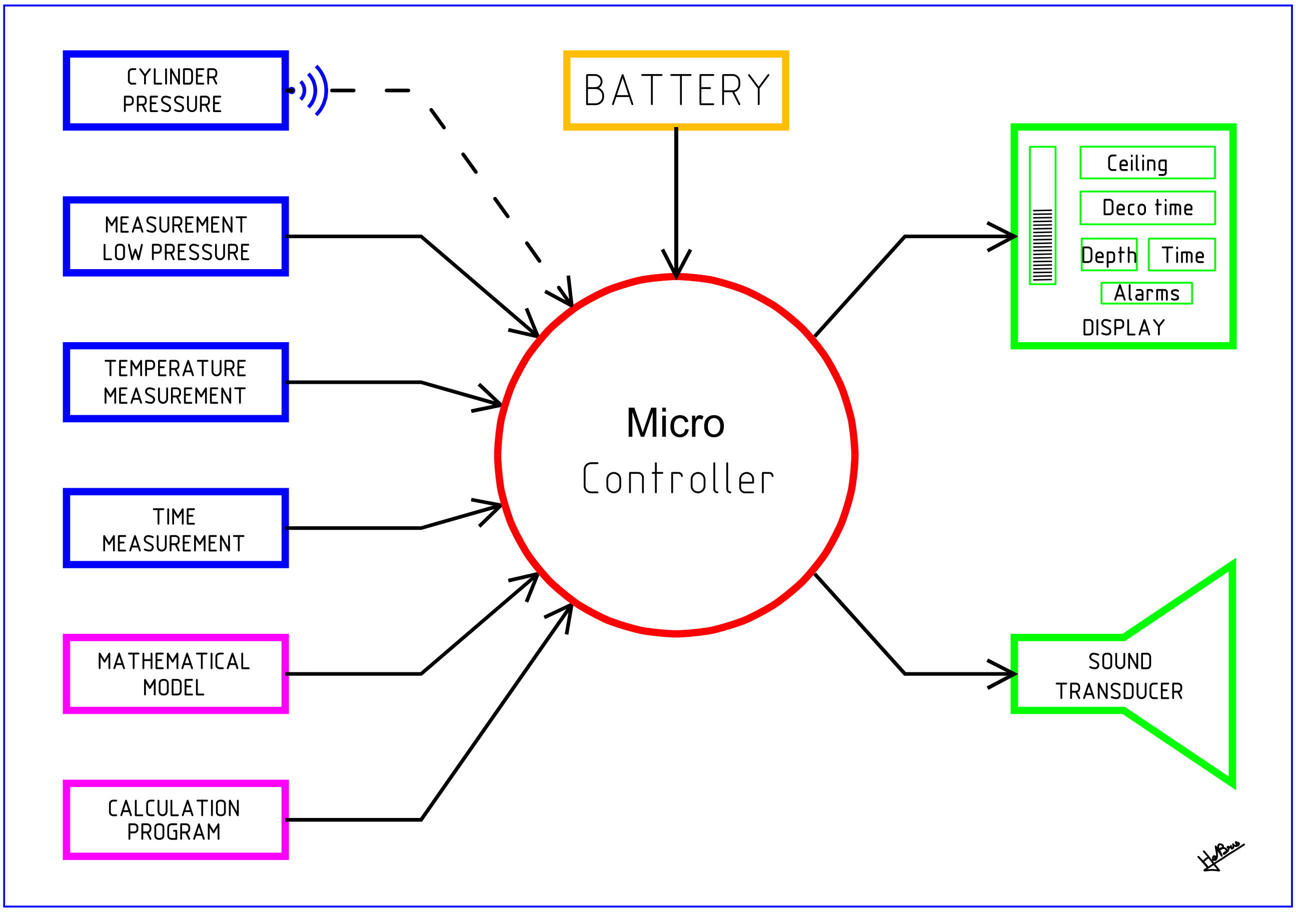



*Figure 02 - **Simplified diagram of a diving calculator***

**General diagram** (See figure 3)
This second diagram gives a more precise idea of how it works. It shows the main functions, some of which will be detailed later.
The sensor (B.P.) provides a voltage proportional to the ambient pressure while, when air management is planned, the sensor (H.P.) provides a voltage proportional to the high pressure of the spacesuit.

The temperature sensor (Temp) corrects the variations of the pressure sensors. The sensor (Bat) measures the voltage of the batteries and possibly integrates the current, which allows to calculate the remaining electric autonomy.
The A/D converter converts the continuous voltages supplied by the sensors into coded signals so that they can be understood by the microprocessor.

The dead memory contains on the one hand the mathematical constants: critical speeds of ascent, periods (T), coefficients (Sc) compartments, O2 toxicity limits for Nitrox devices and other mixtures and instructions necessary to carry out the calculation program.

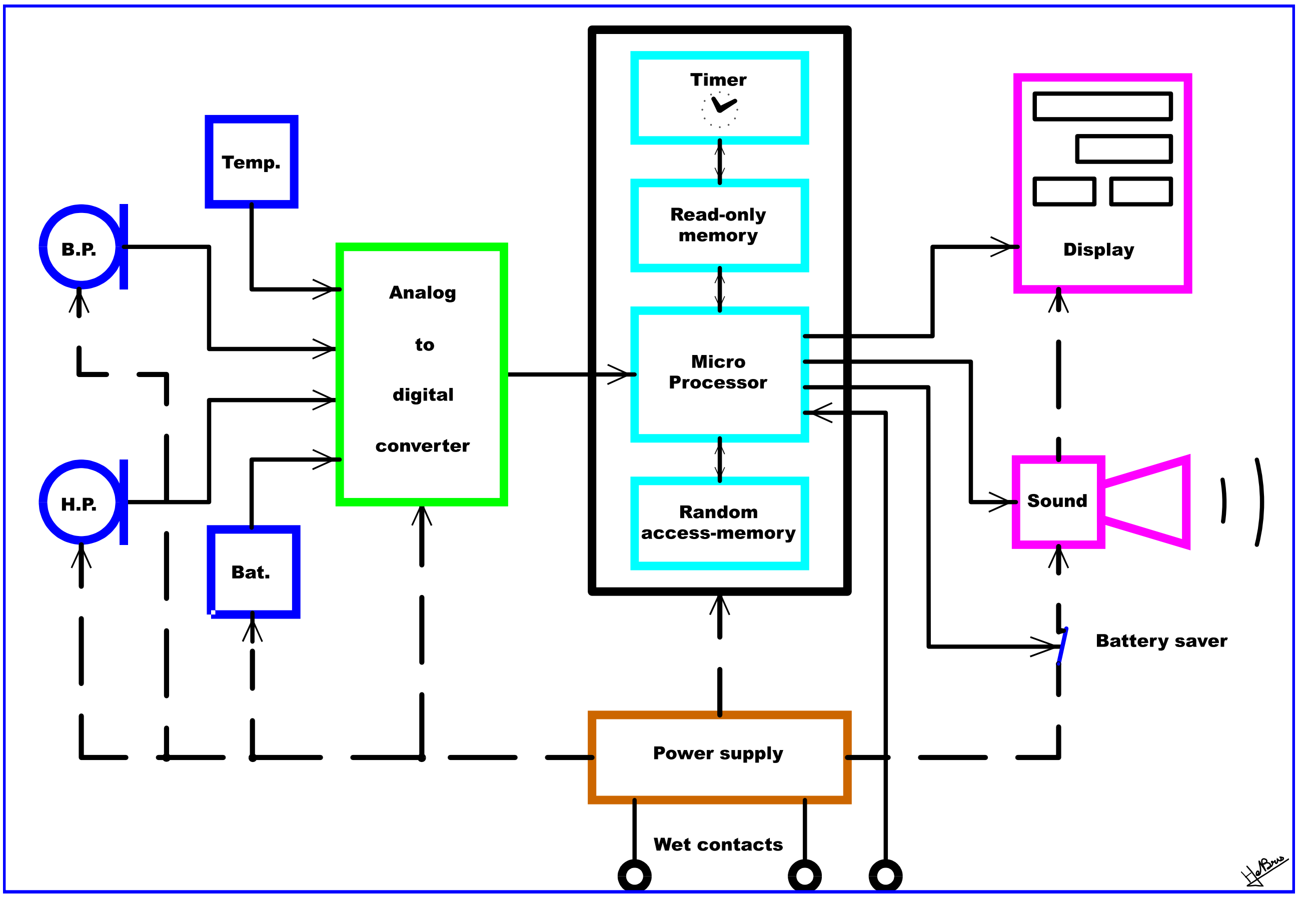



Figure 03 **General diagram of a dive calculator**

This information, which constitutes the mathematical model, is provided directly to the microprocessor. It performs the calculations according to the instructions received, reading and writing the results in the RAM where they are stored temporarily. The useful information is sent back to the screen and the sound transducer.

- Wet contacts enable the device and perform a number of controls.

- The display and the sound transducer (Sound) receive the relevant information from the RAM via the microprocessor via a control circuit.

- The clock runs all these operations. They are synchronized and executed in a fraction of a second.

- The electrical power source provides the necessary power to the various parts of the appliance. The Standby and Sampling switches are intended to supply the transducers and sensors respectively only when necessary. This saves energy and consequently increases autonomy. (See next chapter)

**Notes:**
The analog/digital converter, the microprocessor and the memories are sometimes combined and constitute what is called a microcontroller. The ROM is sometimes of the same technology as the RAM, but it is then fed continuously so as not to lose the information stored there.

At the time of battery change it is therefore necessary to take some precautions.

## Coding of orders

To access the different functions seen above, it is possible to multiply the damp contacts or push buttons (See these components in chapter Description).

You can also use coding that involves acting on contacts, a certain number of times or for a certain period of time. It should be noted that in some cases it is difficult to operate and this is one of the selection criteria.

Thanks to this coding, it is possible to recall the information in memory in the device, to configure it, to simulate dives to plan them or to train in its use.

## Configuration

It consists of modifying certain parameters either directly using the wet contacts of the device or via a personal computer. It allows for example: to customize the device according to age, weight, sex... to take into account risk factors by taking safety margins, to change units of measurement, date, time, gas mixture used, etc.

Most aparatus now add a margin of safety by manually selecting a higher altitude slice. Others prefer to vary the safety factor, up to 50%. It is also possible to modify the mathematical model according to the intended use.

Finally, others allow you to choose between 4 models. Caution: this must be used with discernment. To avoid any errors, UWATEC prefers not to provide access to such possibilities and instead moves towards further automation; other possibilities can still be exploited.

## Operation by an individual computer

Thanks to Bluetooth optical coupling or electrical contacts, it is possible to transfer most of the information into the memory of a desktop computer, process it in a data bank and print it out.

These transfers are sometimes done through an electronic key that protects the software against piracy.

### Core Functions

Manufacturers provide a list of the information displayed by their devices. The information listed below is a minimum.

#### Under water

- **Automatically**:
- present depth; maximum depth reached;
- ceiling or next landing depth, with corresponding prealarm and alarm
- speed of ascent, with pre-alarm and corresponding alarm;
- elapsed dive time;
- remaining time before decompression with corresponding prealarm and alarm;
- total duration of escalation; duration of each tier, if applicable;
- cylinder pressure and or air range, with corresponding prealarm and alarm
- Floor depth (Especially for Nitrox);
- electric range with pre-alarm and corresponding alarm.

#### On surface

***Automatically*:**

- energy source test;
- test of the various functions, display and sound transducer;
- interval;
- cylinder pressure;
- time before flight and/or flight ban;
- ceiling altitude alarm when climbing;
- power source alarm.

***On request:***

- Drop down menu of no decompression dives;
- memory of past dives: depth, time, alarms;
- profile of past dives;
- simulation of dives and training in the use of the apparatus;
- configuration.
- Backlighting of the screen

## Control a rebreather

Apart from the possibility of decompression management and autonomy in air or mixtures, computers are also able to manage the use of mixtures in recyclers. To do this, the false lungs of these devices are equipped with several sensors that accurately manage the partial pressure of oxygen as a function of depth.

Many devices exist but one of the first and best known in this field is the "Buddy Inspiration" made in England. It should be noted, however, that while these devices are the future of diving, their use still presents many technical and financial constraints that do not put them within the reach of first divers.

## Control jacket

Just as they can operate recyclers, computers can operate buoys of all types. For this, they use solenoid valves controlled for inflation as well as for purging.

They can prevent you from exceeding certain pre-determined dive characteristics: duration, maximum depth, speed of ascent, they can take you to the landings at the desired depth and duration.

One may wonder where is the pleasure and mastery of diving which consist in managing all these parameters and above all to modify them according to his desires and sometimes unexpected situations.

Many patents have been taken in this area. I believe that one of the oldest and most complete was filed on 21 April 1976 by L. HANEUSE and J. RIT residing in the Principality of Monaco. To my knowledge, however, it has never been realized and at least never marketed.

On the other hand, there are today two devices:

- The AquaPilot GF which is marketed in England by the company "NJP Marine Technical Services"

- The "Cruise Control of the Swiss company "SUBA. For the trifle of 1500 euros, this is what it will cost you to dive in an armchair…

See also the paragraph "Jackets controling" in the page "Selection criteria" of the Jackets book.

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## ***Guestbook***

# - ***OPERATION*** -

## Detailed table of contents



*This chapter is intended to give some details on the part of the operation that indirectly affects the user. It is therefore not necessary to train in the use of a diving computer.*

*On the other hand, it makes it possible to better understand all the advantages of computers compared to diving tables.*

*In order to show the evolution of recent years, we will also mention some solutions used by some manufacturers even if they are now abandoned.*

### Reduction of energy consumption

It allows to increase the electric range and thus to follow for a long time the variations of pressure to which the diver is subjected. It also reduces the volume of the batteries and therefore the volume of the device. The information given here is only an example. There are as many solutions as there are models and it is not possible to review them all.

### Manual shutdown

Some models, until the late 1980s, could be manually stopped by a simple switch. Unfortunately, they lost the memory of the nitrogen voltages reached previously. These devices are always to be avoided if one proposes to carry out successive dives.

### Stanby

After a few minutes or after complete desaturation, you may have noticed that your computer screen was turning white. However, the device is not shut down, some electrical circuits have simply been disconnected while others remain active in order to constantly calculate the level of nitrogen saturation.

It is then said that the device is in "Standby". Only the essential functions are switched on. Figure 3 shows that the "Standby" switch cuts off the display circuits and the sound transducer.

These can then be manually restarted by wet contacts, or automatically at the next immersion. It’s "activation" or "alarm clock. When it is active, the Aladin Pro, for example, consumes 1.05 milliampere while on standby, it consumes only 35 microamps, or 30 times less.

Humans living at sea level breathe air at a pressure of 1,000 mbar. When they evolve in altitude or depth, their body undergoes variations of saturation or desaturation. Thanks to its very low power consumption and because it never stops completely, the computer can monitor at any time the state of charge of the selected compartments.

They can then decide whether to request bearings, monitor lift speeds and, if necessary, set off an alarm in case of a breach of the chosen protocol, and even plan to desaturate a future dive.

Researchers studying the prevention of decompression accidents can thus better respond to the very complex desaturation problems posed by the physiology of the human body.
For example, consecutive or successive diving concepts no longer pose the same problems as with diving tables.

### Sampling

Pour faire une mesure de pression c'est seulement une quelques milliseconds. In order to save energy, the sensors and some other electronic circuits are only turned on for the time required to perform the measurement.

The pressure is measured in a millisecond for example. This, for example, every second in immersion, every 10 minutes during the surface interval and every 30 minutes thereafter. This is called variable sampling.

This is the function of the switch of the same name in figure 3 of the previous chapter. Special filtering then allows the real pressure variations to be smoothed out. The higher the sampling rate, the more accurate the system is. Aladins, for example, sample at 0.5 seconds in immersion and 1 minute in surface. Figure 6 shows an example of such variable sampling.

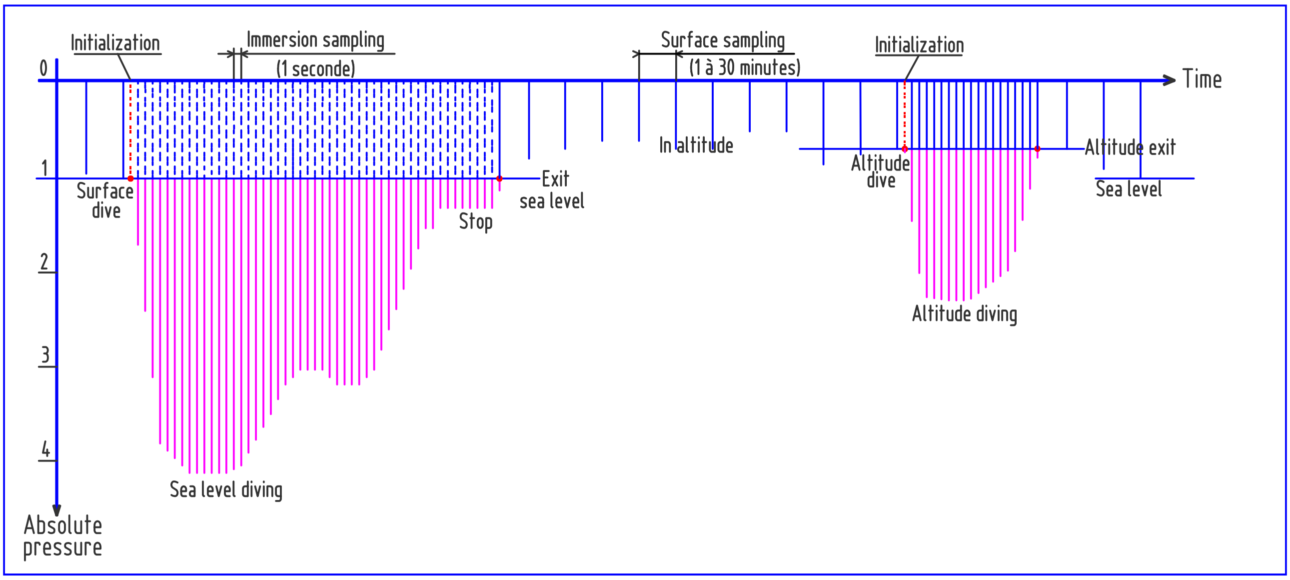



Figure 06 - ***Sampling of pressure measurements***

In immersion, in order for the device to take proper account of the speeds of ascents and especially to manage the production and evolution of micro-bubbles, it is necessary that it makes at least one measurement every second.

## Degree of instruments automation

The ideal device should allow you to immerse yourself without worrying about starting, previous dives or altitude. Such instruments have become widespread.

Although most of the devices on the market are now well automated, there are still some that are only partially automated.

Automation can affect several parameters:

### Activation

When a computer wakes up, it takes a certain amount of time for it to be operational. It goes from a fraction of a second to a few seconds. This time is necessary, for it to stabilize and self-test. In any case, this can be done by manual wet contacts or by immersion, by pressure switch on the H.P, by switch or by push button.

In addition, before any dive a major operation must be performed, it is initialization.

### Initialization Doublon P29

The primary role of a dive computer can be considered to be to safely bring the diver back to the surface at the same pressure as the one from which it originated. To do this, you must:

1) Measure the pressure on the surface of the dive site;

2) Put this pressure in memory to serve as a reference of depth and to return to the surface. These two operations constitute initialization.

For this, the sampling we have discussed above has a disadvantage. Since the measurement is only continuous, it is never certain to measure the pressure exactly at the passage of the surface.

To turn this difficulty there are several methods:

*a) Manual initialization:*

It consists of triggering the measurement each time the device is turned on or on, by touching wet contacts for example. The user must do this before immersing himself. If it jumps into the water with an unactivated device it may cause a dangerous error. This method is practically no longer used.

*b) First measurement in water*

It consists of recording as a reference the first pressure measurement following the moment of activation or contact with water. This method may introduce an error because the measurement can be carried out with at least a delay time equal to that which separates two samples.

DC12 dive computer required 5 seconds to initialize. It is therefore necessary to activate it for some time before diving and above all make sure that it is active before jumping into the water.
In the case of figure 7a, for example, the initialization is done at 2 meters depth, so the computer calculates the decompression for a safe return to this depth, not to the surface. If the diver crosses this threshold, some compartments may pass over critical overload and cause an accident. The device brings you back to safety at 2 meters, not the surface!

To avoid the risks associated with this method, DC12 measured and recorded, (it has not been manufactured for a long time) the minimum pressure at immersion as a reference. After a jump, the diver could eliminate any error, by going up to the surface, before finally immersing himself.

The Maestro Pro and Maestro EAN gave an alarm which indicated that it was necessary to go up to the surface, but obliged to wait for them to go back to standby before resetting them (They are no longer manufactured)

*c) Last measurement in air:*
It consists in remembering the last measurement that was made in the air. This method may also introduce an error when the diver jumps into the water without activating the device. It depends on its evolution at altitude before contact with water and the sampling rate.

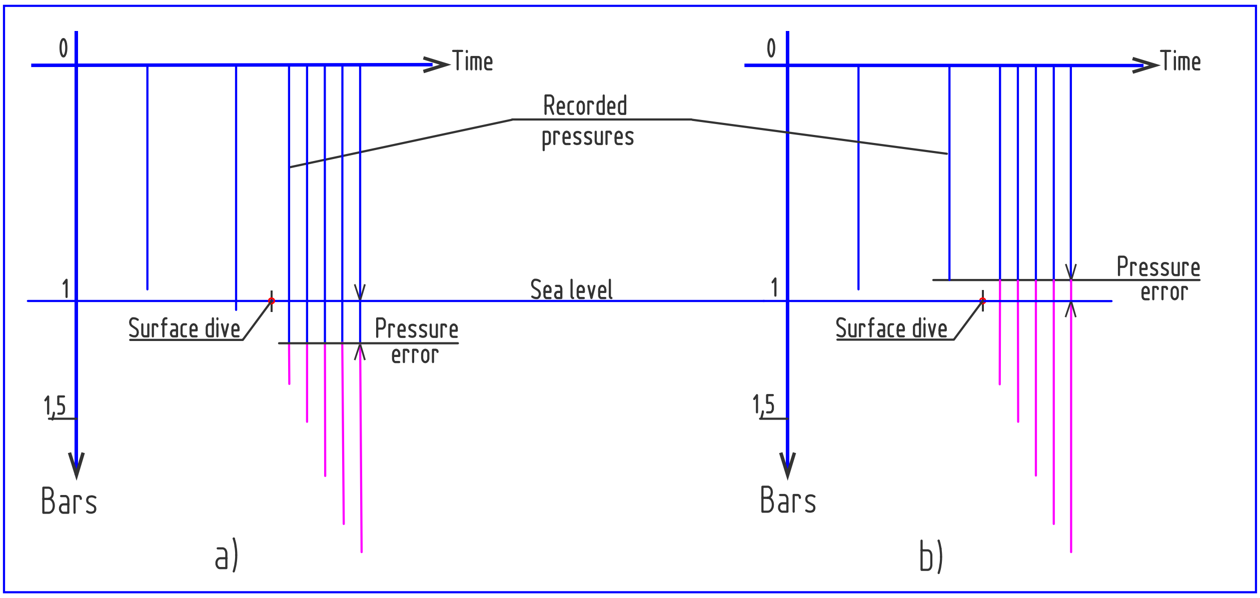



Figure 07 ***Initialization error***

In all cases, therefore, the space between two samples should be as short as possible. The latest Uwatec computers sample every minute on the surface, virtually eliminating any errors.

Figure 7b explains this method. It should be noted that the variations in pressure in air are much smaller than in water, the resulting errors can only be small and, moreover, they go in the direction of safety.

*d) Last initialization*

It is to prohibit underwater initialization. It can only be done manually on the surface. For each dive, the reference pressure is that of the last initialization. This method allows the jump to the water without precaution, provided not to evolve in altitude between the last initialization and the immersion. Be careful not to forget it before any altitude dive.

**Summary:**

Not all dive computers are identical and sometimes require precautions during immersion (especially old models).

We therefore advise you to worry about the characteristics of your device. And above all, always perform an activation and therefore an initialization, just before immersing yourself. This will allow you in addition to making sure it works properly.

## Altitude corrections

Because of the physiological changes that occur with altitude and the influence of water vapour, the critical supersaturation coefficients must be modified according to altitude. As we have already seen, the atmospheric pressure is measured at the dive site, but the corrections are applied according to the slice in which one is found, for example: from 1000 to 900 millibars (0 to 1000 m), from 900 to 800 millibars (1000 to 2000 m) and 800 to 620 millibars (2000 to 4000 m).

For safety, the pressure used for the calculations is the lowest of each unit. The correction consists of automatically or manually selecting the coefficients stored in the ROM associated with the pressure or altitude range in which one is located.

Depending on the instruments, different cases may be encountered:

1. Less automated devices
   - Do not go on standby.
2. Atmospheric pressure measurement, with no display and initialization only at start-up.
   - Manual selection of the altitude range with the associated coefficients. It is essential to perform these operations manually on the surface before submerging. This was the case with NC11, DC11. Which are no longer manufactured but can still be in service.

3. *Semi-automatic apparatus*
   - Automatic switching to standby
   - Periodic measurement of atmospheric pressure, without display and initialization at the time of activation regardless of altitude.
   - Manual selection of the altitude range with the associated coefficients.

It is recommended to activate and select the surface altitude slice prior to immersion when using aircraft models that retain the last initialization in memory

*4) Fully automatic devices*

- Automatic switching to standby.
- Periodic measurement of atmospheric pressure and corresponding altitude display.
- Initialization and automatic selection of altitude-related coefficients at the time of immersion.

It is therefore theoretically possible to immerse without any special precaution except after a rapid climb in altitude (See Uwatec aircraft).

### Specific situations

Based on the models, we cite here some of the situations that can be encountered and the consequences that can result:

- An elevation climb is equivalent to an exit from the water after a long shallow dive at sea level.
- If you select a higher altitude slice, while you have just emerged from a sea level dive, the aircraft may go into alarm as if you had jumped a landing.
- When descending to sea level, after diving aloft, the ambient pressure increases. This makes you less saturated, so you can dive back in sooner or longer. On the other hand if you forget some aircraft in the upper altitude range, it happens that they misinterpret the pressure increase, consider that they leave for a new dive and then, do not stop..., hence the advantage of fully automatic devices.
- When after a dive, the take-off takes place from an airport at an altitude of more than 2000m, there is no risk of accident because the ambient pressure is already equal to or lower than that of the cabin.
- After a climb in altitude or a flight by plane, if you descend to sea level, the time before flight can be very reduced due to the resulting desaturation.
- If the cabin of an aircraft is not pressurized or accidentally depressurizes in flight, an accident may occur. It is therefore always reasonable to wait at least 12 hours before boarding.

- **General rules**
- *Regardless of the degree of automation of a device:*
- Before immersing it, it must have the same saturation state as the diver and that the atmospheric pressure of the site has been stored (Beware of loans between divers).
- You should be familiar with the characteristics of your device as this may lead you to take certain precautions before immersing yourself.

## Role of differents memory

Memory is an essential element of a dive computer. The more important it is the more possibilities the device has. As we have already seen there are two types of memory: dead memory and RAM.

### Read-only memory

It contains the fixed information from which the calculator retrieves the information it needs. It can also contain different mathematical models, units, mixtures etc. which will be chosen by the user during the configuration of the device.

### Random access memory

The latter is itself divided into two parts: that which is used in real time for calculations and display, and that which is used, in a delayed time, by the user.
It is the latter that interests us because it contains more or less detailed information about past dives. We can consider that it is a real "Blue Box", like the "Black Box" of planes or the "Snitch" of road vehicles.

### Memory capacity

For a computer scientist, the memory capacity of a computer is expressed in kilobytes. For a diver, it will express itself more practically by the number of dives or diving hours that it can record. This ranges from a few dives to a few hundred dives or a few hours to a few hundred hours.

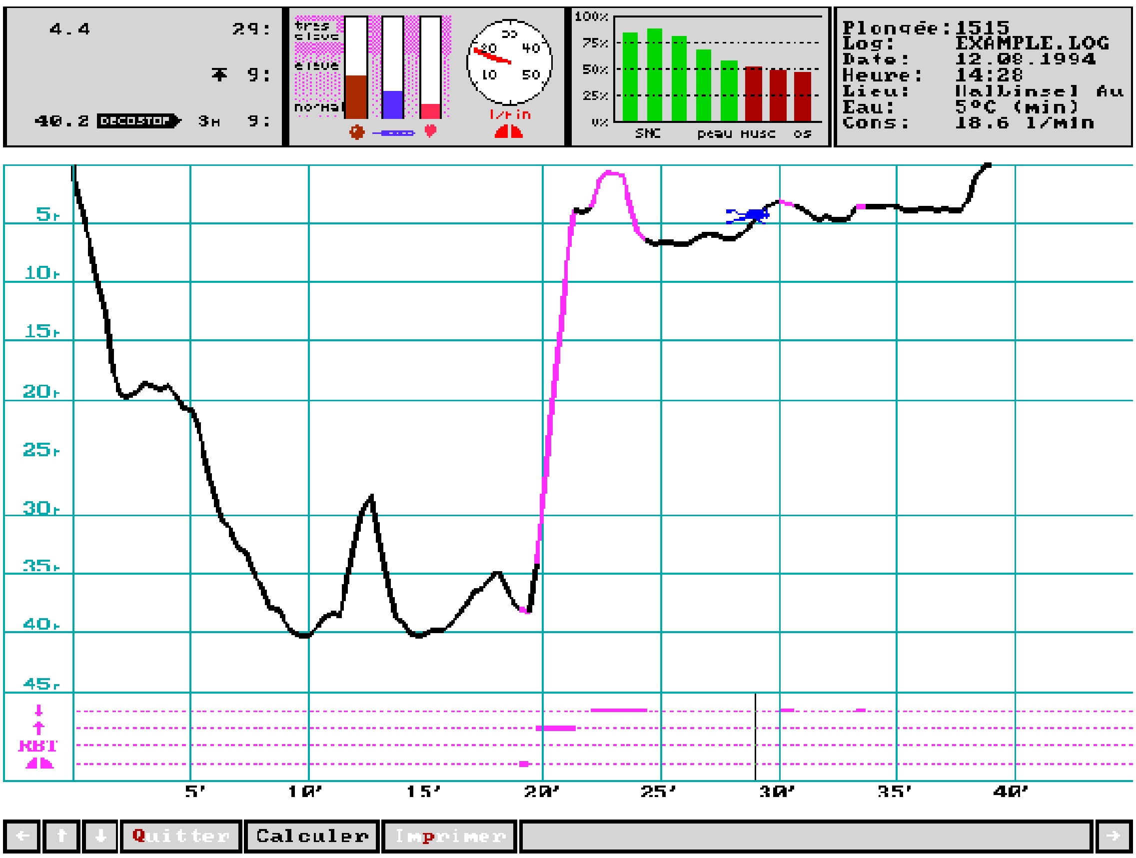
### Content memory and Access

The list below gives the information that can possibly be found in memory. *"Be careful not to tangle the fins".*

- number of the dive;
- maximum depth and duration;
- average or minimum temperature at maximum depth;
- type of dive: with or without decompression, successive or simple;

- offences committed: on the speed of ascent, on decompression;
- surface interval and temperature;
- date, time of departure and departure;
- bottle pressure, at the start and end of the dive;
- consumption index;
- average depth, maximum depth of recorded dives;
- total immersion time;
- immersion altitude;
- saturation level of different tissues;
- battery capacity or voltage;
- complete profiles of dives over time.

*Memory is accessible in two ways:*
- Direct access, as soon as you leave the water.
It then provides a limited amount of information that corresponds to that of a diving logbook, more or less detailed, depending on the aircraft. This can be achieved by scrolling through multiple successive screens.




**Reproduction of a profile: The Monitor III**
*(A such inverted profile is to be avoided)*

It can also provide a step-by-step profile of past dives, but the information must be recorded as they appear.

- Access, delayed, by a personal computer.

If you want to benefit from all the possibilities of the memory of a dive computer, it is better to read it on a laptop or desktop.

The complete profile of the dives can then be displayed with all the information concerning particular points on request. Everything can be printed.

## Recording of dive profiles

Dive calculators can provide much more reliable and comprehensive information than those obtained by testimonial.

To do this, you must record the maximum number of dive profiles but also the consumption indices, the margins taken, the temperatures, the efforts made and the alarms that occurred during the dive and the corresponding dates and times.

The photo shows the profile reproduced from a Monitor 3. Sampling takes place every 20 seconds. This does not allow you to see the fastest speeds. On the other hand, the profile is inverted, which is a significant risk factor.

On the other hand the following photo shows a survey from a Maestro Pro EAN where sampling takes place every second which allows to see much finer details.

The quality of the dive profile depends on the sampling frequency of the measurements. If this, for example, is one measure per second it is possible to follow all the evolutions of the diver even in the case of very fast variations.

However this uses a lot of memory capacity.

There are devices that sample the profile every 0.5 seconds. In this case, the finer details of the dive can be examined. Sampling is sometimes configurable to best suit the diver’s wishes.

For a given device, the quotient of the number of hours of recording by the sampling rate is then constant. For example, the Maestro-Pro can adjust the sampling frequency between 1 and 30 seconds. In this case the recorded dive time varies between 6 and 180 hours respectively (1/6 = 30/180).

Do not confuse the sampling of pressure measurements which can be very fast and that of the reproduction of the profile which can be much slower and therefore not usable.

### Data base

The memory (hard drive) of a laptop or desktop computer is very large, so it is possible to record the dives of many devices. We can also manually add all the desired comments relating to the context of the dives: the place, the temperature, the state of the sea, the name, the age, the sex, the weight of the interested party as well as the name of the other participants... It then becomes possible to have a real database that can be processed to establish statistics …

### Training

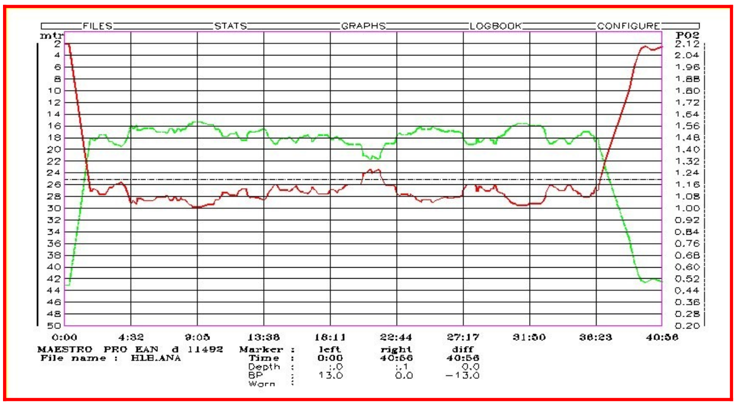
Computers allow, by studying real dives preserved in memory, to make training on concrete cases by showing, after the dive: the holding of bearings, the saturation of the tissues, the mistakes made, the consequences of dives at risk... It also allows to simulate fictitious dives, successive or not. It is thus possible to modify, in the right direction, the behaviour of divers. See also the Training.

## Nitrox and other breathing mix

Equipment for diving mixtures is spreading more and more. They modify the mathematical model based on the percentage of O2 used. They also manage pure oxygen decompression. They give alarms beyond the tolerable exposure time and for the floor depth, depending on the partial pressure of oxygen. The floor depth is calculated by the formula:

$$\text{Prof.plancher} = \left(\frac{P_{o2}}{O_2\%} - 1\right) \times 10$$

Or $P_{O2}$ is the maximum tolerable partial pressure and O2% is the percentage of oxygen in the mixture. For example, for the maximum $P_{O2}$ of 1.6 and a percentage of 40% the depth not to be exceeded is 30 meters.




***Reproduction of a profile: The Maestro EAN***

(Diving Nitrox 40/60 Marseille)

The figure above shows a profile of a 40/60 mixed Nitrox dive. The thick red curve is the depth curve. The fine green curve is that of the partial oxygen pressure. We see that it never exceeds 1.6 and that this corresponds to a maximum depth of 30 meters. The partial pressure is deduced at any time by the formula:

$$P_{o2} = \text{Pabsolute} \times O_2 \,\%$$

To date we did not know how this $P_{O2}$ was taken into account, in variable profile, by manufacturers. It can be assumed that there was an integration of the quantities of U.T. as a function of the exposure time.

Cochran, a dive computer manufacturer, would have adopted the following latency times to account for both types of toxicity.

| $P_{O2}$ | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 | 1,6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Time in minutes** | **1304** | **719** | **496** | **379** | **306** | **257** | **221** | **194** | **172** | **149** | **110** | **44** |

These Nitrox computers must also clearly indicate the percentage of mixture for which they are configured. It is obvious that when using an air recirculating respirator it must have a stability of the O2 level compatible with the safety margins of the computer used.

**Note**: It is desirable to limit the maximum depth of the no-step dive menus to that imposed by oxygen toxicity.

## Algorithms and Algorigrams

An algorithm is a series of instructions to achieve a given result. It consists of a series of elementary operations linked by a certain decision-making logic. For example, in a completely different field, adjust the oil level of a car:

Car algorithm :

(*To adjust the oil level of a car*).

1. Open the engine cover.
2. Take out the oil gauge.
3. Clean it up.
4. Replace the gauge and pull it out.
5. Check oil level (Measurement).
6. If the level is too low, determine the quantity missing (Calculation).

7. Complete the oil level.
8. Repeat in 4.
9. If the level is correct, replace the gauge (Logical Decision).
10. Close the hood.

Un algorithme est souvent très complexe et ne peut être compris que par les spécialistes que sont les programmeurs.

As can be seen, action sequences can include measurements, calculations and logical decisions. They are often presented by a graphical representation called algorigram, following the AFNOR terminology. (The symbols used as well as the links are standardized)

An algorigram is therefore a simplified way to explain an algorithm. The main objective here is to demystify the latter and to give the reader the basics that will enable him to better understand the manufacturers' documentation. Example: The Aladin Pro manual distributed by Uwatec.

In practice, the name of the algorithm is often given to this graphical representation or the mathematical model it represents. It is understandable that each operation can itself be divided into more detailed operations according to the level of understanding that one desires, or chain itself with others to achieve a more important objective.

The operation of an ECU can thus be explained by several algorithms. Figure 08 below shows the two-part decomposition of the sequence of operations in a dive computer. One shows the operations concerning the calculation of the ceiling depth for one compartment, the other those of the speed of ascent.

Other algorithms are used, for example, to detect conditions conducive to the formation of micro-bubbles or to filter variations in air consumption. Manufacturers should use it more often to explain, simply, how certain parts of their computers work.

As the possibilities of diving computers are growing, it becomes difficult to explain simply their different commands and their modes of access. The use of an algorigram often makes it easy to do so.

In the algorithm and algorigram it is possible to make corrections of the decompression according to certain parameters. They are therefore automatically modified in adaptive devices.

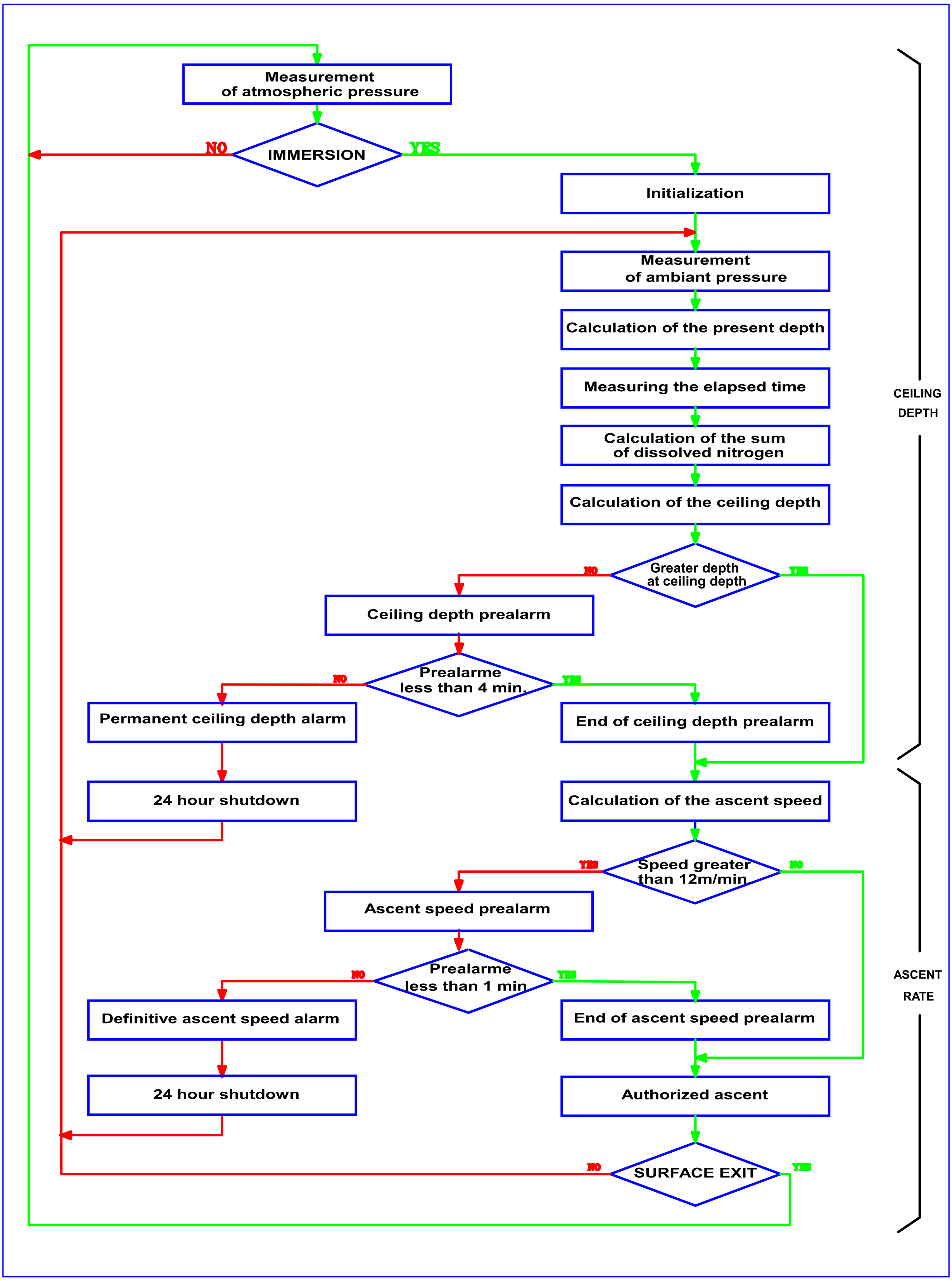



Figure 08 - ***Algorigram***

***Guestbook***

XiTi

# -FONCTIONS -

## Detailed table of contents

*This chapter is intended to give some details about the available functions of dive computers. This, however, is only an indication, as there are many ways, used by manufacturers, to achieve the same result.*

## Implementation of the mathematical model

For each compartment, saturation or desaturation is calculated using expressions such as time period and absolute time and pressure variables. The results obtained are then subjected to a series of logical decisions depending on the value of the critical overload coefficient but also on the circumstances.

It is the set of these expressions, mathematics and logic, that constitute the model simulating our organism. It is often inspired by those used for tables, which is why they are often cited as references. Nevertheless, their model is always adapted to the specificity of computers and is therefore very different from that of the reference table.

Manufacturers often hide behind the names of the specialists who created or adapted these models: Haldane, Workman, Spencer, Rogers, Bühlman, Pauwel, Hennessy, Hempleman and more recently Max Hahn, Bruce Wienke… They rarely give detailed explanations of how they adapt these models to the devices they manufacture. We would like to know more.

Contrary to popular belief, tables are rarely stored in current devices. Some achievements have certainly been made, but they have only had a short-lived life because of the difficulties of their automation and the lack of interest that this presents in relation to the models that carry out the calculations in immersion.

It is inappropriate to speak of a diving computer based on a table. Very quickly, their mathematical models distinguished themselves.

In dive computers, calculations and measurements are carried out at a high rate so that the results do not delay the evolution of the measured parameters. It is then said that the calculations are carried out in real time.

## Calculs in real time

### Monitoring of saturation level

To simplify matters, we shall speak here only of the Haldane model and we shall use the well-known formulae relating to it.

To follow the evolution of dissolved nitrogen in the body, the dive time is divided into very short slices, of a few seconds maximum. These slices are sort of a series of rectangular, consecutive dives. But the comparison ends there. The procedure then differs from that of the tables. (See figure 05)

During each elemental time, the absolute pressure measured is considered to be constant and, by calculation, the resulting $\Delta T_{N2}$ variation in dissolved nitrogen voltage is deduced for each compartment. For such short durations, this is reduced to a few relatively simple operations.

Each variation of the dissolved nitrogen voltage being added to the preceding one, the total value of the nitrogen voltage in each compartment is added at any time by a simple addition, To + S $\Delta T_{N2}$. To is the initial value, $\Delta T_{N2}$ is the dissolved nitrogen voltage during each dive slice. This expression is pronounced "Sum of deltas of $T_{N2}$" or "Sum of variations of nitrogen voltage".

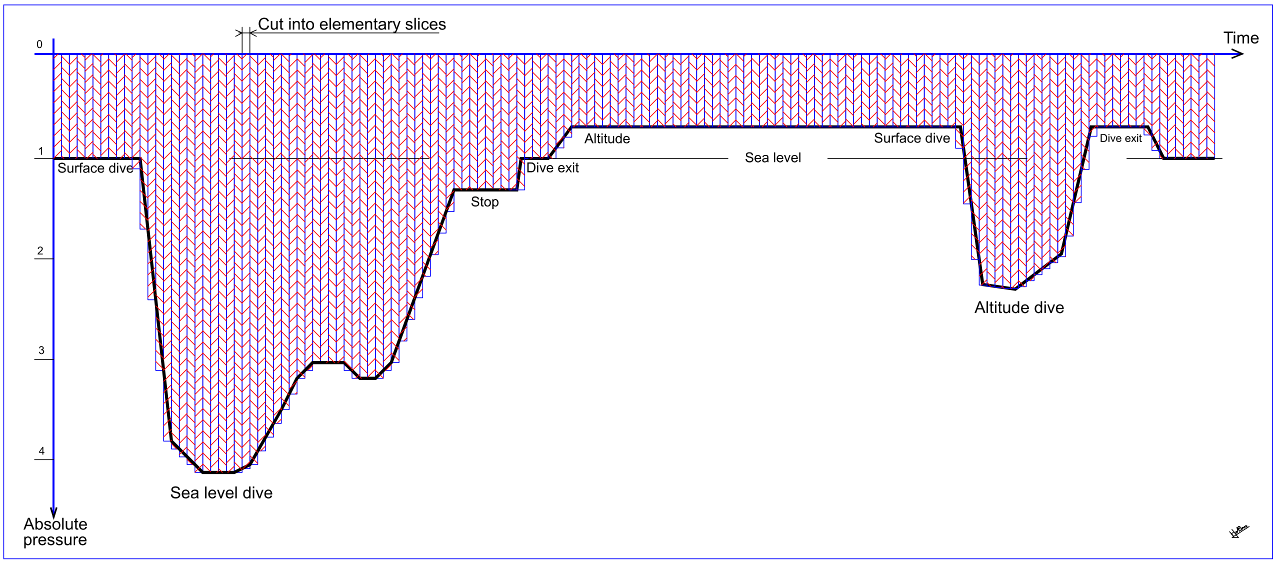



Figure 05 ***Breakdown of dives into elementary time slices***

$$(T_{N2} = To + \Sigma\, \Delta T_{N2})$$

## Minimum tolerable and critical pressure

From the value of Sc, To and S $\Delta T_{N2}$, the minimum tolerable absolute pressure for each compartment is deducted:

$$P \text{ min tolerable} > T_0 + \Sigma \Delta T_{N2}$$

The highest absolute pressure is then used as the critical pressure, that is, the pressure below which one must not descend. This determines the steering compartment during the ascent. If the device is not stopped, the tolerable pressure is known at all times. It should be noted that, for the time being, we are only talking about absolute pressure, not depth. This parameter is calculated separately.

This formula applies at any time, whether you are moving in depth or at altitude. The boundary between air and water does not change this principle.

## Initialization Doublon P15

A dive can be considered a momentary incursion into an environment with a pressure greater than the atmospheric pressure of the site. A diver must, as a matter of principle, at the end of a dive, return to the pressure from which he started.

However, the latter can vary from +20 to -30 millibars depending on the weather on the surface of the sea and especially from 1 to 0.6 bar (0 to 4500 m) depending on the altitude.

It is therefore necessary to measure and record this value, before diving, in order to be able to use it, as a reference, from immersion, knowing that we must necessarily return to it. This is called "*Initialization*" or "*Relative zero setting*". This has the same purpose as manual zeroing of needle depth meters, but must be done automatically before each dive.

### Current depth

In the metric system it is given approximately by the well-known formula:

Present depth = (Absolute Pressure – Atmospheric Pressure) x 10

where the atmospheric pressure is the pressure recorded at initialization and the absolute pressure minus the atmospheric pressure is the relative pressure. At the surface, after initialization, the relative pressure and the present depth must be zero. This allows the device to calculate the decompression up to the water outlet and the diver to have exact depth values regardless of altitude.

**Remarks:** a reading error of +2 to +3% appears in seawater with a calibrated freshwater instrument. But this one has no influence on the decompression. Indeed, during the calculations it is the absolute pressure which intervenes, not the depth. It is only a benchmark to evolve in the third dimension.

Many instruments give the depths in "MEM" (Meters of Sea Water). Aladdin and Monitor give them in meters of fresh water. The Datamax Pro switches from seawater to fresh water above 1200m.

The Maestro-Pro automatically corrects according to the seawater or fresh water by measuring the conductivity. It should be noted that the European standard EN13319 provides for a fresh water calibration.

### Ceiling depth

Its determination is one of the essential goals of dive calculators. By introducing the critical pressure in the formula above, we obtain the critical depth which is then called "Ceiling depth".

$$\text{Ceiling depth} = \frac{(T_O + \Sigma\Delta T_{N2} - Patm)}{Sc} \times 10$$

This is the depth above which the diver cannot climb without significantly increasing the risk of a decompression accident. It varies throughout the dive depending on the state of saturation of the compartments and, as can be seen, it is well dependent on the atmospheric pressure of the dive site.

### Floor depth

In some devices it can be configured manually, to give an alarm, to avoid going down too deep.
For Suunto, who practises continuous decompression, it is the depth at which the total time of ascent begins to increase again.

In the case of Nitrox devices it is calculated automatically from the toxicity rate of the acceptable O2 or the mixture used. This is recorded in the ROM. In case of passing the diver is warned by an alarm. A 40/60 Nitrox, for example, imposes a depth limit of 30 meters (See for example Aladin Nitrox).

### Current altitude

The relationship between pressure and altitude is not linear but is known. The values corresponding to certain pressure values are stored and when one of them is reached the associated altitude can be displayed.

However, most manufacturers do not display it or simply give it in the form of symbols corresponding to altitudes ranges. (Uwatec, Cochran)

### Ceiling altitude

At the end of the dive, the diver usually emerges with a significant over-saturation. It is therefore conceivable that it can also meet a ceiling altitude above which it must not climb.

This altitude is not usually indicated by computers and that is a shame. On the other hand, most of the aircraft display a no-fly time so that the diver will not be exposed to a critical depression on board the aircraft.

### Time of immersion and interval

With these devices, it is not easy to spot the moment when one is permanently immersed, nor the moment when one decides to go up. On the other hand, they can automatically detect the passage at certain depths that are called, as the case may be, the immersion threshold or the emersion threshold.

These values, between 0.5 and 2 metres, may be different from each other. They are used to distinguish whether the diver is on the surface or diving, although this is not entirely accurate. They are part of their characteristics.

The times, which separate the thresholds, are measured using the microprocessor's internal clock. At the end of the dives they are recorded in the RAM.

The duration of the dive is replaced by the duration of immersion which is that which separates the passage of the immersion threshold from that of emersion. The total recovery time is included in this duration. The interval is the time between the crossing of the emersion threshold and the next immersion threshold.

It should be noted that the times thus defined are not involved in the decompression calculations. They serve only as benchmarks during the course of the dives. For example, two dives that are separated by only a few minutes will be considered consecutive.

They will be recorded as one dive. In general beyond 10 minutes on the surface they are considered as successive, that is to say, as two separate dives. However, the duration of the interval is involved in the surface predictions.

## Decompression modes

### Ascent rate

It's part of the decompression mode. It helps to control the production of micro-bubbles and to avoid exceeding the critical overload coefficients specific to very short tissues. These are not taken into account when calculating the ceiling depth. The lift speed must therefore be monitored by the aircraft.

For this, the pressure variation is measured, for example, every second. This variation is compared to a set value previously stored. When it becomes higher, an alarm is triggered. (If, for example, it exceeds 20 millibars/sec this means that the speed of ascent is greater than 12 m/min)

In fact the alarm is not always given immediately; the measurements are sometimes filtered to avoid unwanted alarms due for example to the rapid movements of the arm that carries the device.

- Fixed speed: In most cases it is set to give an alarm between 10 and 12 meters/minutes. The advantage is that the pressure gradient is constant and that the diver can, by training, acquire a certain automatism to respect the speed without monitoring his instrument.

- Variable speed: Some devices require fast speed at depth and slower and slower as the diver approaches the surface. The Phoenix for example has three speeds: 18, 12 and 6 meters per minute, the Aladins also have 3 speeds 20, 10 and 7 meters per minute.

The "Maestro Pro" can be configured for a continuously variable speed, depending on the depth, for example 17 m/min at 17m, 11 m/min at 11 m...
The variable speed of ascent seems to prevail more and more on the new instruments but we repeat it is challenged by some physiologists.

As we have already seen, it helps to limit saturation, reduce air consumption, and quickly escape the cold and stress of the depth.

However, care must be taken with some devices that allow speeds up to 30 m/min in depth. In fact, the micro-bubbles produced can then hinder a good decompression when the diver arrives in the zone of the bearings, even at reduced speed.

Altitude Recovery Speed Correction: For models using critical overload coefficients, the VrA recovery speed should be corrected as follows:

$$V_{rA} = \text{Sea level ascent rate} \times \frac{\text{Altitude pressure}}{\text{Sea level pressure}}$$

### Decompression stops

During his ascent to the surface, to eliminate the excess nitrogen accumulated during the dive, the diver stops for a certain time at predetermined depths, usually 3 in 3 meters, it is then said that he performs a "step decompression".

In this case, the safety margin is not constant, it is minimum at the beginning of the steps and maximum at the end. This practice requires less attention from divers; this was the method used with tables. It is easier to use by a dive leader to group divers at the same depth.

At each bearing depth and for each compartment, there is a minimum tolerable ambient pressure. They are all calculated, stored and when one or more of them are reached, during the dive, the deepest of the corresponding bearings is displayed by the aircraft.

### Continuous decompression

When to remove excess nitrogen, the plunger constantly rises below a ceiling depth corresponding to the minimum tolerable pressure, it is said that it performs a "continuous decompression". This method is in principle the best, the margin of safety being constant.

It gives the shortest decompression for a given safety. This type of decompression can be likened to a succession of small steps, in ascending stairs. The total lifting time is then always above the minimum possible because the diver is always a little below the ceiling depth.

Continuous decompression requires good diver attention to be optimal. (Example: Most Suunto computers)

**Remarks:**

- With step-by-step decompression, a necessary bearing for a short fabric may very well disappear before reaching it due to the desaturation that occurs during the ascent, especially if it is slower than expected.

- Step decompression can be performed with continuous decompression computers. A palanquin guide may, for example, stop the ascent from time to time to regroup his divers, as long as he remains below the ceiling depth. This will simply increase the total run time.

- However, with step decompression computers, this is not possible because these devices do not indicate the ceiling depth but the predetermined depth of the next step. (Maybe one day both options will be possible on some devices)

**Change stops according to altitude**

For models using critical overload coefficients, it should be:

$$\text{Altitude stop depth} = \text{Sea level stops} \times \frac{\text{Altitude pressure}}{\text{Sea level pressure}}$$

In fact, some manufacturers, such as Uwatec, between 700 and 4000 m, divide the 3-metre landing into two landings: one at 4 metres and the other at 2 metres.

## Event calculations

The diver must know in advance what to do during the ascent. Diving computers are able to make predictions, by accelerated simulation and extrapolation. The results update themselves, without stopping, during the dive according to the evolutions of the diver.

## Other calculations for decompression

**Total duration of escalation and duration of landings:**

They are obtained assuming that from the present moment the diver follows the indicated procedure. In continuous decompression, only the total recovery time is calculated (example: the SUUNTO EON).

**Durée avant palier ou autonomie avant palier :**

It is calculated at all times to allow the diver to make arrangements to avoid bearing. The calculation consists, for the depth at which one is located, in determining the time necessary, at each compartment, to reach the state of saturation tolerated for the first stage. The shortest time is displayed by the device.

**Temps total de désaturation :**

This is, by staying at the same altitude level, the time beyond which we can completely ignore the previous dives.

In practice, these instruments calculate the time necessary for the voltage of each compartment to enter into the normal variations of the atmospheric pressure stored during the previous initialization (+/- 30 millibars at sea level).

**Time to Fly:**
This is the time required for all compartments to be sufficiently deactivated to tolerate the low pressure within the cabin of an airliner.
When an aircraft takes off, the pressure in the pressurized cabin increases from 1 to 0.8 bar in a few minutes. If a diver takes off with a certain degree of saturation, he risks an accident because he can no longer, by himself, control the ambient pressure drop. It must therefore wait to be sufficiently deactivated before flight.

Some models simply display a no-fly, while others count hours from 24 to 0 after a dive. Still others calculate the time required before the flight. Since the critical absolute pressure in the aircraft is known for each compartment, the calculation consists of determining how long it takes to reach it before taking off.

L'Undersea and Hyperbaric Medical Society (UHMS) Américaine préconise au moins 24 heures avant de s’envoler après une plongée avec décompression et si possible 48 heures. C'est pourquoi beaucoup d'instruments américains se contentent de counting hours from 48 to zero as soon as the water exits. The devices designed by Cochran calculate this time but never allow the flight before 12 hours. This constitutes a compromise with the recommendations of the UHMS.

**Adaptation time:** when climbing the altitude, the pressure decreases; therefore, it is possible to arrive at the dive site with dissolved gas voltages higher than that corresponding to the alveolar nitrogen pressure (taking into account that of the water vapour). In these conditions, a dive will not be a simple dive. It will be considered consecutive or successive as long as there is no balance between the nitrogen voltages in the compartments and the partial ambient nitrogen pressure, that is to say until complete desaturation.

This requires the user to wait, depending on the case, for a complete desaturation or at least 12 hours before diving. This is called adaptation time. It is sometimes calculated and displayed by the device. It intervenes as an interval after a dive.

However, it is possible to dive without delay. In this case, the device must take into account the handicap of over-saturation at the time of immersion (Devices manufactured by Uwatec generally offer these two possibilities).

**Diving menu without step:** These are the couples of duration and depth allowed without having to step. They are calculated based on the residual voltages in the compartments.
They obviously change with the interval and are a function of the altitude. They also give an idea of the saturation of the compartments by comparison with the values ob-

tained after complete desaturation (safety curves after a given interval assuming a rectangular profile).

### Air time remaining

It would be a shame if a diver who managed his decompression well found himself in difficulty for having mismanaged his air remaining. The computer can perform some calculations to monitor consumption as well as time remaining:

**Consumption index:** Air consumption is difficult to measure. The only parameter available is the change in high pressure during the dive. This is a function of the consumption by the relation:

$$\Delta HP / min = \frac{\text{Consumtion in litres of relaxed air / min}}{\text{Cylinder volume}}$$

By dividing by the ambient pressure one obtains Ic = ΔHP1/ min, variation of HP that one would obtain if one breathed at an ambient pressure of one bar.

$$Ic = \Delta HP1/min = \frac{\text{Consumption reduced to 1 bar}}{\text{Cylinder volume}}$$

This new term is called "Consumption Index"; Respiratory Efficiency or Respiratory Index. It has the advantage of being independent of the absolute pressure and therefore of the depth and altitude of the dive site. It depends on the volume of the bottle, but can be measured without knowing it.

Changing your diving suit, blowing up the regulator, holding a breath hold, breathing together on the same diving suit, inflating a buoy or parachute, and any change in breathing rhythm can lead to errors. These are filtered and periodically updated.

The consumption index is sometimes displayed because it allows to monitor the variations of air consumption whatever the evolutions of the diver (See the Maestro Pro EAN). It can also trigger an alarm in the event of a significant change in consumption. It is thus possible to detect shortness of breath.

We have seen that it depends on the capacity of the bottle used. Manufacturers generally choose to display it for a standard 10 liter bottle volume. If the volume is different, simply multiply the displayed index by the actual volume of the bottle divided by 10. The figure thus obtained makes it possible to compare the consumption of dives with different bottles. To obtain the consumption in relaxed liters per minute, multiply this figure by the absolute pressure.

**Air time remaining:** It is very useful for a diver to know how long he can stay at the present depth without the risk of running out of air. The "Consumption index" we have just calculated will make it possible to estimate this autonomy at any time by the formula:

$$\text{Air time remaining} = \frac{HP}{Ic \times Pa}$$

*Where, at a given moment: HP is the cylinder pressure; Ic consumption index; Pa is the ambient pressure.*

***Note that the calculation does not need to know the volume of the bottle.***

*Exemple : HP = 160 bar ; Ic/min = 2 bar/min ; Pa = 4 bar (à 30 mètres).*

$$\text{Autonomy} = \frac{160}{2x4} = 20\text{min}$$

This calculation, as presented, does not take into account consumption during the run-up. But these instruments can, always by accelerated simulation and anticipation, determine the autonomy at any time of the dive taking into account the speed of ascent and the profile of the decompression to be carried out.

For this, they assume that the consumption index remains constant, that the diver complies perfectly with the recovery procedure. They then calculate the air consumption for the time spent at each depth of the profile to be performed.

They may then suggest starting the lift before running out of air. The calculations are made, of course, by taking sufficient safety margins.This calculation, as presented, does not take into account consumption during the run-up. But these instruments can, always by accelerated simulation and anticipation, determine the autonomy at any time of the dive taking into account the speed of ascent and the profile of the decompression to be carried out.

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**In summary:**

The consumption index makes it possible to:

Monitor the evolution of air consumption;

Detect shortness of breath;

Calculate the remaining range at a given depth.

### Electric time remaining

The diver needs to know if the battery that powers his device contains enough energy to ensure the current dive and possibly some future dives.

Some computers simply measure the voltage of the battery and infer an approximate autonomy. This is not very precise. Others, on the other hand, use a sensor that measures the current consumed during each elementary time period.

The values found are summed continuously in order to know at all times the total amount of current consumed Q in "Ampere hour". This value is subtracted from the amount the new battery is supposed to contain. The result is then translated into %, hours or possibly the approximate number of dives that can still be made. (See Aladins)

## Dive simulation

Most of the devices allow to calculate the decompression of a next dive according to the interval, the depth, the time... They generally do not allow simulations for altitude.

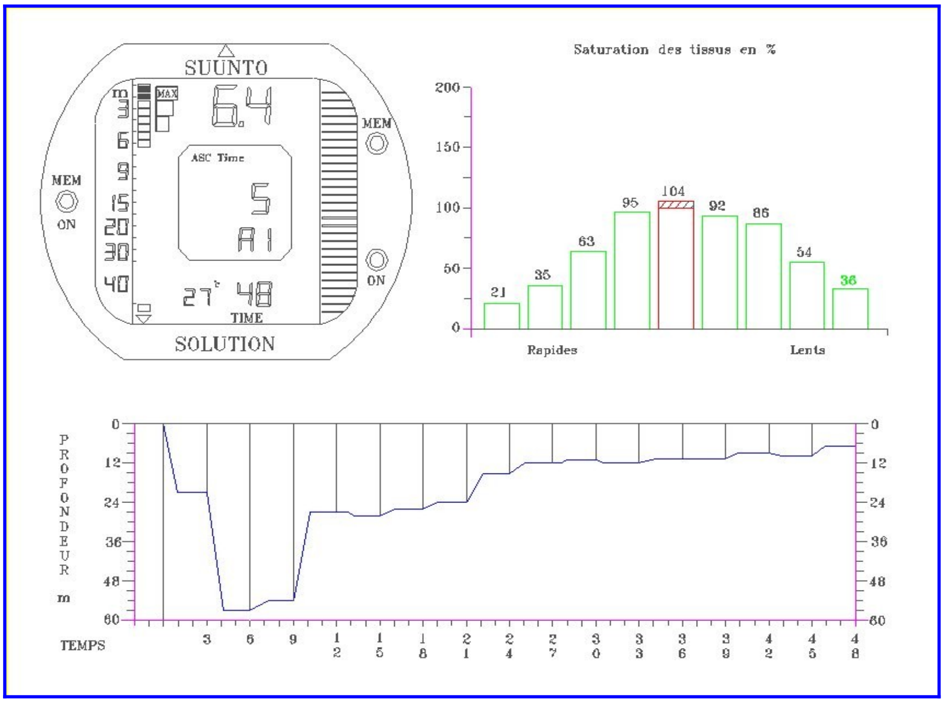



Figure 04 **Dive s*imulation*** (J.F. Mousseau*)*

The parameters are introduced manually, the program is launched in accelerated and at the end of cycles, the instrument gives the characteristics of the dive that one proposes to carry out. These devices are more or less advanced, the Suunto are at the forefront in this field.

The calculations are the same as those made during a dive (Voir le chapitre suivant) They differ in that times and depths are manually introduced by the diver. They also take into account saturation levels already stored by the device. The results are therefore only usable, until complete desaturation, by the diver who used it previously.

Simulation is also a good way to test the various devices on the market before a possible purchase. In addition, it allows the user to be taught, by simulation, the use of the device in comfortable conditions before practical teaching in the field.

Figure 4 shows a simulation performed on a diving computer. We see that after 48 minutes the compartment N°5 exceeds by 4% the permissible saturation and therefore requires a bearing.

## Alarm managements

Another important function of a dive calculator is to give alarms. The interpretation of these requires some explanations:

### Pre-alarms

When the diver climbs above the ceiling depth or exceeds the allowed rate of ascent, he is usually warned by an arrow and sometimes a series of audible "BIP" prompting him to slow down or descend.

This is actually a "pre-alarm" that disappears if it runs immediately. Practically the prealarms always precede the alarms to allow the diver to react before it is too late. (Taking into account an estimated latency time)

### Final-alarms

When a decompression pre-alarm persists beyond the latency time, it becomes a definitive alarm. We can’t erase it even when we go down. The diver must then consider himself in danger and take the necessary measures to deal with a possible accident of any kind.

This alarm usually lasts 24 hours but can go up to 72 hours during which the device is partially, or more than at all usable (See Algorigram).

The air and electrical range and O2 toxicity alarms are also preceded by pre-alarms that give the diver time to make the appropriate decisions.

## Adaptive devices

They are computers that adapt to the circumstances of the dive and certain risk factors. They have a mathematical model that adapts automatically according to some of them. They are said to "Adaptive Procedures". It’s not like tables that have frozen procedures.

The corrections made are certainly approximate and still contain some empiricism but they go in the right direction and seem a response to the main criticisms made against the diving computers of the first generations.

### Micro-bubbles monitoring

It consists of estimating the relative quantity of micro-bubbles present in the body and their evolutions according to past dives and the current profile and sometimes even past dives. The speed of ascent, the number of ascents and their place in the profile are important elements.

### Water température

The measurement of water temperature makes it possible to estimate the temperature of the surface of the body and subcutaneous tissues. This enables corrections to be made to the period of the most sensitive compartments.

Nevertheless it is obvious that this is very approximate because of the physiology of each diver and the different clothes he can use (The Maestro Pro allows to take into account the type of clothing).

### Diving efforts

By monitoring air consumption and breathing or heart rate, it is possible to estimate the diver’s physical effort and, for example, to adjust the time period of some compartments accordingly. This is not very precise either, but is an approach to take into account diving efforts.

Note: The advantage of an adaptive device is that it only increases the decompression time when necessary. The diver who does not put himself in a critical situation does not perform any more decompression than with a conventional device.
This technique, which is a legacy of Dr. Bühlmann’s work, is still in its infancy. This is certainly one of the most promising avenues of current research.

## Future prospects

It is difficult to predict the future. The latest developments take into account the efforts of divers during their immersion by monitoring changes in their air consumption as well as their heart rate. The decompression protocol is adjusted to increase the margin of safety.

Are there other avenues of research? How to predict accidents before it is too late?
An interesting parameter is the distribution of oxygen from hemoglobin to tissue. In the event of a decompression accident, this distribution is severely disrupted, but it can also be disrupted for other reasons which make it difficult to operate. The symptoms do not always appear quickly. Its knowledge would make it possible to detect any abnormalities. So it's an oxymetry problem.

***************************************

***Guestbook***

XiTi

# - DESCRIPTION -

## Table des matières détaillée



*****************************************

*Here we will describe the main components of these devices.*

**Bracelets** (See figure 09 below)
They allow to carry the cases on the wrist. They must be designed to withstand any test (traction of 10 Deca Newtons). They must be elastic or easily adjustable to absorb variations in the thickness of the garment depending on the pressure. Some have an accordion shape.

The weak points are often the spring barettes which ensure the link with the computer or the watch. If one breaks, we risk losing everything. I lost my first watch on a construction site with Jules Manganelli near the cave in Cosquer.

However, there are solutions. See Bracelets maintenance.

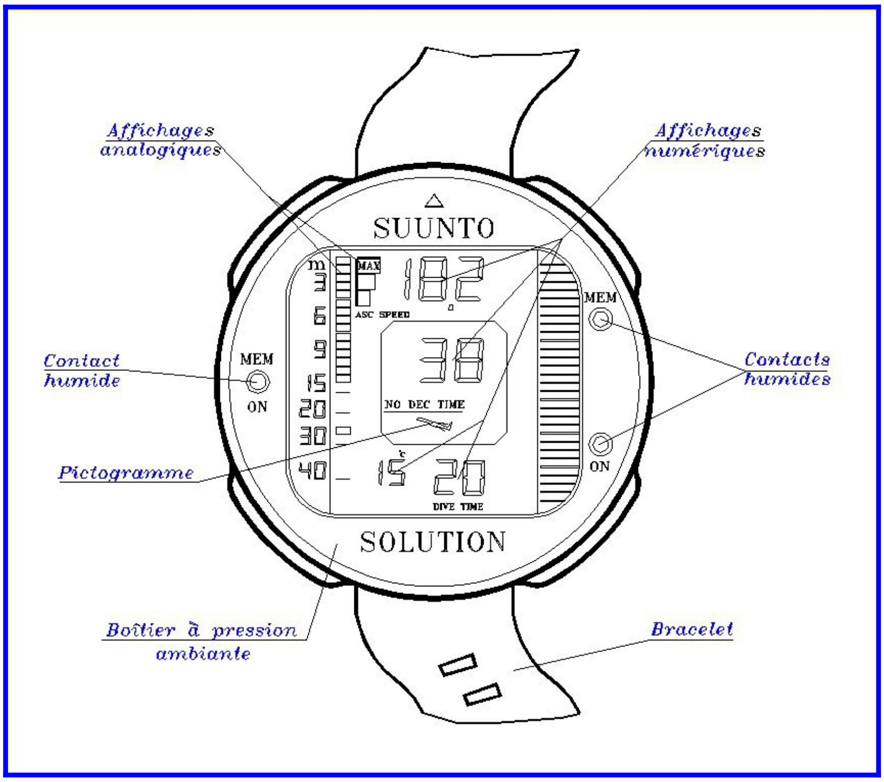



Figure 09 ***General presentation of a dive computer***

Some enclosures can be oriented 90 to 90 degrees, allowing them to be read regardless of their location on the arm. Watch out, bracelets have a limited lifespan. They must be checked regularly or one day lose the computer.

## Consoles

They are made of protective blocks usually made of rubber which, in addition to the dive computer, can incorporate a high pressure manometer and/or a compass. They attach to the end of a high-pressure hose. They make it easy to show the device to another diver. However, in practice, they mobilize an arm to be read.

During the dive, the console must be attached to a specific area of the equipment. Otherwise it may linger, cling to the bottom and possibly lead to an error of a few extra decimetres on the depth measurement.

This can possibly trigger the measurement of a dive time while a surface swim is performed, especially on the back. The pipe must therefore not be too long and especially well below the immersion and emersion thresholds.
If you change your diving gear at the landing, keep the device close to you to complete the decompression.

## Air pressure enclosures

In these cases, the internal pressure is equal to the surface pressure. Sealing is achieved by seals. These models may be subject to water inlets. Therefore, they require preventive maintenance for seal changes.

They are generally made of aluminum alloy. When the battery is interchangeable it is in a separate waterproof part, example: Vyper and Vytec from Suunto.

## Enclosures at room pressure

Here the sealing is obtained by a flexible insulating resin. The components embedded in this product are then in equipression with the medium. This type of enclosure does not fear water ingress and therefore does not require any special maintenance, such as first-generation Aladins.

The flexible resins used, however, fear decompression accidents; they should therefore be subjected to pressure only when immersed in water. The enclosures are made of hard resins: ABS, Macrolon, Polyamide, ...

It is also possible to put the components in an oil bath which avoids the stresses that occur when the resin ages. This solution must be carried out with care to transmit the pressure well while avoiding leaks.



***Scubapro's GALILEO and a smartphone profile***

However, some cases have an atmospheric pressure part to hold the battery, when it is replaceable by the user or the dealer.

## Pressure sensors

They turn pressures into electrical signals. These are absolute pressure sensors, that is, they measure the pressures relative to the vacuum (zero pressure).

At sea level they measure about 1 bar.
To give usable values, they require corrections called "calibration".

For this we compare the pressures suffered by the sensor with the indications it provides. The corrections are stored so that the measured values can be corrected. Corrections are also made according to the temperature. This type of sensor is called "intelligent" (See figure 10). This is a very remarkable clarification.

Linearization: It consists in making the output voltage proportional to the applied pressure in the normal range of use.
Adjustment of scale factors: This is, for example, the factor by which we must multiply the values in millivolts provided by the sensor, to obtain values in millibars usable for the calculations of the decompression.

Another factor is used to calculate depths for fresh water or sea water. A third allows you to select the altitude range (Pressure variations as a function of altitude are not linear).
Zero adjustment: It consists of getting zero for a zero absolute pressure. Do not confuse with "Initialization" which is a zero depth reset (Relative Pressure Zero) at the surface of the dive site.

The sensors are subject to drift over time and therefore require periodic calibrations. Calibrations are usually done in the factory. Figure 10 below shows the consequences of poor calibration on pressure measurements. Unfortunately, these defects can accumulate.

### Low pressure sensor

This is the most important element of the device. The best aircraft on the market currently have accuracy of about 2 per mile, which makes it quality but also price. They use "intelligent" sensors, see above. The calibration must be carried out with care. It should be checked periodically (see Maintenance chapter below).

The decompression time is not just a function of the chosen mathematical model. The accuracy of the sensor may require the manufacturer to take safety margins that lengthen the duration of shutdowns.

To compare devices with each other it is therefore also necessary to compare their accuracy in depth which reflects that of the low pressure sensor.

### High pressure sensor

Today, computers manage not only decompression, but also air autonomy. They then require the presence of an H.P. sensor connected to the spacesuit via an H.P. output of the 1st stage of the regulator.

Most manufacturers offer devices equipped with sensors connected to the computer by a"Inductive link" wirelessly.

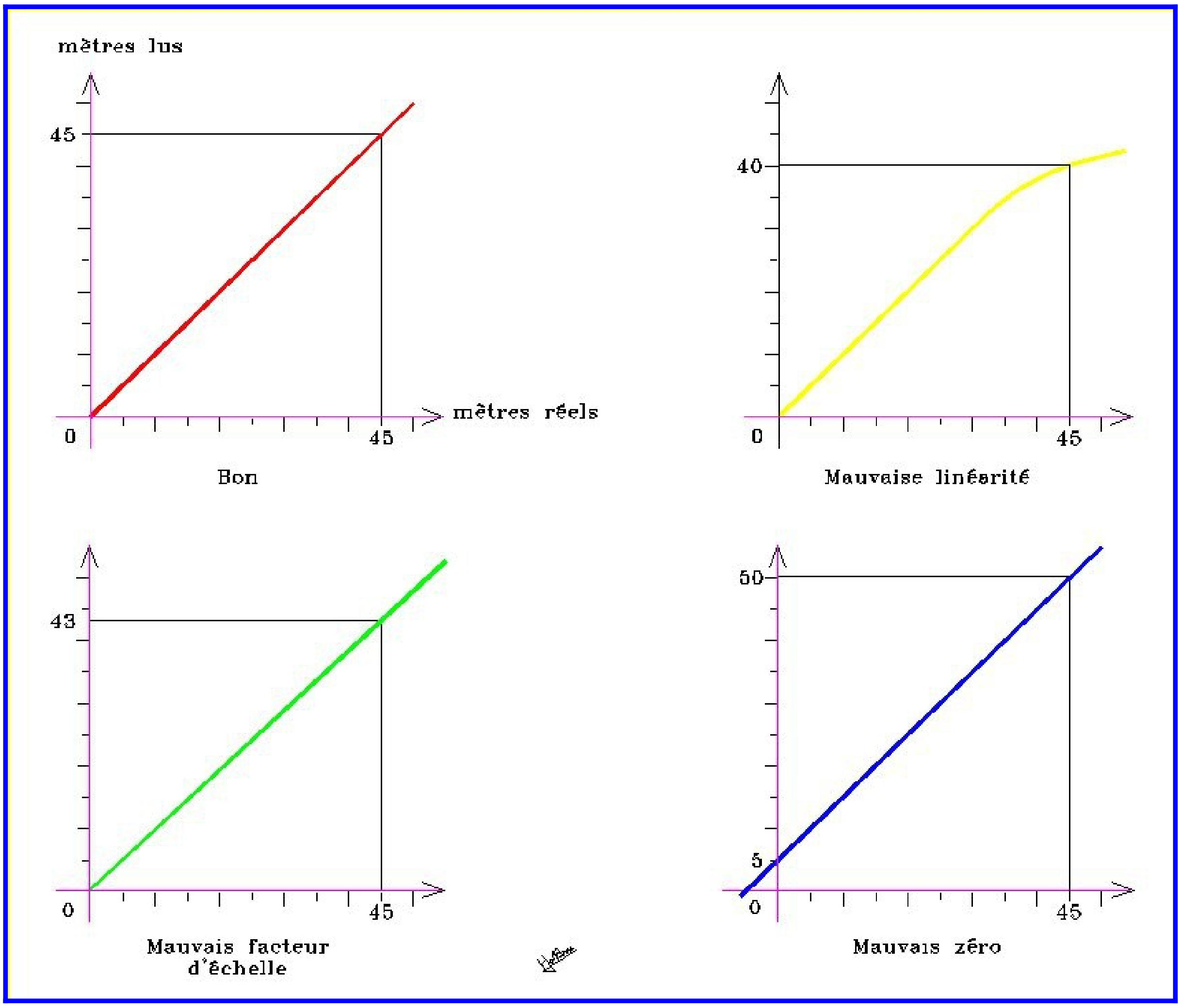



Figure 10 ***Defects of pressure sensors***

*(We see that the sensors are the heart of the dive computers)*

### Temperature sensor

The pressure sensors are temperature sensitive. It is therefore necessary to have a sensor to correct their drift. In addition, this makes it possible to display this temperature and, possibly, to take a safety margin on decompression when the water is cold (see adaptive devices).

### Electric photo sensor

In the dark, liquid crystal screens are difficult to read. Some devices, such as the Computek, are equipped with a photoelectric sensor to turn on a light source located behind the screen so that it can be read as soon as the ambient lighting becomes insufficient. However, this solution is energy-intensive.

### Strainer

It is intended to protect the pressure sensor. It must be in contact with the ambient pressure while remaining protected against the entrances of dangerous objects or particles or against overpressures caused by sudden immersions.

It is often in the form of a grid with small holes or baffle holes drilled into the housing. In enclosures at ambient pressure, the question does not arise because the sensor, embedded in the flexible resin or oil, receives the hydrostatic pressure through it.

### Control systems

They are intended for starting and executing commands. They are often coded by the number or duration of the pulses.

### Wet contacts

These are electrical contacts that by the simple conductivity of the water or wet fingers allow to execute the commands (They are called high impedance because the current that crosses them is very low, lower than the micro ampere). They are essential to guarantee initialization on contact with water and switch to diving mode.

There are up to five of them, depending on the model. They have the advantage of being inundable and offering a large number of possible combinations. They have the disadvantages of unwittingly settling on the surface or in a wet diving bag and being unable to be operated underwater.

### Switches and push buttons

They are waterproof electromechanical components. The contacts are thus insensitive to moisture, but they are nevertheless less reliable over time than wet contacts.

They allow, by moving a magnet, to operate Flexible Leaf Switches known as "ILS", placed in glass bulbs, through nonmagnetic watertight walls.

They are used instead or sometimes in addition to wet contacts, for starting the device and more recently to control alternating screens, see below.

Their main advantage is to be usable in immersion. The Data-Trans, the Guardian for example, use push buttons to change the display, on demand, both on the surface and in immersion.

This increases the amount of information available or the size of the characters without using a periodically alternating display. The Éon Lux and the Favor de Suunto, moreover, have a contact that is established by pressing on the housing to illuminate the screen.

### Mano-contacts

These are electrical contacts connected to a membrane subjected to the high pressure applied to the regulator. They are mainly used to start and initialize the device as soon as the bottle is opened (which avoids forgetting). They do not allow orders to be executed.

They do not allow the exchange of diving suits, in case of lack of air for example (see Delphi and Computek).

They are sometimes supplemented by other types of orders. The Maestro Pro EAN directly uses the H.P. detection by the measuring sensor which continuously tests the cylinder pressure.

### Magnets

These are small magnetic bars provided with the devices. They are used, with ILS contacts, to perform RAM reset to eliminate information from previous dives.
Be careful, this can present dangers for successive dives or at altitude because one can inadvertently or because of an unforeseen magnetic field erase essential information.

### Acoustics

An original command consists in putting an apparatus into operation by acoustic vibrations caused, at a certain point of the apparatus, by scraping it with the nail, a coin or any hard object (See the Maestro Pro EAN of Cochran).

### Inertial

Also at Cochran we find a start and change of display of a few seconds by an inertial contact activated by a movement of the wrist of the user.

## Displays

### Liquid crystal

They fitted almost all computers or electronic depth meters because they consumed virtually no electrical energy. On the other hand, the circuits that control them have a significant consumption. They require a backlight but the display is now in color, especially for the high-end.

They consist of two glass blades between which is a liquid in which "Nematic" crystals are bathed in suspension. These have the particularity of orienting themselves under the effect of an electric field and reflecting or blocking the light.

The glass slides are covered with polarizing filters and transparent metal deposits, one of which contains the different symbols that one wants to display. These appear at the rhythm of the electrical signals provided by the microprocessor.

This type of display always requires light: either external, it is then reflected by the crystals, or internal, it is then stopped by these same crystals. The display can only be read inside a certain angle depending on the filters used. The smaller the angle the greater the contrast. Manufacturers are trying to find the best compromise.

The cold slows the speed of the display while the heat blackens it, but this disappears with a normal temperature. The outer glass blade is protected by a layer of lexan. This material is impact resistant but easily scratched.

***SUUNTO Eon Steel profile***
With organic light-emitting diodes (OLEDS)

Aqualung and Beuchat provide a lexan leaf that holds by suction cup effect and is easily replaced. We find more and more real protection in transparent rigid plastic "Macrolon" which resists most aggressions.
It is a technology increasingly used for computers, TVs, as well as phones and other laptops.

**Benefits:**

Wider angle of vision
Better contrast
Better colour rendering
Lower response time
No auxiliary lighting
Less thick and cheaper screen

**Disadvantages**:

Their lifespan is only 15,000 hours which for a TV is a handicap but for a dive computer is of little importance. (Significant progress is being made)

## Digital

It is a periodically renewed display in which the value to be read is represented by pre-drawn digits, thanks to the combination of contrasted bars. It is commonly used. It gives a precise indication, but measurements are sometimes difficult to interpret when they vary rapidly.

## Analog

It is a display in which the value is represented by a bar of variable length, sometimes called "bargraph", consisting of a succession of points or bars. These displays provide a progressive approach to the alarm. They are less used than the numerical ones and give less precise values, but on the other hand the variations are easier to interpret. This is useful for example for the speed of ascent where the trend of evolution is important due to the inertia due to the mass of the diver.
In fact, in an analog display, there should be no discontinuity. This is why the graphic display name is preferable for systems with variable length by points or bars.

**Note:** Needle displays, such as watches or mechanical depth gauges, are to be classified in analog displays.

## Matrix

In this display, the screen consists of a mosaic of dots. The images are not pre-drawn but obtained by the association of a number of these points, which gives a lot of flexibility. However, the quality of the drawings is not as good as with a conventional display. However, great progress has been made in recent years. Screens of the type used on camcorders or digital cameras could be used. Unfortunately, they are very energy-intensive.

### Pictograms

They are also called "icons". This type of display does not give the value of a parameter but a symbol that represents it. Its advantage is that it is a universal language that does not require translation. Example: the flight ban represented by the drawing of an airplane, the altitudes by mountains of different heights.

### Alternate information

For lack of space on the screen they consist in displaying alternately, two information like the maximum depth and the present depth. However, this creates a risk of confusion that should restrict their use especially in immersion. Example: LeDive Team and Datamax which alternate the dive time and the one remaining before having to perform a decompression.

### Successives

In some cases two pieces of information can be given successively without any risk of confusion. For example, the length of time it takes to complete the steps and the length of the steps themselves.

### Alternate screens

The risk of confusion can however be removed, even in immersion, by altering the display of the screen by using manual systems, push buttons (Nemesis) or inertial contacts (Cochran).


Figure 11 ***Mares QUAD AIR***

*The most important information is displayed commonly while the less important information is called manually for a time of a few seconds. These can often be chosen by the user.*

### Scrolling

It makes it possible to provide a series of successive information of the same nature without having to repeat a command, for example: the safety curve that evolves with the interval and whose time/depth couples are displayed one after the other for a few seconds.

### Permanent

These are engraved or printed indications, usually on the perimeter of the screen. They are intended to facilitate the interpretation of the information given by the apparatus and sometimes to adapt the language to the country concerned. They are distinguished by different colors, very visible, often fluorescent.

### Diplay lighting

As we saw earlier, some displays require a light source.

#### Phosphorescent

Sometimes called luminescent photo. It consists of a layer of phosphorescent material located on the back of the liquid crystal display. It is in fact an accumulator that restores for a certain time the light it has received beforehand.

#### Interior

To facilitate the reading of the display in the dark, some devices have internal electrical lighting that starts by push button or automatically by means of a photoelectric cell.

This lighting is arranged behind the liquid crystal display which then works by transparency (See Computek) It is the backlight. The manual control allows to limit the consumption to the strict necessary.

The Éon Lux and the Suunto Favor are illuminated by a simple press on the housing. This is an "electroluminescent" lighting which requires a high voltage generated by a special circuit.

#### Outdoor

It can be brought by a diving lamp or by a chemical lighting of the type "Cyalum" to be started before the dive and which is fixed close to the screen (See the "Jolly" marketed by Sporasub).

### Sound transducer
It usually gives alarm information. It is the result of a compromise between sufficient power and reasonable energy consumption. Unfortunately the sound power is often too low.

The signals emitted can be encoded, in the form of "BIP" more or less long or fast, to facilitate their interpretation. As we have seen it is usually switched off in "Standby" mode.

**Note:**
The audible alarm is very important because it frees the diver from the obligation to visually monitor the aircraft, especially in critical situations. Moreover, if its power is sufficient, it can be heard by other members of the group.

### Light alarms
They are usually formed by light-emitting diodes of red colour very visible in the water (See "Jolly" from Sporasub and "Delphi").

### Wireless Link
We have seen the advantages and disadvantages of devices physically connected to the first stage of the regulator. Different techniques allow a connection without pipe or without wire.

For example, a high-pressure sensor connected to the first stage of the regulator is associated with an ultrasonic transmitter or inductively coupled between coils (i.e., using magnetic coupling). This system transmits the information to the receiver attached to the user’s wrist. The range is 1 to 2 meters.

Most of today’s high-end devices operate on this principle.

At Uwatec, the information is sent every 5 seconds in the form of pulses modulated by a signal at 8000Hz itself modulated by phase jump.

It is not strictly speaking a radio link as some authors have written because only the magnetic component of radiation is used. This type of link has the advantage of not being influenced by obstacles as would be the ultra-sounds.

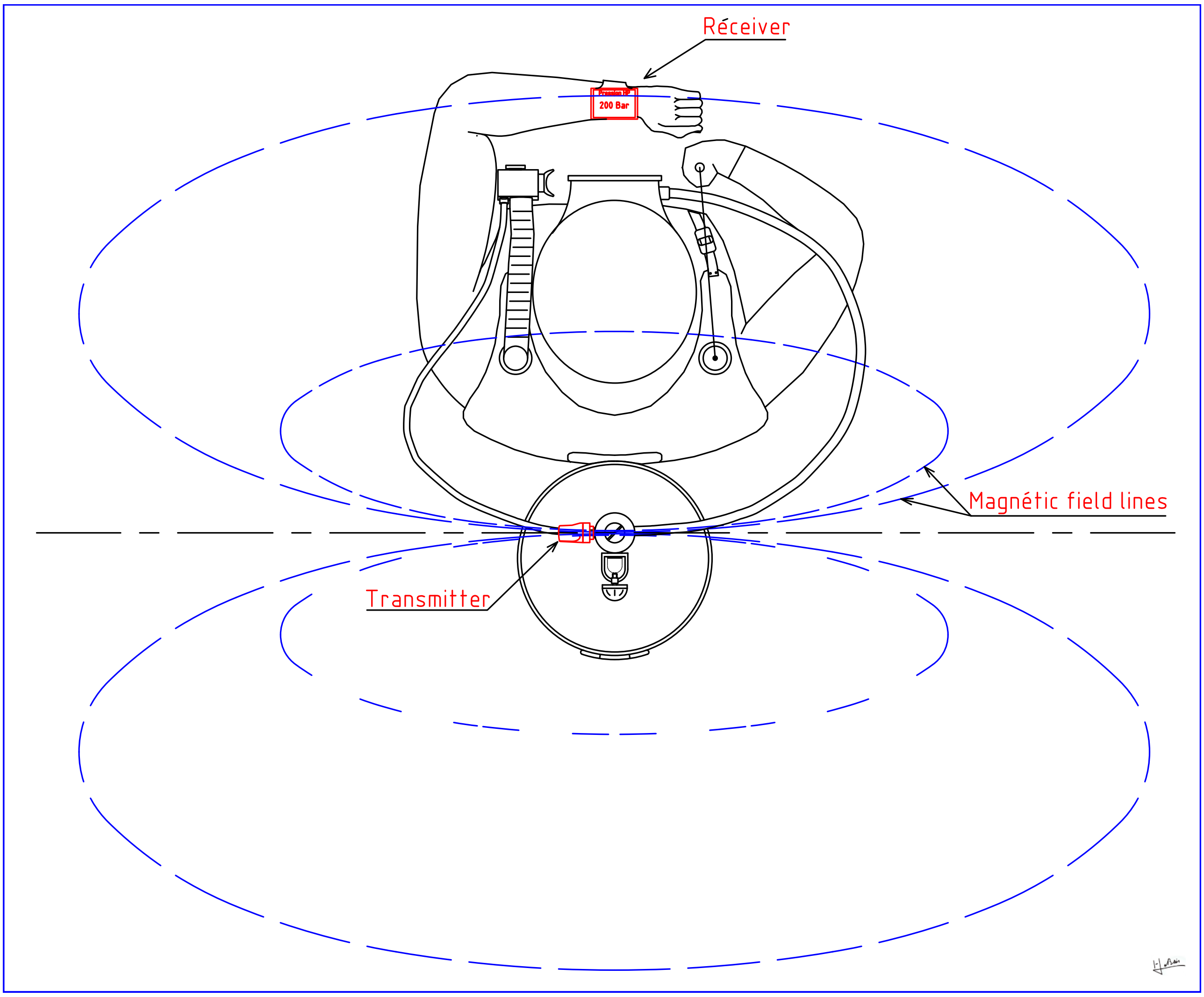



Figure 12 ***Relative position of transmitter and receiver***
*(The best position is where their axes are parallel)*

Figure 13 shows the variations in level received as a function of the angular position of the transmitter and receiver. We see that when their axes are parallel the level is maximum and when they are perpendicular it is minimum. The variation around the minimum is very sharp so the risk of loss of bond is low.

The proximity of large magnetic masses, such as in wrecks, has never allowed us to identify any disturbances.

But an electric locotractor, by the parasites it creates, can permanently disrupt the bond. On the other hand, an electronic flash will only disturb it momentarily.

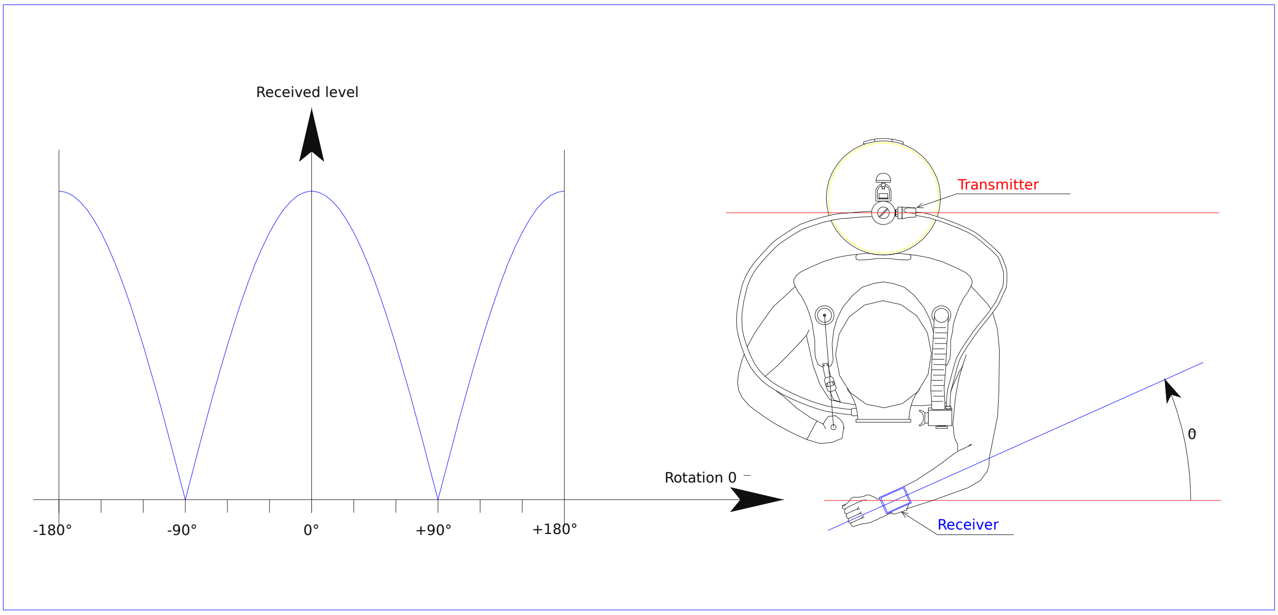
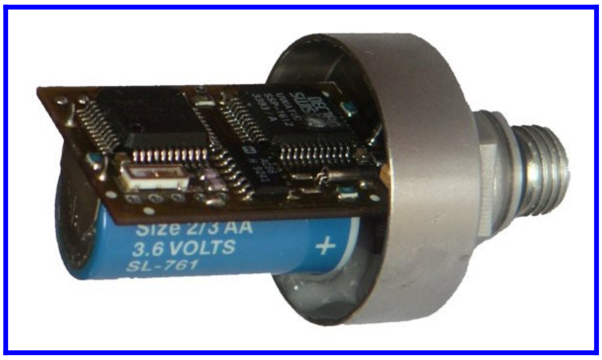
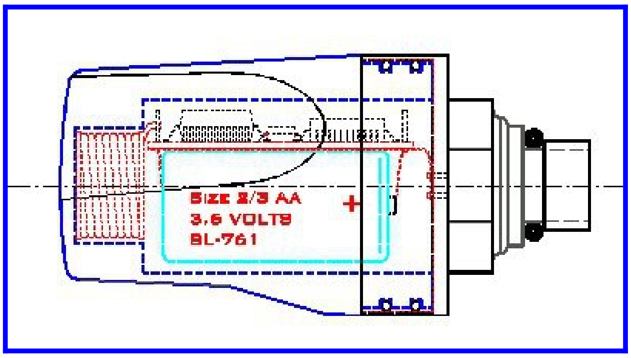



*Figure 13* ***Level received and angular position***
*(Beyond +30° in all planes the level decreases rapidly)*

There may theoretically be transmission interruptions depending on the respective orientation of the transmission and reception windings but practically they are not annoying because they affect only a very small angle and can only be of short duration.

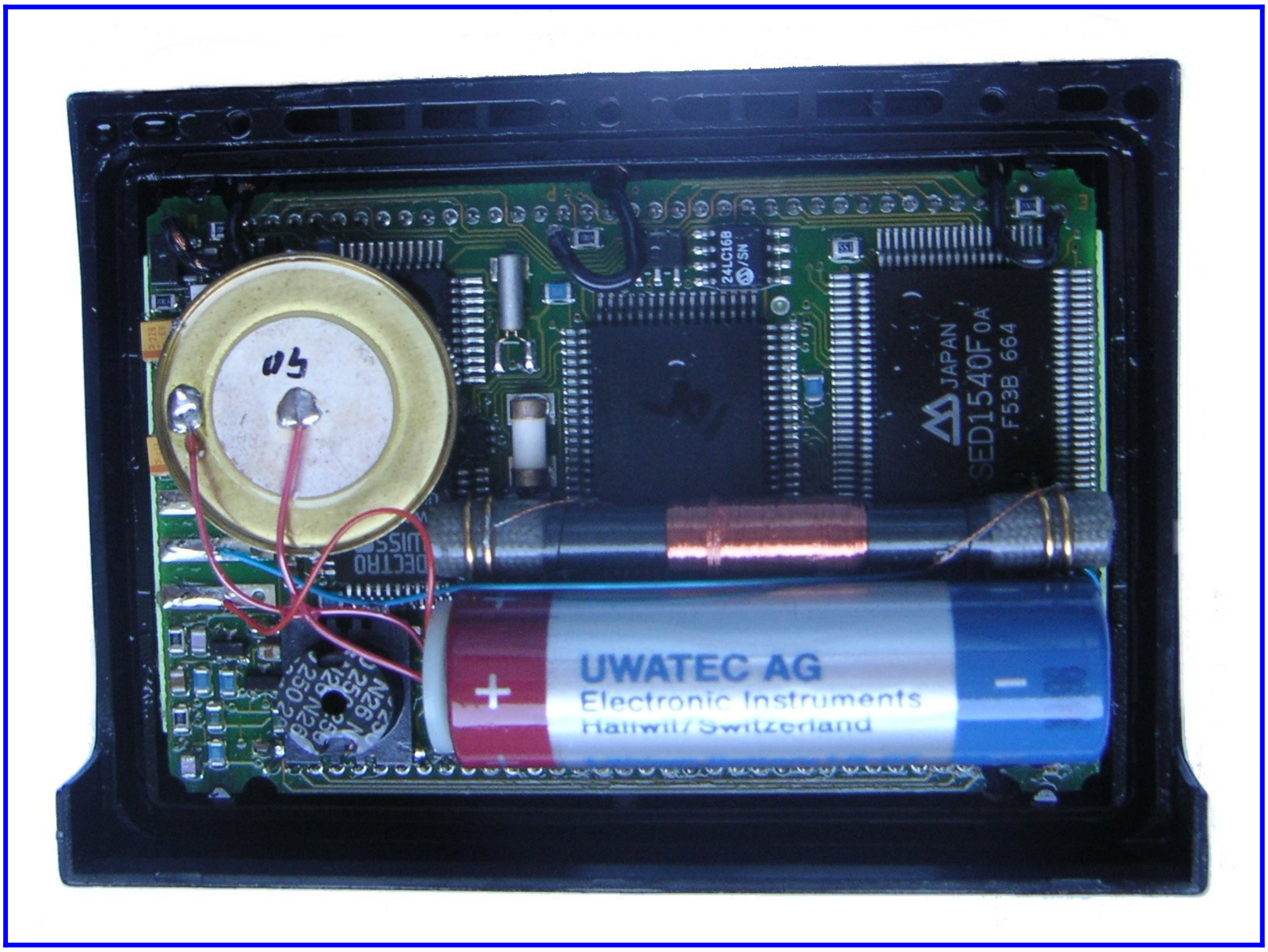
The figure on the left below shows the photo of the transmitter outside its housing, while on the drawing on the right the position of the transmitter winding in the axis of the housing can be seen on the left.




The transmitter block attached to the H.P. output of the regulator has a High Pressure sensor and a temperature sensor.

The resulting signals pass through a shaping circuit and are then processed by a specialized microprocessor before being sent to the low-frequency magnetic wave transmitter.



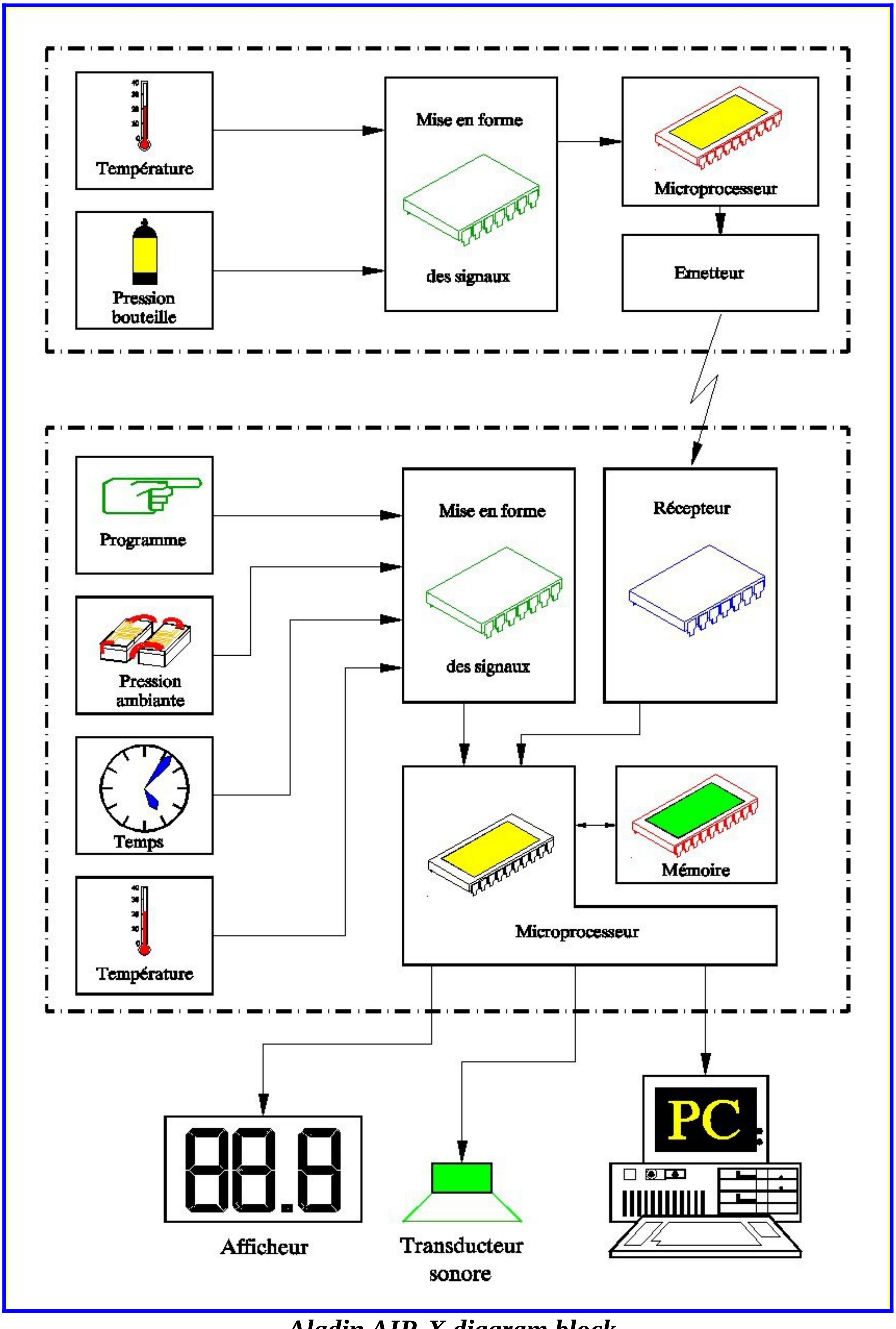

***Monitor III Receiver***

In the picture above, the winding of the receiver is perfectly visible on its ferrite rod. It concentrates the lines of force of the magnetic field to increase the received signal. The axis of this bar must be parallel to the transmitter to obtain the maximum level.

In the case, which is worn on the wrist, the receiver picks up these signals and sends them to the main microprocessor. Pressure and temperature information am
biantes are sent to a formatting circuit, similar to that of the transmitter, then to a real microcontroller that also receives the time and the calculation program.

The RAM stores the variable information while the information to be provided to the diver is sent to the display and the sound transducer. In the above view one can see the interior of the "Monitor III" which was the first computer, wireless, marketed in France.

*The figure in the “AIR-X Aladin Diagram Block” below was kindly communicated to us by Dynatron. It shows the diagram block of such an inductively coupled device.*




***Aladin AIR-X diagram block***

The data collected can be used by a personal computer (provided that it and the associated interface system are available, the cost of which is not negligible).

This provision is marketed in different formats by:

Marès: under the name of "Genius".
Uwatec: under the name of "Aladin AIR X".
Suunto: under the name of "Vytec".

### Pairing

It is essential to avoid interference between devices

#### In factory

The receiver is set on the transmitter once and for all in the factory. One cannot change one without changing the other. (This solution has virtually disappeared)

#### Automatic

After a stop or interruption of the connection, the receiver automatically switches to the nearest transmitter. To do so, he must be in close proximity to the transmitter. When it stops or strays too far, the receiver keeps the code in memory for a while.

This arrangement allows changing underwater diving suits, provided that the other one is also equipped with a transmitter. This may be of interest for dives where it is necessary to change bottles.

#### Manuel

It consists of putting the receiver in a function that allows to record the code of the transmitter placed nearby. This code is kept in memory until a new pairing on another transmitter.

*These codes have a few tens of thousands of combinations and are complex enough that the chances of interference are low (see Uwatec). So you can change one or the other.*

### Energy sources

#### Unique

There is only one battery; this is the most common case. When used in conjunction with a powerful audible alarm and screen lighting, battery life may be reduced, especially in the case of frequent alarms. For example, if contacts are accidentally made in a wet diving bag.

### Multiple

Although they are not widely used, they are advantageous because they separate the power supplies of the lighting or the sound transducer from that of the microprocessor and the display. This preserves essential information. One can thus have both an autonomy and an adequate sound power without risk of being in complete failure at the moment when the alarm works or when the internal lighting turns on (See the "Jolly" from Sporasub).

### Rechargeable

To avoid changing the batteries we sometimes prefer to use batteries. This is a good solution but they must be of good quality, for example with Lithium-Ion. Charging is always a delicate operation.

### Interchangeable

It is sometimes possible to change the batteries yourself. This may seem advantageous, but it must also be taken into account that it is not always easy for a non-specialist; there is a risk of error and loss of watertightness.

Sending the device to the factory for this operation takes time. On the other hand, this provides an opportunity to have it calibrated and checked thoroughly.

When we replace them, we must respect a maximum time without batteries. Beyond that, we risk losing the recorded information. Welded batteries are preferable to pressure contact batteries, but are more difficult to replace. Of course, you always have to have them in reserve.

### Emergency

The Maestro Pro has a low-capacity backup battery which allows essential information to be preserved during the exchange of the main batteries.

## Electric range and service life

A battery is characterized by its voltage but especially by its "Capacity", which when new is expressed in "Amps/hour". Autonomy is the remaining time of possible operation. It is equal to the remaining capacity divided by the current consumed.

It depends a lot on the tricks and the technological means used because the consumption is variable (See réduction in energy consumption). The manufacturer shall indicate the maximum range in %, years, hours of use or number of dives. Some devices calculate it with good accuracy but this is not always the case.

The service life is the time it takes for the source to lose all its useable energy without use, that is to say in self-discharge. It depends on the type of source used:

- lithium battery: 7 years.
- pile au mercure : 5 ans.
- lithium accumulators: 12 months (but they are rechargeable and have an effective service life of 10 to 12 years).

**Attention:**
The life of a battery depends on a number of factors:

- Quality of the battery and its manufacturer.
- Age before entry into service.
- Date of installation.
- Number of alarms and duration.
- Temperature.

In this way, the range can be significantly reduced due to storage prior to commissioning or at low temperatures.

- when an appliance uses several batteries and one of them fails, it is necessary to change them all together, except of course the integrated emergency battery.

- It should be noted that colour displays are energy intensive. Their electric range is limited and requires easily changing the battery or recharging the battery. (Often via a USB socket) In general the device is manifested by an alarm which still allows to carry out some dives before the failure.

**It is important to always have on be a stack ahead or a way and time to recharge the accumulator before a series of dives.**

## Accessories

### Protection of the screen

As an accessory, we find screen protectors for almost all devices on the market. For some time, a lot of original devices have been equipped with reinforced protection.

### Loupe

On some screens, it is possible to adapt a magnifying glass to increase readability.

### PC Interface

It is a software that allows you to transfer the contents of your device’s memory to that of a Desktop computer. It also requires a special cable that is often equipped with protection to prevent piracy.

## Buffer memory

When a large number of dives are performed, it is not always possible to empty the memory of the device into that of a PC. A very small buffer, the "Memo mouse" from Uwatec allows you to store up to 66 dives without the need for a PC. Of course it has an extra cost.

## Documentation

Documentation and regulation:

Documentation is an important element. Documentation is the foundation upon which the proper use of the device depends. It must include:

A description of the instrument.

- Model on which it is based.
- How to wear it, install it, change the batteries.
- Description of the screen, its various indications and how to access them.

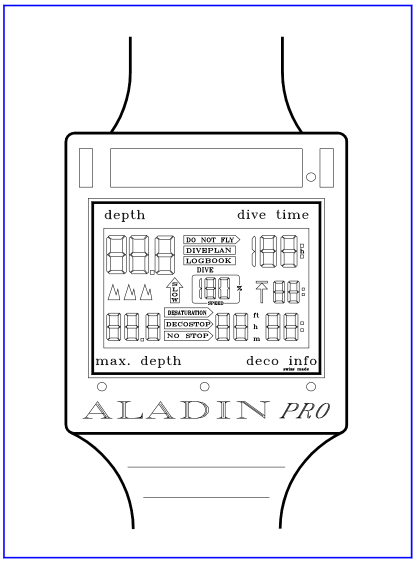



Figure 15 ***Aladin Pro***

*A precise description of its constraints and limits of use.*

General rules: Recall and recommendations for use of the device. Breathable mixture for which it was designed.

- Special rules:

Constraints related to initialization, the transition to pre-alarm and final alarm, clear description of the conditions of the transition to alarm and the pipes to hold.

- *Presentation of use limits:* Maximum depth and duration of dive, maximum depth and duration of decompression, speed of ascent, safety curve, maximum and minimum temperature of storage and use, maximum altitude etc.
- *Preventive maintenance and periodic review rules.*

- *A list of all the numerical characteristics.*
Precision and resolution in depth, time, bottle pressure. Latency time, sampling rate, immersion and emersion thresholds, lift speeds, electrical range, memory content and capacity in hours or number of dives, etc.

- *A list of all functions and how to use them.*
Mode of access to memory, simulation, configuration, PC.

- *A summary usage sheet.*
It is desirable that the detailed documentation be supplemented by a more succinct document. It must recall the essential rules of use of the device that can be used by a third party. (In case of accident for example)
It must be in the form of a laminated sheet, very legible, easy to carry in the diving bag, strong and water resistant. It must be possible to be carried under water, like a diving table, for very technical dives.

These devices should be accompanied by a calibration sheet. However, this does not seem to be about to pass into the mores…

## Future here already?

Manufacturers facing competition are trying to innovate in particular by offering a plethora of new features that users do not use at 80%. To facilitate the use of their computers, They sometimes but not always successfully try to make their use as simple and intuitive as possible.

Some models called "Multi functions", in addition to diving functions can be connected on the surface, indicating your GPS position, your route, altitude etc.

Among the high-end models for diving, we noted:

**Aqualung i750TC:** Colour Display - Decompression with Air, Nitrox - Open Diving in Single Depth, Fresh Water or Seawater, at Altitude, … Multi gas diving, deep bearings, wireless air management, a 3-axis compass with heading lock and reverse heading.
Electric range from 12 to 16 dives.

**The Galileo 2 of Scubapro**
Color Display - Air Decompression, Nitrox – Smartphone Display…

**Descent MK1 de Garmin**
The most complete multisport computer there is.

GPS – Altimeter – 3-axis compass – Topography Europe – Heart rate – Hardening – 40h in dive mode – Depth 100m (Standard EN 13319) But, it lacks one of the most important functions air management and why not speech!


***Garmin Mk1***

**Finally a remarkable recent creation**

The Scuba Capsule, an iphone in a waterproof case with all the functions of a high-end dive computer plus photo and video and more…

Waterproof to 150m - Cost 1000 €…(2019)

Currently only compatible with an iPhone.


[***Guestbook***]

XiTi

# - DIVING TABLES VERSUS DIVING COMPUTERS -

## Detailed table of contents



## General

Diving tables and computers are often compared. This is not an easy task, as in practice these are two very different modes of decompression. First, it is important to know that some definitions are no longer applicable. Indeed the "duration of the dive" with the tables is the duration that separates the moment of immersion from the moment when one decides to go up; it results from a decision of the diver (See figure 16 below).

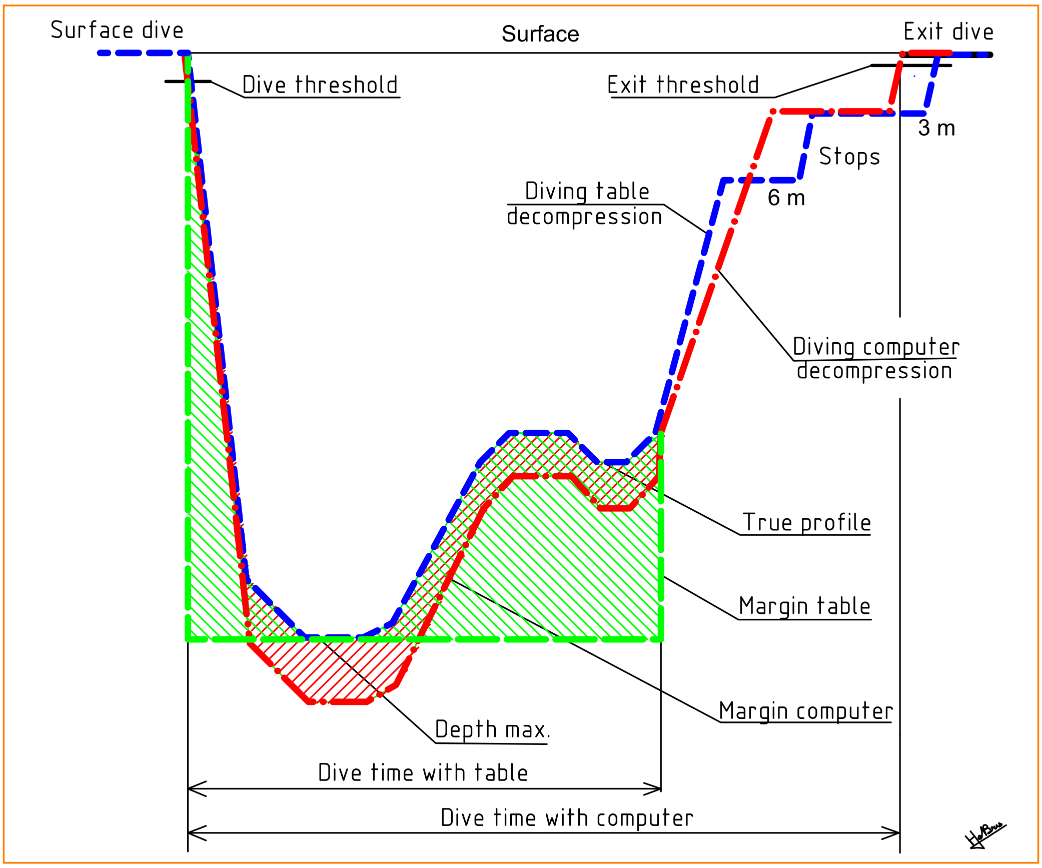



Figure 16 ***Variable profile margins***

We have seen, in chapter V, that in dive computers the passage to the immersion and emersion threshold was recorded as the beginning and end of the dive. Consequently, for these devices, the duration of the dive is replaced by the duration of immersion which is that which separates the crossing of these thresholds.

The duration of the ascent as well as that of the bearings constitutes the decompression. It is included in the duration of the dive. It is the latter that you read, at the exit of the water, on the screen of the device. It is automatically stored with the depth reached. An incursion at a depth lower than the immersion threshold is not considered a dive.

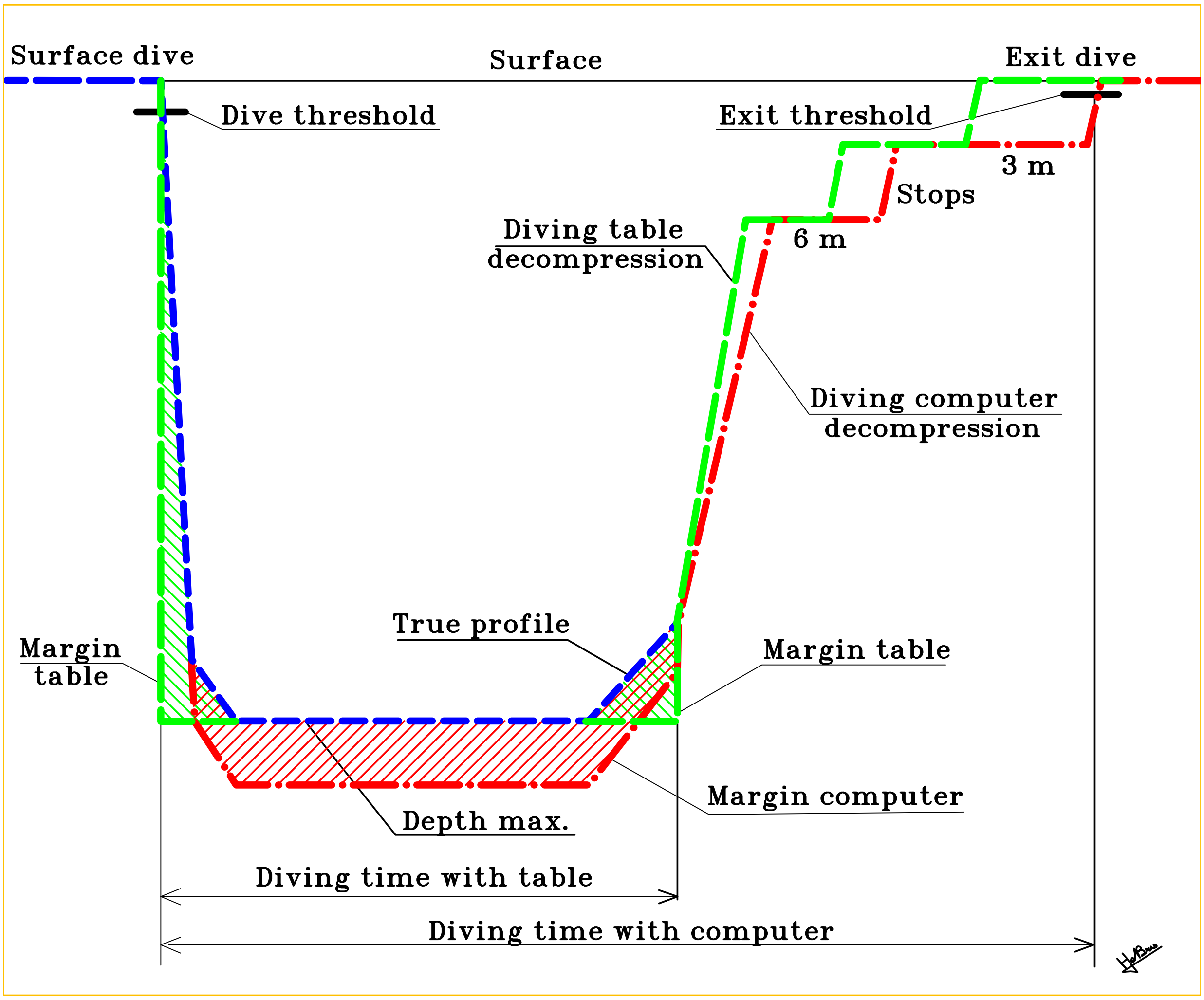



Figure 17 ***Margins in rectangular profile***

Unlike tables, the decompression procedure is not determined by the maximum depth reached and the total duration of the dive (rectangular profile). You should therefore consider these values only as interesting information, to be recorded in your dive book.

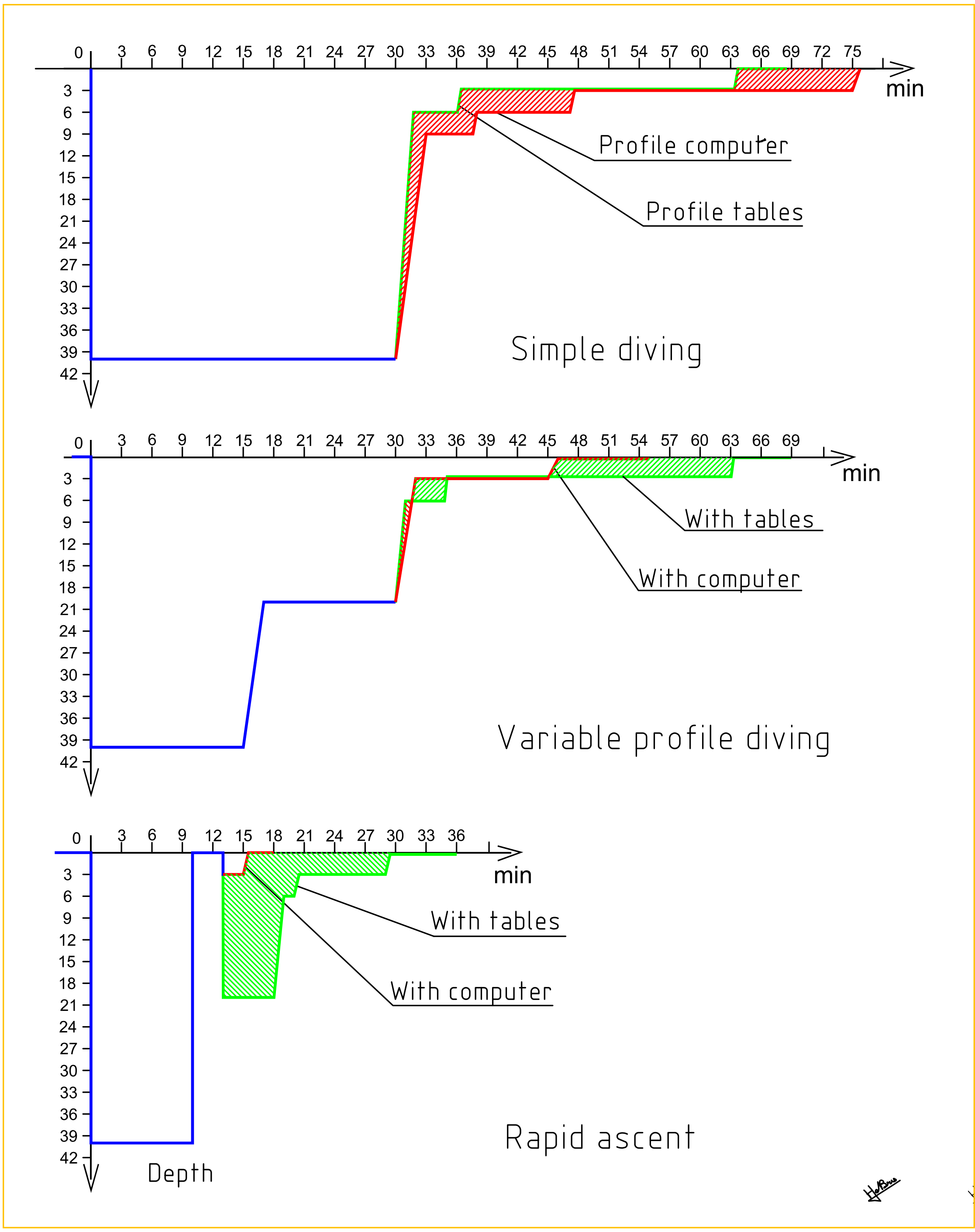



*Figure 18* ***MN90 French Table / UWATEC Computer***

Comparing figures 16, 17 and 18 above, you can see that depending on the dive profile, the computer may require more or less steps than the dive tables. When the profile approaches a rectangle, the steps to follow with a computer increase and even exceed those required by the tables.

Nevertheless, for recreational diving, regardless of the dive tables or computers used, the results will always be to the advantage of the latter.

### Test in a sealing box

The sensor control that tells us the depth and pressure to manage the decompression is very important. The casing in figure 19 has been used for many years to test computers as well as depths. It is very precise and does not require compressed air. The measuring device can be replaced by a reference computer placed in the chamber. However, it will have to be checked regularly.

The theoretical results are confirmed by Figure 18, which shows practical surveys carried out in the sealing box with commercial equipment. We can see the difference in result that we get for two dives of 30 minutes at 40 meters, one with the whole time at 40 meters the other with half at half depth.

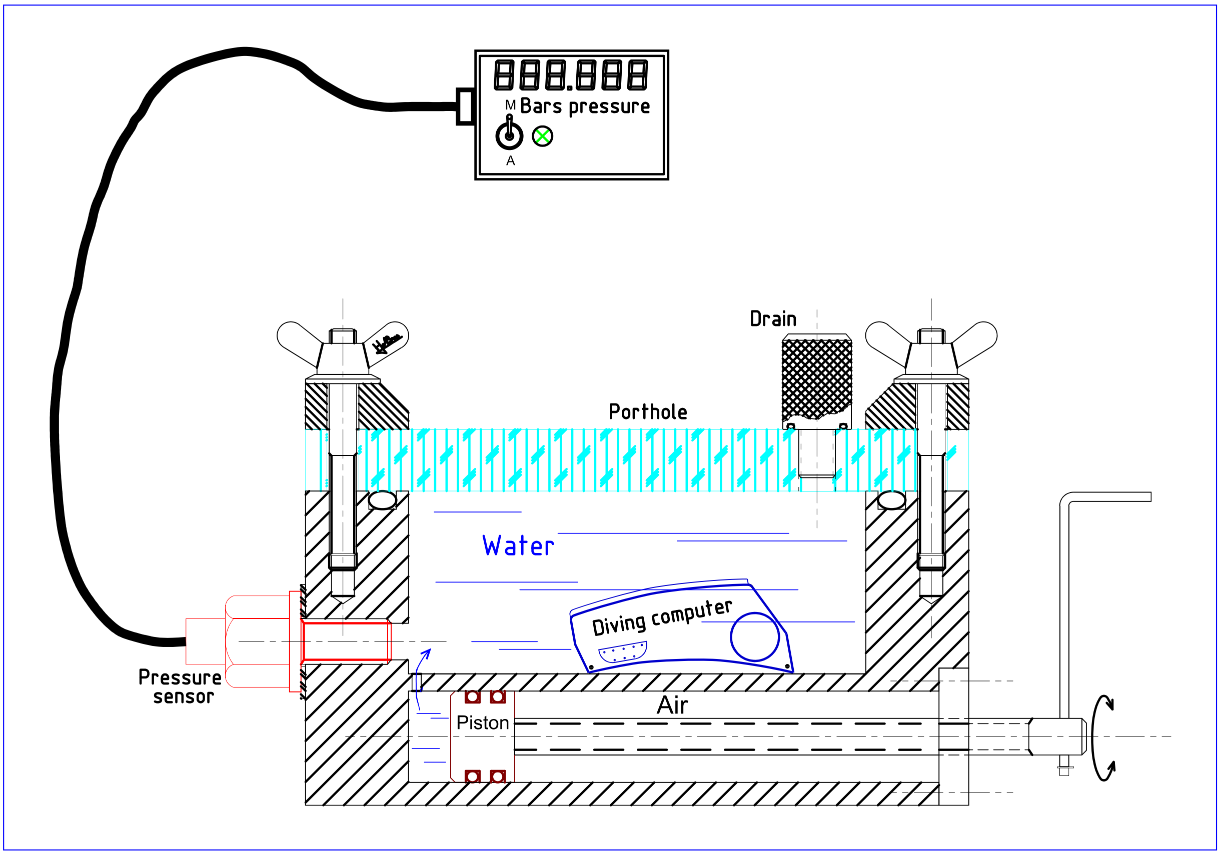



Figure 19 ***Test box for diving computer***

You also see that with a risk factor such as rapid ascent, some devices do not offer a suitable procedure. The diving tables are then more secure, so it is necessary to use their procedure. The comparison also depends, of course, on the model of tables used. We chose the MN90 because they are the ones taught by FFESSM.

One parameter that is often used to compare decompression systems is their safety curve. The figure below shows that the safety curves of computers are more secure than those of tables for low depths in rectangular profiles.

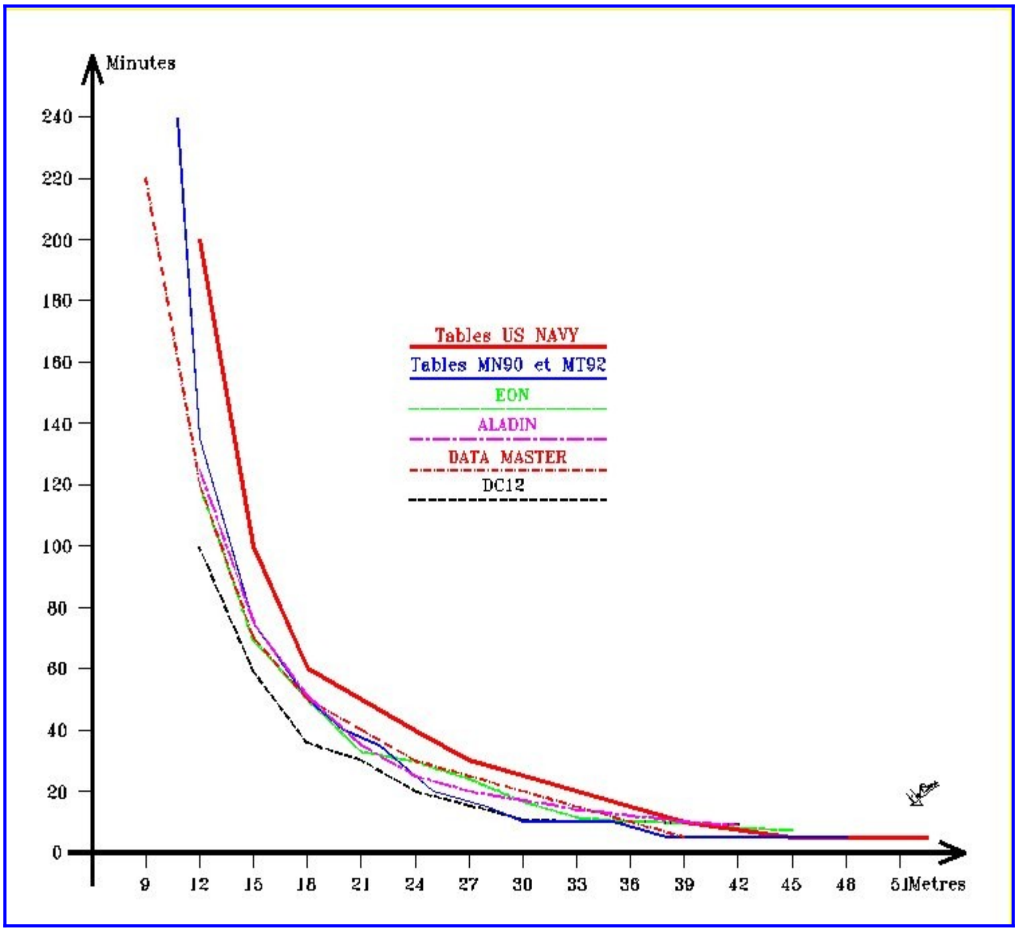



Figure 20 ***Security Curves: Tables/Computers***

It seems that, for use under normal conditions, the probability of an accident is not very different between diving tables and computers. On the other hand, increasing decompression time is not the universal solution to reducing accidents.

To achieve significant improvement, safety margins must be taken in the presence of risk factors. This is done automatically in “Appareils adaptatifs"

## Advantages of diving computers

The decompression procedure is determined by taking into account the actual profile of the dive, and thus more accurate estimated nitrogen quantities, with of course a reasonable margin of safety.

In figures 16,17 and 18, the hatched parts, in two different directions, show the margins taken for tables and computers. With the tables, it is considered that the diver has passed the entire dive to the maximum depth reached, which is rarely the case.

As a result, diving computers have a roughly constant safety margin, while tables have a largely variable margin depending on the profile.

· Computers generally allow greater immersion times for equivalent decompression times. This is because they optimize the decompression according to the different depths where the diver found himself and therefore eliminate the "useless" margins... imposed by the tables.

They are easier to use and limit reading errors.

· They allow, whether immersion, surface or altitude, to automatically take into account all the pressure variations to which the diver is subjected. They thus avoid corrections and tedious calculations that can be a source of error.

The speed of ascent is rigorously controlled.
· The decompression depth is less critical than with tables. This can be done in an area below the ceiling depth, or the bearing, with a wider margin than that imposed by the tables.

Since the procedure is constantly recalculated, it is possible, for example, to complete a decompression at 6 metres instead of 3 if the state of the sea does not allow to level at this depth.

The human factor is less important than with tables (It should not be neglected, however).

· When equipped, acoustic alarms free the diver from the need to consult the display frequently. This is important, especially in critical situations.

They take into account all the tissues and not just one for the calculation of successive dives during the surface interval.

· Some devices give, after the dive, an indication of the exposure in digital or analog form (Datamax). This makes it possible to compare the degree of exposure of different divers, even if they have made different dive profiles.

This is useful, at the time of the ascent to monitor the decompression and also to train the palanquins before a successive dive. (Only after a certain interval)
The time and depth measurements are very precise, much more so than with the mechanical devices still on the market.

They often use a large number of compartments which allow them to better approach the model of our organization.

Some of them use very long compartments, up to 640 minutes, which allows them to better take into account dives over long periods.

Some allow to take into account the probable presence of micro-bubbles depending on the dive profile what the tables do not allow.

· They provide, on the surface, a lot of additional information which, although not always essential, can be useful to the diver. Computers allow an infinite number of dive profiles within certain limits; on the other hand, tables often offer only a few dozen dives outside which one must extrapolate.

This statistically increases the safety of the latter but sometimes considerably increases the decompression constraints and the risk of error.

It is easy, arguing that tables impose large margins, to say that they are more secure. In fact, under no circumstances can the tables adapt to the Yo-Yo dives, to the abnormal speeds of ascents, to the variations of efforts on the bottom...
The tables thus give the illusion of superior security. The computers, little by little, will eliminate these disadvantages while the tables can only evolve little in this direction.

These devices now have a wealth of experience accumulated over many years around the world.

## Disadvantages of diving computers

As soon as these devices appeared, they were the subject of intense criticism, sometimes supposed to be. They seemed less reliable than tables. Bad uses have even caused accidents. Today, they are unanimously adopted and their merits recognized. However, there are still precautions to be taken. The teaching of their limitations is very important.

Unsuspecting users have a blind faith in these devices that apply theories of practical diving that are still far away. It is often the exaggerated exploitation of their theoretical advantages that leads to accidents.

· The main drawback for most of them was that they did not take proper account of certain risk factors or dive profiles, and in particular too rapid or frequent ascents with short intervals (for example, an anchor stall). We know that these profiles often accompany accidents. However, it must be recognized that in recent years they have made great progress.

Another important drawback is that they do not always impose or suggest remedial procedures when those they advocate have not been followed.

Who can indeed claim that he will never, unfortunately, find himself in a critical situation as a result of an error or recklessness? Whenever an alarm has occurred, they should systematically propose or impose a safeguard measure ...

A number of them stopped completely when there was an error or when certain limits were exceeded.

· Their automaticity may cause a dangerous relaxation of attention. It is therefore always recommended, in rescue, to plan the dives and especially the air consumption.

· They should only be used by fully trained or trained divers. These are not magical devices that can be used without precaution.

The freedom they provide tends to reduce the cohesion of the palanquins and, within them, to marginalize divers who are equipped with different means of decompression calculation.

Manufacturers do not provide specifications on the following:
- Their probability of accident, estimated for the mathematical model used; - Their reliability, which is expressed as the average estimated time between failures (MTBF), or their integrity, which is the probability that they can give a false indication when they seem to work well.

Moreover, we have no information on their resistance to shocks or vibrations nor on the quality used for their manufacture. (All this will come one day)

There is as yet no complete standardization of these devices. Only a few functions such as time and depth measurements are standardized (Standard EN13319).

It could include the dimensions and nature of the symbols used.

This would provide increased safety and facilitate training. The signs of dives have been standardized, why not for the instrument symbols. (At least for the most important ones)

**Notes:**

- A criticism often expressed is that, if a diver follows the indications of his calculator, he has all the chances of getting out of the water with a limit supersaturation coefficient therefore with a high probability of accident. This is not true. Indeed, with a diving computer, the diver stands at the limit of the safety margin chosen by the manufacturer and not at the limit of the safety itself.

- All manufacturers, taking advantage of the lengthening of variable-level dives, make a compromise between the advantages of this type of dive and the disadvantages of those with a rectangular profile. For this they decrease the critical overload coefficients which increases the safety margins.

- It is easy to see that for dives with a rectangular profile, they usually require longer decompressions than tables (see and compare Figures 16, 17 and 18). (However, one can sometimes doubt theories that propose dives without step which, depending on the models, vary from 9 to 23 min for a depth of 30 meters).

- In practice a computer very often gives shorter decompressions than tables because it is rare for a dive to be perfectly rectangular and the parameters used for the tables not to be rounded up.

- It can be said, however, that with the tables it is the envelope which has been tested, not the sometimes fanciful profiles which are inscribed. What made the tables safer was that they were not often used to the limit of their possibilities.
It should be noted that the effectiveness of a table or a computer, in terms of accident probability is very difficult to establish. We don’t have an effective measurement.

- Each dive with a computer is a new dive but it is added to the previous ones. So we have to use the existing databases that develop over the years. We also have to believe that our researchers and our manufacturers are constantly working to improve our safety, without forgetting that zero risk will never exist because we are all different.

- Some of the above criticisms may be very negative. However, we must point out that most of the problems mentioned here existed with both tables and computers. The disadvantages of computers should lessen or disappear over time. Those of tables no!
- One of the reasons we have stressed some of these disadvantages is that they have a life span of well over 10 years. The first generations will probably stay in circulation for many years. So we have to be careful.

- Contrary to popular belief, knowledge of the basic principles of how computers work makes it possible to better understand that of tables and not the other way around!

- In the field of recreational diving, the study of tables, their use and teaching is less and less necessary.

(Not to say useless)

***Guestbook***

# - TRAINING -

Detailed table of contents

By prerogatives

What if

- Différent computers

- Complete failure of diving computer

- Diver late to ascent

- Présomption of accident

I- n the event of accident

***Theoretical and practical training***
***are the safest means of preventing accidents.***

Given the importance of the development of these devices, training must be done in the same way as was done for the tables, or even more.
Any diver can buy a dive computer or dive with a frame that is equipped with it. Training must therefore be done at all levels.

It must begin with the general rules of decompression. (Decompression with tables is not necessarily a prerequisite except for its history and for special cases as in some cases of technical dives.

For the use of the different diving computers, each instructor will be able, depending on the level, to draw from this book and the manuals concerned the material necessary for the preparation of his courses.

Today, any diver can acquire a diving computer. He must therefore essentially be able to understand the user manual. If there is a problem, the instructors must be able to help them. They must therefore have more in-depth knowledge.

We cannot recommend users to read and reread carefully the instructions provided with each computer.

The training proposed below is, of course, cumulative from one level to the next. It can evolve in the future according to the evolution and the multiplication of the devices.

## By prerogatives

### Level I

Since these divers are always supervised, they do not need extensive training. It will still be good to introduce them to some models of equipment and to explain the main rules applicable to divers. This is so that they understand the instructions of the leader of the palanquee, even if in their beginnings they do not often possess such an instrument.

Level I must be able to interpret the indications of its own apparatus as part of its prerogatives (Alarms - Present and maximum depth - Speed of ascent - basic level - electric autonomy and possibly air autonomy) and comply with daily maintenance rules. (Rinsing, drying, storage and transport)

Despite his device, he must always remember the safety curve without bearings.

### Level II

They have to dive among themselves and use these instruments up to 40 meters. It is desirable that they have a knowledge of the basic principles and know the essential differences with the tables, especially if they have practiced them.

But above all they must be able to configure the different functions and correctly interpret the information given by their own computer, in particular the air management and the necessary margins. They must be familiar with the different risk dives, especially if they are not managed by their own aircraft.

They must be aware of the limitations and risks of their aircraft, be able to maintain the lift-up speed, and maintain a level when using it. In immersion, the instructor will familiarize them with the pre-alarms of speed of ascent and depth ceiling which will have to be perfectly known.

Demonstrations by simulations or in a box may be carried out.

In the event of a breakdown, they must be familiar with the conduct to be followed, depending on the circumstances.

They must follow the instructions for the use and maintenance of their equipment.

### Level III

These divers can dive between themselves in autonomy. However everyone can take responsibility for the group. They must therefore have knowledge of the instructions corresponding to the hoist guide as well as the application of safety margins.

- With different equipment, they must be able to plan the dives. They will need to know the main functions of the devices used by the hoist and the interpretation of the alarms with the conduct to be maintained. They will have to know how to interpret their indications in particular cases. Hence the usefulness of simplified notices with each device.

- They must be able to take the necessary measures when an instrument becomes a permanent alarm following non-compliance with the procedure.

- They need to know how to chain for compass navigation in immersion.

### Level IV (Dive leader)

- They are required to provide coaching as well as teaching placements to become teachers.

- In supervision with the help of their computer, they must be able to safely drive the boat of divers with different computers and sometimes face unforeseen situations.

- To do this, they must have a good knowledge of the basic definitions and general characteristics of the main equipment and be able to interpret the indications and, above all, the alarms of several standard equipment on the market. Always use simplified notices with each device.

**General Remarks:**

- The diver must acquire an intuitive use of his computer according to his evolutions in depth. Initially he will consult him frequently. With experience, he will get used to getting up at the right speed, stabilizing at the right depth, respecting the depth of the bearings and getting an idea of the time spent… But he must remain vigilant.

- Under the pretext of training, frequent ascents should not be abused, the dangers of which were mentioned at the beginning of this chapter.

- Algorithms are often mentioned in dive computers, but no one is trying to define this term. We therefore propose the following simplified definition:Diving rithme is a suite of mathematical and logical calculations which, from the dive parameters, make it possible to deduce a decompression procedure taking into account the average physiological aspect of the diver population.

Using the tables, this is done manually and on demand. Using a dive computer, it is done automatically.

## What if ?

Any diver should have an answer to this question. The subject is wide-ranging and we will develop here only a few questions concerning the use of a computer. In the case of behaviour, a distinction will be made between the conduct to be carried out according to the prerogatives. A palanquin guide will of course have a special role to play.

### A – Different computers in the group

**Prevention:**

Whenever possible, the palanque must be constituted to avoid this. (Compare computers among themselves)

**Behaviour:**

Follow the most restrictive procedure in principle indicated and monitored by the palanquin guide. The palanquin guide for this purpose can possibly harden his device if he has the possibility. (Attention to the bearings and the air reserve)

### B - Complete computer failure

*(Example: white screen, empty batteries)*

**Prevention:**

1) The palanque must remain grouped. (Compare computers with each other)

2) Having a second computer to back up. (With a staggered autonomy)

3) *Using a dive table, watch and depth meter as a backup is not realistic unless the air consumption and the corresponding dive profile are programmed in advance.*

**Behaviour:**

Dans le cas 1) : Partager l'ordinateur d'un binôme en s'assurant que le profil de plongé est le même sinon, prendre les marges nécessaires, voire importantes.

### C) Diver late to ascent

**Prevention:**

The guide must always ensure the homogeneity of the hoist.

**Behaviour:**

After grouping the palanquin together, they perform the steps of the one with the most constraints.

### D - Presumption of accident

**Prévention:**

Record dive parameters and possible alarms.

**Behaviour:**

Monitor the health of the diver and other members of the palanquin if a symptom appears to follow the procedure for an accident.

### E – In the event of an accident

**Behaviour:**

Immediately record the dive parameters and any alarms for the entire boat and follow the procedure. The computer must accompany the victim(s). Always use simplified records with each device.

### QUESTIONS

In order to participate in the training of readers, we offer them to answer some questions. Try to answer them before searching for them. At what level do you place them?

*1) What are the 2 main types of decompression managed by dive computers, pros and cons?*

*2) What is the best position of the transmitter of a dive computer?*

*3) Is the volume of water in the bottle necessary to calculate the autonomy, (Yes / No) why?*

***********************************

# - DIVING COMPUTER MAINTENANCE -



The daily maintenance of the computers is very simple because it is usually a fresh water rinse after each dive.

**Rinsing** (Computers or Compasses)

Its purpose is to remove any trace of salt, sand or other pollutants from the surface and inside of the device.

However, you must avoid sending a pressurized jet through the holes in the strainer of the computer which could damage the sensor.

A soak of one or two minutes is generally sufficient and is recommended rather than a spray rinse. Similarly, we will avoid introducing anything, other than water, into the holes of the strainer. Especially since some sensors are protected by a membrane.

Soaking should be done by shaking the strainer upwards and then downwards to allow the fresh water to rinse thoroughly inside.

Once this is done, we will shake the computer, strainer down to remove the inner water and then dry the outside with a dry cloth or paper towel and then leave it in a dry place.

## Different types of apparatus

- In some cases, the electronics and pressure sensor are embedded in a jelly that transmits pressure to the sensor while electrically insulating the entire surrounding environment. (There is no strainer)
- In others, the electronics and the pressure sensor are embedded in oil separated from the surrounding environment by a membrane.
- Others are waterproof, only the sensitive part of the sensor is in contact with the surrounding environment.

## The strainer

However, these devices have mechanical protection pierced by holes that constitute a strainer that protects the sensor while leaving it in contact with the ambient pressure. It is not good to submit to a jet of water, the tempered is enough.

## The screen

Most devices are equipped with a plastic screen that will not be cleaned with products other than water unless otherwise specified by the manufacturer.
However, there are increasingly strong tempered glass screens that can be scratched easily. The plastic protection will protect them from this type of aggression.

## The bracelet

After and before each dive, it is important to check its mechanical condition. Apart from the loss of a priced aircraft, it could be very dangerous to lose the means of decompression during a dive. Spring bars are the weak points. If one of them breaks, you lose it. Barton bracelets or Nato bracelets are a solution.


***Bracelet Barton***

The principle is to separate the two spring bars from the bracelet itself in such a way that if one of the bars fails, the other holds the computer or watch.

See also the special case of <u>Suunto D6 et D9</u>.

***Suunto D9 adapter and Barton bracelet***

**Battery exchange:** Attention/Care

*The following information is for your personal use and is your sole responsibility. The modifications made and the methods indicated are in no way the responsibility of the author.*

*We would only recommend that you use a device that has been repaired by you after having sufficiently compared it under the same conditions with a similar device guaranteed by its manufacturer.*

*If you do not feel capable, do not hesitate to entrust your device to a professional who will take responsibility for this exchange anyway.*

## General information on battery exchange

We present below the battery replacement on fairly old devices. Today, most dive computers allow you to easily change the battery.

However, a connection failure or end of life of a rechargeable battery may be required. In this case, we hope that the reading of this chapter will be useful to you to carry out this operation or perhaps on the contrary it will make you give up in the face of difficulties.

When on your computer screen you see the "Err" signal, it usually means that the battery is exhausted. Before you get to that point, the device sometimes tells you the remaining battery capacity in %. Unfortunately, the value at which it no longer works is not specified. This can range from 40% to 60%. The major disadvantage of this defect is that it occurs abruptly at the time when we least expect it.

It is difficult to estimate the remaining capacity of a battery. We believe that for most devices on the market, the estimate is based on the voltage value and/or an approximation combined with the operating time, but this is more than random. A sampling measure of the amount of current consumed such as that used to assess the cylinder's air range would be more accurate.

It should also be noted that each time you reset a computer after a battery change, the software considers the new battery to be new and therefore displays 99% available capacity. If it is not new, it may be 80%, for example. Therefore, only new batteries in perfect condition that have been stored for a short time should be used for the change.

It should be noted that lithium batteries have a very low auto-discharge which allows manufacturers to guarantee them for a 10-year storage period without specifying what is the remaining capacity after that time. (Experience shows that there are at least 50%) On products that wear out even when not in use, the date of manufacture or deadline should be clearly indicated.

In this situation, the immediate solution is to return the device to the manufacturer, directly or through one of its agents. But this has 2 disadvantages: You have to wait several weeks to recover it and pay the high price, that is to say of the order of 80 to 100 € all inclusive for a device that is still in good condition.

The advantage is that the manufacturer who makes the battery exchange is supposed to check your device before returning it to you with a new warranty.

The replacement of the battery is a delicate operation, if not impossible and in any case not very compatible with industrial methods. So it happens that the manufacturer prefers to make you a standard exchange with a new newer device for a few hundred euros. (Not very standard this exchange)

We are sharing with you the work we have done over the past few years to save these devices at a lower cost. However, we warn the electronics apprentices against the difficulties of such an operation and the fact that we do not guarantee that it will recover all its performance and especially its initial accuracy, or even its operation.

We have a test box that allows us to check the operation and accuracy of the depth measurement that is already quite good because the sensor is certainly the Achilles heel of these devices. I've had situations where the depth is gone and it's zero. The program is unlikely to change, but you never know.

- *It can never be repeated enough, after this operation, you will have to use it twice during several dives to make sure it works properly.*
- *However, if you do not feel able to do so, entrust this operation to a competent professional.*

To carry out this operation, it is necessary to count one hour of work and to prepare it by ensuring that one has the following means:

### The tooling

- Soldering iron of about 30 watts with 30 cm of tin solder of 1mm.
- Fine blade knife
- Clockmaker screwdriver.
- Tweezers
- Small flat clamp.
- Cutter

### The type of battery

Those that are not likely to be replaced by the user.
- Common models: 3.6 volt, 2.45 A/h lithium battery type LS14500BA or LS14500CNA from SAFT. They have outlet connections that make it easier to connect them. They're the best on the market. Cost 12 euros on average on the Internet. (The first generation was only 2,25A/h today, we find some that make 2,60A/h)

Those that can be replaced by the user.
- Battery button of variable capacity and dimensions with the devices. They keep well in their packaging. It is therefore recommended to have one available in advance.

### Ingredients (As applicable)

- If the battery has no legs, 1/4 drop of hydrochloric acid. Be careful, it is a dangerous product.
- Half a litre of paraffin oil or 90 grams of resin "4441A 3M". (Cost 10 euro) When possible, recover the existing oil.

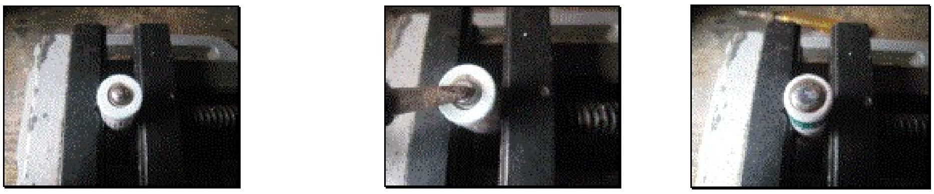
We operated on several different devices that use the same lithium battery.
These are no longer available on the market and sometimes even it is difficult to find a store to proceed with the exchange, however some divers are loyal to them and will appreciate increasing their lifespan by ignoring the performance of new devices:

**Aladin Pro – CX2000 – Monitor 1 et 2 – Monitor 3 air – Aladin Pro Nitrox Monitor 2+ – Aladin AIR X NitrOX (Ces 2 derniers posent problème)**

## I - Aladin Pro et CX2000 de Beuchat

They are characterized by the fact that the battery is in a dry compartment closed by a screw cap, with a seal. The lithium battery is welded to wires that are in this compartment. If the battery has no welding lugs, the difficulty is to make a correct welding.

It is necessary to weld directly on the ends of the battery which is difficult without overheating it. The welds must not exceed 10 seconds on each side. See the welds on the 3 pictures below. (Positive and negative side of the battery)

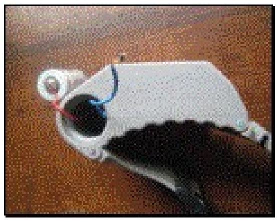


***Positive and negative pole welding***

The solution is to use hydrochloric acid as a paint stripper to seal the ends. (This was the solution used by our grandfathers to seal all kinds of metals) Half a drop of acid is enough. This acid is dangerous to handle, I have not tried others. (After tinning, you must rinse the battery well in fresh water) The quality of the weld is very important.

**Closed**

**Opening**



**Unsoldered**

**Resoldered**

The battery is easy to replace. This is the fifth device I operate. Just un-screw the plug, desolder the old battery and re-solder the new one. Careful not to damage the plastic housing with the soldering iron and not to damage the connecting wires, Red for the most and Blue for the least, First desolder the wire less then pull out the battery completely to have access to the red wire which is on the other side, towards the middle of the compartment

The device resets itself as soon as the battery is welded. However, it has happened to me that it remains indefinitely with all the symbols on or off. I then desoldered it and reset it properly. Care must be taken to close the compartment after cleaning and lubricating the seal.


**Aladin pro ready to use**

**Warning:** The CX2000 then requires a configuration with an interface and a PC to set it to the time and to reset the battery capacity to 100%.

## II – Monitor 1 et 2

In these first-generation computers, the procedure is similar. The housing is made of transparent macrolon. The battery and electronics are drowned in "Removable resin" which has the particularity of adhering to all kinds of materials by preventing any infiltration of water. In addition, it retains a great deal of flexibility to convey pressure. The electronics and the battery are separated by a partition which allows to intervene independently on one or the other.

The product is in the form of two components: the resin is very clear, the hardener is light yellow. They come in 2 separate plastic pockets. For my part, I have transferred them into 25-centimetre glass bottles and I have kept them like this for 15 years. To order in small quantities, indicate the reference "4441A 3M". The "A" means 90 grams. It must also be said that there is a new version that bears the reference "Scotchcast 8882A 3M - High Gel" and that must be equivalent although we have not tried it. Other removable resin: I used a soft RTV Silicone (GE RTV-6126)

**Procedure**

1 - Remove the rubber cover that covers the computer and then the black plate on the back.

2 - With a cutter, cut the jelly that covers the pile to release it. Be careful not to touch the blue and red wires connecting to the battery.

3 - With a small screwdriver lever, release the battery starting with the most. (Red wire side)

4 - Desolder the battery with the soldering iron.

5 - Clean the battery housing perfectly. Finish cleaning with alcohol.

6 - Strip the ends of the pile with a drop of hydrochloric acid after having ground them with sandpaper. Seal the ends of the pile with tin solder. (*It is still better to use a battery with connections*)

7 - Solder the connecting wires, the most to the **red** wire the least to the **blue** wire. Do not pull on these wires.

8 - Check operation of the computer by wet contacts. Pressing the jelly at the pressure sensor should increase the depth.

9 - Prepare 2 cubic centimeters of jelly in a small glass, 50% resin, 50% hardener.

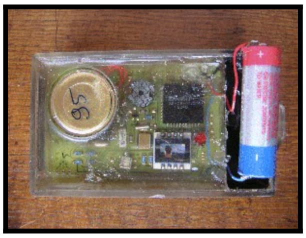
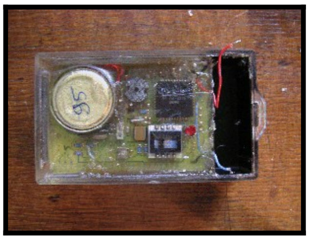
10 - Mix the two components thoroughly for at least 5 minutes. Do not whisk the mixture to avoid bubbling. The liquid must be clear.

11 - Lift the pile to pour the jelly to half the housing.

12 - Push the battery into the mixture as deeply as possible.

13 - Replenish the jelly so that it reaches the shoulder of the case.

14 - Push the wires in to make sure they are covered properly. Do not force.
15 - Wait at least 12 hours for the jelly to polymerize without touching it. The rest in the glass can be used as a control.
16 - Cover the jelly with a transparent plastic sheet to avoid sticking to the lid.
17 - Reassemble the black cover from the bottom of the computer and then the rubber cover.

**Remove the battery** **Clean** **Pour** **Up**

## III - Monitor 2+

I had the opportunity to change the battery of this computer, and then I realized that it was having problems. I then looked for and found a recall (Recall) which, with good reason, strongly advised against using it and proposed an exchange for another model.

**IMPORTANT RECALL**

**MONITOR 2 PLUS Dive Computer Notice:**

If you own or use a MONITOR 2 PLUS, a UWATEC-manufactured diving computer marketed since 1995 by LA SPIROTECHNIQUE, please:

IMPERATIVELY stop using it and return it WITHOUT DELAY to the point of sale where you purchased it, your device may have malfunctions.

## IV - Monitor 3 air

This unit has a wireless connection for air management. A friend gave it to me so I could try to get it back when it had not worked for over a year.

**- Computer battery**
The opening of the housing is quite simple since you just need to unscrew the 3 screws on the back of the housing. Then, lift this side with a screwdriver until the clips on the opposite side are dislodged.

It is then necessary to operate above a container wide enough to recover the oil and in any case not to spread it everywhere. Carefully remove the neoprene membrane with a blunt tip, taking care not to damage it. Allow the appliance to drain for some time to work dry.

Remove the old battery. To do this, use a small flat and thin screwdriver, diameter 3 mm, engage it between the leg and the body of the battery and turn it on itself to blow up the welds. Be careful not to damage nearby components.

You may also prefer to use a cutter to cut the paw. See the following 3 figures a – b – c. Keep and straighten the remains of legs on each side once the battery is removed. (Note that the message "Err" has disappeared)

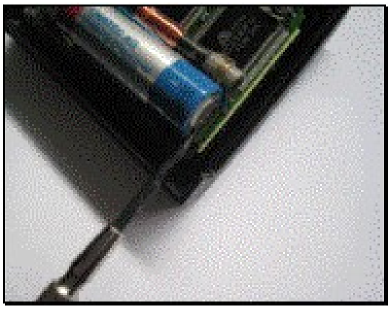


**Photo a**

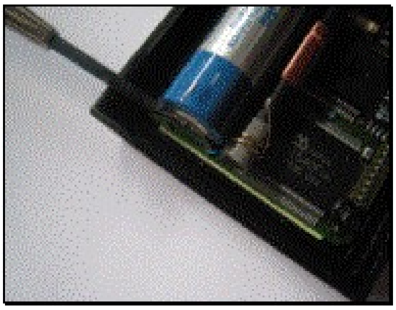


**Photo b**

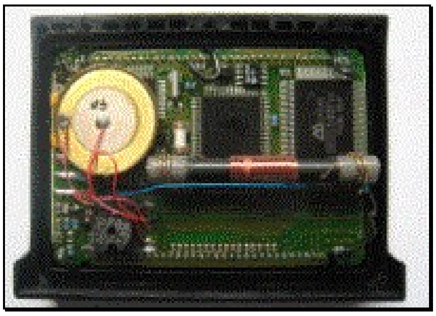
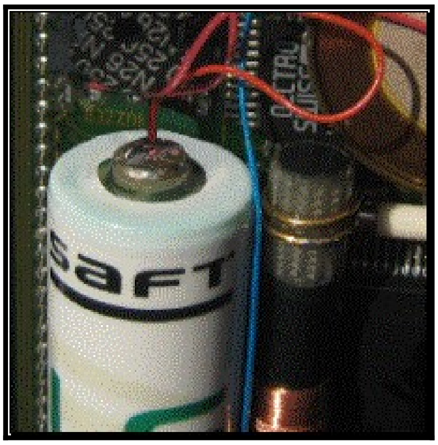


**Photo c**

Then the new pile as described above. Also build the remaining legs of the old pile. Position the new battery with careful attention to polarities. They are indicated on the battery and on the computer's PCB.

**Welding the negative**



**Welding the positive**

Do not confuse with the "+" stamped on the circuit. Then solder the legs on the pile on each side, being careful not to touch the plastic housing with the soldering iron. We then see that the message "Err" has returned.

**99% battery**

**Ready to dive**

Like the Monitor2+, this device, once connected, requires a «Reset». The purpose of this is to restart the operation of the device, to put the battery to 99% of its capacity and to verify that all segments of the screen work correctly. Installing a battery that is not new would be dangerous because the device would show 99% capacity higher than its actual value.

A 3-volt button battery is used, the least of which is connected to the wet contact pierced by a hole at the top right of the screen. Then “scratch” with the wettest contact of a hole in the bottom left. After a few seconds, the "Err" signal disappears and is replaced for 3 seconds by all the signals on the screen.

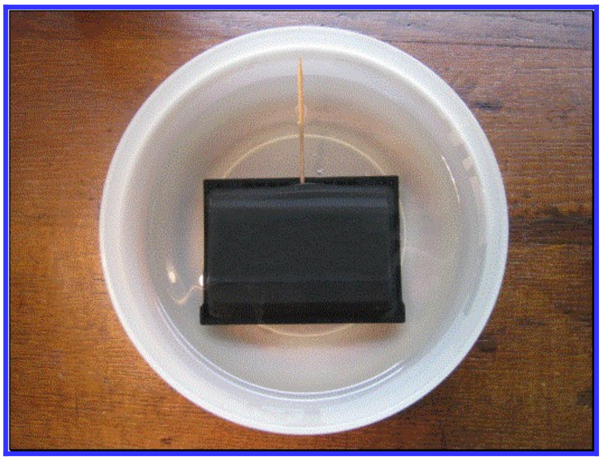
Finally, appears the ready-to-dive signal consisting of 3 small horizontal lines in front of «Depth» and 0 in front of «Time». It should be noted that the wet contacts drilled with holes are those used to transfer the characteristics of the dive to a PC. After a few minutes, the computer goes to standby, white screen.

By touching the right wet contacts, the aircraft restarts and should be seen as in photo 13: Ready to dive.

Oil filling: It is easier to remove the bracelet for this operation. To do this drive out the pins by pressing on the smaller diameter side with a lower diameter tip.

The operation requires a large enough tank. Immerse the different parts of the device together. Shake long enough to flush out any air bubbles. The membrane will be pla-ced well filled with oil. The housing will be closed in immersion.

To facilitate the elimination of bubbles, we leave a space in the membrane that is partially opened by a toothpick and we pump by pressing on the membrane, with the orifice facing upwards.



***Monitor III in oil tank with purge toothpick***

Before the membrane is fully closed, it should be pressed slightly to make it curved inwards. Otherwise, once the internal pressure is closed, there is a risk of a few metres above the surface.

### - Transmitter battery

We have not yet completed this operation completely. Nevertheless, we opened an transmitter that was considered dead.

First, unscrew the 3 screws that close the housing above a tank and recover the oil. Then separate the stainless steel part from the plastic part. This comes easily but there is a high risk of breaking the connecting wires at the bottom of the winding. These wires are only 1/10th of mm. We didn't go any further.

We assume that they are long enough to be desoldered without breaking them unless the winding is welded and then pushed to the bottom of the case during assembly. We simply managed to extend the existing wires to analyze the operation.

## V - Aladin pro NitrOX

The procedure is similar to that of the Monitor 3 air. Pay attention to the quality of the welds. The essential difference concerns the opening of the housing. Indeed, the upper part is not screwed but clipped to the lower part.

To separate them, use a thin blade that is gently engaged along the side cheeks. Be careful, some devices seem to have a glue point. We risk breaking the case.

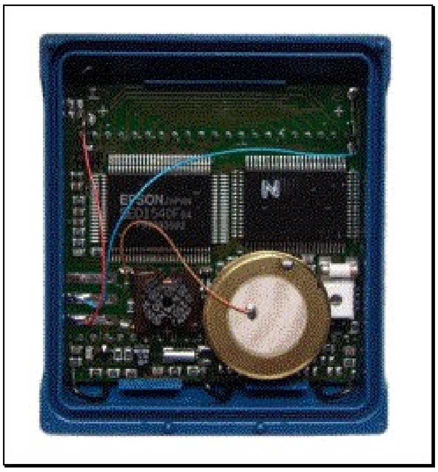


**Photo 15**

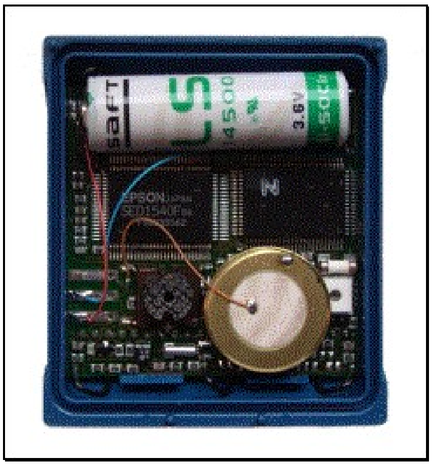


**Photo 16**

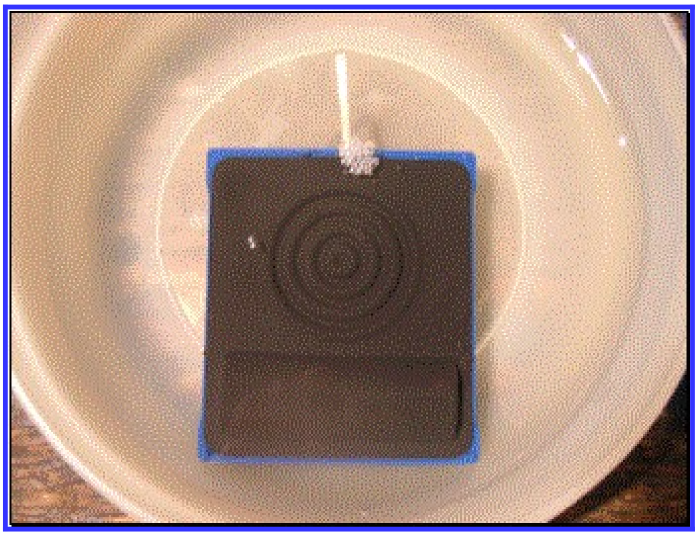
Extra care must always be taken to avoid touching the housing with the soldering iron when soldering the legs on the battery.

## Reset:

A 3-volt button battery is used, the least of which is connected to the wet contact pierced by a hole at the top right of the screen. Then “scratch” with the wettest contact of a hole in the bottom left. After a few seconds, the "Err" signal disappears and is replaced for 3 seconds by all the signals on the screen.

Finally, appears the ready-to-dive signal consisting of 3 small horizontal lines in front of depth and 0 in front of Dive Time. It should be noted that the wet contacts drilled with holes are those used to transfer the characteristics of the dive to a PC.

If "Err" has faded and the screen remains white, it is necessary to continue to grate until all the segments turn on and off.



***Removing air bubbles***

You can then start the computer by touching the contacts "E" and ""B" with wet fingers. The battery capacity percentage display always shows 99% regardless of the state of the battery used.

Then immerse the appliance in the oil, with a toothpick to let out the bubbles. Photo 17 above shows the small bubbles coming out of the device at the end of the pump by repeated supports on the membrane.
We must insist that there are no more bubbles. Otherwise, a bubble may appear on the screen. (In the photo, the bubbles are distinguished near the tip of the toothpick)

After clipping the underside of the case, I do a box test at 40 meters, 9 minutes at the bottom. This requires a 2 minute bearing at 3 meters. At the ascent, every 3 meters, there is only 1 minute of landing left. Exit of the water after 18 minutes of total dive time.

## VI – Suunto D6 - D9

- The battery change is quite easy, provided you have the necessary tool to open the case and get the kit including the battery and the gasket that you have to change each time.

- Changing the bracelet is not difficult, but the bracelet must be purchased and the 2 screws must also be replaced each time.

The polymer bracelet has a limited lifespan. I am the fifth replacement in 14 years. It breaks down with time and manipulation. There is a great risk of losing the computer.


***Suunto D9 Bracelet, Breakup Starts***

There are adapters manufactured under the name of «Tibby-adapters» by the company «Sphere Diving Systems». They make it possible to replace the straps of the D9 and D6 computers by models with spring bars without risk of losing everything.

Nevertheless, one may wonder why some manufacturers still use bracelets with spring bars.

## VII – Aladin AIRX NitrOX

*Although I have already operated two of them, I must consider that it is too delicate and that it is dangerous to try this operation without risk for the computer and therefore for its user. So I removed the exchange of its batteries from my site. I consider it a non-repairable device even by the manufacturer.*

*It has been replaced by the Aladin AIR Z which makes it easier to change the battery.*

****************************************

***Livre d'or***

XiTi

# - CHOICE OF DIVE COMPUTER -

## Detailed table of contents



The investment that constitutes a diving computer is far from negligible and the diver has every interest not to be mistaken in choosing the device that best suits him. The ideal does not exist, it will be led to make compromises: price, qualities, defects. There are currently around thirty models on the market, ranging from 200 to 2000 euros.

For divers who are still used to the tables, the choice is important because it changes their behaviour a lot. This should not increase their likelihood of an accident. It should always be lower than what the tables provided.

### Different categories

They can be classified into 2 main categories characterized by the way they treat decompression and successive dives:

1) Those that allow decompression within the limits allowed in sports diving. They are better suited to how to dive in Europe. Their limits are very wide; they should therefore only be used by divers confirmed in their prerogatives. Today they correspond to a first purchase.
Whatever some literature says, they should not be used for more than one successive decompression dive as long as advances in physiology do not allow it. They were sometimes called "Pro. Examples: the ALADIN AIR Z of UWATEC - the MARES SURVEYOR - the VYPER of SUUNTO - the BEUCHAT CX 2000 -

2) Those which allow the dives to mixtures or even multi gas. These are specialized apparatus which require special training. Examples: the ALADIN PRO from UWATEC - the SURVEYOR NITROX from MARES - the VYPER and VYTEC from SUUNTO but also the new ones that appear every year.

To this distribution, the ranking according to their degree of automation with regard to the consideration of variations in altitude and management of the air reserve must be added.
In addition to these decompression-related features, the potential buyer will need to consider all other functions

## Guidance from major manufacturers

These mainly concern "high-end" appliances. Over the years, it has become clear that new possibilities are emerging, while the lower end is gradually taking advantage of innovations. (As for motor vehicles)

The major brands on the French market are: UWATEC, SUUNTO, MARES, OCEANIC, CRESSI, DIVE RITE, BEUCHAT…

## Qualities to look for

You will not find them all simultaneously on the same device.

- Calculation of the autonomy of air or in breathable mixtures;
- Precise calculation of the electric range;
- Loud sound alarms;
- Ease of use and interpretation;
- Wide screen easy to read without ambiguity;
- Automatic altitude tracking;
- Manual choice of safety margins;
- Rapid sampling;
- Registration and retrieval of profiles
- Reliability (Inquire from other owners and sellers);
- Complete documentation and especially summary usage sheet;
- User changes batteries.

## Defects to be avoided

- writing or symbols that are too small (see Figure 1); small devices are not necessarily the most interesting;
- limits on restrictive uses;
- risk of error when jumping into the water;
- periodically alternating displays in immersion;
- surface controls too difficult to execute with bare hands or gloves;
- no duration of the next step (except in continuous decompression);
- complete decommissioning in the event of a definitive alarm.

*These defects fortunately begin to disappear.*

## Technical characteristics

These are the main features that we would like to find in the leaflet. The values given here, by way of example, are those that we would like at least. Please refer to the comparative tables of the specialised press for the detailed characteristics of the various devices on the market.

1. Maximum depth limit ...........……...75 metres *
2. Total lift time limit .....……………….....20 minutes *
3. Memory capacity...................……...30 dives or 15 hours.
4. Minimum altitude ..............................2500 meters
5. Immersion / Emersion Thresholds…...1 metre
6. Precision in immersion........................0,3 m + 1%
7. Resolution..........................................0.1 metres
8. Operating temperature.......................…-5 to +40°C
9. Storage temperature............……...…20 to +70°C
10. Electric autonomy..............…….........>200 dives or 1000 Hours
11. Power reserve ................……………10 dives or 24 hours, alarm is displayed.
12. Sound alarm level ........……………..…Audible at 2 meters (With hood)
13. Sampling period...............……..……1 second immersion 10 min in air

* As with any measuring device, the limits must be at least one and one-half times the normal operating range.

## Instrument and divers vision

You must choose a device that is easy to read. Nevertheless, too many divers, or even instructors for financial reasons or for coquetry, do not wear masks with corrective lenses. It’s as important an element of safety as the instruments themselves.

Figure 1 below can give you an idea of the quality of your vision.
(But only a practitioner can give you an authorized opinion)

*As a reference, "The Monitor 3" must be 9 cm wide to adjust if necessary with your zoom.*

*If, at a distance of 50 centimetres, you cannot read the screens of the above devices, you must have your sight tested.*

A vision test could therefore be included in the diving fitness visit. The same applies, of course, to the acoustic acuity of sound alarms.

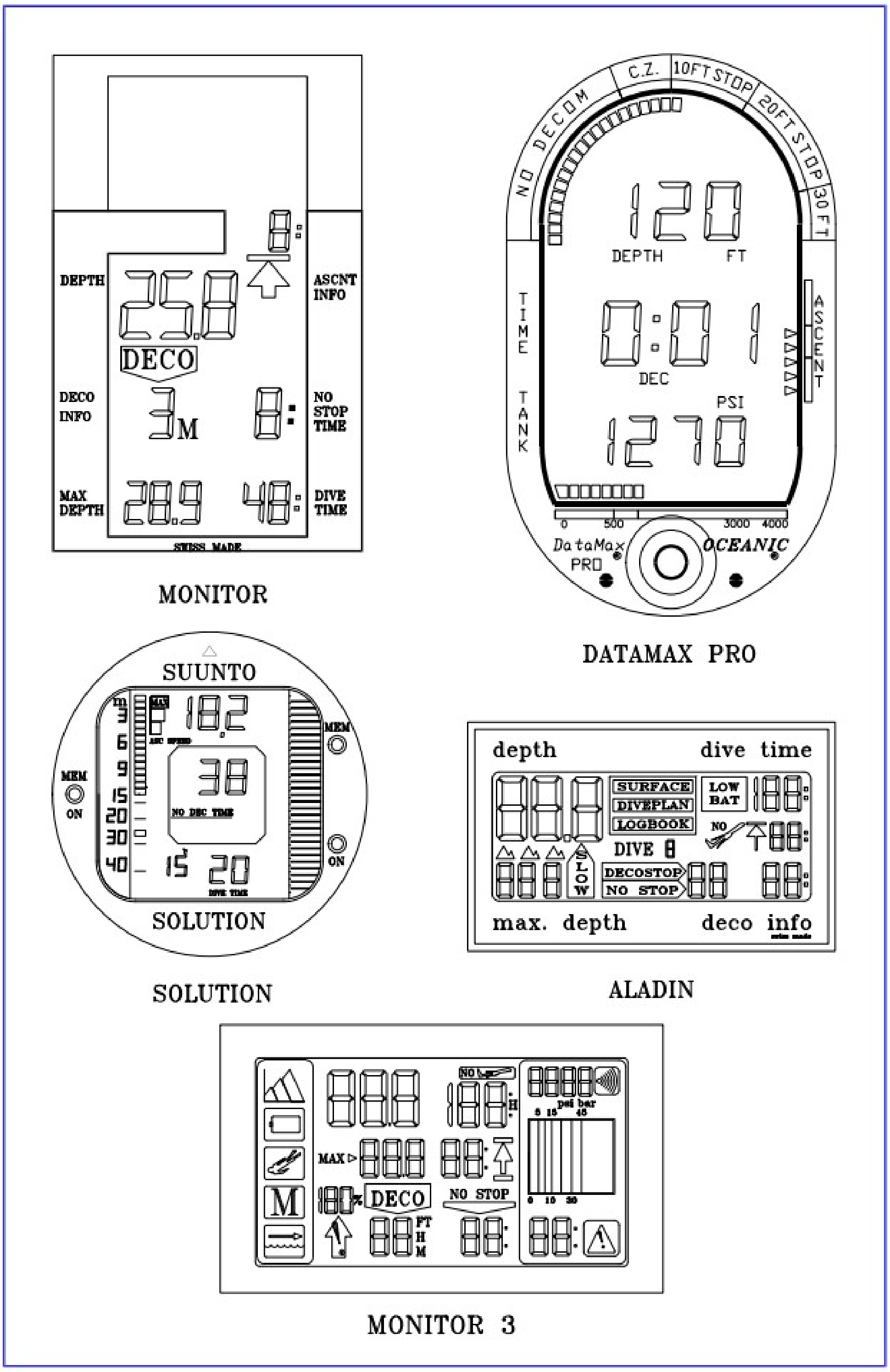



Figure 01 ***Instrumentation and divers vision***

## Reading in the mask

In this regard, it is worth noting that Océanic released in 2006 a computer embedded in the mask which facilitates reading at any time.

(This is done at the expense of a slight loss of the right eye angle, down)

***Display in a mask***
***See also Scubapro HUD***

## ***Guestbook***

# - BRIEF PHYSIOLOGICAL REMINDERS -
# AND THE RISKS INVOLVED

**Detailes table of contents**



**Remarks:**

*The simplified way in which physiology is presented here is only intended to explain how it intervenes in the design of diving computers.*

*The study of decompression is very complex and specialist. The story is ancient and not ready to end.*

*On this subject, we will read the dissertation of instructor of Bernard Shittly*
*http://ffessm67.free.fr/technique/memoiresIR/LaDecompression.BernardSchittly.pdf (french)*

Decompression should not be confused with the tools used to calculate it. (What are computers and different tables) The latter were only a worse gone before the existence of computers. It should be noted, however, that in some special cases tables may still be useful.

## Physiological models

At least in theory, the organism is considered to consist of a number of tissues and compartments *. These are loaded with nitrogen, logarithmically when the partial pressure of the gas imposed on them increases. (And not exponential as we sometimes hear it said) They unload, conversely when it decreases.

The dissolved nitrogen voltage in a compartment is given by the well-known mathematical formula:

$$T_{N2} = T_0 + (P - T_0)(1 - 0{,}5^{t/T})$$

Where: $T_0$ is the initial partial nitrogen voltage in the compartment.

P is the partial free nitrogen pressure imposed on the compartment.

T is the period of the sub-fund.

t is the time variable.

When $P > T_0$ it is said that there is under saturation.

When $P = T_0$ it is said that there is saturation.

When $P < T_0$ is said to be over saturation.

To simplify the writing, by replacing, $(P - T_0)(1 - 0.5^{t/T})$ by TN2 this formula becomes:

$$T_{N2} = T_0 + \Delta T_{N2}$$

Do not confuse $T_{N2}$, $T_0$ and $\Delta T_{N2}$, which are dissolved gas voltages, with T or t which are times.

* Tissues are separate parts of the body while compartments are a set of tissues with the same saturation and desaturation characteristics.

Each compartment is a theoretical concept characterized by two values: its period "T " which is the time necessary for its nitrogen voltage to vary by half of the pressure variation to which it is subjected and its critical supersaturation coefficient "Sc" which is the tolerable ratio between the dissolved nitrogen pressure and the ambient absolute pressure. Beyond this the probability of accident increases sharply.

These two values make it possible to calculate the minimum value of the tolerated absolute pressure.

$$\textbf{Absolute tolerated pressure} = \frac{T_{N2}}{S_C}$$

### Haldane model

These considerations constitute a model whose principle was stated as early as 1907 by John Scott HALDANE. It subsequently served as the base of departure for most others. For your information, we give below the periods and the critical overload coefficients chosen for the calculation of the MN90 tables of the French National Navy (J.L. MELIET).

*These tables were adopted by FFESSM upon their release.*

(Ascent speed: 17 meters per minute)

| Compartment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *T* (min) | 5 | 7 | 10 | 15 | 20 | 30 | 40 | 50 | 60 | 80 | 100 | 120 |
| *Sc* | 2,72 | 2,54 | 2,38 | 2,20 | 2,04 | 1,82 | 1,68 | 1,61 | 1,58 | 1,56 | 1,55 | 1,54 |

.

### U.S. Navy model

It does not use a Sc coefficient but a "M" value which is the maximum tension that a tissue can tolerate before going to a given bearing. M0 is the value of "M" that allows the compartment to reach the surface, M1 is the one that allows it to reach 6 meters …

The following table gives the values of M0 expressed in FSW (Feet of Sea Water) and MEM (Meters of Sea Water) according to the periods of the compartments. This model was used for the US Navy tables and by most American organizations as well as by the Belgian LIFRAS.

(Ascent speed: 18 meters per minute)

| Compartment | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| *T* (min) | 5 | 10 | 20 | 40 | 80 | 120 |
| *M0 (FSW)* | 104 | 88 | 72 | 56 | 54 | 52 |
| *M0 (MEM)* | 32 | 27 | 22 | 17 | 17 | 16 |

.

Nota: FSW are commonly used by Americans to define pressures. MEM is sometimes used in France by some specialists. Therefore, they should not be confused with depths.
The Naval Medical Research Institute (NMRI) studied a new decompression model based on accident probability from existing databases. It is used for the new US Navy tables and is applicable to diving computers.

### Bühlmann model

It was developed especially for diving at all altitudes. It uses a supersaturation coefficient defined by two variables, one "a" varies with the ambient pressure, the other "b" is a coefficient. The absolute tolerated pressure is:

$$\textit{Absolute tolerated pressure} \geq (T_{N2} - a) \times b$$

The table below gives these two variables according to the period of the compartments. It was used in the elaboration of the tables adopted by the Swiss Federation. It is commonly used in a large number of dive calculators.

*(Ascent speed: 10 meters per minute)*

| Compartiment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T (min) | 4 | 6 | 12,5 | 18,5 | 27 | 38,3 | 54,3 | 77 | 109 | 146 | 187 | 209 | 305 | 390 | 498 | 635 |
| *a* | 1,90 | 1,45 | 1,03 | ,882 | ,717 | ,575 | ,468 | ,441 | ,415 | ,416 | ,369 | ,369 | ,255 | ,255 | ,255 | ,255 |
| *b* | 0,80 | ,800 | ,800 | ,826 | ,845 | ,860 | ,870 | ,903 | ,908 | ,939 | ,946 | ,946 | ,962 | ,962 | ,962 | ,962 |

### DCIEM model

*(Defence and Civil Institute of Environmental Medicine).*
It was developed by Canadians for sport diving. It's one of the toughest. It takes into account in particular successive dives and lift dives.

We will see later that these different models, derived from the tables, can be chosen as the basis of calculation in the dive computers. However, in this case, they always undergo adaptations and evolve regularly with the progress of physiology.

The Workmann model was modified by Spencer and then by Rogers. Bühlmann, implemented for the Aladin computers by Ernst Wollm and Marcus Mock, went from ZH12 in 1960 to ZH16 and then to ZH-8 ADT in 1993…

The periods of the compartments used are generally communicated by the manufacturers; on the other hand, the associated real coefficients and the corrections used are rarely known. The latest models are designed to prevent neurological and joint accidents. They take into account phenomena which considerably alter gas exchanges.

**Remarks:**

- Mathematical models have significantly improved the diving accidents. prevention
- Nevertheless, they are only models with limits that depend on many factors. They are still improving but are still the subject of much debate.
- There is no model that can be adapted to each individual.
- Some manufacturers adapt these models taking into account the temperature or heart rate of each diver.
- Are there other tracks not yet used? For example, monitoring blood oxygen saturation: before, during and after a dive. Is this significant? Are existing devices usable?

## Neurological accidents

The Haldane model took into account the dissolved phase of gases up to the time of their transition to the gas phase and assumed that accidents only occurred when bubbles appeared in the body.

### Micro-bubbles and bubbles

The most recent theories consider that micro-bubbles or gaseous nuclei, serve as relays to the production of bubbles. These micro-bubbles, occur permanently in the body by cavitation in the heart or by rubbing in the blood vessels.

As the name suggests, they have a diameter of a few microns. They do not obey Mariotte’s law. They feed on the surrounding nitrogen. Their service life is a few milliseconds when the ambient pressure is stable. They circulate freely, in the venous circulation, without being pathogenic.

As a result of an ascent, when the pressure decreases, their lifespan increases and, by moving from the capillaries to the lungs, they have time to grow, regroup, turn into bubbles, and become pathogenic in the final phase of the dive.

To avoid or in any case reduce this phenomenon, today’s specialists recommend making steps deeper than those usually indicated by the tables. Thus the micro-bubbles, which have a low lifespan, disappear before they can grow. (This is a matter of debate)

The calculation of these new bearings is not yet complete but we know that their depth must be around half the difference between the maximum depth and the first step recommended by the tables.

Example: You dive at 50 meters, according to the tables, you must make a landing at 6 meters. You will perform a deeper first step at 22 meters of 2 to 3 minutes. This, of course, is empirical. We look forward to numbers that would be reliable.

### Action on desaturation

During desaturation and especially during the surface interval, these bubbles clog the lung filter, reduce its performance and thus slow down the desaturation. This is no longer logarithmic. Thalman’s mathematical model introduces a linear desaturation, to account for this phenomenon.

#### Pulmonary shunt

Another, more serious consequence is that these bubbles can force the pulmonary filter to pass directly into the arterial circulation, hence the name "Pulmonary Shunt" given to this phenomenon. For example, after a rapid ascent, the lungs become engorged by an influx of bubbles. If we go down, the diameter of the bubbles is reduced, which allows them to pass through the pulmonary capillaries and end up in the arterial circulation where they are distributed randomly.

At the next rise, these bubbles grow, and can cause a neurological accident. It is therefore necessary to go down deep enough and long enough to dissolve these bubbles. Hence the rule used with the tables, to go down to half depth for at least 5 minutes, after a disaster ascent.

#### Cardiac shunt

In a number of individuals (estimated at 30% of the population) a passage exists between the right and left cavities of the heart. Micro-bubbles can pass through with venous blood. During the following ascent, bubbles can develop in the arterial circulation and cause a neurological accident.

#### Diving like elevator

We have seen that every time a diver goes up, the number and diameter of bubbles increase as well as their lifespan. They can then reach a critical size, beyond which they are more difficult to resolve even if we go down.

A diver, after having climbed several times, even at normal speed, will thus find himself with more bubbles at the last ascent, than if he had spent all the time at the maximum depth.

The closer you are to the end of the dive, the greater the risk. Dive computers that do not manage this kind of profiles, can thus behave like real "bubble pumps" according to successive descents and ascents.

Max H. Hahn, who died in June 2000, had created a model in which each metre of ascent introduced a penalty depending on the time of the dive where one had gone up.

A particularly dangerous situation is the recovery of the anchor a few minutes after the dive. Even at normal ascent speed, the micro-bubbles produced during the second ascent cumulate with those of the first and slow down desaturation.

### Ascent rate

We have just seen that the speed of ascent was decisive in the evolution of micro-bubbles. However, even going up slowly does not eliminate the risk of accidents. Indeed, the filter formed by the lungs is not perfect and a small amount of bubbles can always, after not being able to cross the wall of the alveoli, end up in the arterial circulation. The probability of an accident is therefore never zero.

**Remarks:**

The ideal speed is that for which micro-bubbles resolve spontaneously without developing. This is why in many aircraft very slow speeds were chosen, especially in the vicinity of the surface. However, beyond 20 metres per minute it is essential to apply a safety procedure.

The slower the speed, the more difficult it is to comply with without a measuring device; some specialists consider that we can go up to 17 m/min even if we have to make an additional stop of a few minutes to 3 meters. Its effectiveness in reducing micro-bubbles has been proven.

Others prefer to impose a variable speed, the slower one approaches the surface. This reduces saturation, reduces air consumption, and avoids the cold and stress of depth. This solution tends to spread but is however challenged by the deep tiers.

A good precaution is to go up slowly and, whenever possible, to make a final landing from a few minutes to 3 meters even if there is no landing to make.

One of the roles of dive computers is to control the evolution of micro-bubbles to prevent them from turning into bubbles.

### Joint accident

When a sufficient amount of nitrogen has been accumulated in a tissue and the ambient pressure decreases below a certain value, the micro-bubbles in the tissue turn into bubbles, they may be blocked and give rise to a joint accident.

They can also cause the accumulation of micro-lesions that over time lead to significant joint necrosis. The occurrence of this type of accident depends on both the nitrogen load of the tissue under consideration and the rate of recovery.

It was primarily for this type of accident that the dive tables were originally designed. As in the Type I accident, there is no threshold below the rate of climb. As long as you go beyond a ceiling depth, you risk an accident.

When the decompression rules are not respected, the bubbles can appear and circulate for a certain time, without giving any symptoms: they are then called "silent". However, these bubbles can, at any time, "get stuck" anywhere and become pathogenic.

Therefore, even if an error does not result in an accident immediately, it must be recorded and remain reported in a visual or audible manner to prompt the diver to take appropriate preventive action.

This obviously does not prevent bubbles from appearing spontaneously and abruptly in the event of a significant decompression error.

### The cold

At the beginning of the dive the peripheral tissues load, like the others, in nitrogen depending on the pressure, the depth and their characteristics. But when the temperature decreases, usually at the end of the dive, their infusion decreases in favor of the central tissues.

Their desaturation is slowed down while the critical overload coefficient of the corresponding compartment decreases. These phenomena increase the risk of bubbles developing and an accident occurring there. The temperature must therefore be taken into account when decompressing.

### The efforts during the dive

When the diver makes efforts during the dive the infusion of the muscles concerned increases. They therefore load more nitrogen than if they were resting. During the ascent and especially during the decompression, the infusion of these muscles becomes normal again. This results in an increase in the duration of desaturation and a decrease in their critical overload coefficient.

Most diving tables and computers for recreational diving take into account average diver work. But they neglect the important efforts he may have to make in certain circumstances.

## The altitude

From the Haldane model, it is possible to calculate the decompression according to the pressure variations related to the altitude. In fact, here too, physiological changes appear, for example the variation of partial pressure of oxygen in the alveoli according to the presence of water vapour.

This can lead to the need for profound changes in decompression especially beyond 3000 meters (Le Péchon). Changes in the safety coefficients must therefore be introduced depending on the altitude.

It should be noted that a descent, after a stay in altitude, causes desaturation while after a stay at sea level, a climb in altitude causes an oversaturation. It is enough to climb a few hundred meters after a dive to cause an accident.

## The risk factors

The phenomena described above can be the cause of many accidents as they greatly increase the probability, but they are not the only ones. We have put together some of the best known ones in a non-exhaustive list.

For educational reasons we call them "Risk factors" but they are also called: "*Contributing factors*", "*Cofactors*", "*Aggravating factors*".

These are:

- cold;
- fatigue;
- physical efforts in depth;
- lack of training or poor physical condition;
- successive dives;
- repeated dives without periodic rest;
- lift dive profiles;
- sunburn;
- age;
- obesity;
- history of diving accidents or incidents;
- medical history such as cholesterol and hypoglycemia;
- dehydration;
- poor nutrition;
- taking certain medicines;
- abuse of alcohol;
- tobacco abuse;
- stress;
- poor psychological conditions;
- defective respiratory equipment;

- altitude (hypoxia and mountain sickness above 3000 m).

These factors occur: some by the accumulation of micro-bubbles, others by modifying the volume and breathing rate, the heart rate or the perfusion of tissues. The security margins of tables or computers only partially take them into account. Each of these elements is generally not enough to cause an accident.

However, the combination of 2 or 3 of them can be decisive, especially since, in some cases, their effects are not added, they multiply. (Example: alcohol and drugs)

Looking at the list above, it can be noted that regardless of the computer or tables used, diver behaviour is the primary risk factor. (Bernard Schittly)

## The latency time

As a result of an error, the bubbles produced can be resorbed by re-compression. The diver has some time to eliminate them by re-compressing. Beyond that, if the conditions that gave them birth persist, they surround themselves with blood platelets that isolate them from the environment.

In this case, the elimination of the gas they contain no longer obeys logarithmic laws but poorly known laws, much more complex.

This leads to phenomena, which are difficult to reverse, which maintain themselves. The Decompression Accident (DBA) is transformed and treated as a real disease. That’s why it’s called "Decompression Disease" or MDD.

It is commonly accepted that the time available before the accident occurs is a few minutes. It is this time, known as "latency", that allows the diver to avoid the consequences of certain mistakes. It will be recalled that with the tables, we can tolerate three minutes on the surface after a rapid ascent.

In professional diving, so-called surface decompression makes extensive and efficient use of latency time. The divers at the end of their dive go directly to the surface, desquip before entering the caisson where they are compressed to perform their decompression well dry.

Of course, we must not allow ourselves to be abused, but, remember, after a short error, we have some time to avoid an accident. Computers also exploit this possibility and do not go into "definitive alarm" after a few minutes. So that’s an important feature of these devices.

## Oxygène toxicity

Diving is increasingly oriented towards the use of over-oxygenated mixtures called "Surox" in France and "Nitrox" in Anglo-Saxon countries. But oxygen is toxic based on partial pressure and exposure time.

### Paul BERT effect

It is called Central Nervous System toxicity "CNS" by Americans. It affects the nervous system. Toxicity appears after a latency time that may be zero or a few tens of minutes depending on the partial pressure of oxygen. This time, relatively stable from one individual to another, varies according to temperature, effort, immersion, etc.

Toxicity results in a generalized seizure called a hyperoxic seizure. It can occur very quickly beyond a partial pressure of 1.6 bar. It should never be exceeded. If, in immersion, the subject is not immediately removed from hyperoxia, he risks death by drowning.

| $P_PO_2$ | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 | 1,6 | >1,6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| minute | 720 | 570 | 450 | 360 | 300 | 240 | 210 | 180 | 150 | 120 | 45 | 0 |

In 1990, the U.S. N.O.A.A. (National Oceanographic and Atmospheric Association) created a standard that recommends exposure limits not to be exceeded. The table above gives the values as a function of partial oxygen pressure for single dives. A cumulative effect must also be considered for successive dives.

### Lorrain SMITH effect

It affects the lung system. Toxicity also appears there after a latency time, but this may be a few hours or a few tens of hours after partial oxygen pressure. Symptoms can range from a simple cough, to broncho-pneumonia, for extended durations.

This was the case for some Soviet cosmonauts subjected to breathing O2. These symptoms are reversible after returning to normoxia. It is unlikely that this type of accident will happen to sports divers. Nevertheless, it is conceivable that it occurs in the case of repetitive dives, very long using recyclers for example or, in underwater dwellings.

The amount of $O_2$ absorbed is translated into OTU (Oxygen Toxicity Unit) which is the product of $PP_{O2}$ , time and a correction coefficient Kp. This allows for the non-linear variation in toxicity with $PP_{O2}$. This data is used in some devices manufactured by COCHRAN and SUUNTO.

It is generally assumed that the dose of O2 not to be exceeded is 400 O.T.U. For example, a diver using a 40% O2 mixture and performing a 60 min to 30 m dive accumulates 185 O.T.U.

The amount of admissible oxygen can also be translated into OLI, "Oxygen Limit Index", which translates the amount of oxygen that can be accumulated by taking into account variable profiles, intervals and successive dives.

This is based on a mathematical model developed by Bill Hamilton and Randy Bohrer and used in the Nitrox computer "BRIDGE II from Orca. Nitrox Dive Computers must calculate the absorption and elimination of O2 as they do for N2 but with different parameters.

**Sumary:**

- Generally speaking, contrary to the old theories, the desaturation of compartments does not follow a logarithmic law reproducible and easy to equate.
- It is essential to adapt the mathematical models for dive computers to take into account risk factors, the presence of micro-bubbles, temperature, diver forces and partial oxygen pressure.
- The diver has a grace period to make up for his mistakes, but he must not abuse them.
- The use of oxygen-enriched mixtures requires special equipment, taking into account both PPO2 and exposure time.

The models we cited marked the beginning of research in the field of decompression. They evolve and others are created, but none is universal in solving the various problems raised by decompression.

Also some dive computers add to a basic model a dose of another model responding for example to the limitation of micro-bubbles.

***<u>But the probability of an accident will never be nil</u>***

*It increases rapidly when certain limits are exceeded, especially when risk factors are present.*

*Research is ongoing to determine the individual probability of a diving accident. The reader will have realized the extreme complexity of this subject.*

***We have not yet found a reliable way to trigger an alarm adapted to each diver. Everyone must therefore be concerned about their own risk factors.***

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## ***Guestbook***

# - NAVIGATION INSTRUMENTS -

## Détailed table of contents




Generally speaking, they are used to measure the angle of a direction relative to the magnetic North. We will neglect here the (variable) declination which is the difference between the magnetic North and the geographic North.

*Pocket compass and diving compass are different instruments*

## The boussole

It essentially consists of a magnetic needle mounted on a pivot, sometimes in ruby on bronze to reduce friction. This needle is mounted in a case, not necessarily waterproof, the bottom of which has a graduation in degrees. Reading can only be done when viewed from above. This type of compass is fragile and often has a needle locking system. (Small button on the left of the photo below)

The torque of the needle is low because its magnetic mass is low. The main disadvantage of the compass is that it needs to be horizontal.


***Small pocket boussole***

Some advanced compass have a system to aim at a direction but this is incompatible with underwater use.

## The diving compass

A diving compass has two main functions:
- Reading an angle with the north (bearing)
- Follow a course at an angle with the north (Navigation)

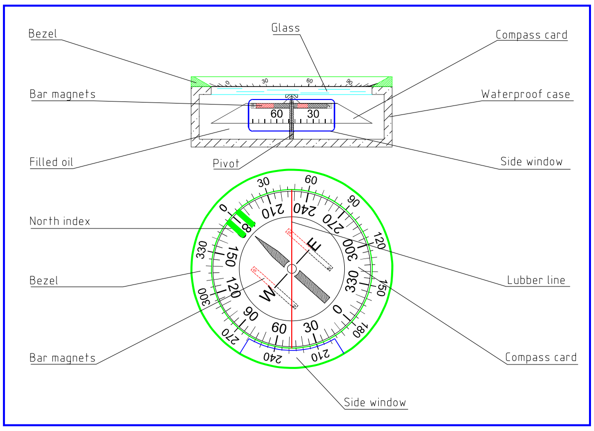
The compass is an instrument which consists essentially of a disk mounted on a pivot. On this disc is drawn a graduated card, usually from 0 to 259 degrees, called compass card. Below this disc, on each side of the pivot, are two magnetic bars with a high magnetic mass.

***Magnetic bars, seen from below***

By tilting the compass and looking out through the window from below, you can make out the two bar magnets.

Everything is mounted in a waterproof case sometimes containing a movement damping liquid. The main advantages of a diving compass are their accuracy and the tolerance of a large angle to the horizontal.

The underwater compasses, objects of this page, are most often graduated from 5 to 5 degrees on 360 degrees, the compass card is reduced to its simplest expression. (North, south, east and west sometime represented by the letters N, S, E and W)


***Suunto SK7 compass with graduated crown and details***

**There are 2 main fonctions of compasses:**

- Compass: As its name indicates, it is intended to follow a course. On board a boat, it is most often integrated with it and to improve its roll and pitch resistance, it is mounted on a gimbal. The centreline of the vessel is called the heading line. The scale of the chart relative to the heading line indicates the course followed.

- Bearing compass: It has a sight window and a moving crown to record the angle at which a target is seen from the magnetic north.

Many mobile compasses, especially diving compasses, combine these two functions.

The declination, which is the variable difference between magnetic north and geographic north, is hardly used by divers because it only comes into play when you want to draw or follow a route drawn on a map.

## Exploded view of a diving compass

The photos below show the different components of a diving compass.
The photo of set 1) below shows a ready-to-use compass.

**1) Assembled**

**2) Base**

**3)**

**4)**

**5) Lid**

**6) Enclosure**

**7) Bezel**

**8) Cover**

**Enclosure 6) :**

It contains a base 2) heart of the device which has an axis consisting of a fine needle which supports the compass card.

The case is filled with an oil intended to dampen the movements of the compass card and to reduce friction on the axle. Full of oil, it is insensitive to external pressure.

**The compass card –** Front 3) and Below 4) or Compass rose

It rests on the needle by a pivot (conical holow block) which, within certain limits, allows it to remain horizontal when the instrument tilts.
On top the lubberline is drawn in red.
Below, you can see the two magnets that frame the needle and orient the compass-card to the north.
Note that to read the compass-card, you must read the values that are right on the outside of the compass card. Seen from above, we see that the North is opposite the180° (Upside-down) and that the zero is to the South (Right-side) On the other hand, when we aim north through the window, the zero appears correctly. This is the case with all the compass of the rotating compass card.

*(Although following a subcontractor error, a few years ago, compasses were sold where the graduation was upside down and read as if the observer was in the center of the compass-card)*

**The lid (5)**

It is transparent and welded on the base.

**The case (6)**

It receives the capsule glued or welded inside.

### The bezel (7)

It is graduated and has a ratchet system that allows it to turn in both directions in 5° jumps.

### The protective cover (8)

The compass is usually protected by a rubber cover attached to the wrist strap of the diver.
However, it is sometimes installed in a console with the HP manometer and the dive computer.
For my part, I prefer to use a bitch attached to a ring of the vest which allows me to hold it in the hand and to better position it when I need it.

## Using a compass

### 1) Need to record a course (Figure 22)

This consists of measuring the direction of a marker which will later be used to navigate underwater. (If visibility is sufficient, it is also possible to raise a heading in immersion, for example to make topography)

### 2) To be on course:

This consists of monitoring underwater the direction measured during a survey.

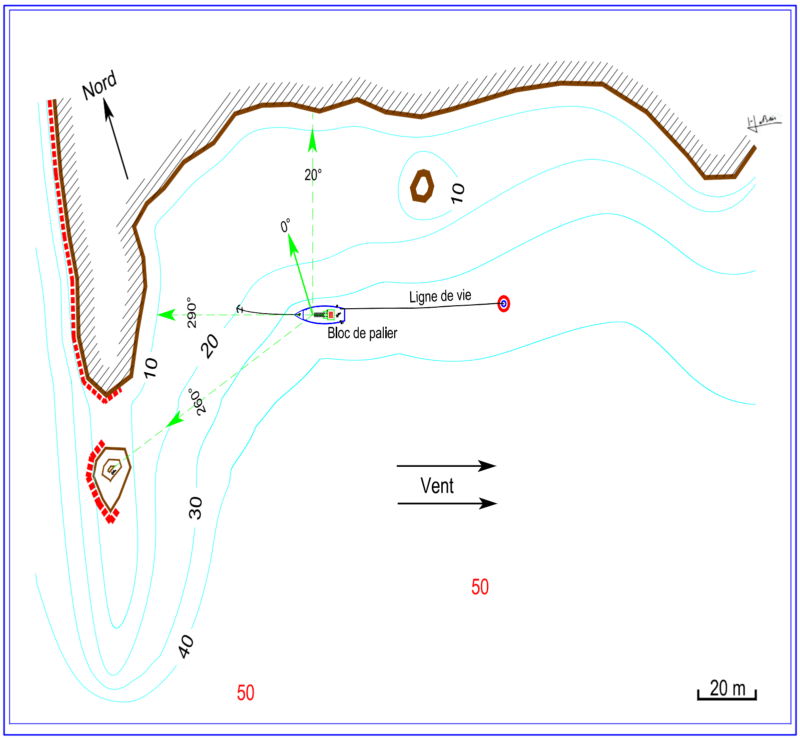



Figure 22 ***Different surveys at a dive site***

The mechanical compasses themselves are divided into 2 categories:

### Graduated bezel compass

It consists of:

1) Of a case: In its axis is drawn a fixed a red «Lubberline». On the front is a view-port with a marker, in the same axis as the lubberline.

2) A mobile “compass-card” where the North, South, West and East are drawn. (This North automatically moves toward magnetic north) A scale of 0 to -360°, usually 5 to 5°. (Read on top and through the side window)

3) A rotating crown, on which we find: A double marker to wedge the north of the compass-card A scale from 0 to -360° usually from 5 to 5°

- **Reading graduated crown compass**

Using the side window marker, aim in the direction you want to look for. Note the angle indicated by the marker on the compass card. If several directions are considered, write them down on your immergeable board.

**Graduated Case Compass:** (These are less and less used)

It consists of:

1) A box on which we find: A circular scale from 0 to 360° usually from 5 to 5°. A side window with a landmark in the axis of the housing a «Lubberline». (On the side)

2) A mobile “compass-card” where the North, South, West and East are drawn. (The North automatically moves toward magnetic north) A scale of 0 to -360°, usually 5 to 5°. (Read on top and in the side window)

3) A rotating bezel with: A line of sight (materialized by 2 notches) A double marker to wedge the north of the compass-card.

- **Reading graduated box compass**

Adjust the crown so that its notches are parallel to the lubberline. Using the notches, aim in the direction you want to spot. Note the angle indicated by the marker on the compass-card. If several directions are considered, write them down on your immergeable board. A heading can be raised at immersion as well as on the surface. (Here, the 2 compasses indicate a bearing of 48°. Note that this is not very precise)

**Graduated crown**


**Graduated housing**

**(*Relevés d'un cap*)**

*There is a crown model where the graduation is turned outwards. This model is not very practical for making surveys.*

**Using the Compass Diving** (Heading, Surface Survey Figure 22)
- Graduated crown: Match the measured angle to the line of faith.
- Graduated case: Put the crown mark on the angle of the direction you have raised.

Here, on the 2 models, the adjustment was made to follow a heading of 48°. We can clearly see the difference between these two types of compass.

Head in the direction indicated by the line of faith by holding the north of the compass-card in the double landmark of the crown. The viewport is no longer used, but it must be aimed at you or you will make a 180° error. However, if you want to retrace your steps, you will need to keep the north of the compass-card towards the simple landmark. (This is called a 180°)

### To be on course

To be on course, it is preferable to hold the compass with two hands, the elbows supported on each side of the chest. The compass is thus at the tip of an indeformable triangle which avoids changing its direction. When you want a good clarification, it's better not to take your eyes off it. However, in current practice, it is sufficient to look at it from time to time.

Experience helps you realize when you change your direction. The compass can be attached to a ring, non-magnetic, of the vest or held on the wrist by a wrist strap to be always close to the hand. When the current is present, the diver is affected and this can result in significant drift. You can reduce that error, if you like, but it's very random. To avoid this and provided that the visibility is sufficient, a
chaining.

**Note:**
During the dive, the force and direction of the current can change unpredictably depending on the tide and wind and also the underwater profile.
How to avoid the drift?

### To be on course by chaining *(As in the past, land surveyors)*

It consists step by step of taking natural landmarks on the background, as far as possible, in the direction in which you wish to go. (Indicated by the lubberline compass)
By joining each marker one after the other, you avoid the error caused by the current and you do not need to keep an eye on the compass.
Do not hesitate to stop from time to time to locate the markers.

To avoid errors due to compass-card friction on the inside of the housing, the compass must be kept as horizontal as possible. When you buy a compass, make sure that it tolerates a large lodging, without blocking itself. This is a feature that is rarely given by the manufacturer. The accuracy of the undersea compasses is a few degrees.
To get an idea of the possible errors, it is necessary to know that an error of 5° over a distance of 100 meters leads to a gap of about 9 meters at the finish.
The compasses described above can be described as mechanical.

## Electronic compasses

They are usually integrated as one of the functions in a diving computer.
The 4 side buttons of the template below allow you to navigate through the menu.
Their advantage is to have "All in one" in a volume sometimes much lower than that of a mechanical compass and especially less fragile.


***The course with the D9 of Suunto***

*However, they have one weakness: They can only be exploited from above. They do not have a Line of Sight, therefore do not allow to realize a chaining at least as easily and with as much precision as thanks to the window of a mechanical compass.*

On the other hand, they allow the memory of a pre-defined heading and to give an alarm as soon as one deviates from the right direction. And can simultaneously provide information about diving.


***SUUNTO EON (Compass functions)***

The Suunto Computer D9 watch displays the time at the bottom left (10:58) and heading: in the middle (NE) and bottom right, numerically (047°).
They make it possible to correct variations in declination.
However, they sometimes require calibration to account for the geographical area in which they are located.

### Compass Questions:

*1) Under what conditions is the mechanical compass more advantageous than the electronic compass?*
*2) What are the advantages and disadvantages of a mechanical compass?*

*3) In diving, how do you link?*

**The Depth gauge** (A Little History)
In the past, when combined with a watch and a diving table, they were used to calculate the parameters of the latter for the prevention of decompression accidents. They were also used to determine the depth at which the diver was navigating in the vertical direction.

These machines were mechanical watchmaking techniques. The pressure transducer consisted of a Bourdon tube or a calibrated spring associated with a membrane which, using levers and gears, actuates a needle in front of a metre-gauge frame.
A second switch point was driven by the first switch point during the descent but did not turn back during the ascent. It thus retained the memory of the maximum depth reached.

The sources of error were numerous and required a zero setting of the two needles on the surface before the dive.
A hundred of these devices had been tested in our specialized chamber during an information campaign in Ile de France.

| Between 0 and 12 meters | Between 12 and 80 metres |
|---|---|
| Better than 30 cm: 18% | Better than ±3%: 36 |
| Between ± 30 and ± 60cm: 25% | Between ± 3 and ± 6 %: 30 |
| Between ± 60 and ± 90 cm: 16% | Between + 6 and ± 9 % |
| Worse than 90 cm: 41% | Worse than 9%: 12 |

The mechanical depth meters were then the subject of a seminar of the Ile de France instructors of the FFESSM on 12 and 13 October 1986. Thirty-six gauges had been tested at sea, which confirmed their dangerousness.

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*<u>I am enclosing here the introduction to the article on depth meters</u>*
*<u>in the magazine SUBAQUA in September 1986</u>*

We have all been able to observe during our dives the high dispersion that prevails in the indications of our depths.
In this situation everyone reacts in his own way. Either by choosing the deepest indication or by correcting a known error by trusting one rather than the other.
It is paradoxical to note that for the calculation of the bearings, we are recommended to be precise to the minute and to the half meter and that a banal watch gives us a precision of one second, while the depth associated with it is precise to a few meters.

It should be remembered that the consequences of error on the depth reached or on the level of the bearings can be very serious in the short but also in the long term, especially if they are cumulated during successive dives.
Il est probables que certains accidents de décompression dits immérités s’expliquent de cette façon.

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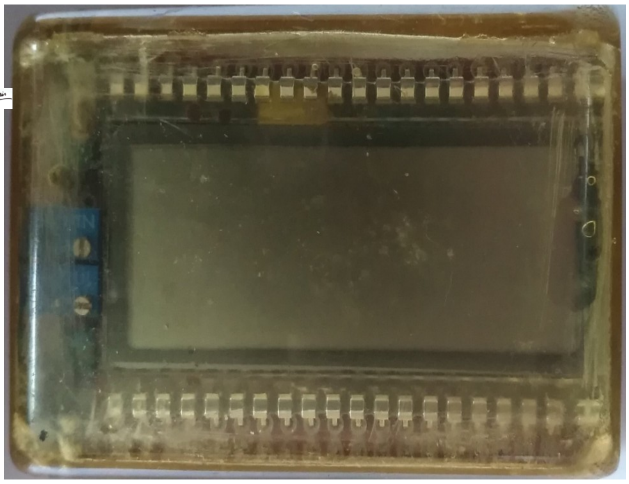

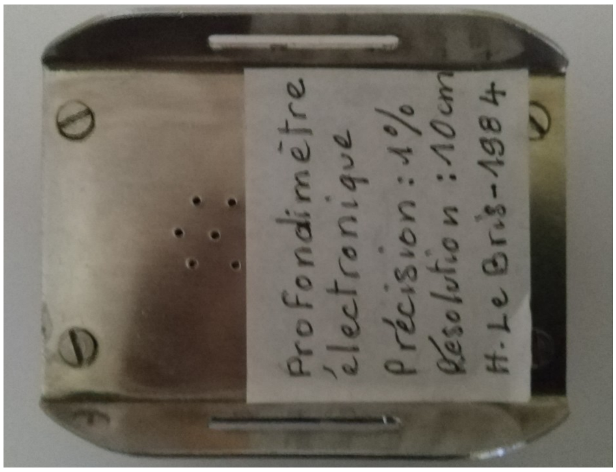


**First and last electronic depth meter!**

The above electronic depth meter had an accuracy of 1% and a resolution of 10 cm. It was designed and manufactured by the author in 1984.
The sensor came from the Bourdon company, which used to make the famous Bourdon tubes. The depth displayed up to 100m was in figures of 15mm in height. It was powered by 3 LM2425 lithium button batteries.

It started with wet contact from immersion. It was tested in box and then first tried at sea by Alain Germain at the time chairman of the Île-de-France committee and finally tested in the laboratories of Aqualung.

As soon as it was born it was dethroned at the end of the 80's by the arrival of dive computers which are today called «Computers of diving».

Today, the functions necessary for the calculation of the decompression and the depth measurement are integrated into the computers where a pressure sensor ensures the measurement of it.

This measure is used on the one hand to calculate the parameters of the dive and on the other hand after a conversion into meter of fresh water or sometimes salt water it is used for deep navigation. The accuracy is much greater.

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***[Guestbook](#)***

# - HIGH PRESSURE INSTRUMENTS -

**Detailed table of contents**



They are generally designed to measure high pressure before and during the dive. A distinction is made between the pressure gauges used on the surface and the pressure gauges used in immersion.

Medium pressure gauges can also be found to check the PM delivered by the first stages of the regulators. (They are instead part of the tooling)

The core of these devices uses a drone tube that deforms under pressure. It is followed by levers that operate the needle in front of a graduated bezel. The framing has coloured sectors indicating the limits not to be exceeded.

All these instruments measure relative pressures whether they are used on the surface or in immersion. Sensors/transmitters intended to transmit the HP value to computers are not pressure gauges. We treat them as regulator accessories.

## Mechanical surface pressure gauges

They are equipped with a DIN bracket or connector. They are used for the control of the HP at any time between the end of the inflation and before being equipped for diving. They are fragile to impact. (Do not drop them on the ground)

***HP surface pressure gauge Méga sport***

## Mechanical submersible pressure gauges

Although this function is often performed in computers, their independent side remains a sure value in the world of diving because of the ease with which divers can share their reading in immersion.

They are used to check the HP from the diving gear to the water outlet. They make it possible to estimate the remaining air range at any time. They are still widely used because of their low cost and also the redundancy they provide, although dive computers perform this function in a much more precise way.


***360 bar immergeable HP pressure gauge with its rotating joint***

*It is an indispensable and cheap accessory for the diver. It is mounted on a regulator high pressure outlet.*

---

*We reproduce below the part of the EN250 directive that concerns them. The paragraphs numbers are those of the directive.*

**Pressure Gauge Directive**

*The pressure gauge must be designed and positioned so that the diver can read it without difficulty. If a flexible coupling is required, it must be protected from the mechanical effects of the environment that are evident during use. If a gas-permeable protective sheath is provided, the volume it encompasses must communicate with the surrounding atmosphere. (It must be pierced with holes to prevent hernias and explosions)*

*The connection of the hose to the pressure gauge, at the level of the expansion system or, if there is no hose, the connection of the pressure gauge, shall be so designed that with an upstream pressure of 100 bar the air flow into the atmosphere does not exceed 100 l/min.*

*The gauge indication range shall be from zero to a value that exceeds the pressure of the air cylinder(s) by 20%.*

*Graduation intervals or increments must not exceed 10 bar. The range below 50 bar must be clearly differentiated to indicate the low pressures. The manometer accuracy shall comply with the following tolerances measured at decreasing pressures:*

*at 40 bar + 5 bar*
*at 100 bar +10 bar*
*200 bar + 10 bar*
*at 300 bar + 10 bar*

*(Pressure gauges up to 400 bar are also available)*

*The pressure gauge must remain watertight to an external pressure of at least 10 bar above atmospheric pressure for at least 15 min. The pressure gauge glass must be made of a material that does not produce splinters when it breaks. The pressure gauge must include a bleed that, in the event of a leak, protects the diver from any risk of injury.*

*The safety device of the mechanical pressure gauge shall normally operate at a pressure not exceeding 50 % of the burst pressure considered. It must also activate at a flow rate of at least 300 l/min.*

*Tests according to 6.2, 6.9.1 and 6.12*

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1) The manometer itself. (It must be equipped with a safety system to prevent the explosion of its housing or its glass, in case of internal leakage)

2) A swivel coupling with 2 joints.

3) A hose that connects to a HP outlet of the regulator. (The regulator outlet must have a limited flow rate to limit air loss in the event of a pipe or pressure gauge failure)

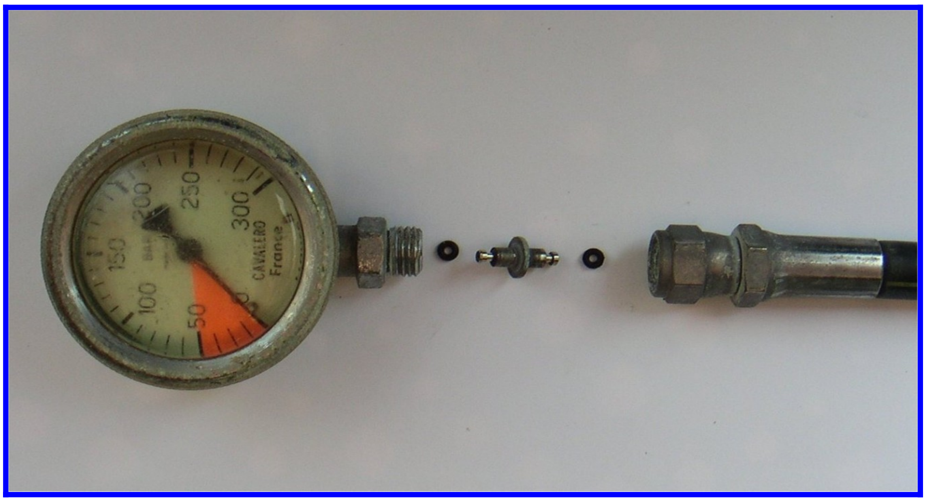
4) A neoprene housing protection system. It has a means of fixing to be always within reach of the diver.

### Maintenance of HP submersible pressure gauges

Daily maintenance consists of flushing at the same time as the regulator to which they are connected.

The images below show the deterioration that occurs after several seasons or even only several months without care.

In the beginning the problem is manifested by the difficulty in orienting the manometer and often by a small leak at the connection of the hose.




**Submersible HP pressure gauge**
**with its hose and rotating gasket**

Their weaknesses include:
1) They are fragile (Technology comes under watchmaking).
2) They are a source of leaks when connected to the hose.
3) Mechanical neoprene protection does not facilitate flushing.

- During immersion, water stagnates in the central part of the rotating coupling, while during daily maintenance, rinsing water is difficult to penetrate.
- The play between the fixed and moving parts is important, which favours the extrusion of the joints at the time of pressurization.
- The combined action of salt, limestone and extrusion of the joints causes deterioration of the joints when the pressure gauge is turned. This results in frequent leaks.

**HP Pressure Gauge Inlet Clogged**

To avoid this problem, it is necessary to dismantle the fitting regularly (Every season), clean it and do not hesitate to put a lot of grease. (Air or nitrox depending on the case)

**Connection of the dirty hose**

Also, do not hesitate to change the whole rotating joint with its 2 joints.

Cleaning the female parts of the fittings is important. To do this, use cotton stalks impregnated with white vinegar, hot if possible. (Finish by rinsing with clear water).

Check the connector gasket at the regulator HP output. As well as the condition of the safety capsule at the rear of the case is in good condition.


**Case back with safety capsule**

### Tek Diving Pressure Gauges

In this type of diving, we often carry several bottles. This can lead to entanglement of HP pipes and the risk of misidentification of the cylinder.

To avoid these disadvantages, mini pressure gauges can be used. They can be attached directly to an HP output from the first stage of the regulator. However the most used are with short pipes. (15cm) They are easier to read and more reliable. They have a small size, diameter of 2 to 3 cm.
Their main disadvantage is having a reduced reading scale. On the other hand, there is no rotating joint which limits the risk of leakage.

**Mini pressure gauge H.P.**

### High Pressure Sensors/Transmitters

These are modules that attach to an HP output of a regulator. They include: a pressure sensor, a micro processor and a transmitter encoded in PSK. (Phase Shift Keyed)

They transmit this signal wirelessly to the dive computer which decodes and displays it on its screen. The resulting signal is processed to calculate the diver's autonomy at the depth at which it is located and the time required to regain the surface.

It thus takes into account the speed of ascent and the bearings to be performed. It is powered by a lithium battery which gives it a range of up to 1000 dives.
It can be considered as a connecting device between the regulator and the computer. Further details can be found by clicking on the "Wireless link" paragraph of the "Regulator Principle".

***Le Smart + LED***
*(Capteur / Émetteur Scubapro)*

**There are a few variations:**
The picture above is that of a Scubapro module. It has a Led diode on top. (In operation, it is green above 50 bars, red below) Some even have a small symbol display.
Others like the one put on the market by the Italian company Ratio flash in different colors depending on the High Pressure.

RATIO, the Italian manufacturer of diving instruments has introduced a coded light transmitter that provides a high pressure indication in addition to that transmitted wirelessly to its iDive and iX3M dive computers.

**RATIO Light coded transmitter**
(30 mars 2017)

The translucent body transmitter uses a system of flashing LEDs to indicate the contents of the bottle, above 100 bars it flashes green,
from 100 to 50 bars it flashes yellow and when it is less than 50 bars it flashes red.

The power comes from a rechargeable USB battery. The price is £275 or about 350€. (2017)

The advantage is that all members of a palanquee can take this information into account. The drawbacks are the high price and that they are probably not compatible with other manufacturers' computers.

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***Guesbook***

XiTi

# ANNEX

## Glossary of terms used by manufacturers

For a better understanding of the functions of the instruments, please find attached the glossary of terms used in their documentation. This one comes from Scubapro but it is almost used by all manufacturers and in the literature concerned.

**AMD:**

Absolute minimum depth – the depth at which the mixture can begin to be used, depending on its oxygen content.

**AVG:**

Average depth, calculated from the start of the dive or from the time of the reset.

**CNS O2:**

Oxygen toxicity to the central nervous system.

**DESAT:**

Desaturation time. The time required for the body to completely remove all nitrogen absorbed during the dive.

**Dive Time**

Time spent below the depth of 0.8 m. (3 feet)

**Gas:**

Refers to the gas mixture that is selected for the ZH-L16 ADT MB algorithm.

**Local time:**

The time of day in the local time zone.

**Prof. max:**

The maximum depth reached during the dive.

**MB:**

Microbubbles. Microbubbles are tiny bubbles that can form in the body of a diver during and after a dive.

**Level of MB:**

One of the nine levels of the customizable SCUBAPRO algorithm.

**MOD:**

Operating Depth Limit. This is the depth at which the partial oxygen pressure (ppO2 ) reaches the maximum allowable level (ppO2max). Diving deeper than the MOD exposes the diver to dangerous levels of PPO2.

**Nitrox :**

mélange respiratoire fait d'oxygène et d'azote, avec une concentration en oxygène égale ou supérieure à 22 %. Dans ce manuel, l'air est considéré comme un type de Nitrox particulier.

**NO FLY :**

(Temps d'interdiction de vol) – durée minimale que le plongeur doit attendre avant de prendre l'avion.

**No-stop:**

(Duration without step) – it is the time during which you can remain at the current depth and go directly to the surface without having to make a decompression bearing.

**O2:Oxygen O2%:**

Oxygen concentration used by the computer for all calculations.

**PDIS:**

Profile-dependent intermediate bearing, an additional deep bearing that is suggested by the G2 at depths where the 5th, 6th or 7th compartments begin to release gases.

**$ppO_2$ :**

(Partial oxygen pressure). This is the pressure of oxygen in the respiratory mixture. It depends on the depth and concentration of oxygen. PPO2 greater than 1.6 bar is considered dangerous.

**ppO22 max:**

Maximum allowable value of ppO2 . With the oxygen concentration, it defines the MOD.

**Pressure:**

The action of pressing one of the buttons and releasing it.

**Extended pressure:**

pressing and holding a button for 1 second before releasing it

**MSA:**

Surface interval, the time counted from the moment the dive is completed.

**SOS Mode:**

Results from completing a dive without meeting all required decompression obligations

**Stopwatch:**

A stopwatch, for example to measure the duration of certain phases of the dive.

**Gas change depth:**

The depth at which the diver must switch to a higher oxygen-rich mixture when using the multigas option of the ZH-L16 ADT MB PMG algorithm.

**UTC:**

Coordinated Universal Time, refers to time zone changes during travel.

**TAT: (Total Ascent Time)**

Total recovery time.

**RBT: (Remaining Bottom Time)**

Possible remaining duration of the dive

**CCR: (Closed Circuit Rebreather)**

Closed circuit recycler.

**Trimix:**

Gaseous mixture containing oxygen, helium and nitrogen.

**PMG:**

Predictive multi-gas.

**OTU: (Oxygen Toxicite Unit)**

Units of oxygen toxicity.

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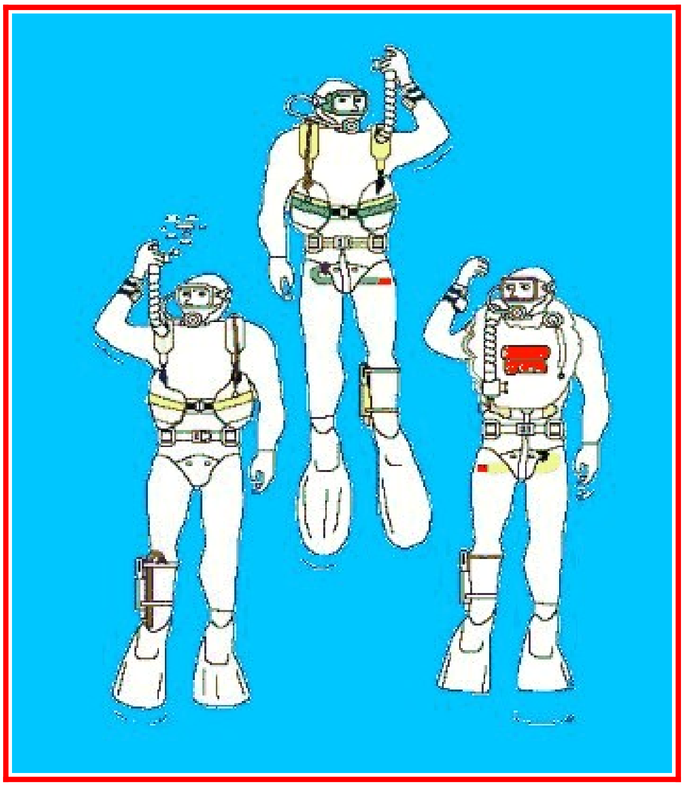

## *Guestbook*

XiTi