

# SCUBA DIVING ASSISTANT

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## USER MANUAL

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This document is a basic user instruction of package “Diving Assistant” Diving Assistant. Please refer to it before using the application. Software is under constant development, that is why some of the descriptions, photos can be slightly different from the current version of the application. In this case, if you notice significant differences between the application and the user's manual, please let us know and contact the REAL DATA. (<http://www.real-data.pl/en>).

## *Special Thanks !*

We would like to thank multitude of researchers, scientists and divers whose work has contributed to the safe diving like today, and this application could not be created.

Due to the contribution of many people, including Dr. Albert A. Bühlmann, Haldane JS, Workman RD, Baker EC, Hamilton RW, Lambertsen CJ, Arieli R., Butler FK, Kenyon DJ, Peterson RE, Harabin AL, Beers DM, Shykoff BE, Bornmann RC, Wienke BR, O'Leary TR, Hyldegaard O., Kerem D, Melamed Y, and many many other prominent figures and organizations working for a safety of diving such NOAA, DAN, CMAS, and many other, processes occurring during the dive we are becoming better understood. This made it possible for many years to improve the rules and principles of diving, use of the benefits of what today we all divers worldwide.

*Piotr Orlewicz*  
*REAL DATA S.C.*

## Table of content

The basic package features:	6
1 Symbols	7
2 IMPORTANT !!!	8
2.1 Purpose	8
2.2 Diving safety	8
2.3 Limited warranty	8
3 A few words of introduction	9
4 Measure units	10
4.1 Atmospheric pressure	10
4.2 Absolute pressure, hydrostatic pressure	10
4.3 Operating pressure	10
4.4 Altitude	10
4.5 Depth	10
4.6 Time	11
4.7 Volume	11
4.8 Capacity	11
5 System configuration	13
5.1 Environment	13
5.1.1 Altitude and atmospheric pressure	13
5.1.2 Type of water	14
5.2 Breathing set	14
5.2.1 Cylinder selection	14
5.2.2 Breathing mixture	15
5.2.3 SCR – surface consumption rate	15
5.3 Safety limits	15
5.3.1 The maximum depth	16
5.3.2 The maximum dive time	16
5.3.3 CNS limit	16
5.3.4 END – equivalent narcosis depth	16
5.3.5 Multidiving – repetitive dives	17
5.3.6 Minimum pressure in diving cylinder (reserve)	17
5.4 Simulation settings	17
5.4.1 Computer operation mode	17
5.4.2 Limits tables	18
5.4.3 Deep stops	19
5.4.4 Automatic atmosphere (switching)	20
5.4.5 Dive cylinder filling	20
6 Breathing sets editor	21
6.1 Blend configuration	21
6.1.1 MOD – the maximum operation depth	21
6.1.2 ENP – equivalent narcotic potency	21
6.1.3 Description	22
6.2 Configuration of diving cylinder set	22
6.2.1 Operating pressure (nominal pressure)	22
6.2.2 Volume, Capacity	22
7 Limits and safety	23

7.1 Decompression.....	23
7.2 Oxygen related limits.....	23
7.2.1 Acute form of central nervous system (CNS).....	23
7.2.2 Chronic form, pulmonary (OTU).....	23
7.2.3 Drop of the vital capacity of the lung (VCD).....	24
7.3 Partial pressure of oxygen (PPO2).....	24
7.4 Equivalent narcosis depth (END).....	24
7.5 Amount of the breathing gas.....	24
<b>8 A dive planning and dive profile.....</b>	<b>25</b>
8.1 The user's plan.....	26
8.1.1 The choice of the rounding way.....	26
8.1.2 Description of plan columns.....	26
8.1.2.1 Action type.....	26
8.1.2.2 Cylinder.....	27
8.1.2.3 Depth.....	27
8.1.2.4 Time (duration).....	27
8.2 The resulting plan (dive profile).....	27
8.2.1 Compact plan columns description.....	27
8.2.1.1 Start time.....	27
8.2.1.2 Action.....	27
8.2.1.3 Time of duration.....	28
8.2.1.4 Pressure in the diving cylinder (tank pressure).....	28
8.2.1.5 PPO2.....	28
8.2.1.6 END.....	28
8.2.1.7 CNS%.....	28
8.2.1.8 OTU.....	28
8.2.1.9 VCD%.....	28
8.2.1.10 Cylinder.....	28
8.2.1.11 Comment / Remarks.....	29
8.3 A graphical view of diving profile.....	29
8.4 Summary.....	29
8.5 Advanced charts.....	29
8.5.1 Tissue partial pressure.....	29
8.5.2 Inert gas pressure.....	30
8.5.3 Inert gas tissue saturation.....	30
8.5.4 Final tissue saturation.....	31
8.5.5 M-Values.....	31
<b>9 Profile data – details.....</b>	<b>33</b>
9.1 Column description.....	33
9.1.1 Action.....	33
9.1.2 Depth.....	33
9.1.3 The exposure time.....	33
9.1.4 Total dive time.....	33
9.1.5 Beginning (Initial) pressure.....	33
9.1.6 Gas pressure.....	34
9.1.7 The next decompression stop.....	34
9.1.8 Next deep stop.....	34
9.1.9 No-decompression time.....	34
9.1.10 Time to fly.....	34
9.1.11 Ceiling (window).....	35




9.1.12 V tank.....	35
9.1.13 P tank.....	35
9.1.14 Rock Bottom.....	35
9.1.15 END.....	35
9.1.16 Total CNS.....	35
9.1.17 Total OTU.....	35
9.1.18 Vital capacity drop.....	36
9.1.19 Deepest stop.....	36
9.1.20 Leading saturation [%].....	36
9.1.21 Leading saturation [bar].....	36
9.1.22 Target GF.....	36
9.1.23 Altitude.....	36
9.1.24 Blend (gas mixture).....	36
9.1.25 Water.....	36
9.1.26 Compartments count / quantity of tissues.....	36
9.1.27 Total time.....	37
9.1.28 Messages.....	37
<b>10 Warning and alarms.....</b>	<b>38</b>
10.1 Step of plan reported an exception, some limits can be exceeded (Default).....	38
10.2 Maximum depth is exceeded (MaxDepth).....	38
10.3 The maximum dive time is exceeded (MaxTime).....	38
10.4 Limit of equivalent narcotic depth is reached (END).....	38
10.5 The limit of the oxygen toxicity has been exceeded (OTU).....	38
10.6 The daily limit of oxygen toxicity (OTUD).....	38
10.7 Oxygen toxicity limit is reached (CNS).....	38
10.8 The oxygen toxicity for the nervous system has not been counted (CNS).....	39
10.9 The depth limit for the oxygen has been exceeded (ODL).....	39
10.10 Too low the partial pressure of oxygen (OTL).....	39
10.11 The diving cylinder is empty (NoAir).....	39
10.12 The pressure of the breathing mixture has reached a dangerous level.....	39
10.13 The depth of the current dive is greater than the previous one.....	39
10.14 Insufficient amount of gas for safe escape (RockBottom).....	39
10.15 Insufficient amount of gas for safe escape even for one diver (RockBottom1).....	40
10.16 Deco stop missed (DecoMissed).....	40
10.17 The risk of ICD (Isobaric Counterdiffusion) and DCS type III (ICD).....	40
<b>11 Examples.....</b>	<b>41</b>
11.1 Two dives in “Czarny Staw” in the Tatra Mountains.....	41
11.2 Diving in quarry Horka (Saxony).....	42
<b>12 The required technical parameters of a computer system.....</b>	<b>46</b>
12.1 The operating system.....	46
12.2 The hardware requirements.....	46

## The basic package features:

Feature	Description
Calculation algorithms	<ul style="list-style-type: none"> <li>- The basic algorithm based on ZH-L16 (Albert A. Bühlmann)</li> <li>- Deep stops: Pyle, SSA/CMAS, NAUI, GF</li> <li>- Safety stops</li> <li>- Atmospheric pressure model: ISA, NOAA, Linear</li> <li>- Maximum partial pressure: NOAA</li> <li>- Oxygen toxicity limits: NOAA</li> <li>- Vital capacity: Harabin, Arieli.</li> </ul>
Modes	Computer: <ul style="list-style-type: none"> <li>- conservative</li> <li>- dynamic</li> </ul> Profiles: <ul style="list-style-type: none"> <li>- standard</li> <li>- altitude diving</li> <li>- multi-gas diving</li> </ul>
Sampling	<ul style="list-style-type: none"> <li>- 1 minute resolution (on constant depth)</li> <li>- every 0,1m (variable depth)</li> </ul>
The limit tables	Build-in limit tables: <ul style="list-style-type: none"> <li>- ZH-L16A (16/17 tissues / compartments)</li> <li>- ZH-L16B (17 tissues / compartments) – typical for decompression tables</li> <li>- ZH-L16C (17 tissues / compartments) – typical for dive computers</li> </ul>
Type of limit tables	<ul style="list-style-type: none"> <li>- The ability to use tables based on the Wormann or Bühlmann model</li> <li>- No limit of tissues / compartments quantity (*engine only)</li> <li>- Open XML format</li> </ul>
Other limits	<ul style="list-style-type: none"> <li>- Dynamically calculated oxygen toxicity (OTU, CNS)</li> <li>- Vital capacity drop</li> <li>- The equivalent narcosis depth (END)</li> <li>- The minimum and maximum partial pressure of gas</li> <li>- Depth and time limits.</li> </ul>
Supported gases in the breathing mixes:	Each blend based on: Oxygen, Nitrogen and Helium. The build-in definitions of typical mixtures: Oxygen, Nitrox (30-50%), Trimix (selected). Breathing set editor: any Oxygen/Nitrogen/Helium blends.
Environment settings:	<ul style="list-style-type: none"> <li>- The ability to choose the water area: fresh (inlandwater) and seawater</li> <li>- The ability to adjust the altitude above sea-level or the atmospheric pressure</li> </ul>
Individual settings:	<ul style="list-style-type: none"> <li>- Computer mode</li> <li>- Limits table (M-Values)</li> <li>- Type of breathing mix</li> <li>- Parameters of diving cylinder set</li> <li>- Typical air consumption rate</li> <li>- The maximum depth</li> <li>- The maximum dive time</li> </ul>
Measure units	Depth and altitude: m (meters), ft (feets). <ul style="list-style-type: none"> <li>- metric / European (bar,m,l,hPa,atm,at,mmHg)</li> <li>- imperial (psi,ft,cf,inHg)</li> </ul>

Table 1: Basic software properties

## 1 Symbols.

Marking method	Description
	Very important information. The information contained in sections marked by this symbol have critical impact on safety.
	Sections marked with this symbol are particularly important.
	Additional information and comments.
<b>[ Button name ]</b>	Button descriptions. Navigation tabs. Grid columns names.

*Table 2: Symbols used in document*

## 2 IMPORTANT !!!

Before using the software please refer to this documentation. Pay particular attention to the elements that describe the potential risks and suggestions how to improve safety and reduce described limitations.

**Below and in the license contains important information related to this Software. If you do not agree, please discontinue use of this application.**

### 2.1 Purpose.



The application has been developed to assist in the planning and in the process of diving training. The application does not replace the decompression tables or training. It is addition to knowledge and skills, additional facilitation. The application cannot be used as the only source or primary source of information and knowledge. We recommend you to review the plans with alternative sources, such as diving computers. In case of conflict or different results, at the first of all, your knowledge and skills gained during the training should always be the most important and overriding.

### 2.2 Diving safety.



Many of mechanisms are put in the computational engine which minimize the risk of injury and increase the safety of the dive. Note, however, that no security and algorithms do not guarantee that the DCS or other problems do not occur. The risk is strongly associated with individual predispositions, your health, fitness, well-being, atmospheric conditions on the surface of the water and the water environment. It is good to see and check the results and indications by comparing them with other sources - such as decompression tables or to another computer.

Absolutely follow and use rules you learned on dive courses. Never exceed the limits which you are allowed reach based on the certificates and permissions you possess.

### 2.3 Limited warranty.

We put lot of work that this software was free from error, but we do not give a full guarantee on them. We give you the software to use "AS-IS". We guarantee that each bug report or suggestions to improve will be taken seriously and thoroughly investigated. All found errors will be removed as soon as possible and collected in the form of a software update. Detailed information about the service and limited warranty there are in the License Agreement.



### 3 A few words of introduction.

Each of us has a hobby. Besides the horse riding my hobby is diving. It has started with a trip to Egypt and Intro to one of the most beautiful coral reefs in the world. Then came the time for the course diving and the first independent dive. In this way has begun a lot of people.

Just like any sport as well diving requires adherence to safety rules. It is required to be trained and, first of all, the prudence. A large part of the theoretical knowledge and practical skills provide us the training systems. It is very important to start our adventure with diving at first with proven training center or the dive center. Remember that the risk of injury during diving without proper training is much higher. Both diving without proper preparation and simply irresponsible diving can result in problems such as DCS (decompression sickness that is), injuries, pressure, oxygen poisoning or nitrogen narcosis. Although the problems that can happen to us under the water there is quite a bit, I must admit that, thanks to the contribution of many organizations and individuals, the diving is much safer than it was in the past and now it is one of the recreational sports.

Although there is several programs on the market that helps to plan the dives, we decided to invest the time to create something new. The following goals have been placed on the way of development of this software:

I. The package should be the supplement of your existing knowledge and skills. It has to be your assistant during planning diving. It has to be an effective helper, so it must be easy to use and friendly use and also at the same time not limiting the ability.

II. Another very important goal was a good balance between the mathematical model used for calculations and safety rules. Therefore, the software has been woven into a number of additional mechanisms, which increase the safety margin. In the next version it will be expanded and improved.

III. The third goal is to enable easy implementation of simulation, what makes the process of training is the easy-to-understand visualization and consolidation of knowledge by simulating of the example scenarios. For example, we need almost three clicks, to compare the dive profiles for air and nitrox.

We give you this software in the hope that it will be a real help for training, simulation and planning of real dives. We also hope that in this way we will contribute to the reduction of risk while the sport of diving.

*Deep dives.*

## 4 Measure units.

Before we get to set up and work with the application, you need a few words about the unit of measurement that have been used. The calculation engine always uses the same unit of measurement internally for the calculation. Used units are meters to specify the altitude and depth, bars to pressure and minute to specify the time, liters to specify volume and capacity.

However, the engine provides a wide unit conversion mechanisms which allow applications to be constructed in such a way that it is user friendly. Knowledge of the internally used units, may have an impact on some of the value rounding, so you should pay attention to it.

From the point of view of the user application provides a much wider range of possibilities for the insertion and presentation of value. In many places it is possible to insert values in one of several popular units. Most of them cannot be converted to each other to complete and the total values, and therefore it was assumed that the values to be used for the calculation are displayed on the light fields and rounded values on the gray fields. The program will convert and recalculate measure units, after the user enters values in your chosen unit of measurement. Besides, in some areas there are tool tips with additional information.

### 4.1 Atmospheric pressure.

To make it easier the application provides the possibility configuring values of atmospheric pressure in hPa (hecto Pascal) or inHg (inches of mercury at 0°C) units. The first is typically used in the SI and European countries, the second one is imperial unit, used for example in the United States. After entering the atmospheric pressure will also be converted to a typical altitude at which the pressure is.

For illustrative purposes the program also calculates the pressure on the other units at (technical atmosphere), atm (atmosphere physical) mmHg (millimeters of mercury at 0°C).

### 4.2 Absolute pressure, hydrostatic pressure.

The application calculates the absolute pressure in bar. The engine allows for the conversion of pressure to a number of other units: atm, at, msw and fsw (the amount of salt water), hPa or inHg, mmHg.

### 4.3 Operating pressure.

Operating pressure is given in the bar or psi.

### 4.4 Altitude.

Altitude can be entered in meters (m) or feet (ft) above sea level. After entering the value it will be converted to common prevailing atmospheric pressure which is at this altitude.

### 4.5 Depth.

Just as altitude, depth is also given in m or ft. In addition, pay attention to the method of

determining of the automatic stops in the following chapters.

#### **4.6 Time.**

Time of duration is always inserted in the minutes. However, the results will be presented in a user-readable form, it means in hours, minutes and seconds.

#### **4.7 Volume.**

The volume is given in liters. This is the value used in determining the parameters of diving cylinders - the so-called water volume.

#### **4.8 Capacity.**

Capacity is used to define the amount of gas stored in the diving cylinders. The imperial system is used cubic feet, metric is used liters.

Symbol	Name	Description
m	meter	Unit of length, used also to determining of altitude and depth
ft	feet	Unit of length, altitude and depth, 1m $\approx$ 3.2808ft
l	liter	Measure unit of volume and capacity, 1l = 1dm <sup>3</sup> .
cf, cuft	cubic feet	Volume and capacity unit used in imperial measurement system, 1cf $\approx$ 28.32l
bar	bar	Unit of pressures. 1bar is equivalent to standard pressure and corresponds approximately to 10m of water.
psi	Pound per square inch	Pressure unit in imperial system, 1psi $\approx$ 0,0689bar.
Pa	pascal	Unit of pressure in SI, 1hPa = 1mbar.
mmHg	millimeters of mercury	Pressure unit, commonly used in meteorology. These units are also used in medicine and physiology, eg. in the description of the process of oxygen transport in hemoglobin. Pressure is given at 0°C. 1mmHg $\approx$ 133.32Pa.
inHg	inch of mercury	The barometric pressure unit in the imperial system, based on the density of mercury in 0°C 32°F. Please note, in the past was used unit converted to mercury density in 60°F. 1inHg $\approx$ 3386.39Pa.
msw	meters of salt water	Pressure unit defined by amount of sea water (pressure at given depth), 1msw = 0.1bar.
fsw	feets of salt water	Measure unit defined by pressure at specified depth of sea water, 1fsw $\approx$ 0.3064msw.
at	technical atmosphere	Pressure unit, 1at $\approx$ 980.66hPa.
atm	physical atmosphere, standard atmosphere	Pressure unit. 1atm is equivalent to standard barometric pressure at sea level, 1atm = 1013.25hPa.
min	minute	Time interval unit..
UPTD	unit pulmonary toxicity dose	Arbitrary units used to determine the dose of oxygen toxicity to the pulmonary system.

Table 3: Measurement units used in diving

## 5 System configuration.

System configuration is possible by inserting a number of parameters on a single, summary tab. The parameter values are restricted as far as possible in the application to safe, legal ranges.

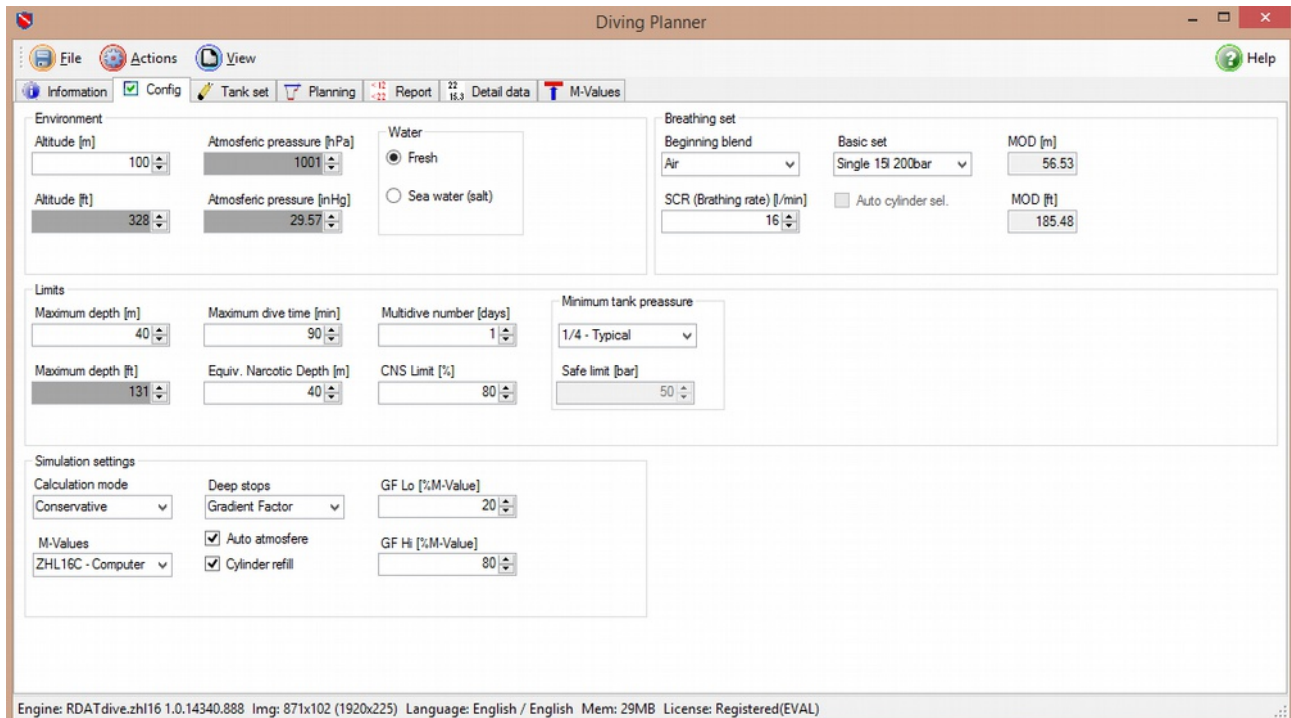


Illustration 1: View of configuration tab

Configuration panel is divided into several sections described later in this document.

### 5.1 Environment.

Section "Environment" allows you to set the basic parameters for the water area (i.e. a lake), where we dive.

#### 5.1.1 Altitude and atmospheric pressure.

Depending on the altitude (height above sea level) of the water area, there is a different atmospheric pressure. The higher height above sea level the pressure is lower.

It is possible to set the parameters pressure and altitude, but both of them are closely related. In general, diving takes place in water areas that are located low and it is taken the altitude level of the sea (zero meters 0m) for it. It may happen, however, that during the dive we will want to perform at a higher altitude. The atmospheric pressure will reduce and it will affect two factors:

- absolute pressure during the dive - the impact rather not too much,

- atmospheric pressure after the end of the dive.

Both of these factors affect a safe depth during deep diving decompression. Lower pressure at the end of the dive should also be taken into account. It may turn out that even though the pressure difference is not large in comparison with the level of the sea, it's enough to have begun to precipitate individual bubbles of nitrogen and consequently lead to a whole range of symptoms of DCS.

Diving at altitudes above 300m (~ 1000ft) should be carried out only with relevant experience or the assistance of an instructor or colleague with the appropriate qualifications. Some people already at an altitude of 2500m (~ 8200ft) may experience the first symptoms of hypoxia.



If diving is not scheduled by the sea, it is good to know the approximate altitude. If you do not know, you can for belaying enter value of about 100m, but not more, because they will significantly increase the speed of getting rid of excess gases from medium and long tissues.

The program allows you to set the height above sea level in two ways:

- a) set the altitude,
- b) an indication of atmospheric pressure.

Possible setting range is 0 to 3000m (~ 9800ft). The typical atmospheric pressure is the amount calculated by non-linear scale.

### **5.1.2 Type of water.**

Depending on whether we dive in lakes and others water areas of inland or seas, select the type of water. Depending on the salt content, the water has a different density, which affects the conditions prevailing at the depth of the absolute pressure. There are two predefined settings:

- a) Freshwater (Fresh) - for freshwater areas and low salinity seas,( not too much salt-low level, brackish),
- b) Salt water - for water areas are heavily and medium saline ( slat level is medium and higher).

Depending on the chosen options , you will see little differences in the results of the calculations. Most area waters are salty seas and oceans, so it is assumed that the waves may be higher. For fresh water areas, the safety depth stop and the last decompression stop was set at 5 m, for freshwater areas - 3 m For imperial units, these values were set at respectively on 15ft and 12ft. An example of a salty water area is Red Sea. In the case of lakes, water areas in quarries or the Baltic Sea, but rather to choose fresh water.

## **5.2 Breathing set.**

### **5.2.1 Cylinder selection.**

The application allows you to select one of the predefined sets of typical diving cylinder. This allows you to quickly and easily plan a dive on one set of cylinders,

typically up to 40m / 130ft.

In addition, the application has a built-in editor of cylinder sets, which allows you to define any sets cylinders and gas blends to be used in the planning of complex dives.

### **5.2.2 Breathing mixture.**

The application provides a drop-down list contains several common breathing mixtures from air by Nitrox from 30% to 50% and some popular Trimix mixtures. This allows for easy planning of typical dives on one mixture, typically up to 40m / 130ft.

With the selection of the gas mix is given typical operating depth MOD (ppO<sub>2</sub> = 1.4bar / 20psi, salt water). Remember that when planning, MOD will be determined based on the maximum variable fraction of oxygen, the type of water and atmospheric pressure, and may differ from the value shown on the configuration tab.

Additionally, the application provides the editor of sets, which allows to define any breathing gas mixture based on oxygen, nitrogen, and helium.

Blends with a lower oxygen content should be used with caution. They are used in technical diving. The use of mixtures of helium reduces the resultant narcosis potency, but it can accelerate tissue saturation and increase decompression time.

Hot nitrox and oxygen are used for accelerated decompression at small depths.

Particularly complex is planning a dives with gas switching. These are generally deep dives burdened with additional risk. Planning such dives should only be performed by trained technical divers.

Apart from the obvious impact on the decompression times, the choice of mix will also affect the maximum depth and dive time (other gas partial pressure) - the system takes into account the properties of narcotic gases and potential toxic effects of oxygen. The values of decompression time and the minimum time to flight will presented completely different.

### **5.2.3 SCR – surface consumption rate.**

SCR values can be set in the range defined by most organizations as safe. Remember that when you dive, you should never hold your breath. Saving the air very quickly can result in the accumulation of carbon dioxide in the body, which at least can be troublesome symptom of severe headache. On the other hand, too rapid breathing can also be a symptom of problems.

The data of the set breathing air consumption are included in the calculations and presented in numerical and graphical form.

## **5.3 Safety limits.**

To improve the safety of the application supports the control limits for different values of dive profile data. Some of the limits are static, some calculated dynamically depending on the simulation results. You can configure the basic restrictions in this

section. In addition as described in the following sections, there are additional limits that are permanently programmed in the internal mechanisms of the application (see 5). After exceeding limits of any of the calculations, they are still continuing and profile items are marked with appropriate warnings.

### **5.3.1 The maximum depth.**

Set the maximum depth under his certificate. Depending on the organization of a typical training allow recreational diving to a depth of 12, 18, 30 and 40m, respectively 40, 60, 100 and 120ft.

### **5.3.2 The maximum dive time.**

Although the dive time is not explicitly limited, it is easy to see that the longer the dive, the easier it is to reach the required decompression, increasing the dose adopted oxygen and other gases. Not without influence is also chilling the body and fatigue. So it was good for you to determine the appropriate limit. In our opinion, the novice divers should not exceed 60 minutes for a single dive.

### **5.3.3 CNS limit.**

This is the limit of an acceptable oxygen dose from the perspective of the potential impact on our nervous system. This is a very important parameter, which can result in exceeding the acute form of poisoning with oxygen. In typical recreational diving should not be, however, never exceeded.

Configuration of application allows you to set a limit for the adopted dose CNS expressed as a percentage. Accepted standard level of 80%, despite the fact that doses below 100% are not dangerous. This level was set in accordance with the principle of continuous belay. Just like do not dive alone, but always with a partner, you should also assume that nothing will happen, or that if you have a diver is in trouble, this materialize only one risk. It was assumed that an accident can happen, which will require the application of pure oxygen on the surface. This means that the oxygen partial pressure is given close to 1 at (not 0.21), as a result, the CNS will be further increasing although a dive will be finished. For example, this means that in extreme cases, the symptoms of DCS reach acute oxygen toxicity and significant increase in the risk of injury.



A value above 80% can be used for training and simulation.

### **5.3.4 END – equivalent narcosis depth.**

Screen showing the configuration in which we can insert a safe limit the depth to which the nitrogen toxicity is not dangerous. For recreational diving it is assumed 40m. This parameter should be set according to the knowledge acquired during the training.



Greater than 40m / 130ft values can be used only by experienced technical divers.



END is calculated for each of the selected breathing mixture. If you exceed the limit, a warning is triggered.

### **5.3.5 Multidiving – repetitive dives.**

If you repeatedly dive a few days, day after day, you should insert the number of these days, including the current one. This allows you to better estimate the allowable limits of oxygen units.

This parameter is important primarily for the calculation of the risk of poisoning with oxygen in the form of pulmonary - OTU.

### **5.3.6 Minimum pressure in diving cylinder (reserve).**

It specifies the adopted reserve of the breathing mixture in the diving cylinder.

For standard recreational diving it takes a 1/4 capacity (50bar for 200bar cylinders, 750psi for 3000psi cylinder).

You can also choose a larger reserve of 1/3, which typically takes at cave dives (the possibility to return using one set with partner).

Regardless of the setting, the system calculates the minimum amount of air for one and two divers necessary for emergency ascent - the so-called Rock Bottom.



Rock bottom is calculated for typical no-decompression dives. In the case of a decompression dive or gas switching this function may not return results. Status can be verified by reviewing retail data.

## **5.4 Simulation settings.**

The program can use several settings that must be set according to our experience, and risk of diving in a specific water area at a specific time of year and weather conditions. More experienced divers can use individual settings, less experienced suggest leaving the default settings, the more conservatives.

### **5.4.1 Computer operation mode.**

There are two modes of calculation engine operations (planner):

- a) Conservative,
- b) Dynamic.

#### **5.4.1.1 Conservative mode.**

The first mode (conservative) is designed for less experienced divers. It is so designed to raise maximum safety and compensated for ambiguous states. The results will be similar to decompression tables. The main features of this mode are:

- get the target depth during immersed,

- get the original depth during ascent,
- overstepping the safe depth for the next step of the plan.

In the simplest terms it can be said that this mode "exceed" for us the depth of decompression from the previous step to the next and it takes always the maximum depth of the change to calculate, which eliminates the variable speed of descent and ascent of the typical first dives and reduces the risk of problems during the and after the dive. Let us imagine that you want to dive to a depth of 30 meters (~ 100ft) for about 25 minutes and next another 5 minutes to admire underwater world at a depth of 10 meters (~ 33ft). The computer will show us the one stop for decompression and also a safety stop. But what if the 30m (~ 100ft) loose our concentration and we spend about three minutes longer? Or let us ask the question whether, if we want to put out earlier of time with a depth of 10 meters. Will it be safe?

The answer is simple - the risk of injury will definitely increase. The use of three principles described above will make that the plan will calculate a small additional margin of safety and the risk of DCS is lower. Remember, however, that it always will be existed.

M-Values table type ZHL16C is recommended.

#### 5.4.1.2 Dynamic mode.

Dynamic mode is for more experienced divers and simulation for training purposes and their own. This mode should not take a beginner divers.

Dynamic mode is characterized by:

- high resolution of calculating steps (typically 1 minute),
- high resolution of steps during changing depth (typically 0.1 m).

During the calculation each user command is divided into a series of small steps. Calculation engine does not exceed the calculated safe depth for the next step. Due to the high resolution the calculation results are averaged during the descent and ascent. For this reason, this plan is closer to the actual conditions and allows you to better fit the plan to your needs and gives you the ability to better follow the results at each stage of diving. However, it has not, an additional safety margin.

#### 5.4.2 Limits tables.

In theory, using the algorithm ZHL-16 can be made the necessary calculations, assuming the proposed half-time and pure mathematics. The world around us is impossible, however, to describe the end of the rules of mathematics and physics, which, moreover, makes it more interesting and more beautiful. The first version of the algorithm (ZHL-16A) is supplemented by an additional two variants ZHL-16B and ZHL16C. This last one is the most conservative and it is assigned to use in diving computers. This option is normally set in the application. Version B is generally used to generate decompression tables.

Dive Assistant package allows you to select the option by selecting the so-called

limit tables (M-Values). In the basic version, you can choose one of four built-in tables:

a) ZHL-16A (Original).

The first published version algorithm based on 16 half-time intervals. This option is the least safe and should be used only by the experienced and conscious divers. This option is the successor algorithm ZHL-8, which in various forms is used to this day in the dive computer.

b) ZHL-16A (Theoretical)

Original limit table extended by 17<sup>th</sup> nitrogen compartment of 5 minutes half-time.

c) ZHL-16B (Tables)

ZHL-16B variant supplemented by an additional interval of nitrogen. The variant has been developed primarily to generate decompression tables. It can be used successfully also for experienced divers during planning dives.

d) ZHL-16C (Computer)

ZHL-16C variant supplemented by an additional interval of nitrogen. It is the most conservative set limits and therefore it is preferred. This option is often used in modern dive computers.

### 5.4.3 Deep stops.

The first publication of the so-called. deep stops belongs to Richard Pyle, who is now considered the father of "deep stops". Using deep stops, reducing the so-called sub-clinical symptoms of decompression sickness, felt as fatigue, headache and malaise. The essence of additional stops, is to increase the margin to the limit value of the supersaturation of tissues with gas. Until recently, there was not enough researches to be able to confirm their reasonableness, mainly because of the lack of sufficient research methods. Now, there are already available research results, which confirms that a properly planned stops, there is a significant reduction of nitrogen micro bubbles after diving. We encourage you to search for new results and refer to their followed conclusions.

The application allows you to select one of the options below. Modification was implemented into the algorithm by developers,. This modification causes the stops will be determined only if the saturation level of tissues reaches a minimum required value. It will eliminate situations where an extra stop might bring the opposite result - the additional saturation of the tissues, rather than desaturation. For example, they may be the short dives to greater depths and rapid ascent (at recommended speed) to a depth below.

a) None – without deep stops.

Deep stops are not used.

b) Pyle.

It is an implementation of the method invented by the creator of deep stops, whose recommended 2-3 minutes break in the middle between the operational depth and the next mandatory stop.

c) SSA/CMAS.

This is a modified method adapted to dive based on the tables and algorithms of Bühlmann. This method allows you to schedule short, one-minute stops based on absolute pressure until the first mandatory stop.

d) NAUI.

Implementation of the recommendations of NAUI 2008 S&P p 2.16. - one 3-minute deep stop.

e) GF.

The method is based on the variable gradient factor described by Eric. C. Baker. It involves the use of variable factor of safety margin during ascent, which gives additional stops. This results in precise control of tissue saturation. The application uses GF algorithm parallel to the basic algorithm. Additional stops are marked as "deep". GF factor is determined in the range from the deepest, possible decompression stop to the safety stop depth.

#### **5.4.4 Automatic atmosphere (switching).**

The activating this option will automatically switch the calculation engine to breathe atmospheric air after reaching the surface. This is especially useful for planning multiple dives.

Note - the computer does not switch if the input data of the action, we will set the depth dive at a depth of 0m (instead surface). This is a deliberate action, which allows you to plan the return to the entry place, on the surface or little bit below it.

#### **5.4.5 Dive cylinder filling.**

Like the previous option, this feature works on the surface. It causes the automatic refilling of the diving cylinder. Select the option, if you plan to dive a few times and you are supported by the diving center that can fill your set of diving cylinders. If you plan to do two dives, using only one diving cylinder, this option should be disabled.

## 6 Breathing sets editor.

Application version 1.1 provides a quite new module for building complete sets of breathing. Unlike most other programs, Dive Assistant provides not only the opportunity to give the composition of the gas mixture at every step, but a complete subsystem for building sets of cylinders and gas blends in many configurations. This made it possible to reflect the real situation during the dive.

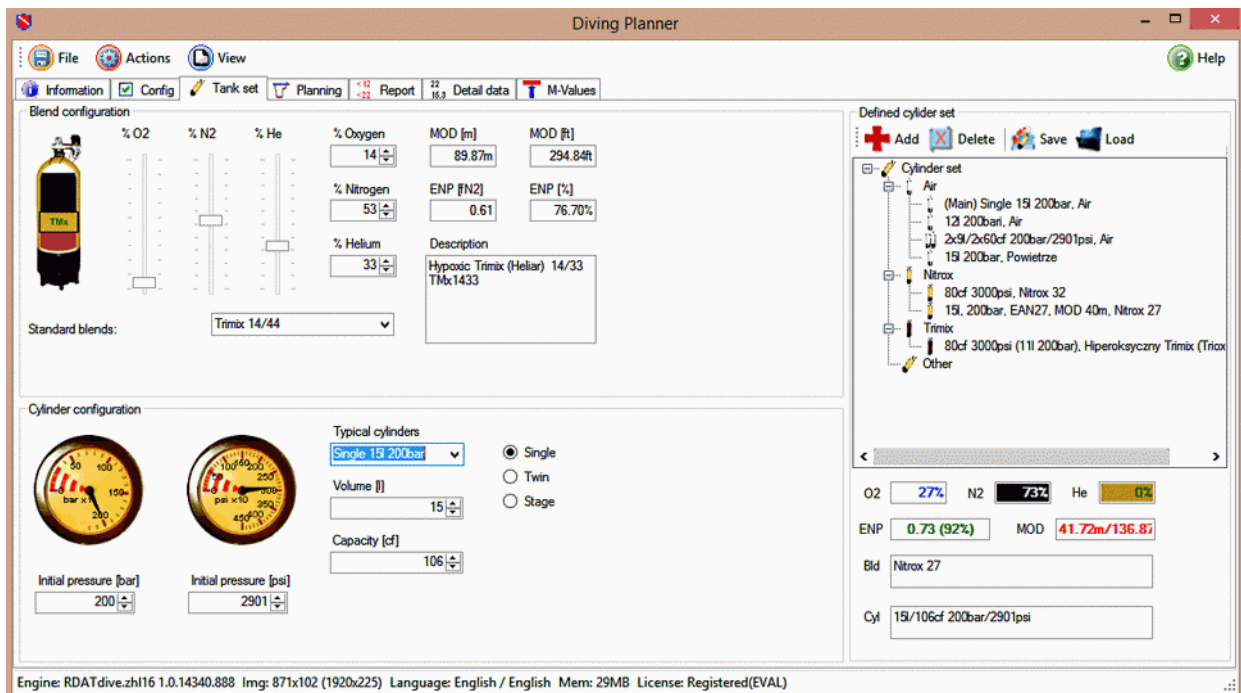


Illustration 2: View of diving cylinder editor

The editor is divided into three panels: the configuration of gas, the configuration of the cylinder and the list of defined sets. Defined sets are saved when you close the application and loaded upon start-up. This allows the use of defined sets, as long as there are removed from the list by the application user.

### 6.1 Blend configuration.

Panel allows to define any gas blend on basic of oxygen, nitrogen and helium. Percentage part of each gas in the mixture is set using the convenient sliders or numeric up-down fields. For your convenience, there is also a selection of standard, pre-defined blends.

For the current blend are given basic properties.

#### 6.1.1 MOD – the maximum operation depth.

Maximum operating depth is calculated on basis of oxygen fraction. MOD value is given for salt water and standard maximum partial pressure of oxygen (currently  $ppO_2 = 1.4\text{bar}$ )

#### 6.1.2 ENP – equivalent narcotic potency.

Combined narcotic potency is calculated in two ways:  
- as an equivalent fraction of nitrogen in Nitrox blend,  
- percentage value of potency related to pure nitrogen.

### 6.1.3 Description.

For each blend is generated automatic description. It contains full name, type and short code. It can be used to mark diving cylinder.

## 6.2 Configuration of diving cylinder set.

The second component of breathing set is diving cylinder. For each set of cylinders must be entered basic parameters. For easy of operation, application presented the view of pressure gauges in both measurement unit systems. Similar to the blend configuration, you can also select the pre-defined cylinder set.

### 6.2.1 Operating pressure (nominal pressure).

Operating pressure of cylinder. Is is possible to enter values in bars or pounds per square inch (psi).

### 6.2.2 Volume, Capacity.

Depending on the measurement units system, you must specify the following parameters:

- the volume in liters of water bottles,
- capacity in cubic feet of gas (the resultant of volume and pressure).



It should be noted that depending on the units is evolving definition of the amount of gas. The European system is given the volume of the cylinder. To calculate the amount of available gas, you must multiply the volume by gas pressure. The imperial system is given capacity, which is at once the amount of available gas.

## 6.3 List of breathing sets.

In the third panel is located list of defined sets. This list is retained even when the application is closed, so that once defined set can be used many times.

For ease of use, the sets are presented in the form of a tree, grouped by major types of diving gas. To select a particular set to preview the details, edit, or delete simply press it (single click). Next mouse click to the selected set will bring you to edit its name. In this way, you can easily mark the set according to individual needs.

Panel provides addition tool bar with few useful functions:

- [ **Add** ] - Adds to the tree new set based on current configuration of gas blend and cylinder,
- [ **Delete** ] - Removes selected set from tree,
- [ **Save** ] - Save all defines sets to XM file,
- [ **Load** ] - Loads the sets from previously created XML file and adds them to the tree.

Below the tree are the details of the highlighted set: the composition of the gas mixture, the narcotic potency, the maximum operational depth, the name and description.

## 7 Limits and safety.

One of the main purposes of which was put in the creation of this software was to increase the level of diving safety. Therefore, the planning application has been equipped with a number of mechanisms which control the admissible limits. Besides the obvious limits, resulting from the certificate level of training and experience, which we must always follow, the application lets you control additional indicators that require more complicated calculations.

### 7.1 Decompression.



Remember that the diving organizations recommends no-decompression diving to recreational grade divers. So please try to use this software to plan just such dives.

Decompression parameters are controlled in software by the following mechanisms:

- ZH-L16 algorithm in various variants and operation modes (the main mechanism),
- safety stops,
- deep stops.

The results are also affected by such factors as:

- depth and dive time,
- number of subsequent dives, surface times,
- speed of descent and ascent,
- barometric pressure, altitude,
- the type of water in the water area,
- the type of breathing mixture,
- selected configuration, limits.

### 7.2 Oxygen related limits.

For recreational diving, using air as the breathing mixture very rarely, if ever, occurs oxygen poisoning. During long or deep dives ability to estimate the toxicity of oxygen, however, has been very important. Currently, the program includes support for three types of oxygen clocks:

#### 7.2.1 Acute form of central nervous system (CNS).

It attacks the central nervous system, it is a form of acute oxygen poisoning. The effects of such poisoning is very serious.

Application Configuration allows you to set a limit for the dose CNS expressed as a percentage

Values higher than 80% are life-threatening.



#### 7.2.2 Chronic form, pulmonary (OTU).

Decrease in vital capacity, which in turn can lead to serious complications.

Depending on the number of dives during the day and the number of diving days limits are different. Limits are determined mainly by the NOAA tables.

### 7.2.3 Drop of the vital capacity of the lung (VCD).

The second method of control pulmonary form of oxygen poisoning is direct simulation of drop of vital capacity expressed in percent.



It is assumed that a decrease of 4% is irreversible and causes permanent damage to the human respiratory system.

### 7.3 Partial pressure of oxygen (PPO<sub>2</sub>).

Both too low and too high partial pressure of oxygen is detrimental. Oxygen partial pressure below 0.16bar/2.3psi can cause hypoxia. Too high pressure between 1.2bar/17psi and 1.6bar/23psi can cause of paralysis of nervous system. The maximum oxygen partial pressure is determined by the program based on the time of diving. PPO<sub>2</sub> limits restrict the minimum and maximum operating depth for a given mixture. PPO<sub>2</sub> also has a direct effect on the CNS, OTU and VCD ratios.



Never exceed the oxygen partial pressure of 1.6bar / 23psi above.

### 7.4 Equivalent narcosis depth (END).

The maximum limit of END is configurable. It was assumed 40m as a standard. The application specifies the result level, based on the relative narcoticness of individual gases. It is assumed that the highest level of narcoticness gas which are commonly used in diving is nitrogen (index of 1). Noble gases can be much higher than nitrogen narcotic properties, but in practice they are not used.



Also requires comment narcoticness of oxygen. Some groups, mainly associated with cave diving, report bad experiences with mixtures of nitrogen and oxygen and they suggest taking oxygen index the same as for nitrogen.



Due to the number of processes related to metabolism and oxygen transport mechanism assumed that the effect of oxygen on narcotic potency of gas blend during normal dives is of marginal importance. The system does not examine the impact of oxygen on change of narcotic potency of diving gas.

### 7.5 Amount of the breathing gas.

The calculating the right amount of the breathing gas is one of the basic skills which we acquire in trainings. In practice, however, we often forget this, what in result may lead to a change in our previously developed plan and thus increase the risk. This program allows you to easily simulate consumption of air and verify the necessary reserve (configurable).



## 8 A dive planning and dive profile.

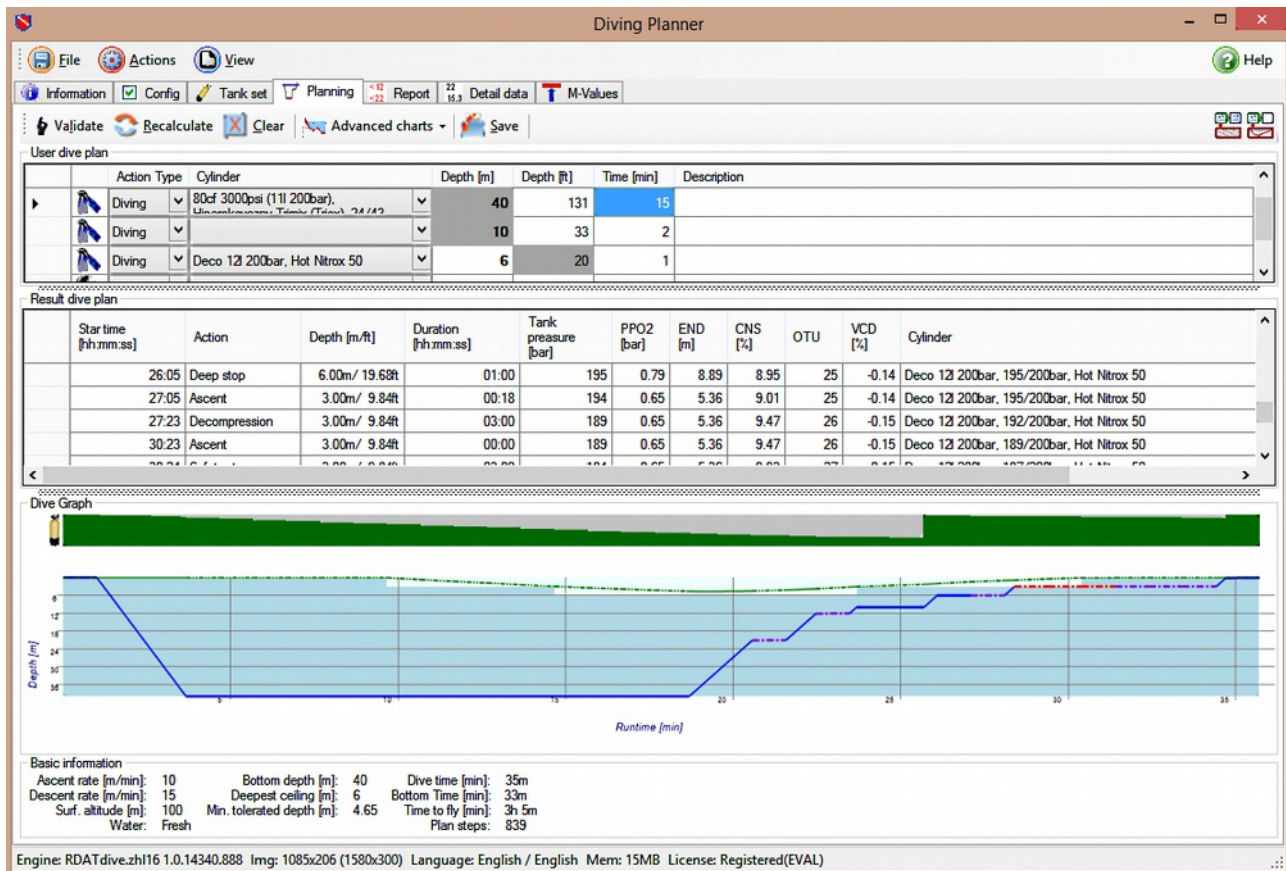


Illustration 3: View of dive planner

After entering basic configuration you can go to the plan of your dives. The separate tab is used for this purpose. It is called "Planning", where are placed all the basic information about the current profile, and thus the assumed plan of the dive, the resulting data of the dive profile with the optional alerts, graphical representation of the profile and summary. Individual panels can be scaled using grips between them and dragging them by mouse to the left-right or up and down.

Data entering on this tab is very easy. There is a simple table to fill in the upper left panel. This table discussed in the next sections.

On the top toolbar buttons are as follows:

- [ **Validate** ] - verifies the entered user plan and makes possible correction,
- [ **Recalculate** ] - calculates the dive profile for our plan, including deco plan,
- [ **Clear** ] - deletes the user's plan,
- [ **Advanced charts** ] - drop-down menu with set of advanced chars,
- [ **Save** ] - save complete dive plan do XML file.

During the calculation all configuration parameters are taken into account. Additionally decompression stops are calculated and safety stops also are planned. Calculation results can be seen in the run-time table and on the graph at the bottom. On a separate tab are also available detail data. In addition, potential threats are checked and the values of the limits. Warnings are collected for each segment calculations and available in tabular view. Available warning alarms are arranged in a separate chapter.

## **8.1 The user's plan.**

The panel is used to enter the assumed data dives by the user. Simple information is required to enter: the type of action, cylinder, the time in minutes, the depth in meters or feet and an optional comment. For most dives, it is enough to fill out only one line, specifying the action "Diving", introducing depth and time. Then pressing the button [ **Recalculate** ], we start the simulation and after a while we've got ready the diving profile.

### **8.1.1 The choice of the rounding way.**

Because the application allows you to enter the depth of the metric or imperial system, it is important to select, for which values are to be compensated the depths of the automatic stops. This is done by clicking on the column header ([ **m** ] or [ **ft** ]). The values in this column will be bold. This setting has no effect on the values entered by the user in the table, but only at a depths determined by the program automatically.

### **8.1.2 Description of plan columns.**

#### **8.1.2.1 Action type.**

Specifies the type of action we want to perform. Depending on the entered type, the program will execute the appropriate planning steps of simulation. Depending on your choice, the edition of some fields of the plan may be limited.

##### **8.1.2.1.1 Beginning.**

It should always be set at the beginning. This step marks the start of the planning and initializes all input parameters, in particular the beginning gas tissue saturation.

##### **8.1.2.1.2 Descent.**

It causes planning of the descents to the given depth with the assumed speed of the descent.

##### **8.1.2.1.3 Diving.**

It means the diving during a specified period of time at the predetermined depth. If the operating depth was changed from the previous step, the ascent or descent will be automatically processed. An interesting feature is the planned dives at depths of 0m, what it will be equivalent to swimming over the surface of the water while using a breathing regulator. In some cases, it may be useful possibility to swim to the entry point in situation when the high waves appear.

##### **8.1.2.1.4 Ascent.**

It shows the planning of the ascent to the specified depth. The parameters of the

tissues saturation will be controlled during the ascent process. They will be controlled to set the required decompression stops and optional deep stops and safety stops.

#### 8.1.2.1.5 Surface.

It allows to take into account the typical activities between dives in the simulation. So the transition to the atmospheric air breathing (we stop the consume the breathing gas from the diving cylinder and it may lead to change of the breathing gas if there was e.g. Nitrox in the diving cylinder) and charge the diving cylinder. Program calculate also value of desaturation. The behavior of this action is configurable.

#### 8.1.2.1.6 The end (finish).

It means the end of our dive. This action is always at the end of the plan, but not between dives. Use action "Surface" between dives.

### 8.1.2.2 Cylinder.

It is possible to select for each dive step an appropriate set of cylinder and gas. Breathing sets are defined on [ **Tank set** ] tab. Gas shift will be done before each step. If the following steps will not be given a new set, the last will be used. If the plan is not given any cylinder, the program will use the main cylinder set from configuration tab.

### 8.1.2.3 Depth.

This is the target operating depth in meters or feet. The units can be rounding during the calculation operation. The rounding values are presented on a gray background. The accurate values which were typed from the keyboard are displayed on a bright background. The depth value is not given for some actions.

### 8.1.2.4 Time (duration).

Duration of the action is in minutes. The time of ascent and descent will be calculated automatically. This time duration is depended on the speed of depth changes.

## 8.2 The resulting plan (dive profile).

The resulting plan is to present the results of the simulation in the compact form – the run-time. The detailed data of profile is available in a separate tab. Both plans are refreshed only after recalculation action. Change in the user profile without starting recalculation does not change of the resulting plans. The compact plan provides basic data about the individual parts/stages of the diving, including occurred warnings.

### 8.2.1 Compact plan columns description.

#### 8.2.1.1 Start time.

Step time counted from the start of diving (run-time).

#### 8.2.1.2 Action.


It is the type of action which is described in the stage of the plan.

All the actions described in the previous section (8.1.2.1) and described further below may occur.

#### 8.2.1.2.1 The deep stop.

This is the so-called deep stop. Remember that if the deep stops were planned, it should not be ignored. This is due to the fact that this stop can affect the point of the mandatory stops and the safety stop. If you do not want to use the deep stops, turn it off in the configuration.

#### 8.2.1.2.2 Decompression.

 The mandatory decompression stop. The occurrence of such step in the plan means that it probably will not be the recreational diving. If your diving organization for your grade recommends no-decompression dive, you should modify the input data, for example, reduce the estimated time or reduce the depth of the dive. It may also help change breathing mixture to Nitrox (but not sure the Trimix). Note - the omission of the decompression stop is not acceptable for any reason.

#### 8.2.1.2.3 Safe stop.

This is a standard safety stop, recommended by all diving organizations. The duration of this stage may be subject to minor changes, depending on other stops.

### 8.2.1.3 Time of duration.

Duration of the current step.

### 8.2.1.4 Pressure in the diving cylinder (tank pressure).

The breathing mixture pressure in the diving cylinder at the end of the stage. Pressure is presented in bars or psi.

### 8.2.1.5 PPO2.

The current partial pressure of oxygen in the breathing mixture at the end of the stage.

### 8.2.1.6 END.

Equivalent narcosis depth at the end of step.

### 8.2.1.7 CNS%.

The percentage of the permissible value units of oxygen clock from the point of view of the nervous system. The value is presented at the end of the step.

### 8.2.1.8 OTU.

The total quantity of the assumed units of oxygen toxicity. The necessary value to determine the possibility of chronic poisoning with oxygen.

### 8.2.1.9 VCD%.

Specifies drop of vital capacity of lung.

### 8.2.1.10 Cylinder.

Description of the diving cylinder used in the stage, including the type and pressure value of the mixture.

#### 8.2.1.11 Comment / Remarks.

There are additional descriptions, including the content of the warnings and threats in this column. Rows needs attention are marked by additional exclamation icon.

### 8.3 A graphical view of diving profile..

The resulting dive profile is presented in the third panel in a simple graphical form. Visualization allows you to quickly get to know the result. Below there is the sample chart of profile together with the description of each items.

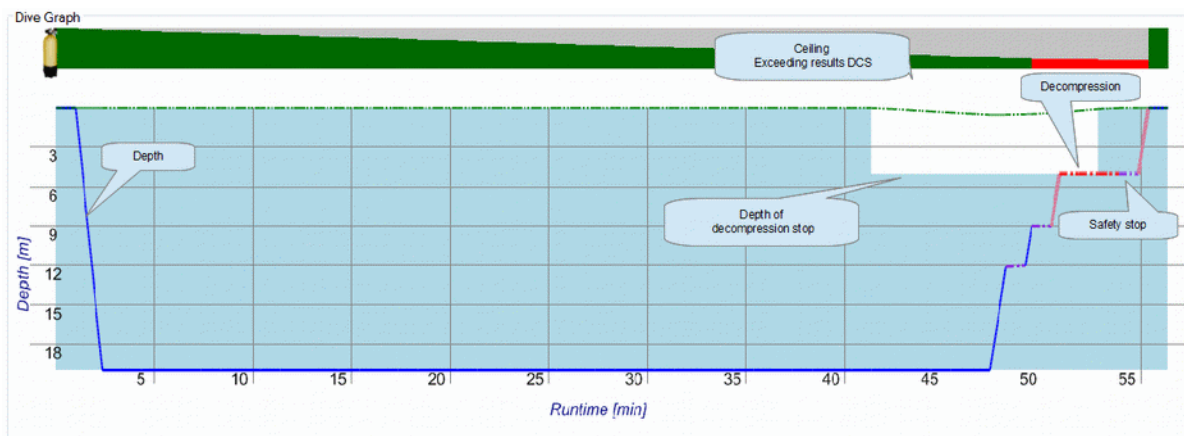


Illustration 4: Dive profile graph

### 8.4 Summary.

In the chart part there is a panel with a summary of the profile. Here are general but useful information, such as total time of the plan or the deepest decompression stop.

### 8.5 Advanced charts.

For each planned profile is possible to see several advanced charts. It help to additional analysis of data.

#### 8.5.1 Tissue partial pressure.

Presents the change of partial pressures of the individual gases in groups of tissues as a function of time. Using the chart, you can quickly trace the characteristics of saturation and de-saturation of the gas during the dive.

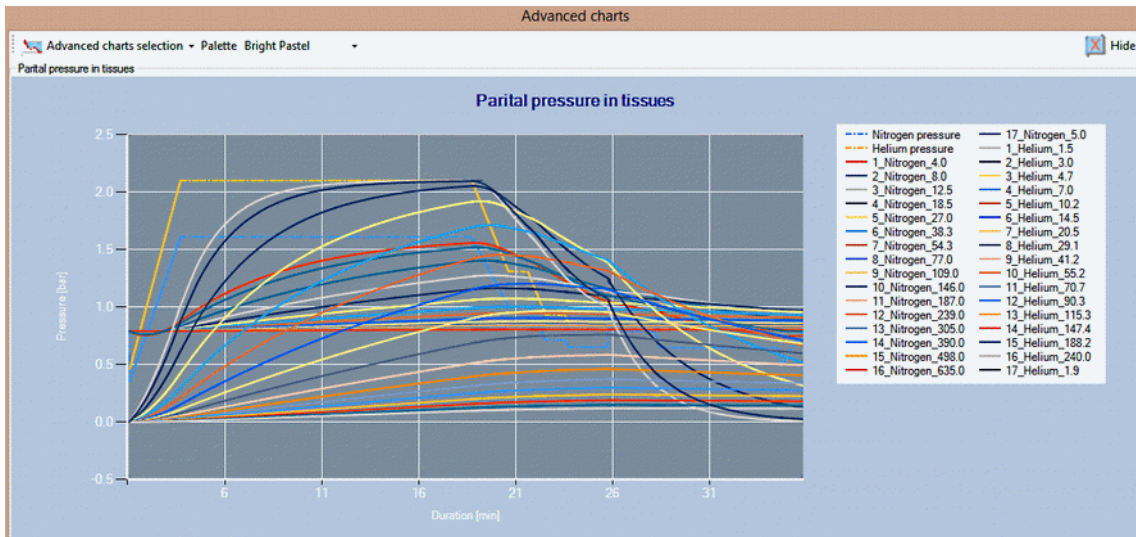


Illustration 5: Partial pressure chart

### 8.5.2 Inert gas pressure.

Shows the combined pressure of inert gases in groups of tissues and minimum allowable ambient pressure.

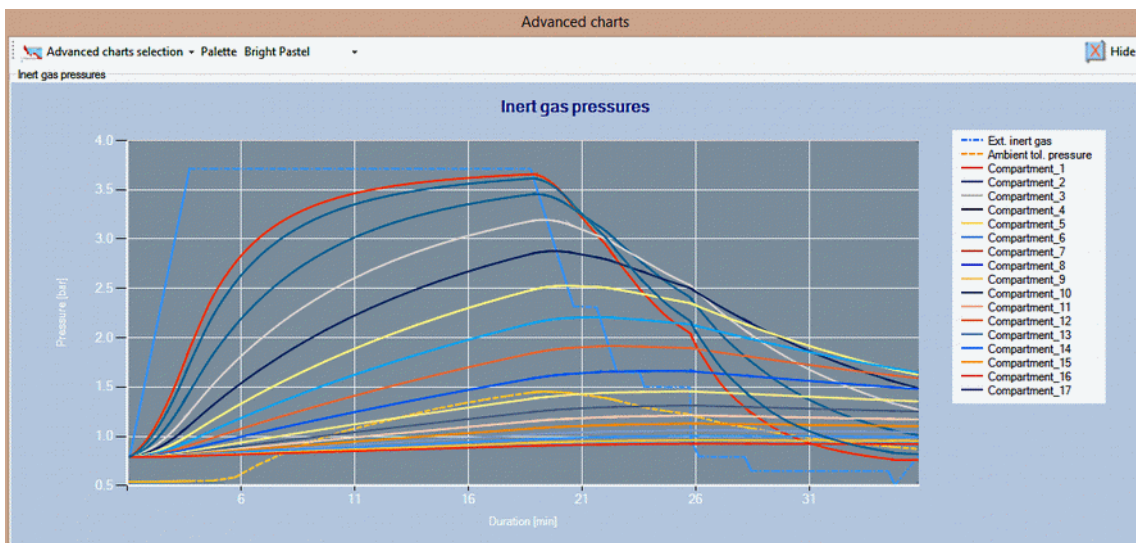


Illustration 6: Inert gas pressures chart

### 8.5.3 Inert gas tissue saturation.

Chart has been built to present range of saturation of particular gases. The upper part of the area shows the percentage saturation of the most saturated tissue, the lower part of the area corresponds to the minimum saturation. The additional line is used to determine the depth.



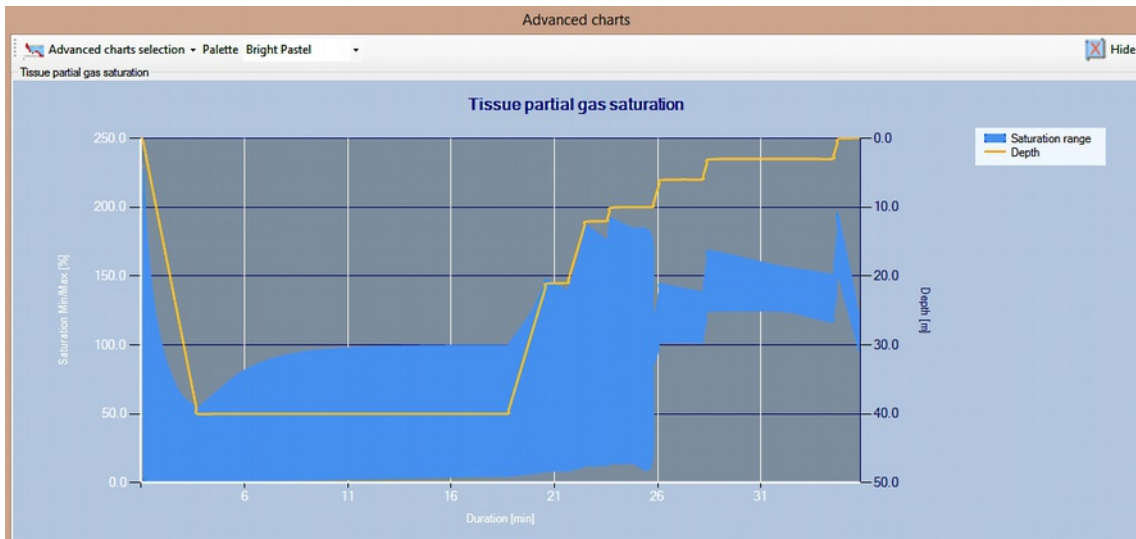


Illustration 7: Tissue saturation range chart

### 8.5.4 Final tissue saturation.

Presents saturation for each group of tissue at end of diving plan. Each bar present saturation of specified tissue in bar. Additional lines shows minimum level of tolerated ambient pressure. The dashed line corresponds to current ambient pressure. With proper planning, the lines of the minimum level should not exceed the ambient pressure line.

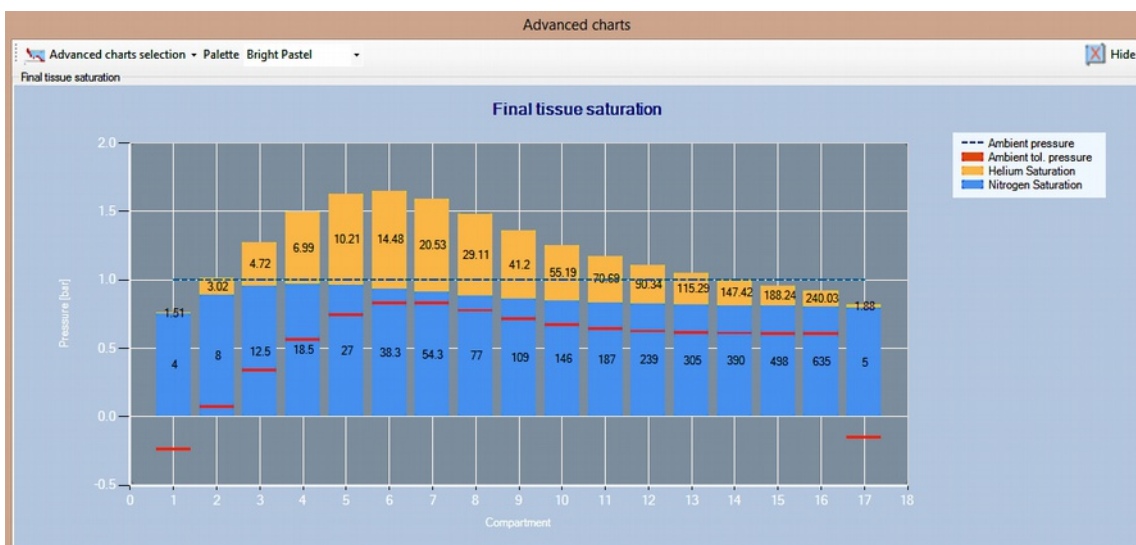


Illustration 8: Tissue saturation at end of dive

### 8.5.5 M-Values.

Chart shows characteristics of selected variant of ZH-L16 algorithm.



*Illustration 9: Characteristic of variant of decompression algorithm*



## 9 Profile data – details.

Dive profile details can be found on separate tab. Information is calculated and stored in the memory with accuracy of one minute or with more accuracy for the dynamic mode or with the accuracy of the stage for the conservative mode. In this way you can check the expected parameters in any moment of our dive plan.

	Depth [m/ft]	Expo Time [h:mm:ss.mss]	Dive Time [h:mm:ss.mss]	Beginning Pressure [bar]	Gas pressure [bar]	Next Deco Stop [m/ft]	Next Deep Stop [m/ft]	No deco time [h:mm:ss]	Time to fly	Ceiling [m/ft]
	39.70m/130.25ft	0:00.400	2:38.800	3.0351	4.8557	0.00m/ 0.00ft	3.00m/ 9.84ft	00:06	1'00:00	0.
	39.80m/130.58ft	0:00.400	2:39.200	3.0416	4.8654	0.00m/ 0.00ft	3.00m/ 9.84ft	00:06	1'00:00	0.
	39.90m/130.91ft	0:00.400	2:39.600	3.0481	4.8751	0.00m/ 0.00ft	3.00m/ 9.84ft	00:06	1'00:00	0.
	40.00m/131.23ft	0:00.400	2:40.000	3.0546	4.8848	0.00m/ 0.00ft	3.00m/ 9.84ft	00:06	1'00:00	0.
	40.00m/131.23ft	1:00.000	3:40.000	3.0611	4.8848	0.00m/ 0.00ft	9.00m/ 29.53ft	00:05	1'00:00	0.
	40.00m/131.23ft	1:00.000	4:40.000	3.5787	4.8848	0.00m/ 0.00ft	12.00m/ 39.37ft	00:04	1'00:00	0.
	40.00m/131.23ft	1:00.000	5:40.000	3.9302	4.8848	0.00m/ 0.00ft	15.00m/ 49.21ft	00:03	1'00:00	0.
	40.00m/131.23ft	1:00.000	6:40.000	4.1729	4.8848	0.00m/ 0.00ft	15.00m/ 49.21ft	00:02	1'00:00	0.
	40.00m/131.23ft	1:00.000	7:40.000	4.3435	4.8848	0.00m/ 0.00ft	15.00m/ 49.21ft	00:01	1'00:00	0.
	40.00m/131.23ft	1:00.000	8:40.000	4.4659	4.8848	0.00m/ 0.00ft	18.00m/ 59.05ft	00:00	1'00:00	0.
	40.00m/131.23ft	1:00.000	9:40.000	4.5555	4.8848	3.00m/ 9.84ft	18.00m/ 59.05ft	00:00	1'00:00	0.
	40.00m/131.23ft	1:00.000	10:40.000	4.6224	4.8848	3.00m/ 9.84ft	18.00m/ 59.05ft	00:00	1'00:00	1.
	40.00m/131.23ft	1:00.000	11:40.000	4.6733	4.8848	3.00m/ 9.84ft	18.00m/ 59.05ft	00:00	1'00:00	1.
	40.00m/131.23ft	1:00.000	12:40.000	4.7127	4.8848	3.00m/ 9.84ft	18.00m/ 59.05ft	00:00	1'00:00	2.

Illustration 10: Tab with detail data of diving profile

### 9.1 Column description.

The meaning of the each columns of the result sheet are described in the following points.

#### 9.1.1 Action.

The Meaning is the same as the user's plan and the compact profile described in sections 8.1.2.1 and 8.2.1.2.

#### 9.1.2 Depth.

The depth at the end of the action, which is expressed in meters or feet of water column.

#### 9.1.3 The exposure time.

The exposure time of the breathing mixture for the action on the diver's body, counted in minutes.

#### 9.1.4 Total dive time.

Total time from the start of dive plan.

#### 9.1.5 Beginning (Initial) pressure.

For the row of type "Beginning" it is the atmospheric pressure prevailing for the specified altitude.

For other rows, it is approximate value of the gas pressure in the tissues of the diver while diving. It is shown for illustration purposes. For the calculation purposes are used the partial pressure of gases which are calculated for each type of tissue /compartment separately.

#### **9.1.6 Gas pressure.**

The pressure of the breathing mixture after the reduction on the specified depth, which the diver inhales and it acts on his body.

#### **9.1.7 The next decompression stop.**



The depth of next mandatory decompression stop at the specified moment of the dive plan. In the case of the stops of the shallow depth, it will be depended on the type of a the water area (freshwater, salty).

#### **9.1.8 Next deep stop.**



The depth of next deep stop. Planned deep stops should not be omitted, because it may cause much higher risk of DCS. Value 0 means that there is not scheduled deep stops.

#### **9.1.9 No-decompression time.**

The approximate dive time, calculated in minutes at the specified depth (for the specified segment) without the need for planning of decompression. This time will be different and depending on the used breathing mixture, the depth and configuration. In our application we used the method of "finding" the longest possible time. After analysis, the limits of algorithm, even with the high calculation precision of present computers are so large, that we used the slower method with the greater demand for calculating power which gives much better and more reliable results.

#### **9.1.10 Time to fly.**

This value is very similar to the no-decompression time, however, it calculates the shortest time that diver must not get on a plane. To calculate the pressure which prevails on specified altitude, we assumed logarithmic scale (similarly as in other calculations). As in the previous paragraph, we have used the method with the greater demand for the calculating power (successive approximation).



In this case, however, we must comment on the results. From our review of the available methods and results which are get from the dive computers, they show the huge flexibility in the approach to the subject e.g. different values of altitude to which is reduced the pressure in the cabin of the aircraft are accepted. Some use a level similar to 2400m/7800ft above sea level, others more conservatively to about 4000m/13000ft above sea level. Some computers do not take into account the limitations of the algorithm, what about it has been already mentioned, and it is the reason that the part of the calculation is "ignored". Others apply to results only so-called "longest tissues" or only "central tissues". For examples of dives, the results are reported in the range of a few to several hours. Thus, the discrepancy of values is very large.

To avoid all these nuances in this application we used:

- the method of finding the time basis on successive approximation,

- time to fly is calculated only on the surface,
- it was assumed, on the basis of several publications of civil flights parameters, the maximum pressure up to 2400m/7800ft above sea level, and in an emergency 4200m/13600ft above sea level.
- In the standard version of application, to provide better security, we take to reduce the pressure to the level of emergency (optional ability to change)
- Besides nitrogen, We take into account the remains of the residual helium, although it will not have a greater importance in most cases.



As you will notice, the completely get rid of the remaining residual nitrogen for the typical dives with use of air, before the end of a 24 hours is almost impossible. Significant differences can be seen only when using Nitrox. For this reason, as well as a scuba diving school, we recommend that you do not get on a plane within 24 hours after the last dive, regardless of the results of calculations.

#### **9.1.11 Ceiling (window).**

This is a real, safe depth to which we can ascend. The value is shown only for illustrative and training proposes. To determine the depth of the stops, it must be used appropriately the values of depths with the rows: "The decompression stop" (Deco), "The deep stop" (Deep Stop) and "The safety stop" (Safe Stop).

#### **9.1.12 V tank.**

The actual amount of breathing gas in diving cylinder in liters at pressure reduced to 1 bar.

#### **9.1.13 P tank.**

The actual pressure of gas in diving cylinder.

#### **9.1.14 Rock Bottom.**

The minimum amount of gas required for emergency ascent. Current version has limited this feature to standard no-decompression dives.



For more complex dives, with decompression or gas shifts value of rock bottom time may not be calculated.

#### **9.1.15 END.**

Calculated, the current equivalent narcosis depth for the breathing mixture.

#### **9.1.16 Total CNS.**

Expressed as a percentage, at present received by diver body, the rate of oxygen dose for the limits of poisoning of the central nervous system. To calculate its value, we used a set of linear equations defined by NOAA. In fact, the CNS is not linear, but this level of accuracy is sufficient and widely used.

#### **9.1.17 Total OTU.**

The total number of OTU units used to determine the possibility of a pulmonary

oxygen poisoning. The acceptable dose limits are dependent on the partial pressure of oxygen, the time and the number of dives on the previous days. The application estimated daily and total limits. Exceeding the limit is indicated by a corresponding alarm.

#### **9.1.18 Vital capacity drop.**

Specifies total drop of vital capacity of lung expressed in percent. This is the alternative to OTU factor of oxygen toxicity on human respiratory system.

#### **9.1.19 Deepest stop.**

Specifies the possible deep of next stop. Making a stop at a greater depth would cause further tissue saturation and bring a counterproductive effect. It is associated with non-linear saturation rate of individual tissues.

#### **9.1.20 Leading saturation [%].**

Maximum gas saturation of most saturated tissue expressed in percent.

#### **9.1.21 Leading saturation [bar].**

Like previous, but expressed as pressure in bar.

#### **9.1.22 Target GF.**

Value of target gradient factor used to calculate deep stops.

#### **9.1.23 Altitude.**

Altitude above sea level, where there is the water area. Altitude affects absolute and atmospheric the pressure and may cause other results of the calculations. The water areas placed above a few hundred meters should be used for diving by the experienced persons. If you are not sure if you can do the dive, consult your instructor or a more experienced colleague..

#### **9.1.24 Blend (gas mixture).**

Used the breathing mixture.

#### **9.1.25 Water.**

Type of the area water - fresh or salty water. For area water with low salinity should be chosen value of parameter "fresh water" in the setup of configuration. An example of the fresh water area (low salinity) may be the Baltic Sea. Similarly, for the Red Sea it should be used the salt water settings.

#### **9.1.26 Compartments count / quantity of tissues.**

In his work, prof. Bühlmann defined initially 8 and later 16 tissue groups. Because they are theoretical, in order not to confuse them with real tissue, so the name was changed to compartment. This value shows the quantity of ranges, which are summed for all included gases. For example, for the 16 ranges in the tables of limits (so-called M-Values) and the two gases (nitrogen and helium), the value displayed in this field will be the 32. Traditionally, the compartments of the lower numbers

represent the tissue of short half-times of the saturation and the higher numbers with the longer half-times. In our applications, the built-in tables may contain additional short-time ranges, which are appended at the end. The values of each range can be viewed in the "(M-Values) variant" tab.

#### 9.1.27 Total time.

Total time of whole dive plan. This is the sum of all planned dives and surface time.

#### 9.1.28 Messages.



The column contains a descriptive messages of warnings and alarms. **The occurrence of any message (except user comments) means the increased risk of diving or lack of possibility its execution. A good plan should not contain even a single warning and alarm.**

## 10 Warning and alarms.

During the calculations process for each of the segment are checked the parameters of profile and they are detected dangers and alarms. They are presented in a tabular view of the resulting profile in the form of messages and icons in each column.



Occurrence at least one warning or alarm message means that the diving is dangerous and you cannot do it.

Below, there are description of the typical situations that are detected during calculation of the dive profile and they are presented as a clear message.

### 10.1 Step of plan reported an exception, some limits can be exceeded (Default).

It is detected an alarm or warning. The application has not found a better description. It should be considered that this dive cannot be done and in case of doubt, please verify the results by yourself (eg, tables) or consult with a more experienced colleague. If you suspect that the problem does not apply to the profile but it is rather the error of application, please contact technical support.

### 10.2 Maximum depth is exceeded (MaxDepth).

The depth of the dive exceeds the entered limit in the configuration tab. Probably, your current diving certificate does not allow for such a dive.

### 10.3 The maximum dive time is exceeded (MaxTime).

The dive time entered in the configuration is shorter than the current total time in the resulting profile. You can try to change the limit in the configuration, but remember that it should be matched to your ability.

### 10.4 Limit of equivalent narcotic depth is reached (END).

The current equivalent narcosis depth exceeded the acceptable limit. The performing of such dives may result in loss of control and, consequently, may result in serious consequences. If you have not yet exceeded the maximum depth of the dive, try to change the breathing mixture to another (e.g. air to Nitrox 36) and calculate the profile again. Note, remember, that there may be other limitations associated with an increased oxygen content in the mixture.

### 10.5 The limit of the oxygen toxicity has been exceeded (OTU).

The total received dose of oxygen for a pulmonary toxicity has been exceeded. You can try to change the breathing mixture to another (for example, Nitrox 36 to Trimix). But the replacement from the Nitrox to air probably will extend the decompression stops, so diving in that case will be impossible. Note that this limit applies generally very complex and long dives. Profile for such dives should be carefully verified.

### 10.6 The daily limit of oxygen toxicity (OTUD).

Similarly as in the previous paragraph, however, concerns the daily limit. The alarm can occur when dives were performed continuously a day after day.

### 10.7 Oxygen toxicity limit is reached (CNS).

The dose limit of the oxygen poisoning of the nervous system has been exceeded. Under no circumstances you should attempt to execute such a dive. In some cases, you can try to change the breathing mixture to Trimix.

#### **10.8 The oxygen toxicity for the nervous system has not been counted (CNS).**

Current parameters do not allow for the calculation of oxygen toxicity. Probably it has been exceeded some others limits (such as the partial pressure of oxygen). Under no circumstances you should attempt to execute such a dive.

#### **10.9 The depth limit for the oxygen has been exceeded (ODL).**

You can not dive using this breathing mixture at this depth, because it has been exceeded acceptable partial pressure of the oxygen. The acceptable pressure is selected dynamically, depending on the diving time, according to the NOAA recommendations (between 1.2 and 1.6bar). The alarm occurs often after exceeding the acceptable depth (MOD) and for so-called "hot" mixtures which are used to reduce the decompression time.

#### **10.10 Too low the partial pressure of oxygen (OTL).**

For the selected mixture, the partial pressure of oxygen at a current depth is too low (typically 0.16bar) and there is a risk of increased effort and even fainting, and consequently diving accident. The alarm is generally occurs for so-called. 'Deep' Trimix mixtures at the low diving depths.

#### **10.11 The diving cylinder is empty (NoAir).**

The diving cylinder is empty. You can try to change the set of diving cylinders. You can also try to further define your individual air consumption rate and enter it to the configuration. However, we warn against, lowering the value of this parameter or entering it as low as possible (SRC) can be dangerous.

#### **10.12 The pressure of the breathing mixture has reached a dangerous level.**

The level of the gas reserve has been reached in the diving cylinder. The reserve is an important factor of the safety. Remember, that in the case of the diving problems, the reserve should give you and your diving buddy a chance to safe ascent. It should not be exceeded.

#### **10.13 The depth of the current dive is greater than the previous one.**

Safety rules say, that the following one after another, the next dives were not deeper than the previous one. The deepest dive always should be planned as a first. After diving in the body for some time, there is the even higher level of nitrogen and other gases. There may appear the single bubbles of nitrogen. Each subsequent dive performed in that day, is associated with a higher level of the risk, so it is better to reduce the depth than to increase it.

#### **10.14 Insufficient amount of gas for safe escape (RockBottom).**

There is not enough gas in cylinder for safe escape. Assumed that diving is always done in pairs and gas reserves must be sufficient for both divers. In most cases, in the first

place occurs a warning associated with static reserve (10.12), but with deep dives, it is possible that a simple gas backup is too small.

#### **10.15 Insufficient amount of gas for safe escape even for one diver (RockBottom1).**

In the cylinder was left too little gas for emergency ascent even for one diver. It also means that until the end of diving is not enough air.

#### **10.16 Deco stop missed (DecoMissed).**

During the additional check, system detect that one of the mandatory decompression stop was missed. Is absolutely necessary to correct the dive plan.

#### **10.17 The risk of ICD (Isobaric Counterdiffusion) and DCS type III (ICD).**

The risk of isobaric counter-diffusion was detected. This may occur during dives with gas shifts and is related to different speeds of saturation. Tissues are saturated with helium as about 2.6 times faster that with nitrogen. This may result in temporary increase of saturation and the formation of a specific form of decompression sickness DCS type III. During the technical and saturated dives must be strictly followed safety rules. Specialized training is required.



## 11 Examples.

The following plans are only examples. Do not treat them as ready-made plans for diving. Remember to always choose the parameters of the dive and plan for your individual needs and current conditions. Consult your plans with your dive partner and never dive alone.

### 11.1 Two dives in “Czarny Staw” in the Tatra Mountains.

This example reflects the typical planning of the dives in low mountains. In this case, choose a glacial lake situated at an altitude of 1624m/5328ft above sea level. Typically, these lakes are characterized by clear water and poor flora. Be sure to take the warm shoes, warm suit, diving gloves and boots, the spare diving cylinder and rescue set as well as hot tea. Due to the relatively low temperature (possibly in the range 4-12°C/39-54°F) you should establish the dive time on short 40 and 30 minutes. Because we have all spare equipment on site, so the break between dives we set the time relatively short. Both of dives we will perform to a depth of 15 meters.

We set the basic configuration parameters - the altitude, the kind of mixture and the type of diving cylinder.

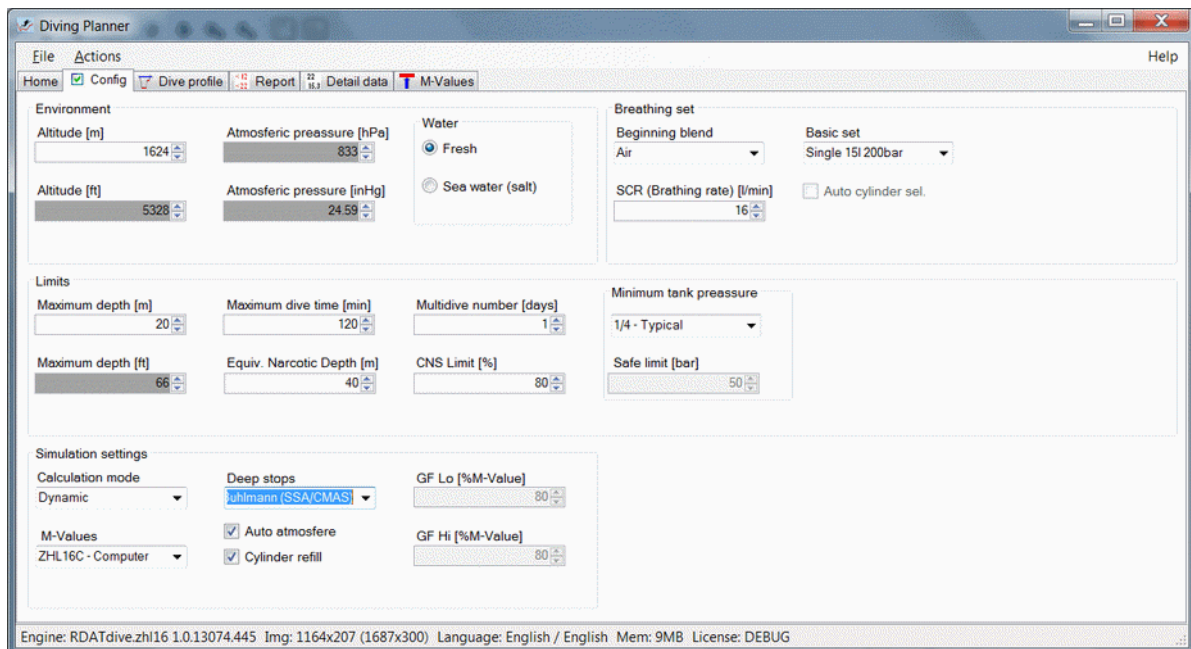


Illustration 11: Example 1 - Configuration

Next, enter the input data. Just enter only the basic actions - "The Diving" and "The Surface". Other elements are optional. They are not mandatory.





User dive plan						
		Action Type	Depth [m]	Depth [ft]	Time [min]	Description
		Diving ▼	15	49	40	First dive
		Surface ▼	0	0	40	Break
		Diving ▼	15	49	30	Second dive
▶*		Diving ▼	0	0	0	

Illustration 12: Example 1 - User profile, input data

Then calculate our profile. The program will automatically add the missing elements and perform simulations of our dives. The results are shown in the right panel, and on the graph.

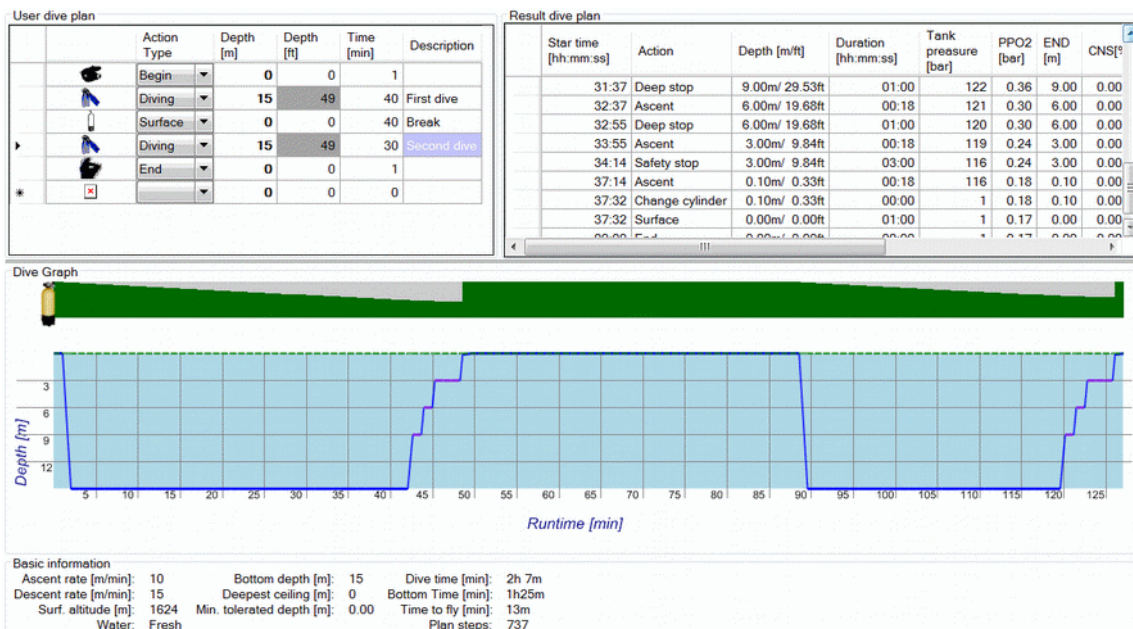


Illustration 13: Example 1 - Calculated profile

The plan looks good, the program does not report any warnings. They will be no-decompression dives. Verify and compare the results with the no-decompression tables, check the weather forecast and we are ready to move on. In the dives like this, it is important to acclimatize into the specified altitude before diving and not move into higher altitudes after dives. Otherwise we risk to suffer from DCS. This dive seems to be easy, but due to the enormous effect of high altitude in the mountains, it should be treated as technically difficult.

## 11.2 Diving in quarry Horka (Saxony).

There is an interesting quarry in the town Horka near Dresden in Germany. In the area of the quarry there is a well-equipped dive base. The best to go diving with a group of

friends. The water is clear and transparent in the water area, all over the year. Visibility reaches 10m. Depth of just over 30m. Dives here are safe and interesting. To dive all around the quarry, efficient diver takes about an hour, but we advise you to do a few shorter dives, it allows for a quiet visit the water area without unnecessary effort and stress. Horka is also ideally suited for night dives, so be sure to take the underwater torches.

So we are planning three dives, two during the day and one at night. The first one is getting to the depth of 20m/66ft, the second one shallower 15m/49ft and third by night to the deep 10m/33ft. Between each of the dives we are planning a minimum 2 hours of the break.

We are entering the basic parameters. During our previous dives we measured the typical air consumption. If you have not perform measurement before, or for example, you're a little tired, we advise you to assume value 20l/m - not like are shown in example 16. It is important to agree the times /length/ of dives and other parameters with a partner. You must determine them together, so as not to cause danger to any of you!

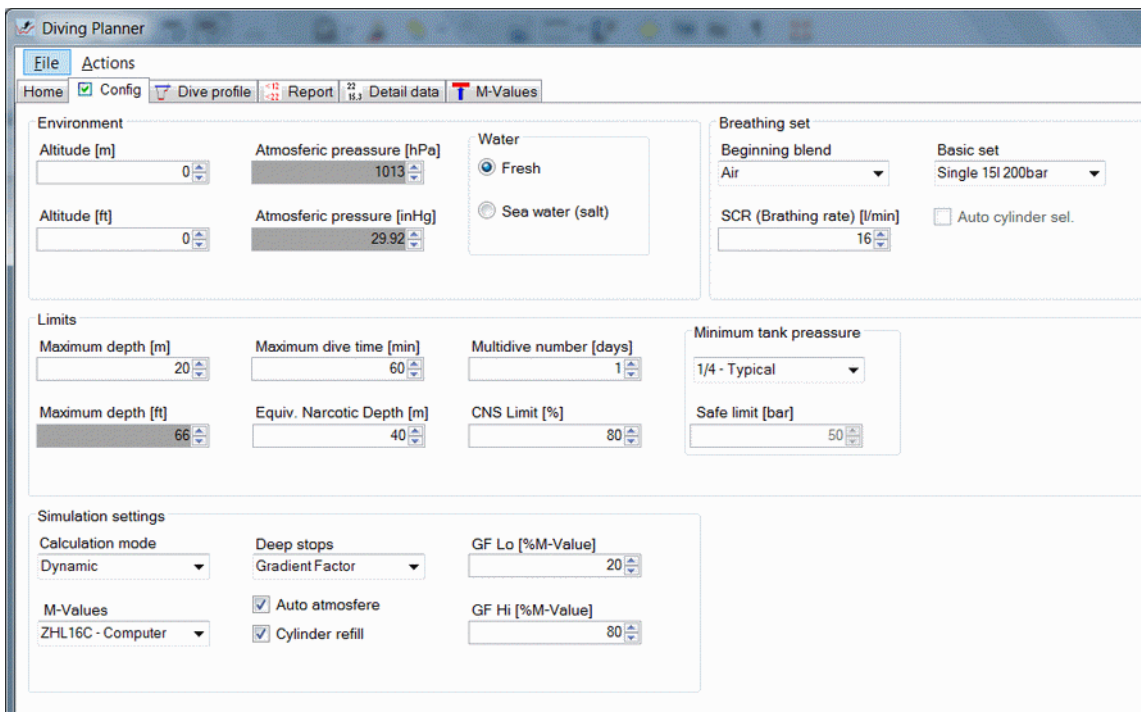


Illustration 14: Example 2 - Configuration

Then we plan our dive. We introduce three dives at intervals of 2 hours. We recommend to do not more than 3 dives a day. In fact, the interval may be longer, especially before a night dive.

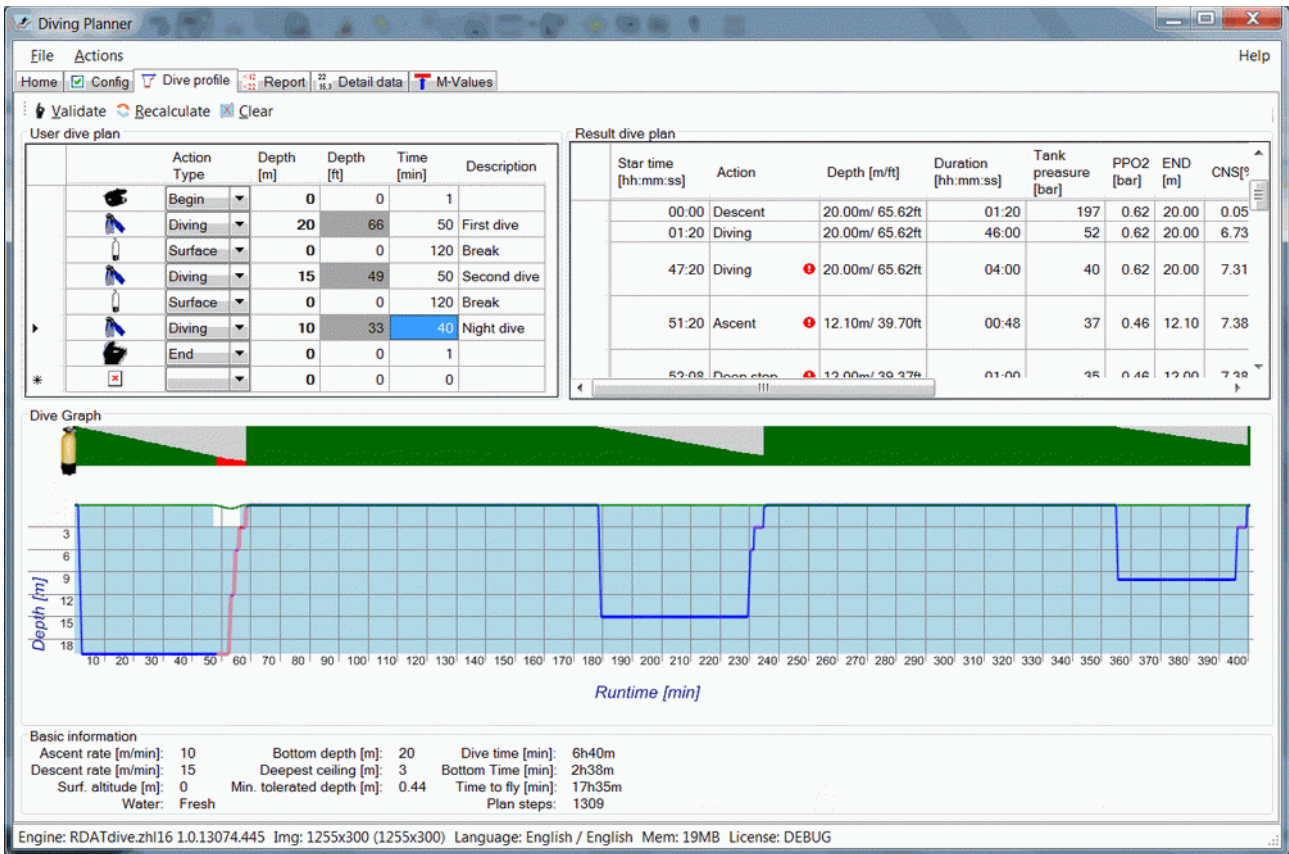


Illustration 15: Example 2 - Wrong diving profile

Unfortunately, because of the depth, the first dive is too long. It is not enough air to us. Such dives cannot be done! So we must decrease the time of the first dive and increase little bit the time of the second dive. Let's check again.

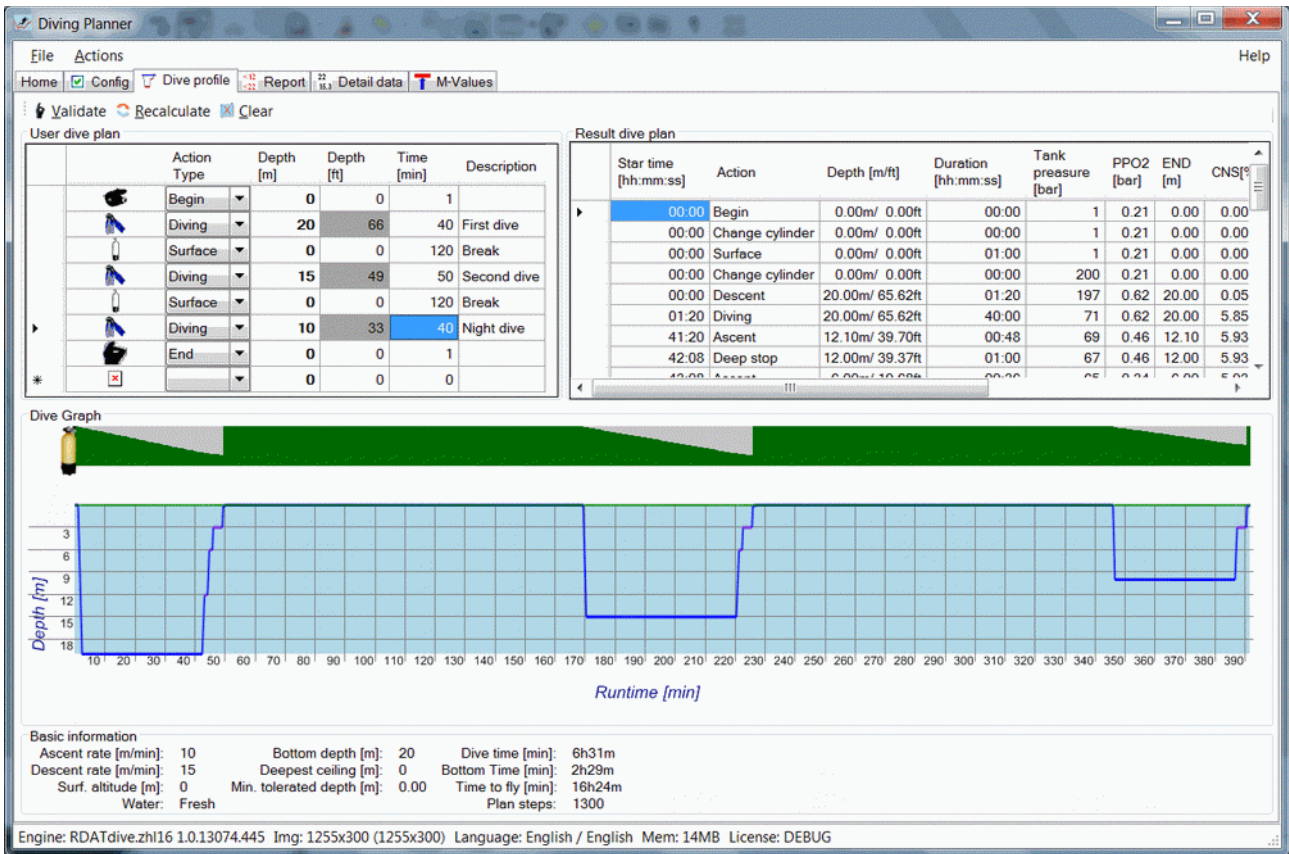


Illustration 16: Example 2 - Correct diving profile

It's safe now. We check and compare the results with tables of decompression and our dive computers and you may continue the preparations.

## 12 The required technical parameters of a computer system.



To make the software worked correctly, it should be met the following recommendations for your computer and the operating system configuration parameters. The application can run on other computers, but there is no guarantee (they were not tested).

The recommendations are also included in the License Agreement.

Also note the limited support for older operating systems.

### 12.1 The operating system.

The application was created for Microsoft Windows in the latest versions - Windows 7 SP1 and Windows 8 and Windows 8.1.

We also tested the correct operation of the ever-popular Windows XP SP3. The application should also work correctly on Windows Vista, but on this platform was not fully tested. These are the older systems and therefore are associated with limitations in support of the application.

We recommend that before the installing process, it was installed the Microsoft .NET platform, but not older than version 4. However, the installer contains the necessary elements of .NET.

It should be noted that the security software (firewalls) do not block the application access to the Internet. The internet network is required to run the application.

### 12.2 The hardware requirements.

Our internal tests show that the application works in practice correctly on any popular hardware platforms. On slower computers, or equipped with less memory, simulation can calculate longer, but within an acceptable time. To ensure optimum comfort we recommend that the computer on which you install the program, meet the following minimum requirements:

- processor: INTEL PENTIUM or Athlon 64,
- memory RAM: 1GB,
- graphics adapter: any with minimum resolution 1024x768 or 1280x720, 16th colors,
- network: an active connection to Internet,
- 20 GB of free space on hard drive.

We received excellent results of the computer performance on systems equipped with Intel Core i5 2.4GHz processor, 8GB of RAM, graphics card with HD-installed under Windows 8.1 Pro 64 bit control.